República de Moçambique
Ministério da Terra, Ambiente e Desenvolvimento Rural

MRV Road Map. Moçambique

Governo de Moçambique

december 2016

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Ministério da Terra, Ambiente e Desenvolvimento Rural

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v. dezembro 2016

Conteúdo

Component 3: Reference Emissions Level/ Reference Levels

Rationale

A MRV system should be, as required, a robust and transparent national forest monitoring system for the monitoring and reporting REDD+ activities, providing estimates that must be transparent, consistent (over time and with the established Forest Reference Levels) and accurate (taking into account national capabilities and capacities). All REDD+ results based actions should be fully measured, reported and verified. Furthermore, as the REDD+ scheme is expected to deliver emission reductions and other co-benefits, the MRV system should be designed to help track a range of other indicators such as biodiversity and social benefits.

A National MRV system should be designed to be able to accommodate multiple stakeholders. A coordination mechanism at National Level should be put in place to provide a link between policy and practice at different scales. MRV-related activities and arrangements should be linked to existing relevant structures, institutions (e.g. higher education and research institutions) and ongoing monitoring activities at the local level. In this regard the national MRV system should also consider the development of innovative participatory approaches aimed at engaging forest-dependent communities in monitoring and verification work build understanding and local ownership. In this sense the following proposal framed in the project as defined below is drawn.

Mozambique is one of the 47 countries selected to benefit from the Forest Carbon Partnership Facility (FCPF) to access funding to develop and implement strategies aiming to reduce emissions from deforestation and forest degradation (REDD+). The Readiness Grant Agreement dated January 25, 2012 (US$200,000) was used for formulating the Readiness Preparation Proposal; R-PP. The Preparation Grant Agreement (US$3.6 million) dated July 15, 2013, and amended on August 29, 2014, enabled the country to move ahead with preparation for readiness.

Through the Additional Grant, Third Grant Agreement (US$5,000,000), dated February 12, 2016, Mozambique is carrying out the Additional Readiness Preparation Activities, contributing to the adoption of the national REDD+ strategy and of the national legal and institutional framework for REDD+. These activities consist of the following parts: (1) REDD+ Readiness Management Arrangement, Legal Framework and Pilot Projects, (2) Forest Reference Emission Level /Forest Reference Level and (3) Monitoring Systems for Forests, the latter through: (a) establishing and operationalization of an MRV task force and system and (b) providing goods for the development of activity data and forest inventory. Parts 2 and 3 were funded with US$2.5 million of this additional grant.

In February 2016, the National MRV Road Map, where the main M&MRV activities are planned, was drafted with frequent updates throughout 2016.

On November 29th, 2016, the Government of Mozambique, in the Council of Ministers, approved the National Strategy (+ the Action Plan) for reduce emissions from deforestation and forest degradation, and foster conservation, sustainable management of forests, and enhancement of forest carbon stocks (REDD +). In section 7 of this National Strategy, the M&MRV component is described. The Monitoring, Measurement, Reporting and Verification (M & MRV) procedures of REDD + activities will be transparent and robust, as envisaged by the United Nations Framework Convention on Climate Change (UNFCCC) and are methodologically based on the most recent guidelines from the Intergovernmental Panel on Climate Change (IPCC).

It is explicitly referred to in this National Strategy that the standards, procedures and guidelines for monitoring and measuring REDD + activities and results in Mozambique should be prepared considering the strategic objective that aims to ensure the **active participation of local communities** (participatory or community-based MRV; PMRV), and include useful information for the definition of **environmental indicators** related to the reduction of deforestation and forest degradation and related emissions, **economic and social indicators** linked to integrated rural development, as well as the specific indicators of **environmental and social safeguards**, as set out in the Environmental and Social Management Framework (ESMF) of REDD+.

According to the National Strategy, the M&MRV procedures of REDD + activities and results should essentially: (i) guide and ensure the generation of data and information to demonstrate , based on results, the REDD + commitments assumed by the country in particular to those contributing to the mitigation of global climate change; and (ii) ensure and influence that aspects related to the scientific-technical and economic effectiveness as well as the strategic-political, and governance aspects present are pertinent to the successful implementation of REDD+ initiatives in the country and open up greater possibilities to improve the forest management and integrated rural development.

A M&MRV system and specifically the measurement and verification components should be able to demonstrate REDD + results with internationally accepted transparency, consistency, technical-methodological robustness and credibility. The establishment and implementation of this system in Mozambique will entail important technical and financial challenges, as well as important opportunities and improvements in the planning and management of the territory at national level.

Main design elements

Scope

The main objective of this PMRV will be to collect local carbon stock data (AGB, BGB, DOM and SOC) and additional forest variables (non-carbon data), variables on drivers of deforestation and forest degradation, activity data (deforestation, forest degradation and forest enhancement) and environmental and social information and impacts of REDD+ implementation (safeguards information) to fulfil the M&MRV requirements of REDD+ program in Mozambique and to improve carbon accounting at the national level (in compliance with international standards) and increase the participation of local communities to maximize the co-benefits of REDD+.

First of all, we should define for these M&MRV tasks: the geographic boundaries, vegetation types, activities and GHG to be accounted.

Geographic boundaries

The MRV system to be developed, although will be initially tested in 15 specific districts of Zambezia and Cabo Delgado, should not be specific to these test areas to allow be replicated in other districts and provinces all over the country (78,946,564.3063 ha – national map layer estimation).

Countries are allowed, as an interim measure, to define sub-national and project level M&MRV systems that will be integrated in the emerging sub-nationals and national M&MRV. But finally, and this is the objective of this document, the national M&MRV system must be defined. Regarding the FREL/FRL, It will be calculated at national level and specific program or project's FREL/FRL will be estimated from the national one considering a stratified approach by vegetation types.

Of course, we should consider that this broad geographical boundary will be reduced depending on the selected REDD+ activities (deforestation, forest degradation and forest enhancement). For the two first activities that's mean that we are just considering forests; deforestation can only occur on lands that are forest and are converted to non-forest and degradation can only occur on lands that are forests and remain as forests. For forest enhancement monitoring purposes we should focus on forest and non-forest land (A/R activities).

According to the results of the project of Mozambican Agro-ecological Zoning ('Zoneamiento Agroecológico de Moçambique', ZAEN, 2010-2014) based on the interpretation and verification of Landsat images from 2009-2010, the area occupied by Semi-natural terrestrial vegetation is 62,575,825 ha, by Semi-natural aquatic vegetation 2,389,959 ha and by Cultivated & managed terrestrial areas (only forest plantations) 11,864 ha. If we focused on tree based ecosystems (mainly forests and woodlands) the total survey area sets to 45,503,861 ha; 539,814 ha of Semi-natural aquatic vegetation, 44,952,183 ha of Semi-natural terrestrial vegetation and 11,864 ha of forest plantations (Table 1).

Code	LC Category	Domain	Group	Name	Area
1TCW	Cultivated & managed terrestrial areas Total	Tree crop		Forest plantation	11864
Cultivated & managed terrestrial areas Total					**11864**
4FEP	Semi-natural aquatic vegetation	Forests	Evergreen	Mangrove dense	319713
4WEP		Woodlands	Evergreen	Mangrove open	152291
4WET		Woodlands	Evergreen	Woodland temporarily flooded land	67809
Semi-natural aquatic vegetation Total					**539814**
2FD	Semi-natural terrestrial vegetation	Forests	Semi-deciduous	Semi-deciduous forest	4703095
2FDB				Miombo dense	2844808
2FDC				Mopane dense	203563
2FE			Semi-evergreen	Semi-evergreen forest	719219
2FEA				Mecrusse dense	388408
2FEG				Gallery forest	943433
2FEM				Semi-evergreen mountainous dense forest	348297
2GCT		Grasslands		Tree savanna	1375521
2WD				Semi-deciduous open forest	24843442

Code	LC Category	Domain	Group	Name	Area
2WDB		Woodlands (Open forests)	Semi-deciduous	Miombo open	3507022
2WDC				Mopane open	1979576
2WE			Semi-evergreen	Semi-evergreen open forest	2421296
2WEA				Mecrusse open	137941
2WEM				Semi-evergreen mountainous open forest	536561
Semi-natural terrestrial vegetation Total					**44952183**
Grand Total					**45503861**

Table 1. Tree vegetation types according to 'Zoneamiento Agroecológico de Moçambique', 2010-2014.

Forest definition

This definition is critical to define the geographical boundaries where the FREL/MRV system is going to be established and to define the spatial and radiometric resolution (and hence the costs) required for EO-based monitoring.

The Marrakech Accords[1] outlined a range of minimum threshold values for the main quantitative parameters in the forest definition with minimum mapping unit, minimum crown cover and minimum height at maturity, and it required Parties to submit approved forest definitions. Mozambique submitted a forest definition to the UNFCCC for CDM AR activities[2], and in October 2016 [3] was submitted to the Council of Ministers, the approved proposal of Forests, Deforestation and Forest Degradation Definitions under REDD+.

As a result of a detailed analysis and a participatory process, forest definition was expressed as follows: '*Forest are lands that occupy at least 1 ha with canopy cover> 30%, and with trees with potential to reach a height of 3 meters at maturity, 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*'.

REDD+ Activities

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

According to Centro de Estudos de Agricultura e Gestão de Recursos Naturais (CEAGRE) & WinRock International (2016)[4] the main drivers of deforestation and forest degradation (being

[1] FCCC/CP/2001/13/Add.1, Decision 11/CP.7; Land use, land-use change and forestry, Marrakesh Accords, p. 54.

[2] http://cdm.unfccc.int/DNA/index.html. *A single minimum tree crown cover value of a 30 per cent, a single minimum land area value of 1 hectare and a single minimum tree height value of 5 metres.*

[3] Definição de Florestas, Desmatamento e Degradação Florestal no âmbito do REDD+. Outubro, 2016. Mário Paulo Falcão e Micas Noa para o FNDS. http://www.redd.org.mz/uploads/SaibaMais/ConsultasPublicas/Relatorio%20definicao%20de%20floresta%20V5_19.10.2016.pdf

[4] Identificação e análise dos agentes e causas directas e indirectas de desmatamento e degradação florestal em Moçambique. Relatório final. Abril, 2016. Centro de Estudos de Agricultura e Gestão de Recursos Naturais (CEAGRE) & WinRock International. http://www.redd.org.mz/uploads/SaibaMais/ConsultasPublicas/Estudo%20sobre%20Causas%20Directas%20e%20Indirectas%20do%20Desmatamento%20e%20Degrada%C3%A7%C3%A3o%20Florestal.pdf.

that usually act in a combined or sequential way over time) in Mozambique are linked to Shifting cultivation (89,407 ha/year and 7.8 MtC/year, 65%), followed by Urban Expansion (16,285 ha/year, 1.4 MtC/year, 12%). Other relevant drivers were identified as logging and firewood and charcoal, and livestock grazing. Commercial (large-scale) agriculture and mining become of great relevance at local level.

Logically economic, social and natural characteristics of each province may also determine the main drivers and its rate of deforestation and forest degradation. Just an example related to the current forest type; mopane areas suffer mainly (i) charcoal production, (ii) logging, and (iii) cattle or goat grazing, while miombo areas undergo relevant changes due to shifting cultivation or commercial agriculture.

On the other hand, analysis shown forest degradation (including selective logging, firewood and charcoal and fires) plays a very important role in emissions accounting for up to 30% of total emissions.

‘**Reducing Emissions from Deforestation’** and ‘**Reducing Emissions from Forest Degradation’** would probably be significant and that they should be accounted for. Accounting for both would ensure that there are no leakage emissions from displacements of deforestation drivers that could cause an increase in emissions from degradation (VCS JNR requirement). FCPF CF Methodological Framework requires selecting deforestation and degradation if it represents more than 10% of total forest-related emissions. Additionally, there is an interest to account for ‘**Enhancement of forest carbon stocks**’ (ECS), but limited to afforestation/reforestation (A/R) activities. Regarding the potential GHG removals or emissions from REDD+ activities ‘Conservation of Forest Carbon Stocks’ and ‘Sustainable Management of Forests’, are expected to be insignificant compared with the above mentioned.

Scope Summary

Scope	Definition
Geographical boundaries	Mozambique national boundaries. The PMRV system will be initially tested in 15 specific districts of Zambezia and Cabo Delgado.
Forest definition	MMU 1.0 ha / CC 30 % / TH 3 m
REDD+ activities	▪ Reducing emissions from deforestation, ▪ Reducing emissions from forest degradation, ▪ Enhancement of forest carbon stocks (Afforestation/Reforestation)

Table 2. Summary of Scope specifications.

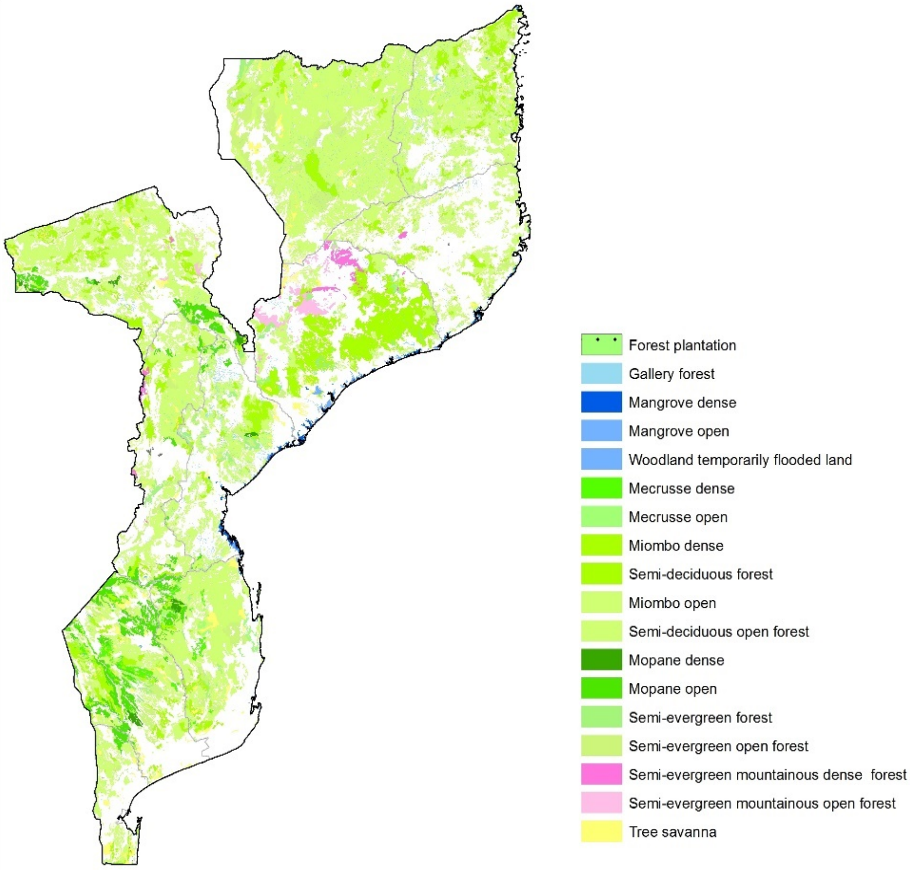

Figure 1. Area of interest: forests (Zoneamiento Agro-ecológico Nacional, 2010-2014) by vegetation type.

Methods

Monitoring and measuring methods should be simple in Community Based Systems but scientifically robust and unbiased to provide accurate and reliable data. These methods depend on the activities and pools whose changes we try to monitor and measure. It is convenient to start by defining the activities that in the previous section we said we should monitor.

Definitions

Deforestation - Under Decision 16/CMP.1, UNFCCC defined deforestation as: '... the direct, human-induced conversion of forested land to non-forested land'. Effectively this definition means a reduction in crown cover from above the threshold for forest definition (30%) to below this threshold.

Following the term 'categories' as used in IPCC reports; Forest Land converted to Cropland, Forest Land converted to Grassland, Forest Land converted to Wetlands, Forest Land converted to Settlements, and Forest Land converted to Other Land, are commonly equated with 'deforestation'.

Non-forest land converted to forest land would generally be referred to as 'forestation' and is reflected in new forest area being created.

Deforestation causes a change in land use and usually in land cover. Common changes include: conversion of forests to annual cropland, conversion to pasturelands, conversion to perennial plants (oil palm, shrubs), and conversion to urban lands or other human infrastructure.

In October, 2016, the approved proposal of Forests, Deforestation and Forest Degradation Definitions under REDD+ was submitted to the Council of Ministers. As a result of a detailed analysis and a participatory process, deforestation was expressed as follows: **Deforestation** is the conversion, directly induced by man, of land with forest to land without forest (it will be considered the national forest definition: a reduction in canopy cover from above the threshold for forest definition, 30% to below this threshold).

Forest degradation (and enhancement of carbon stocks; the opposite trend and definition) within forest land, occurs in forest areas where there are anthropogenic net emissions (i.e. where GHG emissions are larger than removals), during a given time period (no longer than the commitment period of the accounting framework) with a resulting decrease in canopy cover/biomass density that does not qualify as deforestation.

A net decrease, at national or sub-national scale, in carbon stocks of Forest Land remaining Forest Land is commonly equated to 'forest degradation'. A net increase, at national or subnational scale, in this category would refer to the 'enhancement of carbon stocks'.

Developing a monitoring system for degradation involves identifying the causes of degradation, and assessing the likely impact on the carbon stocks.

Area of forests undergoing **selective logging** (both legal and illegal) with the presence of gaps, roads, and log decks is likely to be observable in remote sensing imagery, especially the network of roads and log decks. The reduction in carbon stocks from selective logging can also be estimated through indirect methods related to the reduction of canopy cover, implementing a visual assessment using high resolution imagery or through direct methods using radar imagery and biomass data from the National Forest Inventory. Besides, it could be estimated without the use satellite imagery, i.e. based on methods given in the IPCC GLAFOLU for estimating changes in carbon stocks of 'forest land remaining forest land'.

Degradation of carbon stocks by **forest fires** could be easily monitored with existing satellite imagery depending on the severity and extent of fires. Practically all fires in tropical forests have anthropogenic causes.

Degradation by over exploitation for **fuel wood** or other local uses of wood is often followed by **animal grazing** that prevents regeneration, a situation more common in drier forest areas. This situation is likely not to be easily detectable from satellite image interpretation always depending on the rate of degradation and its impact on the canopy cover (visual assessment) or on the carbon stocks (radar approach).

In October, 2016, the approved proposal of Forests, Deforestation and Forest Degradation Definitions under REDD+ was submitted to the Council of Ministers. As a result of a detailed analysis and a participatory process, forest degradation was expressed as follows: **Forest degradation** is the long-term reduction of canopy cover and/or carbon stock that leads to a reduction in the provision of benefits from the forest, which includes timber, bio-diversity and other products and services. This reduction is through logging, burning, cyclones and others, provided that canopy cover remains above 30%.

General method for estimating CO2 emissions and removals

The IPCC Guidelines refers to two basic inputs to calculate as a product the greenhouse gases emissions and removals: activity data and emissions/carbon-stock-change factors. Activity data refers to the extent of a category (areal extent of deforestation, forestation and forest degradation/ enhancements). Emission factors refer to emissions/removals of greenhouse gases per unit area (in metric tons of carbon per hectare) resulting from land-use conversions and the consequent carbon stock changes.

Activity Data

'Activity data' refers to the extent of a category, and in the case of deforestation, forestation and forest degradation/enhancements refers to the areal extent of those categories, presented in hectares. Practically speaking activity data is referred to as area data.

Approaches

We can consider three different approaches to assess activity data:

1. Measuring total area for each land use category, without information on conversions (only net changes),
2. Tracking of conversions between land-use categories (non-spatially explicit land-use conversion matrix between 2 points in time),
3. Spatially explicit tracking of land-use conversions over time.

We should consider the third one as the most desirable to be reached, in order to understand the drivers of deforestation and forest degradation and plan the adequate mitigation activities. It is in fact required for measuring deforestation by the FCPF CF MF and the VCS JNR, and the selected approach at National Level.

Approach 3 considers two different options for obtaining the activity data: a) through wall-towall mapping or b) through sampling. It has been repeatedly demonstrated that a well-designed sampling approach to train a supervised classification of changes on a multi-temporal stack of images results more accurate than just a simple comparison exercise between two static in time LULC maps, even when these maps are pretty precise. Result through this sampling approach could be also a map of changes, that is not exactly an updated version of a LULC map, although, of course, ideally should show a good degree of agreement. Considering the historical analysis necessary to produce the FREL it is clear that it has no sense to prepare historical LULC maps, but in the future, to monitor the implementation of the mitigation activities and their impact (and for other purposes as NFI design, forest management, etc.) would have a lot of sense to elaborate updated versions of the LULC maps (update methodology must be simple but accurate and consistent with the analysis of changes). Both methods are acceptable by the FCPF CF MF and the VCS JNR. This mixed approach has been selected at national level to monitor and measure AD. In other jurisdictional programs and projects, in order to ensure consistency with the national level, a similar decision should be taken on this regard. It is necessary to rely on the national level data for the historical analysis (top-down approach to apply a FREL based on vegetation type stratification) but more detailed information could be prepared at local level (bottom-up perspective) to train a change detection mosaic under a sampling approach methodology or to produce an updated version of a LULC map.

Regarding the sensors, at national level was decided to rely on optical sensors working at VNIR and SWIR of high spatial resolution, Sentinel-2, and using additional support of SAR sensors, e.g. ALOS PALSAR combined with high resolution imagery, to track forest degradation processes. To monitor and measure AD at local level in a PMRV project it is highly recommended to use also high resolution imagery, e.g. Sentinel-2, 10 m, (or Ikonos, Quickbird, Worldview, Geoeye, …) for preparing field maps or applications.

Sentinel-2 mission was launched on the 23rd June 2015. In Mozambique, the first Sentinel-2 images date from December of the same year. This satellite provides multi-spectral data with 13 bands in the visible, near infrared, and short wave infrared part of the spectrum, that is available through a free and open data policy framed in the context of the ESA-European Commission Copernicus Programme.

The mission provides a systematic global coverage of land surfaces from 56° S to 84° N, coastal waters, and all of the Mediterranean Sea. The mission provides a global coverage of the Earth's land surface every 10 days with one satellite (the A mission currently in orbit) and 5 days when its twin brother, Sentinel 2-B (foreseen for 2017) will be available, making the data of great use in on-going studies.

Sentinel-2 A is equipped with the state-of-the-art MSI (Multispectral Imager) instrument that offers high-resolution optical imagery spatial resolution of 10 m, 20 m and 60 m (Table 3). The field of view is of 290 km.

Sentinel-2 Bands	Central Wavelength (µm)	Resolution (m)
Band 1 – Coastal aerosol	0.443	60
Band 2 – Blue	0.490	10
Band 3 – Green	0.560	10
Band 4 – Red	0.665	10
Band 5 – Vegetation Red Edge	0.705	20
Band 6 – Vegetation Red Edge	0.740	20
Band 7 – Vegetation Red Edge	0.783	20
Band 8 - NIR	0.842	10
Band 8A – Vegetation Red Edge	0.865	20
Band 9 – Water vapour	0.945	60
Band 10 – SWIR - Cirrus	1.375	60
Band 11 - SWIR	1.610	20
Band 12 - SWIR	2.190	20

Table 3. Sentinel -2 A bands.

By using Sentinel-2 for MRV purposes (LULC map 2016 and LULC changes monitoring) we could achieve, due to its spatial resolution (10m/20m) and its absolute geolocation uncertainty: 20 m at 2σ confidence level without Ground Control Points and 12.5 m 2σ with GCPs (absolute geolocation < 11 m at 95.5% confidence, baseline 02.04, 08/12/2016), a MMU of approx. 1,000 m^2 (10,000 m^2 is the required MMU).

Sentinel-2 imagery will be used to produce the benchmark map necessary to complete the historical AD analysis and as a starting point for MRV purposes. MRV Unit at FNDS is preparing this LULC 2016 map based on Sentinel-2 products. For this purpose 4 national mosaics (2 epochs / 2 spectral resolutions and 2 spatial resolutions 10 m/20 m) have been prepared (Annex1. Se.

The first mosaic covers the entire area of Mozambique with Sentinel-2 A images **dated May-June 2016**. It was checked that before May 2016, the majority Sentinel images available are not valid due to an excess of cloud coverage. This is coherent with the fact that during the first three months of the year, the rain is abundant in Mozambique.

The second Mosaic is meant to support the classification of (semi-) Deciduous formations. In view of the fact that Dry Miombo loses leaves along July-August, and that Wet Miombo along August – September, it is decided to select **August-September** reference period to image deciduous with no leaves, and in this way improve the classification result.

As described above Sentinel-2A captures data in three different spatial resolutions. While Blue, Red, Green and Near Infrared bands have a spatial resolution of 10 m, the Red-Edge and Short-Wave Infrared (SWIR) channels capture data at 20 m spatial resolution. So, 2 raster files per granule and mosaic (May-June and August-September) were generated: one with the 10 m bands, and another with the 20 m bands.

Every single Sentinel 2 band needed to be processed independently: from the correction of atmospheric effects and computation of BOA reflectance, to the gap-filling work to be performed in case of clouds presence. The following workflow summarizes the process above outline.

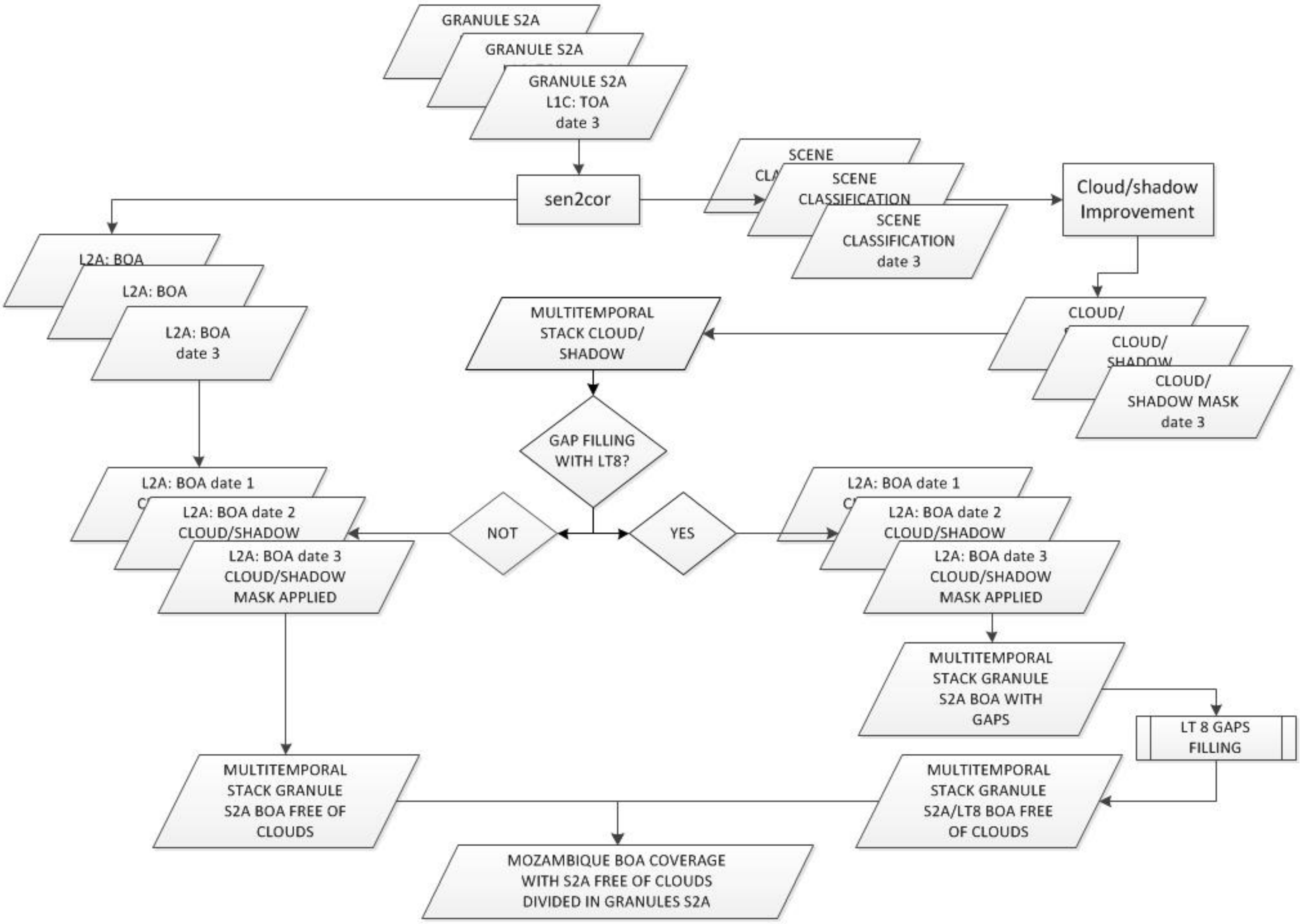

Figure 2. Workflow to obtain Mozambique BOA coverage with S2A, free of clouds.

Once Sentinel 2 bands have processed (atmospheric correction and computation of BOA reflectance, gap-filling clouds analysis) we can start the classification analysis.

The entire area of the country has been visually assessed on a 4 x 4 km grid at national level (the same grid used to allocate the NFI clusters from the Stratified Random Sampling design) using high and medium resolution imagery. The spatial assessment unit is almost the equivalent a 3 x 3 block of Landsat pixels (100 x 100 m), where a plot of same dimensions and an internal grid of 5 x 5 points is overlapped. This precise set of data which characterizes the current LULC and the changes produced in the historical series, will be used to decide the training areas for the LULC 2016 (sentinel-2) and for the image stack of Landsat 8 OLI and Landsat 5 TM (historical AD analysis); training subset (70%). A subset of data will be used for validation purposes of both products; test subset (30%) (Annex2.AD Accuracy Assessment).

Reference data are the high and medium resolution image repository available through Google Earth and Earth Engine, automatically accessible through the Collect Earth tool (www.openforis.org) along with scripts accessible through Earth Engine code that facilitate vegetation type’s interpretation (e.g. MODIS or Landsat NDVI time series).

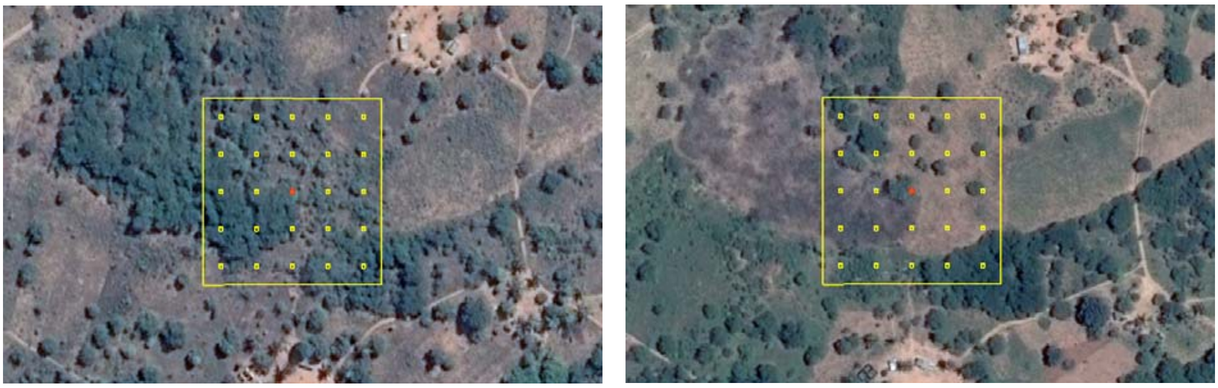

Figure 3. LULC changes detection using Collect Earth Tool. (www.openforis.org). High resolution imagery from Google Earth.

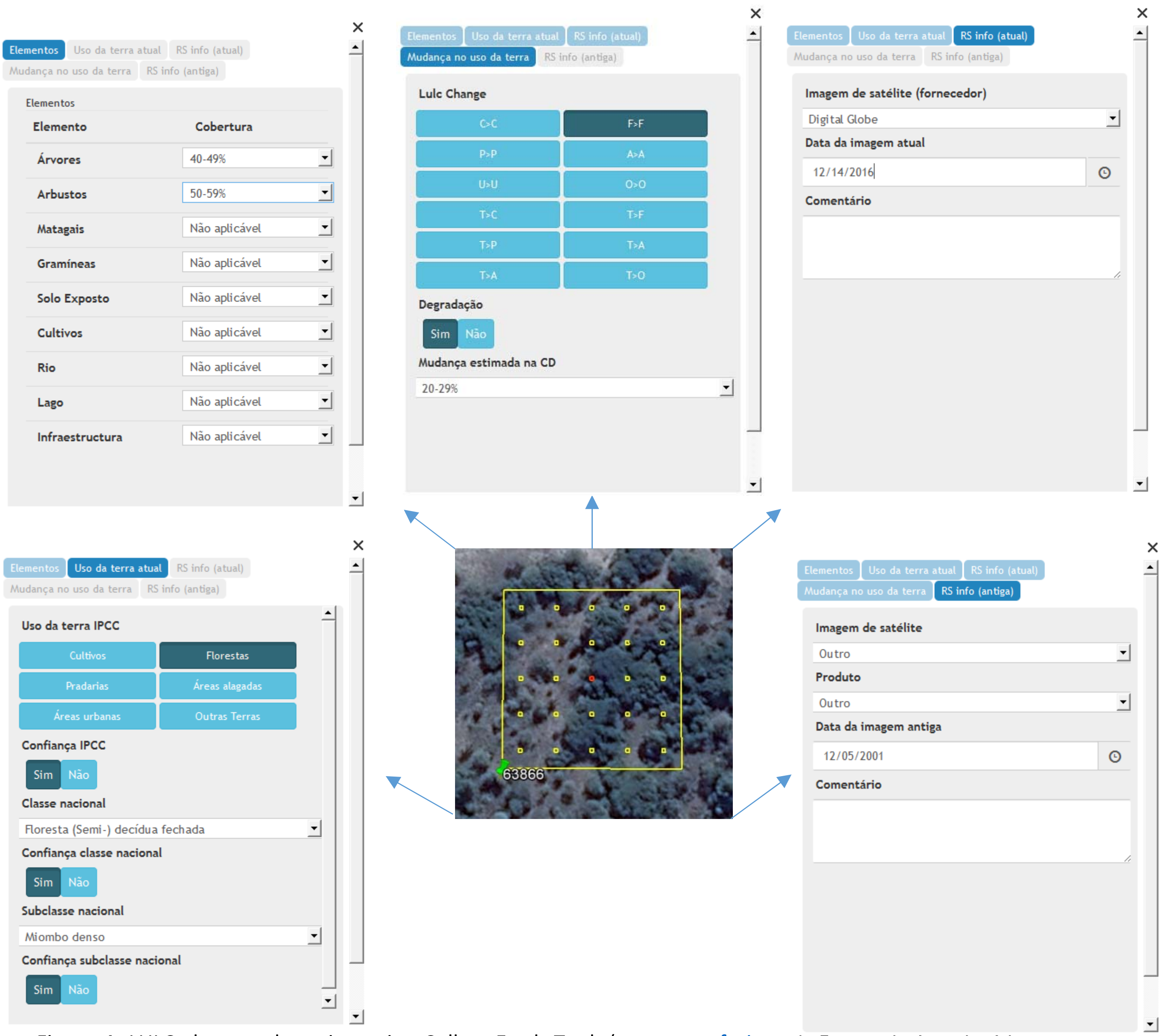

Figure 4. LULC changes detection using Collect Earth Tool. (www.openforis.org). Forms designed with Collect Tool.

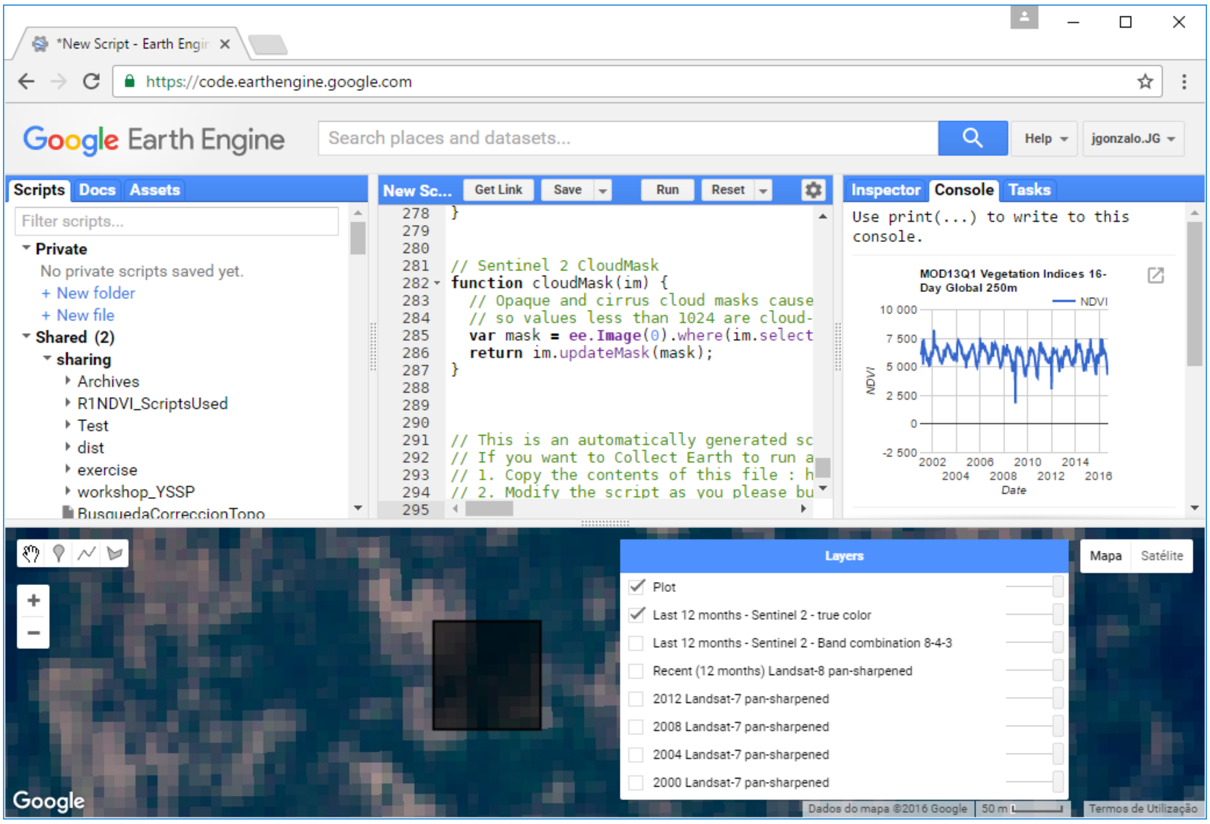

Figure 5. Earth Engine code accessible trough Collect Earth Tool. (www.openforis.org). Scripts of NDVI series.

We can summarize the classification workflow as shown in Figure 6.

Landsat 8[5] spatial resolution is 30 meters for VNIR and 15 meters for panchromatic. By using this product (and Landsat 5 TM) for historical AD analysis we could achieve, due to its geometrical accuracy of 1 pixel (30m)[6], a MMU of 3 x 3 pixels = 90 m x 90 m = 0.81 ha, lower than the 1 ha MMU. It is highly recommended (2015 GOFC-GOLD REDD Sourcebook) to use for the historical analysis the Global Land Survey (GLS) collection of Landsat imagery, orthorectified and cloud free images/composites, of 1990, 2000, 2005 and 2010. This MMU definition is fully compatible with FCPF CF MF (it does not specify any requirement on this regard), and VCS JNR (Sections 3.11.8. 1) and 2)): final spatial resolution of no coarser than 100m x 100m and minimum mapping unit size shall not be more than one hectare irrespective of forest definition).

In addition SAR (Synthetic Aperture Radar) data, specifically Phased Array type L-band Synthetic Aperture Radar (PALSAR is an active microwave sensor using L-band frequency to achieve cloud-free and day-and-night land observation) from ALOS (2006, Advanced Land Observing Satellite – JAXA - Japan Aerospace Exploration Agency) and from the new ALOS-2 (launched in 2014) would provide useful and complementary information for specific vegetation types and activities

[5] The Landsat 8 satellite payload consists of two science instruments—the Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS). These two sensors provide seasonal coverage of the global landmass at a spatial resolution of 30 meters (visible, NIR, SWIR); 100 meters (thermal); and 15 meters (panchromatic).

[6] Because of this constraint we should consider a positional accuracy of any geo-info product better (or equal) than 30 m.

(forest degradation). JAXA, has produced the 4 year-25m spacing global PALSAR mosaics, that Advanced Land Observing Satellite (ALOS)/ Phased array Type L-band SAR (PALSAR) collected globally from 2007 to 2010 using the accurate SAR processing, and the same product for 2015 (ALOS-2). These products are free available from:

http://www.eorc.jaxa.jp/ALOS/en/palsar_fnf/data/index.htm.

One unit data contains PALSAR HH, HV backscatter, forest/non-forest map, local incidence angle, mask info (layover, shadowing, ocean flag, effective flag, void flag) and total dates from the launch. SAR backscatter data is slope corrected and ortho-rectified using the SRTM3, and radiometrically calibrated.

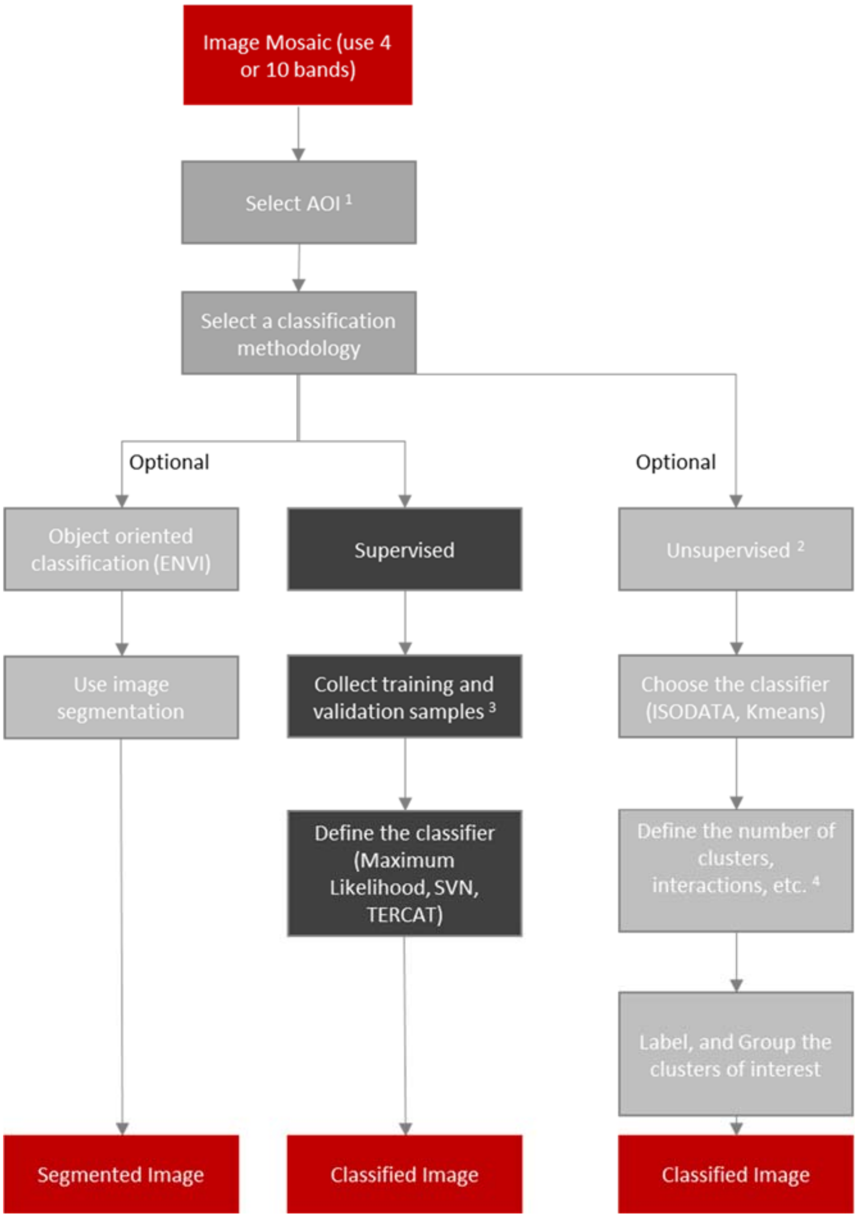

Figure 6. Workflow to obtain the LULC 2016 map based on S2A imagery. Classification, Post-Classification and Validation.

Classification system

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

(i) 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.

(ii) Cropland: This category includes cropped land, including rice fields, and agro-forestry systems where the vegetation structure falls below the thresholds used for the Forest Land category.

(iii) 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.

(iv) 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.

(v) 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.

(vi) 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:

(i) FF = Forest Land Remaining Forest Land, LF = Land Converted to Forest Land

(ii) GG = Grassland Remaining Grassland, LG = Land Converted to Grassland

(iii) CC = Cropland Remaining Cropland, LC = Land Converted to Cropland

(iv) WW = Wetlands Remaining Wetlands, LW = Land Converted to Wetlands

(v) SS = Settlements Remaining Settlements, LS = Land Converted to Settlements

(vi) 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 REL 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).

National LULC classes (level 2) and national subclasses (level 3) and their correspondence with the IPCC classes (level 1) are shown in table 4.

Level1 IPCC		Level2 National Classification		Level 3 National Classification	
1	Cropland	1TCF	Tree crops	1TCF	Tree crops
		1FC	Field crops	1FC	Field crops
				1SCT	Shrub Plantation (Tea)
				1FCR	Rainfed field crops
				1FCI	Irrigated field crops
				3AC	Rice crop
		1CXF	Shifting cultivation with open to closed forested areas	1CXF	Shifting cultivation with open to closed forested areas
2	Forest Land	1TCW	Forest Plantation	1TCW	Forest Plantation
		2FXC	Forest with shifting cultivation	2FXC	Forest with shifting cultivation
		2FE	Broadleaved (Semi-) evergreen closed forest	2FE	Broadleaved (Semi-) evergreen closed forest
				2DEC	Coastal dense woody vegetation
				4FF	Mangrove dense
				2FEA	Mecrusse dense
				2FEG	Gallery forest
				2FEM	Closed broadleaved (Semi-) evergreen mountaineous forest
		2FD	Broadleaved (Semi-) deciduous closed forest	2FD	Broadleaved (Semi-) deciduous closed forest
				2FDB	Miombo dense
				2FDC	Mopane dense
		2WE	Broadleaved (Semi-) evergreen open forest	2WE	Broadleaved (Semi-) evergreen open forest
				2DEO	Coastal open woody vegetation
				4WF	Mangrove open
				2WEA	Mecrusse open
				2WEM	Open broadleaved (Semi-) evergreen mountaineous forest
		2WD	Broadleaved (Semi-) deciduous open forest	2WD	Broadleaved (Semi-) deciduous open forest
				2WDC	Mopane open
				2WDB	Miombo open
3	Grassland	2GL	Grasslands	2GL	Grasslands
		2T	Thicket	2T	Thicket

Level1 IPCC		Level2 National Classification		Level 3 National Classification	
				2TE	Broadleaved (Semi-) evergreen thicket
				2TD	Broadleaved (Semi-) deciduous thicket
		2S	Shrubland	2S	Shrubland
				2SE	Broadleaved (Semi-) evergreen shrubland
				2SD	Broadleaved (Semi-) deciduous shrubland
4	Wetlands	4SF	Aquatic or regularly flooded shrublands	4SF	Aquatic or regularly flooded shrublands
		4HF	Aquatic or regularly flooded herbaceous vegetation	4HF	Aquatic or regularly flooded herbaceous vegetation
		7WB	Artificial water bodies	7WB	Artificial water bodies
		8WB	Natural water bodies	8WB	Natural water bodies
		17	Salt lake	17	Salt lake
5	Settlements	5	Settlements	5	Settlements
6	Other Land	6BS	Bare soils	6BS	Bare soils
		6BR	Bare rocks	6BR	Bare rocks
		6SS	Dunes	6SS	Dunes

Table 4. LULC Classification system in Mozambique.

The National Classification presented here matches the National (level 2) and Provincial classes (level 3) of the 'Integrated Assessment of Mozambican Forests' (AIFM 2007, Mazorli, A., Rural Consult Lda., Agriconsulting, Cooperazione Italiana) and the LULC classes (level 3) of the 'Zoneamiento Agroecológico de Moçambique' (ZAEN, 2010-2014). Provincial Forest Inventories conducted by JICA (Japan International Cooperation Agency) in Gaza and Cabo Delgado (2015-2016) and the current National Forest Inventory (2016-2017) use strata that are sets of classes previously detailed.

For REDD+ purposes, non-forest classes could be aggregated as long as conservative estimates would be used for the whole non-forest class, but disaggregation is a requirement of the 2006 IPCC GL for reporting purposes. Thus, as a first approach, we can consider a sole non-forest class (bringing together Grassland, Cropland, Settlement, Wetland, and Other Land) to estimate EFs (see next chapter) but for the proper performance of the PMRV, also non-forest classes should be disaggregated following National and IPCC classifications.

Temporal boundaries

FCPF CF MF requires that the historical period have a length of about 10 years up to 15 years (with convincing justification) (indicator 11.2), ending the most recent date prior to two years before the TAP starts the independent assessment of the draft ER Program Document and for which forest-cover data is available to enable IPCC Approach 3 (exceptions allowed with convincing justification (indicator 11.1). It is expected that the TAP technical assessment of the ER-PD in Mozambique will start in 2017, and therefore the period of historical analysis could be extended until 2015. Given that the first Sentinel-2 images date from December of 2015 in Mozambique and first images that meet the quality requirements necessary for the elaboration of a LULC map are from 2016 (most recent date for which forest-cover data is available to enable IPCC Approach 3) we consider to extend the historical period until 2016.

VCS JNR offers two possible options depending on the way the REL is set (section 3.11.12.1); a historical period covering a period of 8 to 12 years (historical average) or 10 years (historical trend) ending within two years of the start date of the current jurisdictional baseline period. This would mean that in order to comply with the requirements of both standards, historical data for a period of 10 years ending on 2016 should be enough: (2004) 2006-2016. It could be extended (with convincing justification) to the period 2001-2016 if we only consider compliance to the FCPF CF MF.

Accuracy Assessment

The accuracy of the LULC map 2016 (based on sentinel-2 imagery) that is being elaborated by the MRV-Unit (FNDS) must be finally reported based on independent reference data, applying statistical sampling to measure overall accuracy, errors of omission and commission for each class (VCS JNR requires a minimum overall accuracy of 75% for the forest and non-forest classes). Also an accuracy assessment exercise should be implemented for the LULC changes map (AD), to estimate confidence intervals of each LULC change class (Olofsson et al., 2014[7]). FCPF CF MF requires to estimate uncertainty of activity data using accepted international standards, and to propagate these in order to estimate uncertainty of emission reductions using Monte Carlo methods in order to report uncertainty with a two-tailed 90% confidence interval (VCS JNR keeps equivalent requirements).

The complete methodological proposal to quantify uncertainty and errors and to estimate LULC changes areas can be found in Annex 2.

[7] Pontus Olofsson, Giles M. Foody, Martin Herold, Stephen V. Stehman, Curtis E. Woodcock, Michael A. Wulder, Good practices for estimating area and assessing accuracy of land change, Remote Sensing of Environment, Volume 148, 25 May 2014, Pages 42-57, ISSN 0034-4257, http://dx.doi.org/10.1016/j.rse.2014.02.015.

AD Summary

Activity Data	Definition
Approach	▪ 3.Spatially explicit tracking of land-use conversions over time, with a well-designed sampling approach (4 x 4 km grid) to train a supervised classification of changes on a multi-temporal stack of Landsat Imagery (historical AD) or Sentinel-2 Imagery (M&MRV purposes). ▪ EOS: Sentinel-2 (spatial resolution 10 m VNIR, 20 m Red Edge & SWIR/60 m SWIR & others), Landsat 8 OLI (spatial resolution 30 m VNIR, 15 m - panchromatic) and Landsat 5 TM in combination with other high resolution imagery and SAR (Synthetic Aperture Radar) data (e.g. PALSAR from ALOS/ALOS2). ▪ Positional accuracy of any geo-info product better (or equal) than 30 m. (11 m Sentinel-2, 30 m Landsat)
Classification System	Consistency: 2006 IPCC categories, National Classification in 'Integrated Assessment of Mozambican Forests' (AIFM 2007, Mazorli, A., Rural Consult Lda., Agriconsulting, Cooperazione Italiana), 'Zoneamiento Agroecológico de Moçambique' (ZAEN, 2010-2014), Provincial Forest Inventories conducted by JICA (Japan International Cooperation Agency) in Gaza and Cabo Delgado (2015-2016) and National Forest Inventory (2016-2017). Table 4.
Temporal boundaries	▪ Historical period of the FRL covering of 10-15 years ending 2016. Three historical epochs before 2016 and not beyond 2001 with a separation of at least 2 years between epochs. ▪ Benchmark map of 2016 will be required for monitoring purposes (Sentinel-2).
Accuracy Assessment	Accuracy assessment of the LULC and LULC changes (AD) categories, to estimate two-tailed 90% confidence intervals of each category (Olofsson et al., 2014).

Table 5. Summary of AD specifications.

Emission Factors

'Emission factors' refers to emissions/removals of greenhouse gases per unit area, e.g. tons carbon dioxide emitted per hectare of deforestation. Emissions/removals resulting from landuse conversion are manifested in changes in ecosystem carbon stocks, and for consistency with the IPCC Guidelines, we use units of carbon, specifically metric tons of carbon per hectare (t C ha^{-1}), to express carbon-stock-change factors for deforestation and forest degradation[8].

Approaches

We can consider three different approaches (tiers) to assess emission factors:

1. Using IPCC default factors,
2. Preparing country specific data for key factors (e.g. using secondary sources of related information),

[8] 'Carbon dioxide equivalent' or 'CO_2e' is a term for describing different greenhouse gases in a common unit. For any quantity and type of greenhouse gas, CO_2e signifies the amount of CO_2 which would have the equivalent global warming impact. Global Warming Potential (GWP): (i) Carbon dioxide (CO_2) = 1, (ii) Methane (CH_4) = 25, (iii) Nitrous oxide (N_2O) = 298, (iv) Hydrofluorocarbons (HFCs) = 124 – 14,800, (v) Perfluorocarbons (PFCs) = 7,390 – 12,200, (vi) Sulfur hexafluoride (SF_6) = 22,800, (vii) Nitrogen trifluoride (NF_3)[3] = 17,200.

A quantity of CO_2 can be expressed in terms of the amount of carbon it contains by multiplying the amount of CO_2 by 0.27 (12/44, ratio of C atomic weight and CO_2 molecular weight).

3. Conducting a detailed national inventory of key C stocks, with repeated measurements of key stocks through time and modelling.

Again, we should consider the third approach (tier 3) as the most desirable to be reached, in order to accurately estimate carbon stock changes due to selected REDD+ activities.

2006 IPCC GL recommends to prioritize resources in significant pools by reaching a Tier 2, whereas using conservative estimates at Tier 1 for non-significant pools. FCPF CF MF and VCS JNR require at least Tier 2 for monitoring (VCS JNR prescribe that tier 1 should be used on those carbon pools representing less than 15% of the total carbon stocks).

Currently, there are two ongoing projects that are expected to be completed in 2018 and to generate the necessary information to produce the EFs estimations under Tier 3: the National Forest Inventory and the Establishment of a National Net of Permanent Plots to estimate repeatedly over time key C stocks.

National Forest Inventory (2016-2017)

Overall aim is establishing a National Forest Monitoring System (NFMS) for the country to support decision-making on sustainable forest management with scientific evidence and also the development of a sustainable forest policy at national level. The FMS should periodically collect complete, accurate and updated information on forest status.

The specific objectives of the Project are:

• To determine the total volume of timber forest products in the country
• To determine the volume of forest products for commercial species in the country
• To calculate the volume per hectare of forest products by vegetation type
• To estimate the volume of commercial species available for forest exploitation
• To characterize and analyze the condition of each vegetation type / land use (composition, tree structure, condition)
• To estimate the carbon content for aboveground and below ground biomass, dead organic matter (litter and dead wood) and soil pools by vegetation type/ land use.

NFI is being coordinated by the Direcção Nacional de Florestas (Ministério da Terra, Ambiente e Desenvolvimento Rural, MITADER), and implemented by Serviços Provinciais de Florestas e Fauna Bravia (MITADER), Department of Natural Resources Inventory (DIRN), IIAM and UT-REDD+ (MRV Unit, FNDS), and with the support of other collaborating Institutions (Eduardo Mondlane University).

Target area of this NFI is all land national territory of Mozambique, but specifically it focuses on natural and semi-natural forest systems.

We must stress that although the national forest definition to emissions reporting is currently based on the following minimum thresholds, 1 ha of Mapping Unit, 3 m of tree height (at maturity) and 30% of canopy cover, and the information collected in the inventory should facilitate its discrimination; the inventory shall not gird this definition, covering the entire forest area of the country (that which is or may be subject mainly to forest management against which is mainly the subject of agricultural management or other uses). Information about mangroves and forest plantations will be collected and analyzed from other sources.

According to the results of the project of Mozambican Agro-ecological Zoning ('Zoneamiento Agroecológico de Moçambique', 2010-2014) based on the interpretation and verification of Landsat images from 2009-2010, the area occupied by Semi-natural terrestrial vegetation is 62,575,825 ha, by Semi-natural aquatic vegetation 2,389,959 ha and by Cultivated & Managed terrestrial areas (only forest plantations) 11,864 ha. If we focused on tree based ecosystems mainly forests and woodlands, the total survey area sets to 45,503,861 ha; 539,814 ha of Semi-natural aquatic vegetation, 44,952,183 ha of Semi-natural terrestrial vegetation and 11,864 ha of forest plantations.

In table 6 we can see the strata used in the inventory design whose classification is in agreement with the classification systems described in the AD section.

Strata	LC Category	Domain	Group	Name	Area
1	Semi-natural terrestrial vegetation	Forests	Semi-deciduous	Semi-deciduous dense forest (+Miombo dense)	7,547,903
2				Mopane	2,183,139
3			Semi-evergreen	Semi-evergreen dense forest (+Gallery forest)	1,662,652
4				Mecrusse	526,349
5				Semi-evergreen mountainous forest	884,858
6		Woodlands (Open forests)	Semi-deciduous	+Semi-deciduous open forest (+Miombo open + Tree savanna)	29,725,985
7			Semi-evergreen	Semi-evergreen open forest	2,421,296
Semi-natural terrestrial vegetation Total					**44,952,183**
Grand Total					**44,952,183**

Table 6. A priori strata for the National Forest Inventory (2016-2017).

Considering these strata, National Forest Inventory information from 2007 (AIFM 2007, Mazorli, A., Rural Consult Lda., Agriconsulting, Cooperazione Italiana) was overlaid and processed, calculating the coefficients of variation of the total volume per stratum. This variable has been used to calculate the number of clusters (simple random sampling) needed to estimate the total volume per stratum with a maximum relative error of a 10% (for all the strata but open vegetation types; 15%). We conducted an optimal sample allocation according to variability of substrata.

With the results from the NFI we will be able to calculate by the end of 2017 the carbon content for aboveground (AGB) and below ground biomass (BGB), dead organic matter (litter and dead wood) (DOM) and soil pools (SOC) by vegetation type/ land use, and the corresponding EFs. All methodological aspects regarding the NFI are explained in detail in Annex 3. NFI Guidelines.

N	Strata	Area (ha)	N/ha	AB/ha	Vt/ha	Cv	nº clusters
1	Semi-deciduous dense forest (+Miombo dense)	7,547,903	88.2	6.4	60.9	57.0	**127**
2	Mopane	2,183,139	77.4	2.8	20.9	50.0	**98**
3	Semi-evergreen forest (+Gallery Forest)	1,662,652	91.0	5.2	47.9	50.0	**97**
4	Mecrusse	526,349	58.5	3.1	26.3	40.6	**66**
5	Semi-evergreen mountainous forest	884,858	58.3	4.0	39.2	38.4	**59**
6	Semi-deciduous open forest (+Miombo open + Tree savanna)	29,725,985	81.9	4.3	33.3	71.9	**91**
7	Semi-evergreen open forest	2,421,296	73.6	3.4	24.8	68.3	**82**
	Total	**44,952,183**					**620**

Table 7. Strata characterization and number of clusters.

10% more clusters were added as a reserve in case of no accessibility.

NFI started its implementation in July 2016 and three provinces; Maputo, Nampula and Inhambane have been surveyed so far (besides the two provincial forest inventories in Gaza and Cabo Delgado provinces, projects funded by JICA).

Establishment of a National Net of Permanent Plots (2018)

Despite the relevance of native forests in Mozambique, knowledge about their species composition, structure, and dynamic is still limited, which makes it difficult to elaborate sustainable management plans.

UT-REDD+ (MRV Unit) in close collaboration with IIAM and UEM has planned to establish a net of permanent plots in key ecosystems in Mozambique to deepen the knowledge of species composition, structure, dynamic, and specifically to serve as a basis of the MRV system allowing estimate repeatedly over time key C stocks and EFs.

It is intended to add 60 permanent plots to the existing 36 and complete the representativeness of the different vegetation types. In table 8 permanent plots' distribution by vegetation types in forest ecosystems in Mozambique is summarized.

The net of permanent plots should be remeasured every two years to report differences in carbon stocks and EFs (48 plots are measured per year). It is a sustainable proposal on which we can base the EFs' updating process (Tier 3), rather than on the National Forest Inventory that should be updated every 10 years.

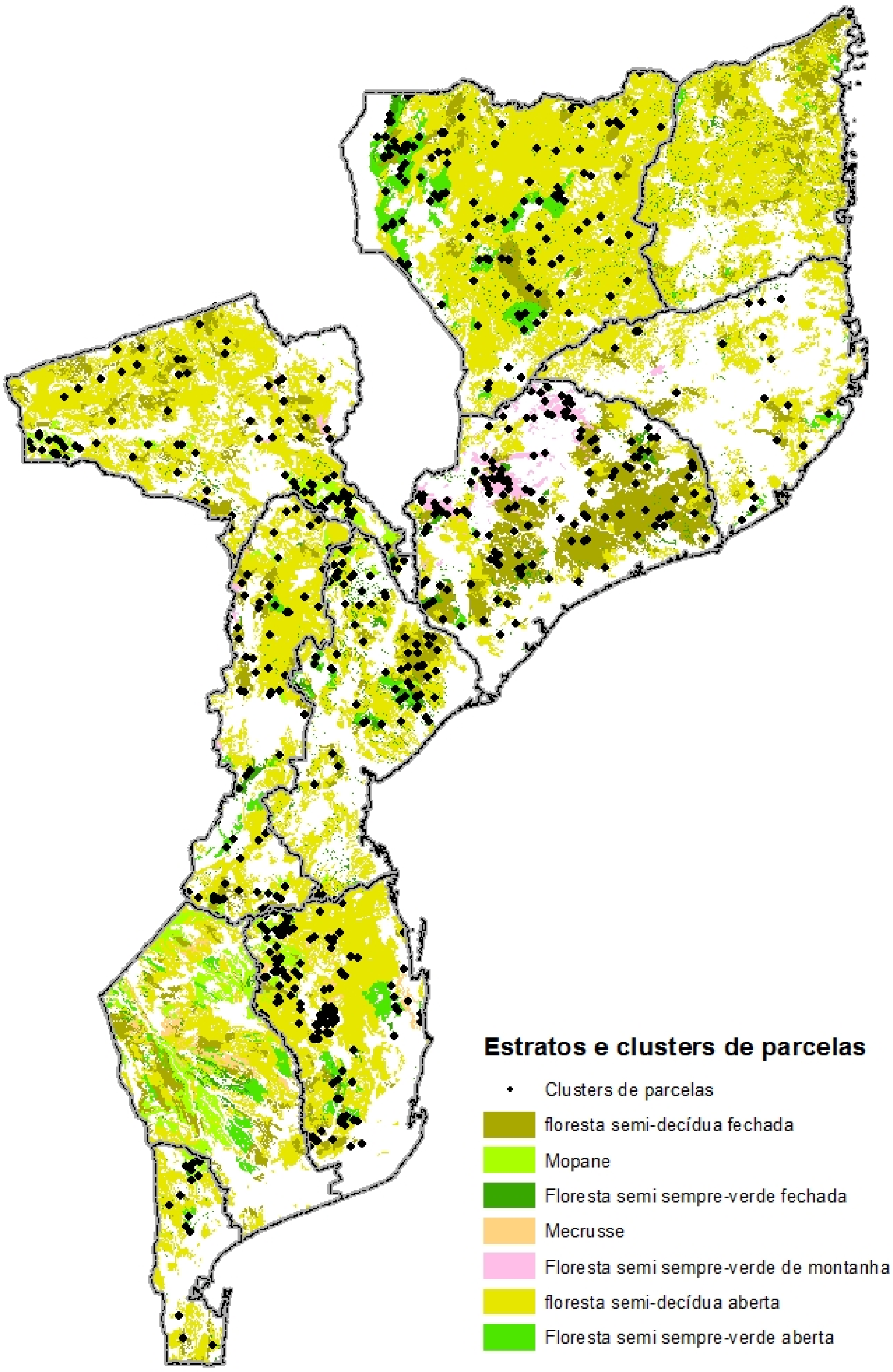

Figure 7. National Forest Inventory Strata and clusters distribution

Vegetation types	Existing variables	Additional variables	Permanent plots that already exits	New permanent plots
Floresta sempre verde	DBH, Ht, Hcomercial, quality, health status and altitude	Aboveground biomass (AGB) and below ground biomass (BGB), dead organic matter (litter and dead wood) (DOM) and soil pools (SOC), EFs	5	10
Floresta sempre verde de montanha	DBH, Ht, Hcomercial, quality, health status and altitude	Aboveground biomass (AGB) and below ground biomass (BGB), dead organic matter (litter and dead wood) (DOM) and soil pools (SOC), EFs	0	12
Floresta semi decidua	DBH, Ht, Hcomercial, quality, health status and altitude	Aboveground biomass (AGB) and below ground biomass (BGB), dead organic matter (litter and dead wood) (DOM) and soil pools (SOC), EFs	0	12
Miombo	DBH, Ht, Hcomercial, quality, health status and altitude	Aboveground biomass (AGB) and below ground biomass (BGB), dead organic matter (litter and dead wood) (DOM) and soil pools (SOC), EFs	19	3
Mopane	DBH, Ht, Hcomercial, quality, health status and altitude	Aboveground biomass (AGB) and below ground biomass (BGB), dead organic matter (litter and dead wood) (DOM) and soil pools (SOC), EFs	9	6
Mecrusse	DBH, Ht, Hcomercial, quality, health status and altitude	Aboveground biomass (AGB) and below ground biomass (BGB), dead organic matter (litter and dead wood) (DOM) and soil pools (SOC), EFs	3	7
Mangal	DBH, Ht, Hcomercial, quality, health status and altitude	Aboveground biomass (AGB) and below ground biomass (BGB), dead organic matter (litter and dead wood) (DOM) and soil pools (SOC), EFs	0	10
Galeria	DBH, Ht, Hcomercial, quality, health status and altitude	Aboveground biomass (AGB) and below ground biomass (BGB), dead organic matter (litter and dead wood) (DOM) and soil pools (SOC), EFs	0	0
Savana	DBH, Ht, Hcomercial, quality, health status and altitude	Aboveground biomass (AGB) and below ground biomass (BGB), dead organic matter (litter and dead wood) (DOM) and soil pools (SOC), EFs	0	0
Total			**36**	**60**
Grand Total				**96**

Table 8. Permanent plots by vegetation types in Mozambique.

It is intended to test a new sustainable and accurate methodology for the remeasurement of permanent plots after establishment in 2018 based on the restitution of pairs of hemispherical photographs.

Hemispherical images are obtained through a fisheye lens and have a field of view of one hundred eighty degrees, giving a circular projection. The distance from any point to the image center is proportional to the zenith direction. In the stereoscopic hemispherical images the trees show an angular displacement from one image to the other.

These properties can be used to determine the 3D position of any point matched in both images. This is the basis for distance, diameters and height measurement, and, if we know the sampling probability of the measured trees, the basal area and stand volume can be estimated.

Based on this principal, the prototype 'ForeStereo' will be tested. The current prototype has two five megapixel cameras that are handled from a notepad using a software specifically developed for forest inventories. The first step of the matching process is the segmentation, which classifies the pixels of the image as belonging to the sky, foliage and stems using as classifiers the intensity, the directional variance in the radial and tangential directions, and the ratio between the green and the sum of the three color channels. Pixels classified as stems are labeled as individual trees using a region growing process under geometrical constrains.

Thereafter the correspondence between pixels in both images is carried out under similarity, uniqueness and ordering constrains. The corresponding point in one image should lie on the epipolar line of its homologous in the other image. The matching method developed incorporates a priori information on the stand structure, similarly to human vision process.

The matching process provides data on the distance, height and diameter of the matched sections of the stems. This information is used jointly to the terrain model to fit taper equations for each species and obtain the tree position, DBH and volume. The sampling probability depends on the distance and diameter of the trees, and also the probability of shadowing by other trees. Once we have calculated the sampling probability, the basal area, stand volume and diameter distribution can be estimated. Moreover, as we know the spatial arrangement of the trees, forest structure indices can be calculated. We will use a very user friendly Matlab software package integrating the matching process and variables estimation.

The stereoscopic hemispherical images are a cost efficient technique to obtain detailed information on diameter distribution and species composition that can be used complementarily to remote sensing in a double sampling scheme.

Carbon Pools

A carbon pool is considered significant, and therefore should be measured following IPCC guidance, if it represents >20% of the total emissions of its category (Chapter 1 of 2006 IPCC GL Volume 4). But FCPF CF MF and VCS JNR require accounting significant carbon pools as those potentially responsible of above 10% of the total emissions, and allow excluding carbon pools that would underestimate emission reductions (i.e. conservative principle). These requirements refer to 10% of total emissions (combining EFs with AD) while the 2006 IPCC GL refers specifically to the emissions within each category.

2006 IPCC GL refers to the main 5 carbon pools (i.e. Biomass pool which includes the AGB and the BGB, Dead Organic Matter which includes the Litter and DW carbon pools and Soil Organic Carbon), and VCS JNR requires in addition to consider aboveground non-woody biomass and the wood products pools. It is not expected (considering the drivers of deforestation and forest degradation analysis) that wood products pool will be significant as firewood collection and charcoal production give short lived products.

In summary although we should consider the third approach (tier 3) as the most desirable to be reached (after completing a periodic FI; NFI and/or permanent plots inventory), at least a tier 2 should be used in significant pools (those that represent >10% of forest-related total emissions), and in any case default values may only be applied where a carbon pool represents <15% of total carbon stocks.

We should consider AGB, BGB, DOM and SOC pools, which are currently being measured in the NFI and will be measured in the national network of permanent plots. Emission periods or decay periods proposed by the VCS JNR could be used (AGB 0 years, BGB and DOM 10 years and SOC

20 years) but Indicator 4.2[9] of the FCPF CF MF refers to the reference period. According to the 2006 IPCC Guideline (Volume 4) a carbon pool is considered significant if it represents >20% of the potential total emissions of its category, but FCPF CF MF and the VCS JNR standards consider those which account for >10% of the total emissions during the reference period.

Emissions from deforestation and forest degradation should be expressed as net emissions (considering both the carbon stock of the forest being cleared and the carbon stock of the replacement land use). Gross emissions overestimate the impact of avoided deforestation on the atmosphere and 2006 IPCC GL provides methods expecting a comprehensive accounting of emissions throughout different land uses.

To avoid double accounting if degradation is accounted separately from deforestation (considering that most of the deforestation processes start with a degradation process) it would be highly recommended to derive deforestation emission factors from degraded forests and stratifying different types of forests depending on their degree of degradation.

Accuracy Assessment

Regarding data quality to estimate EFs, VCS JNR has specific requirements:

(i) EFs for aboveground biomass shall be derived from direct measurement with quantifiable uncertainty;

(ii) Existing inventory data may be used as long as it can be demonstrated that the data are accurate and representative of existing strata within the jurisdiction;

(iii) Field measurements used to calculate carbon stocks shall have been collected within 10 years prior to the start of the program start date.

These requirements are very easy to fulfil programming a local forest inventory or using periodic NFI data.

On the other hand and with regard to the accuracy assessment and uncertainty reporting (considering various sources of errors: measurement errors, methodological errors, sampling errors, etc.), FCPF CF MF and VCS JNR require to report two-tailed 90% confidence intervals, and the VCS JNR allow a relative margin of error of 10%[10], establishing discounting mechanisms if this is not reached.

[9] Carbon Pools and greenhouse gases may be excluded if: i. Emissions associated with excluded Carbon Pools and greenhouse gases are collectively estimated to amount to less than 10% of total forest-related emissions in the Accounting Area during the Reference Period; or ii. The ER Program can demonstrate that excluding such Carbon Pools and greenhouse gases would underestimate total emission reductions.

[10] VCS JNR requirements 3.14.12. – VCS Standard methodology requirements 4.1.4: '…Where a methodology applies a 90 percent confidence interval and the width of the confidence interval exceeds 20 percent of the estimated value or where a methodology applies a 95 percent confidence interval and the width of the confidence interval exceeds 30 percent of the estimated value, an appropriate confidence deduction shall be applied…'

EFs Summary

Emission Factors	Definition
Approach	3. We should consider the third approach; conducting a detailed inventory of key C stocks, with repeated measurements of key stocks through time and modelling) as the most desirable to be reached (after completing a periodic FI; NFI and National Permanent plots Inventory), but at least a tier 2 should be used in significant pools (those that represent >10% of forest-related total emissions), and in any case default values may only be applied where a carbon pool represents <15% of total carbon stocks.
Carbon Pools	We should measure AGB, BGB, DOM and SOC pools (IPCC considers a significant pool if it represents >20% of the potential total emissions of its category and FCPF CF MF and the VCS JNR standards consider those which account for >10% of the total emissions during the reference period). Decay periods proposed by the VCS JNR should be used (AGB 0 years, BGB and DOM 10 years and SOC 20 years).
Accuracy Assessment	Accuracy assessment of the EFs, to estimate two-tailed 90% confidence intervals of each category. Allow a relative margin of error of 10%, establishing discounting mechanisms if this is not reached.

Table 9. Summary of EFs specifications.

Monitoring of change in forest land remaining forest land

As we explained a net decrease, at national or sub-national scale, in carbon stocks of Forest Land remaining Forest Land (therefore not qualifying it as deforestation) is commonly equated to 'forest degradation'. A net increase, at national or sub-national scale, in this category would refer to the 'enhancement of carbon stocks'.

Developing a monitoring system for degradation involves identifying the causes of degradation, and assessing the likely impact on the carbon stocks. As we also indicated, and according to the national analysis of drivers of forest degradation, these are linked to selective logging, charcoal and fires followed by grazing and/or shifting cultivation (forest degradation emissions accounting for up to 30% of total emissions according to this analysis). Logically economic, social and natural characteristics of each province may also determine the main drivers and its rate of forest degradation. 2006 IPCC GL does not establish any requirement regarding the drivers to account for; VCS JNR indicates that degradation may not be comprehensive, and FCPF CF MF allows to exclude forest degradation when it represents less than 10% of the total forest-related emissions.

Approaches

Broadly, the techniques to monitor changes within forest land (which leads to changes in carbon stocks) provide lower accuracy 'activity data' and gives poor complementary information on 'emission factors'. There are limiting factors to all methods described below that might be taken into consideration when mapping forest degradation: (i) spatial signatures of the degraded forests change quickly (after one year) so frequent mapping (annually) is required, (ii) human-caused forest degradation signal can be confused with natural forest changes (as seasonal changes) so it can be reduced by using more frequent satellite observations, and (iii) all EOS based methods are based on optical sensors which are limited by frequent cloud conditions in tropical regions so SAR sensors and LIDAR data should be used to monitor forest degradation.

We can consider EOS based methods (direct and indirect approaches) and non-EOS based methods (direct; field inventories and indirect approaches; proxy data) for assessing forest degradation (2015 GOFC-GOLD REDD Sourcebook, and 2006 IPCC GL).

1. Direct Methods:

a. EO-based: There are two possible methodological approaches to map cleared forest areas: i) identifying and mapping forest canopy damage (gaps and clearings); or ii) mapping the combined, i.e., integrated, area of forest canopy damage, intact forest and regeneration patches. Estimating the proportion of forest carbon loss in the latter mapping approach is more challenging requiring field sampling measurements of forest canopy damage and extrapolation to the whole integrated area to estimate the damage proportion but anyway GHG emissions would be estimated similarly to deforestation by applying EFs to transitions between different forest strata.

Mapping forest degradation associated with fires is simpler than that associated with logging because the degraded environment is usually contiguous and more homogeneous than logged areas. Moreover, the associated carbon emissions may be higher than for selective logging.

The methodological chart would be as follows:

1. Define the spatial resolution: fine (<5m) to detect and map the forest canopy damage (i) or fine (<5m) to train and multitemporal series of medium (10-60 m) to operationalize for integrated area (ii),
2. Enhance the image: atmospheric correction, histogram stretching, texture filter, spectral mixing. NDFI (Normalized Difference Fraction Index). Robust techniques to map selective logging impacts are based on fraction images derived from spectral mixture analysis (SMA). Fractions are sub-pixel estimates of the pure materials (endmembers) expected within pixel sizes.
3. Choose the mapping feature: forest canopy damage / Integrated area,
4. Select the appropriate method: visual interpretation / automated classification, 5. Validate the results.

b. Continuous Forest Inventory: In the context of projects and program, a periodic field inventory, combined with forest area change mapping would be the optimal tool to properly identify and quantify changes in forest remaining forest and related carbon stock in the future. But in order to set the historical degradation rates (baseline) we would find serious difficulties due to the lack of historical inventories.

2. Indirect Method:

a. EO-based: When direct approach cannot be applied due to infrequent coverage and little spectral evidence remains from the canopy gaps (degradation intensity is low), the remote sensing analysis focuses on the spatial distribution and evolution of human infrastructure (i.e. roads, population centres), which is used as a proxy for newly degraded areas (Herold et al., 2011, and 2015 GOFC-GOLD REDD Sourcebook), or on the identification of forest fragmentation and specific forest distribution patterns that indicate the presence of degradation. This EO-based indirect method is used to estimate past degradation emissions and rates based on these proxies. GHG emissions would be estimated similarly to deforestation by applying EFs to transitions between different forest strata.

b. Use of proxies: Amongst non-EO-based methods we find the use of proxies such as the use of statistical data and survey information in order to use proxies to determine degradation, e.g. application of the IPCC gain-loss method through non-spatial explicit methods. Applied to firewood collection, the estimation of degradation could be done by estimating the consumed firewood (e.g. surveys) and use supply models in order to estimate the difference between demand and supply. The result would be a deficit which can be expressed in tCO2 and is an indication of degradation.

FCPF CF MF allows estimating degradation through the direct method, or if data/method is not available, it allows estimating degradation through other methods such as survey data, proxies derived from landscape ecology, or statistical data on timber harvesting and regrowth. VCS JNR also allows the use of other methods other than the direct methods, provided that it is demonstrated that such proxies are strongly correlated to with actual land use change.

We should remind the methodological frameworks requirements for EFs estimation; 2006 IPCC GL recommends to prioritize resources in significant pools by reaching a Tier 2, whereas using conservative estimates at Tier 1 for non-significant pools. FCPF CF MF and VCS JNR require at least Tier 2 for monitoring (VCS JNR prescribe that tier 1 should be used on those carbon pools representing less than 15% of the total carbon stocks). We should consider the third approach (tier 3) as the most desirable to be reached (after completing a periodic FI), and at least a tier 2 should be used in significant pools (those that represent >10% of forest-related total emissions), and in any case default values may only be applied where a carbon pool represents <15% of total carbon stocks. Anyway degradation cause a reduction of carbon stocks mainly on the AGB pool, being the impact lower in the BGB and in some cases in the DOM. The 2006 IPCC GL propose the assumption that carbon stocks in the SOC pool and the DOM pool are in equilibrium under Tier 1 level, indicating that changes in these carbon pools are expected to be minor. Therefore, GHG emissions from forest degradation should account for the AGB pool, and the BGB pool if data is available.

The methodological approach that we will test to measure forest degradation is a combination of visual assessment and radar application.

As we have explained before the entire area of the country has been visually assessed on a 4 x 4 km grid at national level using high and medium resolution imagery. The spatial assessment unit is almost the equivalent a 3 x 3 block of Landsat pixels (100 x 100 m), where a plot of same dimensions and an internal grid of 5 x 5 points is overlapped. This precise set of data that characterizes the LULC changes produced in the historical series, will be used in this case to decide the training areas for the image stack of Landsat 8 OLI and Landsat 5 TM for the historical AD analysis (training subset, 70% /test subset 30%, Annex2.AD Accuracy Assessment). Among the activity data, as we know, the characterization and quantification of forest degradation is a great challenge. Visual assessment includes the characterization (precise measurement) of the canopy cover in at least three points in time in case of forest degradation or forest enhancement. This allows us to generate trends in canopy cover changes in at least two different periods.

On the other hand annually composited mosaics from the Japan Aerospace Exploration Agency (JAXA) ALOS PALSAR 1 and PALSAR 2 of years 2007, 2008, 2009, 2010 and 2015, are free available and could be used for this purpose as a first approach. The ALOS PALSAR L-band intensity dataset at 25 m spatial resolution is slope corrected, ortho-rectified and radiometrically calibrated for both polarizations (HH and HV). The Forest/Non-forest (FNF) map derived from these data classifies forest with the FAO definition (areas larger than 0.5 ha with forest cover over 10%).

The tiles that are needed to cover the entire area of Mozambique can be downloaded from http://www.eorc.jaxa.jp/ALOS/en/palsar_fnf/data/index.htm.

HH and HV digital numbers can be converted to gamma naught values with the equation 1 suggested by JAXA and EORC (JAXA 2016).

http://www.eorc.jaxa.jp/ALOS/en/palsar_fnf/DatasetDescription_PALSAR2_Mosaic_FNF_revA.pdf.

Gamma = 10 log (DN2) + CF, being CF = -83.0 (eq. 1)

In addition to HV and HH intensity values, other image derived features can be calculated to explore their capacity as potential explanatory variables of the forest AGB. Texture co-ocurrence parameters (mean, variance, homogeneity, contrast, dissimilarity, entropy, second moment, correlation) and the Radar Forest Degradation Index (RFDI) (equation 2), an index related to forest structure (Mitchard et al. 2012) were derived from the 2015 radar images.

RFDI = HV –HH / HV + HH (eq. 2)

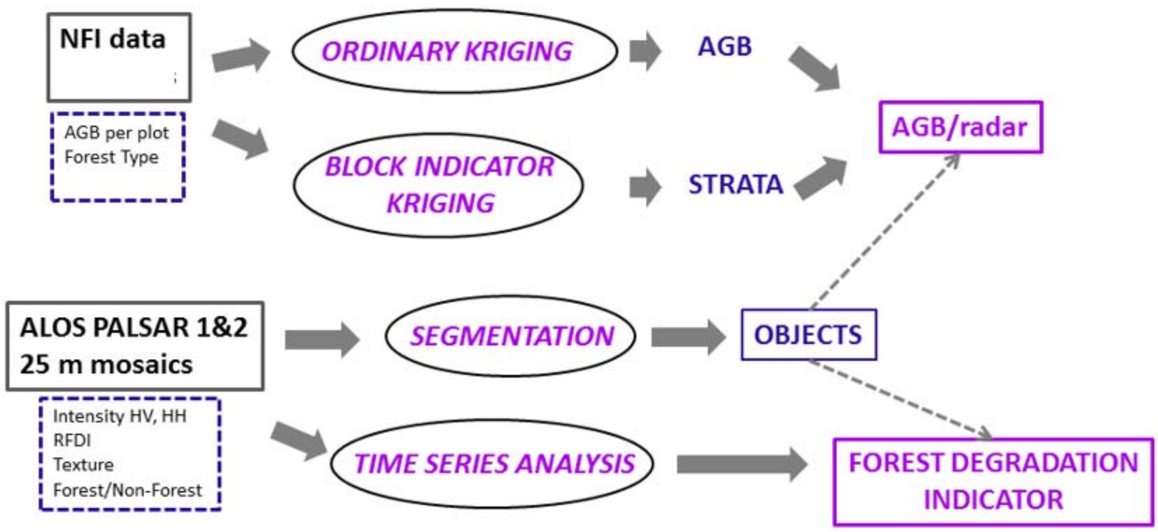

Figure 8. Schematic representation of the methods to be applied. Plot data from the NFI would serve as base for AGB and strata definition, led by the spatial units defined by radar 2015 HV intensity. Radar HV and HH intensity and derived features as the Radar Forest Degradation Index (RFDI) will be related with these values of AGB at the polygon level. Finally Radar data time series cold be used to derive an indicator class of forest degradation.

An initial exploration of the relationship between AGB and PALSAR HV intensity data can be carried out at the plot level. HV intensity statistics (mean, median, stdev, var) would be evaluated in areas centred at the plot coordinates (5x5 pixel windows). The relationship can be explored by forest strata as classified by the NFI data.

In order to obtain homogeneous spatial units for analysis of the AGB-radar data relationship, the most recent (2015) HV intensity image can be segmented with Definiens Cognition Developer Technology®, using the following parameters: colour-shape: 09-01, smoothness: 05, scale 150. This division process should be constrained by the 2015 Forest /Non-Forest mask included in the PALSAR dataset. The polygons generated under this segmentation process are the drivers of all subsequent spatial analysis. Values of HH and HV intensity, as well as RFDI in each polygon can be obtained for further analysis.

An Ordinary Block Kriging process will be used to interpolate the plot level AGB values obtained in the field by the NFI at the polygons resulting from segmentation of the PALSAR data.

Statistics of HV and HH intensity values per polygon can be calculated. AGB values (as derived with the geostatistical approach) – radar attributes at the polygon level will be adjusted with a number of models in Matlab with *regress* (e.g. linear, polynomial, exponential, log).

The relationship between AGB and radar data is presumably specific over individual strata, where the forest has particular characteristics, and stronger than at the country level. Three spatial levels of stratification will be explored: level 2/level 3 of the LULC National Classification and a Potential Vegetation Classification system.

To assign Forest Type probabilities to each of the polygons obtained from the radar data segmentation, Block Indicator Kriging could be used or a direct assign method if the LULC map 2016 based on sentinel-2 is available.

Finally, values of the HV intensity time series (2007, 2008, 2009, 2010, and 2015) could be compared and trends analysed. As this is a short and irregular time series, an interval approach should be used. Pairs of values for consecutive intervals, as well as the initial-final date interval (2007-2015) would be compared (intensity date 2 minus intensity date 1) and a four class scheme could be adopted in which class zero represents areas with no decreasing HV radar intensity during the 2007-2015 period (that is, intensity remained the same or increased), and class 3 represents areas with continuous decrease of HV radar intensity. It is important to note that this classification would provide just an indicator of possible degradation, and for estimation of the degree of degradation (e.g. level of AGB or cover loss), changes in intensity should be calibrated.

Values of change in canopy cover (from the visual assessment) could be kriged (Ordinary Block Kriging) over the radar derived polygons and again the relations between canopy cover changes and radar series changes will be analysed by strata.

This three stage inventory design joining PALSAR data, high resolution imagery and field sampling will be a scientific and robust approach for forest degradation monitoring.

Some interesting alternatives for improving this workflow could be:

- Incorporating data from **previous field inventories** (e.g. NFI, 2007) would provide opportunities to elaborate more accurate AGB models at a single date and models of change for analysis of temporal AGB dynamics. In time series analysis the inclusion of various dates for calibration has demonstrated to be highly positive.
- Employing **anniversary data of preferred dates** (e.g. wet season) according to local phenology would facilitate the identification of specific forest characteristics and would help the analysis of real change. Although a composited mosaic built up with data from different dates provides a general overview of forest conditions, it may be obscuring some of the key characteristics of vegetation that only show up during certain seasons.
- Incorporating other polarizations of radar data to evaluate height with **interferometry** would make a big difference for evaluation of AGB.
- Increasing the density and extending the **temporal series of radar data**, ideally to an annual series would facilitate the study of trends in AGB and forest state condition. Time series analysis provides estimations of relative change that can be calibrated with field data of good quality.
- Including other radar derived **metrics** (e.g. texture) in combination with intensity values, as well as features derived from other sources of data (e.g. optical data) might provide accurate models of AGB.
- **Modelling** with machine learning approaches such as Random Forest or Support Vector Machine might provide accurate estimations providing the number of variables and the quality of calibrating samples are adequate.

Accuracy Assessment

We indicated in the General method for estimating CO2 emissions and removals that the FCPF CF MF establishes that uncertainty must be reported as two-tailed 90% confidence intervals, so we should conduct an:

- Accuracy assessment of the LULC and LULC changes (AD) categories, to estimate two tailed 90% confidence intervals of each category (Olofsson et al., 2014, as it is described in Annex 2).
- Accuracy assessment of the EFs, to estimate two-tailed 90% confidence intervals of each category, allowing a relative margin of error of 10%, establishing discounting mechanisms if this is not reached.

The VCS JNR in addition requires that the accuracy of indirect GHG emission calculations shall be at least 75% (3.14.12.(2)).

Forest Degradation Summary

Forest Degradation	Definition
Approach	▪ Drivers of Forest Degradation: linked to (i) selective logging, (ii) charcoal production and (iii) forest fires followed by (iv) grazing and/or (v) shifting cultivation. ▪ Direct Method: a Continuous Forest Inventory (NFI and National net of permanent plots) combined with forest area change mapping (EOS approach combining high - visual assessment, and medium resolution imagery - multitemporal stack Landsat 8 OLI and Landsat 5 TM-historical period, or multitemporal Sentinel-2 stack) will be the optimal tool to properly identify and quantify changes in forest remaining forest and related carbon stock. ▪ Other EOS methodologies SAR will be tested: three stage inventory design joining PALSAR data, high resolution imagery (visual assessment) and field sampling. ▪ Indirect methods should be also considered for those hardest drivers to be detected.
Carbon Pools	GHG emissions from forest degradation should account for the AGB pool, and the BGB pool if data is available.
Accuracy Assessment	▪ Accuracy assessment of the LULC and LULC changes (AD) categories, to estimate two-tailed 90% confidence intervals of each category (Olofsson et al., 2014). ▪ Accuracy assessment of the EFs, to estimate two-tailed 90% confidence intervals of each category, allowing a relative margin of error of 10%, establishing discounting mechanisms if this is not reached. ▪ Indirect GHG emissions calculations shall reach an accuracy of 75%.

Table 10. Summary of Forest Degradation specifications.

Monitoring of change in forest land remaining forest land. Non-CO2 emissions from forest fires.

Non-CO2 emissions from forest fires is considered as an independent emission source according to the 2006 IPCC GL. The 2015 GOFC-GOLD REDD Sourcebook also indicates that this GHG emission source should be analysed and according to the most stringent requirement (FCPF CF MF), non-CO2 emissions from fire burning may be excluded (also VCS JNR indicates that degradation may not be comprehensive) if they account for less than 10% of the forest related emissions or if it is conservative to exclude them.

Most forest fires in Mozambique are man-caused, especially in the preparation of the crop fields, during the honey harvesting, charcoal production, hunting and pastures renewal. Uncontrolled fires occur almost every year throughout the country during the dry season, especially from June to December (and at the beginning of the agricultural and hunting campaigns), when herbaceous vegetation is mostly dried and the deciduous trees and shrubs drop their leaves, thus constituting a potential fuel to be burned. Mean burn-back rate in tropical dry forest systems in Mozambique is two short (3-5 years), which can be a monitoring challenge.

Approaches

2006 IPCC GL provide specific equations to estimate non-CO2 emissions from forest fires (Lfire). These are estimated by multiplying Activity Data (AD) by an Emission Factor (EF). The AD is expressed as the area affected by fire (A) while the EF is the multiplication of the fuel loading per unit area (Mb), a combustion factor (Cf), i.e. the proportion of biomass consumed as a result of fire, and an emission factor (Gef), i.e. the amount of gas released for each gaseous specie per unit of biomass load consumed by the fire. The last two factors are usually derived from IPCC tables as local values for these parameters are usually not available, so the estimation of non-CO2 emissions depends on the AD and the mass of fuel available.

$$Lfire = A \cdot Mb \cdot Cf \cdot Gef \cdot 10^{-3}$$

Where:
Lfire is expressed in tonnes of each gas
A in hectares
Mb in tonnes/hectare
Cf is dimensionless
Gef in grams/kilogram dry matter burnt

Accuracy Assessment

'Mb' should be derived from the EFs estimated for deforestation in order to ensure consistency, while the 'A' must be derived using specific data that tracks fires in forest areas. As we indicated previously a Tier 2 (FCPF CF MF) must be reached and default values can only be applied where the carbon pool represents less than 15% of the total carbon stocks (VCS JNR), and in particular AGB must be based on direct field measurements not older than 10 years (VCS JNR). The only carbon pool that should be considered for the estimation of non-CO2 emissions from forest fires would be AGB and DOM. Non-CO2 GHG emissions from burning of SOC and BGB may be considered as negligible (unless we had forest areas under peat lands or organic soils). We should consider the temporal boundaries and accuracy requirements that we indicated in the general method and forest degradation indirect method.

Non-CO2 emissions from forest fires Summary

Forest Degradation	Definition
Approach	▪ Lfire = A · Mb · Cf · Gef · 10^(-3) Where: Lfire, non-CO2 emissions from forest fires, is expressed in tonnes of each gas A, area affected by fire, in hectares *Direct Method: a* a Continuous Forest Inventory (NFI and National net of permanent plots) combined with forest area change mapping (EOS approach combining high - visual assessment, and medium resolution imagery -multitemporal stack Landsat 8 OLI and Landsat 5 TM-historical period, or multitemporal Sentinel-2 stack) will be the optimal tool to properly identify and quantify changes in forest remaining forest and related carbon stock *• MODIS active fires and burned areas (University of Maryland /NASA). Monthly fire frequencies from the period 2000-2011 at 500 m spatial resolution;* Mb, fuel loading per unit area, in tonnes/hectare Cf, combustion factor, is dimensionless (fom IPCC tables) Gef, emission factor, in grams/kilogram dry matter burnt (from IPCC tables)

Carbon Pools	GHG non-CO2 emissions from forest fires should account for the AGB pool (based on direct measurement not older than 10 years) and DOM pool.
Forest Degradation	**Definition**
Accuracy Assessment	▪ Accuracy assessment of the LULC and LULC changes (AD) categories, to estimate two-tailed 90% confidence intervals of each category (Olofsson et al., 2014). ▪ Accuracy assessment of the EFs, to estimate two-tailed 90% confidence intervals of each category, allowing a relative margin of error of 10%, establishing discounting mechanisms if this is not reached. ▪ Indirect GHG emissions calculations shall reach an accuracy of 75%.

Table 11. Summary of Non-CO2 emissions from Forest Fires.

Monitoring of change in Other Land to Forest land. Enhancement of carbon stocks: Afforestation/Reforestation

Increases in forest area can occur for a variety of reasons, including recovery from fire, natural forest regrowth following crop abandonment, fallow periods in shifting cultivation systems, and growth of tree plantations. Usually these increases occur relatively slowly (although as we have explained before, burn-back rate in tropical dry forests of Mozambique can be extremely short) being identified after several years. That's why time series of images should be used to distinguish seasonal behavior from regrowth of secondary forests (e.g. from reforestation/afforestation or crop abandonment).

Although enhancement of carbon stocks in forestlands remaining forestlands could have a significant potential within the national boundaries, this section will only focus on the enhancement of carbon stocks due to the conversion of other land (i.e. non-forest lands) to forestland, i.e. afforestation/reforestation. The estimation of enhancement of carbon stocks in existing forests relies on the same methods defined for degradation with the precaution that longer time series are required; thus plantations can be identified through cycles of clearing and/or harvesting, and planting (managed forests).

Plantations are an increasingly important land use in the tropics and developing technologies, including hyperspectral and LIDAR, are promising to distinguish plantations from forests based on characteristic spectral responses of plantations species (hyperspectral) and vegetation structure (LIDAR). Also textural measures, in particular on high resolution imagery (< 10m) may distinguish automatically plantations due to the regular spacing of planted trees.

Regarding the activities that are eligible under enhancement of forest carbon stocks, may be excluded based on the conservative principle.

Approaches

Methods to estimate enhancement of carbon stocks due to afforestation/reforestation activities are described in the 2006 IPCC GL. These Guidelines consider two different methods to estimate GHG removals in non-forest lands converted to forest lands: the stock-difference method and the Gain-Loss method. The Guidelines recommend, under Tier 2, to use the Gain-Loss method for the AGB and BGB pools, either method for the DOM pool and a specific stock-difference method for the SOC pool. But these are not prescribed methods; it would be possible to apply a similar method used for estimating GHG emissions from deforestation consisting in multiplying AD by and EF (negative, i.e. removal factor, considering a linear growth during a transition period to be defined).

$$EFi\,(LULC1 \rightarrow LULC2, t) = \frac{44}{12} \cdot \frac{[Ci\,(LULC1) - Ci\,(LULC2)]}{t}$$

Where:

EFi (LULC1→LULC2,t): Emission factor from change in carbon pool i from LULC 1 to 2 in a transition period t (tCO2e ha-1 year-1);

Ci (LULC1): Carbon density in carbon pool i for LULC 1 (tC ha-1);

Ci (LULC2): Carbon density in carbon pool i for LULC 2 (tC ha-1);

t: Transition period (years).

Therefore for afforestation/reforestation activities, AD methods and carbon stock values would be the same as those defined for forest degradation but considering a transition period. Also textural measures, in particular on Sentinel-2 imagery (10m spatial resolution), will be used to help to distinguish automatically plantations due to the regular spacing of planted trees. FCPF CF MF allows estimating enhancement of carbon stocks through the direct method, and if this is not available, through other methods such as survey data, proxies derived from landscape ecology, or statistical data on timber harvesting and regrowth.

Transition period in assisted natural regeneration: a specific parameter to be defined is the transition period between initial and final LULC classes or strata. If the carbon stocks estimates used to derive the EFs represent the average estimates of all forests (including mature and new growing forests), the transition period may be assumed to be zero, as the new forest would be part of the population and the average estimate of carbon stocks is representative of the whole population. However, if carbon stocks estimates used to derive EFs are not representative of all forests, and it represents for instance mature forests, a transition period should be defined.

For AGB, BGB, DOM, and SOC, 2006 IPCC GL assume a 20 year transition period, but under Tier 2 this may be revised based on local available data. It may be assumed that the increase in the BGB and DOM pools is linearly related to the increase in the AGB pool, and net growth yields could be used in order to estimate the time for a new forest to reach the average estimate. On the other hand if Mozambican-specific growth models for commercial plantations are available for the main species of interest, these growth models could be used to estimate sequestration in the AGB, BGB and DOM carbon pools, using at least IPCC default conversion factors. A default 20 year transition period is assumed for SOC in both cases; assisted natural regeneration and plantations.

It is expected that the implementation of afforestation/reforestation activities would cause an increase in all carbon stocks in degraded lands with low carbon stocks, except in the case of productive grassland transformation that may led a net decrease in SOC pool. It would be recommended to account for all carbon pools that are being accounted for deforestation in order to ensure a full consistency in GHG accounting for different activities.

As we have explained previously a Tier 2 must be reached, and default values may be used where a carbon pool represents less than 15% of total carbon stocks, but it would be desirable, to implement a Tier 3 through a detailed inventory of key C stocks, with repeated measurements of key stocks through time and modelling. Furthermore afforestation perimeter should be measured in the field using a GPS with accuracy better than 10 m.

Accuracy Assessment

As we indicated in the General method for estimating CO2 emissions and removals, the FCPF CF MF establishes that uncertainty must be reported as two-tailed 90% confidence intervals, so we should conduct an:

- Accuracy assessment of the LULC and LULC changes (AD) categories, to estimate two-tailed 90% confidence intervals of each category (Olofsson et al., 2014).
- Accuracy assessment of the EFs, to estimate two-tailed 90% confidence intervals of each category, allowing a relative margin of error of 10%.

The VCS JNR in addition requires that the accuracy of indirect GHG emission calculations shall be at least 75% (3.14.12.(2)).

Afforestation/ReforestationSummary

Aforestation/Reforestation	Definition
Approach	▪ AD relies on the same methods defined for degradation with the precaution that longer time series are required. Afforestation perimeters should be measured in field using a GPS with accuracy better than 10 m. Also textural measures, in particular on Sentinel-2 imagery (10m spatial resolution), will be used to help to distinguish automatically plantations due to the regular spacing of planted trees. ▪ EFs, EFi (LULC1→LULC2,t)=44/12·[Ci (LULC1)-Ci (LULC2)]/t Where: EFi (LULC1→LULC2,t): Emission factor from change in carbon pool i from LULC 1 to 2 in a transition period t (tCO2e ha-1 year-1); Ci (LULC1): Carbon density in carbon pool i for LULC 1 (tC ha-1); Ci (LULC2): Carbon density in carbon pool i for LULC 2 (tC ha-1); t: Transition period (years). To be defined: transition period for assisted natural regeneration (AGB,BGB,DOM) and 20 years (SOC). *We should consider tier 3 (conducting a detailed inventory of key C stocks, with repeated measurements of key stocks through time and modelling) as the most desirable to be reached (after completing a periodic FI), but at least a tier 2 should be used in significant pools (those that represent >10% of forest-related total emissions), and in any case default values may only be applied where a carbon pool represents <15% of total carbon stocks.*
Carbon Pools	It would be recommended to account for all carbon pools that are being accounted for deforestation in order to ensure a full consistency in GHG accounting for different activities: we should measure at least AGB, BGB and SOC pools (IPCC considers a significant pool if it represents >20% of the potential total emissions of its category and FCPF CF MF and the VCS JNR standards consider those which account for >10% of the total emissions during the reference period). Values for AGB must be based on direct measurement not older than 10 years.

Accuracy Assessment	▪ Accuracy assessment of the LULC and LULC changes (AD) categories, to estimate two-tailed 90% confidence intervals of each category (Olofsson et al., 2014). Accuracy assessment of the EFs, to estimate two-tailed 90% confidence intervals of each category, allowing a relative margin of error of 10%. ▪ Indirect GHG emissions calculations shall reach an accuracy of 75%.

Table 12. Summary of Afforestation/Reforestation removals.

Reference Emission Level (REL)

In this section we will explain the overall framework and integration of the National REL at Provincial (Programs) and local (Projects) level. We can consider three different levels: National, Provincial (Programs) and Local (Projects) with a top-down approach from National to Provincial (Programs) and Local (Project) level but at the same time with integration of low level data at higher levels.

Thus the scale for the REL would be from National to Provincial (Programs) and Local (Projects) level; multi-scale nested project-level activities are integrated into an accounting scheme of a larger jurisdiction (top-down approach with integration of low level data at the high level). Procedures for MRV and Reference emissions levels would need to be harmonised between subnational and national levels. The system will be entirely consistent if we consider a common vegetation type stratification for AD and EFs calculations and if we integrate more detailed information from project-level activities in the higher levels (for both elements). In the near future deforestation, degradation and A/R monitoring information at national level and the REL for these activities will be downscaled to the lower levels (provincial and local). It only means that there will be consistent monitoring datasets at national level but these also will gather on field information from the lower levels. Provincial (Programs) and Local (Projects) levels may also account additional activities or additional pools (e.g. enhancement of carbon stocks).

A REL/RL is required in order to access to performance based payments, as the performance of a REDD+ initiative would be measured by comparing actual GHG emissions and removals with a defined level of GHG emissions or removals (historical emission level or the projected business as usual, BAU, scenario). For selected REDD+ activities (Reducing emissions from deforestation, Reducing emissions from forest degradation, Enhancement of Carbon Stocks: Non-Forest to Forestlands, A/R), the REL and uncertainties will be estimated and reported separately (FCPF CF MF requirement) and as a unique (aggregated):

$$REL/RL = REL_{Deforestation} + REL_{Forest\ degradation} + RL_{A/R}$$

There are three different approaches to set the REL/RL for the selected REDD+ activities: (i) a **historical REL/RL**, based on the assumption that future emissions/removals will be similar to the average emissions or will follow the trend from the recent past, (ii) a **historical adjusted REL/RL**, based on justified evidence that historical data are not enough to set an accurate REL (iii) and a **projection of a REL/RL model**, based on historical data and its correlation to various covariates. Average emissions level is the required approach by the FCPF CF MF (in very few cases allows the historical adjusted reference level). VCS JNR requires defining at least two historical RELs:

one based on the historical average; another one based on a historical trend or a model choosing the more conservative option. In any case it is recommended to analyse trends, even modelling, to define a realistic BAU scenario.

REL/RL needs to be revised periodically launching an updating process to ensure that new socioeconomic conditions are well gathered and most current and accurate information is being used. The FCPF CF MF states that a REL/RL must be valid for the period of the ERPA (Emissions Reduction Purchase Agreement), for 5 years, whereas VCS JNR requirements set this validity period in 10 years.

As we indicated previously, in order to comply with the requirements of both standards, historical data for a period of 10 (-12) years ending on 2016 should be enough: (2004-) 2006-2016. It could be extended (with convincing justification) to the period 2001-2016 if we only consider compliance to the FCPF CF MF.

A spatial explicit REL/RL will be set as a final target. A spatial explicit estimation of GHG emissions and removals would provide more accurate estimates of REDD+ activities and would allow understanding the patterns of deforestation and forest degradation establishing appropriate mitigation measures. For this purpose it will be necessary to have spatial explicit historical data for all the activities or quality spatial covariates to generate it.

Finally overall uncertainties of the estimates must be reported as required by the 2006 IPCC GL, the FCPF CF MF and VCS JNR. Reporting at 90% of confidence level is required, and the estimation of the overall uncertainty must be estimated using Monte Carlo Methods as required by the FCPF CF MF.

We have elaborated the following methodological summary for setting REL/RL (table 13):

REL/RL Specifications	Definition
Activities (accounting methods were described in the corresponding sections)	▪ Reducing emissions from deforestation (deforestation from unplanned drivers and planned drivers must be separated in the REL for deforestation if large scale deforestation, >1000 ha, exceeds 10% of historical deforestation in the historical reference period). ▪ Reducing emissions from forest degradation. ▪ Enhancement of carbon stocks (A/R). ▪ Non-CO2 emissions from forest fires, Conservation of carbon stocks and Sustainable management of forests will be excluded.
Method to set REL/RL	▪ A historical average and a historical trend will be applied, selecting the conservative option. ▪ Projections will be made to understand deviations between the BAU and the historical emission level. ▪ The historical period of the REL/RL must cover 10-(12) years ending in 2016 (convincing justification). A benchmark map of 2016 is required as a last point of the historical analysis and for monitoring purposes, for all activities. ▪ A Spatially explicit REL/RL will be set for unplanned deforestation and forest degradation.
Updating frequency	▪ Every 5 years.
Uncertainty	▪ Overall uncertainty of the GHG emissions at 90% confidence must be reported. ▪ Propagation of errors must be done through Monte Carlo methods.

Table 13. Methodological summary for setting REL/RL at Nacional Level

The mechanism for calculating the reference level at national level is planned as a stepwise approach. A zero version is currently available using global AD databases (Hansen *et al.* 2013)[11] and national emission factors (secondary information). A disaggregation of total forest loss to annual time scales, corresponding to loss detected primarily in the year 2001–2014, respectively, was used. In February 2017, when the AD visual assessment is finalized throughout the country, as described above, REL version 1 will be produced with the results of this analysis and national emission factors. Finally, at the end of 2017 with processed data from IFN, the EFs will be recalculated at the national level and more precise measurements will be obtained in the new and definitive reference level version 2.

[11] Hansen, M. C., P. V. Potapov, R. Moore, M. Hancher, S. A. Turubanova, A. Tyukavina, D. Thau, S. V. Stehman, S. J. Goetz, T. R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C. O. Justice, and J. R. G. Townshend. 2013. "High-Resolution Global Maps of 21st-Century Forest Cover Change." Science 342 (15 November): 850–53. Data available on-line from: http://earthenginepartners.appspot.com/science-2013-global-forest.

Component 4: Monitoring Systems for Forests, and Safeguards

Subcomponent: 4a. National Forest Monitoring System

Implementation

MRV overall framework

MRV system must have the same overall framework that we explained for REL/RL. We must consider a multi-scale (three different levels: National, Provincial and Local) system where selected activities (deforestation, forest degradation and enhancement carbon stocks; A/F) are integrated into an accounting scheme of a larger jurisdiction (top-down approach with integration of low level data at the high level). There will be consistent monitoring datasets at national level but these also will gather on field information from the lower levels. Provincial and local levels may also account additional activities or additional pools.

In particular the national PMRV for Mozambique will measure, report and verify the selected activities: deforestation, forest degradation and enhancement of carbon stocks (A/F) through the implementation of a **Continuous Forest Inventory (National Forest Inventory and National Net of Permanent Plots)** combined with **Forest area change mapping** (mainly through several EOS approaches). These results will be gathered and integrated at National Level with access from the provincial and local levels.

AD will be updated every 2 years (consistent with the biennial reporting set under the UNFCCC), but annual reporting capacity will be generated at MRV Unit (FNDS) and a new LULC map based on Sentinel-2 can be generated every 5 years. EFs will be updated every 2 years with the survey of the National Net of Permanent Plots (48 plots should be surveyed each year). The NFI could be updated every 10 years to obtain a global, complete and accurate forest information at the national level.

AD will be measured through various activities: all of them have been described in the previous sections except those that aim to gather Community based information on LULC and LULC Changes based on the Adaptation of Participatory tools with available Geospatial technologies (Collect Earth[12])

In the context of a national forest assessment and monitoring, there is neither the time nor financial resources to support participatory approaches and even in these communities based initiatives, village focus groups interviews and key informant interviews currently talk in general terms about the forest changes in the area of interest with limited ability to pinpoint the area being discussed. Aerial photographs and satellite images haven’t proved very functional in the

[12] Collect Earth is a tool belonging to OpenForis tools set (FAO free open-source solutions for environmental monitoring: http://www.openforis.org/tools/collect-earth.html) that enables data collection through Google Earth. In conjunction with Google Earth, Bing Maps and Google Earth Engine, users can analyse high and very high resolution satellite imagery for a wide variety of purposes.

village context; high costs, limited availability and need of abstraction of lower resolution imagery (it has been demonstrated in the early stages of implementation of the national forest inventory where it has not been operationally possible to implement at the same time the collection forest information and other indicators more related to the Safeguards Information System (Social and Environmental variables).

Google Earth covers most rural landscape areas at a high resolution with fairly updated images, meaning that it is possible to view villages and landscapes in considerable detail. It is thus adequate to conduct 'virtual transects'. It would be possible to conduct village focus groups discussions pinpointing areas in the landscape with the assistance of Google Earth. For this purpose Internet connectivity is not necessary, as it is possible to download workable imagery of the village areas to be discussed ahead of time. We would recommend to pilot local level (key informant and focus group) interpretation of Google Earth images in order to assess currents LULC and LULC changes.

Through pilot testing of the PMRV system in Mozambique in 15 districts of the Cabo Delgado and Zambezia provinces during the 2018, we will detect optimal areas for local interpretation (square rectangle that represents the surroundings of the village: e.g. 15 km). Collect Earth tool could be designed in such a way that it facilitates the collection of biophysical forest and social descriptors and information from specific points plotted on a grid though Google Earth. Sampling design and data entry forms could be designed for specific information requirements. The current grid format of Collect Earth actually provides greater opportunities for participatory analysis of the landscape with focus groups than a transect line. It would be possible to sit with a focus group and a computer running Collect Earth and pick out points in the landscape on the grid of particular interest to develop a further understanding of e.g. current LULC, recent or past changes of LULC, management regimes of particular forest blocks, social and economical conditions etc. Thus a combined biophysical and socio-economic survey (e.g., a household survey, part of the SIS) could be conducted at the same time with the proper design of tables and forms that will be more effectively and efficiently answered in a focus groups setting, with the aid of the Collect Earth tool. These forms will be accessible by clicking on the grid plots in Google Earth.

Equations to estimate GHG emissions and removals

The set of equations needed to estimate the GHG emissions and removals (fully consistent with the equations used to define the REL/RL) are:

Description	Equations
GHG emissions/removals in the AOI occurring in year t; tCO2 year-1.	$E_{AOI,t} = \sum_{i}^{n} E_{AOI,t,i}$ *i, activities*
GHG emissions/removals in the AOI by activity in year t; tCO2 year-1.	$E_{AOI,t,i} = \sum_{p,q}^{m} E_{AOI,t}(j_{p\to q})$ $j_{p\to q}$= *LULC change from class p to q.*
GHG emissions/removals in the AOI for a change from LULC class p to q in year t; tCO2 year-1.	$E_{AOI,t}(j_{p\to q}) = \sum_{t}^{t-t\prime} \Delta area_t(j_{p\to q}) \times EF_t(j_{p\to q})$ *t'=Transition period for $j_{1\to 2}$; years.* $\Delta area_t(j_{p\to q})$*, Activity Data, LULC change from class p to q; ha year-1.*
Emission/Removal factor for a change from LULC class p to q in year t; tCO2e ha-1 year-1.	$EF_t(j_{p\to q}) = \sum_{k}^{l} EF_{k,t}(j_{p\to q})$ *k =Carbon pool.* *AG = Aboveground, BG=Belowground, LT=Litter, DW=Dead Wood, SOC=Soil Organic Carbon.*
Emission/Removal factor for a change in carbon pool k from LULC class p to q in year t; tCO2e ha-1 year-1.	$EF_{k,t}(j_{p\to q}) = \frac{44}{12} \times \frac{(C_{pk} - C_{qk})}{t'_k}$ *C_k=Carbon density of carbon pool k of a LULC class; tC ha-1.* *t'_k=Transition period for $j_{p\to q}$ for carbon pool k; years.*
UNFCC: Half width 90% or 95% confidence interval of Emission/Removal factor for a change in carbon pool k from LULC class p to q in year t, tCO2e ha-1 year-1	$CIEF_t(j_{p\to q}) = \frac{\frac{44}{12} \times \sqrt{\Sigma_k (CI(C_{pk})^2 + CI(C_{qk})^2)}}{t'_k}$ $CI(C_k)$ = Half width 90 or 95% confidence interval of carbon density of carbon pool k of LULC class, tCO2 ha-1.
VCS JNR compliant half width 90 or 95% confidence interval of Emission/Removal factor for a change in carbon pool k from LULC class p to q in year t, tCO2e ha-1 year-1.*	If $CIEF_t(j)/EF_t(j) > 0.15 \rightarrow EF'_t(j) = (1 - \frac{CIEF_t(j)}{EF_t(j)} + 0.15) \times EF_t(j)\ ;\ CIEF'_t = 0.15$ If $CIEF_t(j)/EF_t(j) \leq 0.15 \rightarrow EF'_t(j) = EF_t(j)\ ;\ CIEF'_t = CIEF_t$ *$EF'_t(j_{p\to q})$= VCS complaint emission/removal factor for change in year t from a LULC class p to q; $tCO_2e\ ha^{-1}\ year^{-1}$.*

Half width 90 or 95% confidence interval of GHG emissions/removals in the AOI for a change j from LULC class p to q in year t, tCO2 year-1.	$CIE_{AOI,t}(j) = \sqrt{\sum_{t}^{t-t'}((CIEF'_t(j) \times \Delta area_t(j))^2 + (EF'_t(j) \times CI\Delta area_t(j))^2)}$ $CI\Delta area_t(j)$ = *Half width 90 or 95% confidence interval of area of transition j in year t, ha year-1.*
Half width 90 or 95% confidence interval of GHG emissions/removals in the AOI by REDD+ activity i in year t, tCO2 year-1.	$CIE_{AOI,i,t} = \sqrt{\sum_{p,q}^{m}\left(CIE_{AOI,t}(j_{p\rightarrow q})\right)^2}$
Half width 90 or 95% confidence interval of GHG emissions/removals in the AOI in year t; tCO2 year-1.**	$CIE_{AOI,t} = \sqrt{\sum_{i}^{n}\left(CIE_{AOI,i,t}\right)^2}$

Table 18. Equations to estimate the GHG emissions and removals in the AOI.

*Under the VCS JNR, emission factors with an uncertainty above 30% at the 95% confidence level, must be corrected using appropriate methods.

**Under the FCPF CF MF the uncertainty of the GHG emissions/removals under the AOI (,) must be estimated using Montecarlo methods as described in the 2006 IPCC GL – Volume 1 – Chapter 3. Equations for the Montecarlo simulation cannot be provided as the simulation consists in conducting various iterations (e.g. 10000 iterations) where the average estimate of the AD, EF and other factors are a random variable following a normal distribution (or other types) with average the estimate and the standard deviation equivalent to the standard error of the estimate.

ER Program CF Buffers

As part of the ER Program CF Buffer[13], two (2) separate buffer reserve accounts will be established, which are ER Program-specific:

1. An *Uncertainty Buffer* to create incentives for improving uncertainty associated with the estimation of ERs and manage the risk that the emission reductions were overestimates for prior reporting periods,

2. A *Reversal Buffer* to insure against potential Reversals.

In addition to the ER Program CF Buffer, the Buffer manager will also establish a *Pooled Reversal Buffer* account to insure against potential large scale Reversals which exceed the amount of ERs set aside in the Reversal Buffer (pooled across all ER Programs for which an ERPA has been signed).

The proportion of ERs that must be set-aside in each buffer reserve account for an initial reporting period may change (for the following reporting periods) depending on quantification improvements or revisions to Reversal Risk assessments.

[13] ER Program Buffer Guidelines. Draft, October 2 , 2015.

At the outset of an ER Program, separate accounts must be created in an appropriate ER Transaction Registry for the exclusive purpose of receiving, disbursing, or canceling ERs that will be allocated to the Uncertainty Buffer, the Reversal Buffer and the Pooled Reversal Buffer. Transfers of ERs to and from the accounts, and cancelation of ERs from the accounts, may only be initiated by the Buffer Manager.

The Reversal Buffer and the Pooled Reversal Buffer accounts will exist separately from any reversal risk management accounts established under an ER Program to manage reversal risks for ERs that are not subject to the ERPA and which, therefore, will not be transferred to the CF.

Once Total ERs are determined for a particular reporting period, the ER Program Entity and/or Trustee should instruct, or help instruct, as applicable, the administrator of the ER Transaction Registry to establish serial numbers for the amount of Total ERs and to transfer and deposit a portion of the serialized ERs, as Buffer ERs, into the Uncertainty Buffer account, into the Reversal Buffer account and into the Pooled Reversal Buffer account.

Uncertainty Buffer account

Calculation Method (conservativeness factors were included in criterion 22 of the CFMF)

For deforestation the amount set aside in the buffer reserve is determined using the conservativeness factors of table 20. For forest degradation: the same conservativeness factors may be applied if spatially explicit activity data (IPCC Approach 3) and high quality emission factors (IPCC Tier 2) are used. Otherwise, for proxy based approaches, apply a general conservativeness factor of 15% for forest degradation Emission Reductions.

Aggregate Uncertainty of Emissions Reductions	*Conservativeness Factor*
≤ 15%	*0%*
> 15% and ≤ 30%	*4%*
> 30 and ≤ 60%	*8%*
> 60 and ≤100%	*12%*
100%	*15%*

Table 19. Conservativeness factors for uncertainty buffer account.

Update conservativeness factors for current reporting period and estimates for prior reporting periods

As a result of an improvement in the MRV system the aggregate uncertainty is reduced compared to the prior reporting period: consequences: lower conservativeness factor and updated estimates for prior reporting periods:

1) **Cancelation**: if the result is a **lower estimate of Total ERs** for the prior reporting periods, then the Buffer Manager should apply the followings steps:

a) Calculate the quantity of Buffer ERs to be cancelled using the following formula:

$$Q_c = G_0 - G_1$$

Q_c=The quantity of Uncertainty Buffer ERs to be cancelled
G_0=The original estimate of cumulative Total ERs for the prior reporting periods
G_1=The revised cumulative estimate of Total ERs for the prior reporting periods, after improvements in measurements and respective reduction in uncertainty

b) **If Qc calculated under step a) is greater than the balance of Buffer ERs** deposited in the Uncertainty Buffer account for prior reporting periods, then the Buffer Manager should only cancel all Buffer ERs deposited in the Uncertainty Buffer account for prior reporting periods. Buffer ERs should be cancelled by removing them from the Uncertainty Buffer account and permanently retiring their associated serial numbers.

c) **If Qc calculated under step a) is less than the balance of Buffer ERs** deposited in the Uncertainty Buffer for prior reporting periods, then the potential quantity of Buffer ERs to be **released**, if any, is calculated as follows:

$$Q_r = D_0 - Q_c - (G_1 \times CF_1)$$

Q_r=The quantity of Uncertainty Buffer ERs to be released
D_0=The balance of Buffer ERs deposited in the Uncertainty Buffer account for prior reporting periods
Q_c=The quantity of Uncertainty Buffer ERs to be canceled (as per step a)
G_1=The revised cumulative estimate of Total ERs for the prior reporting periods, after improvements in measurements and respective reduction in uncertainty
CF_1=The revised conservativeness factor, after improvements in measurements and respective reduction in uncertainty

Only if is positive the Buffer Manager may release ERs from the Uncertainty Buffer equivalent to and transfer them to an account designated to hold ERs following the instructions of the ER Program Entity or Trustee, as applicable.

2) **reAllocation**: If the result is an **equal or higher estimate of Total ERs** for the prior reporting periods, then:

a) Revise quantities for allocations to the Uncertainty Buffer, the Reversal Buffer and the Pooled Reversal Buffer.

b) If the revised quantity of required allocations to the Uncertainty Buffer for the prior reporting periods is greater than the original allocation, then additional ERs should be allocated to the Uncertainty Buffer to make up the difference.

c) If the revised quantity of required allocations to the Uncertainty Buffer for the prior reporting periods is less than the original allocation, then the Buffer Manager may **release** ERs from the Uncertainty Buffer and transfer them to an account designated to hold ERs following the instructions of the ER Program Entity or Trustee, as applicable. The quantity to be released should be equal to the difference between the original and revised allocation requirements.

d) Additional allocations of ERs to the Reversal Buffer and the Pooled Reversal Buffer should be made as necessary.

Extinction of the Uncertainty Buffer

If the ER Program Entity does not wish to maintain an uncertainty buffer reserve beyond the end of the ERPA term, then the Buffer Manager should **cancel** the ERs in the Uncertainty Buffer account in the ER Transaction Registry prior to the end of the ERPA term. ERs should be cancelled by removing them from the Uncertainty Buffer account and permanently retiring their associated serial numbers.

If the ER Program Entity wishes to continue maintaining a buffer reserve serving the same function as the Uncertainty Buffer beyond the end of the ERPA term, then the Buffer Manager should **transfer** ERs from the Uncertainty Buffer account in the ER Transaction Registry to an equivalent buffer account designated and controlled by the ER Program Entity or any other entity designated by the ER Program Entity prior to the end of the ERPA term.

Reversal Buffer and Pooled Reversal Buffer account

Calculation Method (developing criterion 19, option 2 -indicator 19.1- of the CF-MF and criterion 22)

The percentage of Contract ERs and Additional ERs to be set aside in the Reversal Buffer and Pooled Reversal Buffer accounts should be determined by the Trustee, following consultations with the Program Entity, or by the Buffer Manager, as applicable, in accordance with the following Reversal Risk assessment tool:

Factors	*Examples of Risk Indicators*	*Default percentage*	*Discount*	*Resulting percentage*
Default risk	• *Not applicable, fixed minimum amount*	***10%***	***Not applicable***	***10%***
A. Lack of broad and sustained stakeholder support	• *Are stakeholders aware of, and/or have positive experience with FGRM, benefit sharing plans etc. or similar instruments in other contexts?* • *Have occurrences of conflicts over land and re-sources been addressed?*	***10%***	*Risk is considered high: 0% discount;* ***OR***	***10%***
			Risk is considered medium: 5% discount; ***OR***	***5%***
			Risk is considered low: 10% discount	***0%***
B. Lack of institutional capacities and/or ineffective vertical/cross sectoral coordination	• *Is there a track record of key institutions in implementing programs and policies?* • *Is there experience of cross-sectoral cooperation?* • *Is there experience of collaboration between different levels of government?*	***10%***	*Risk is considered high: 0% discount;* ***OR***	***10%***
			Risk is considered medium: 5% discount; ***OR***	***5%***
			Risk is considered low: 10% discount	***0%***
C. Lack of long term effectiveness in addressing underlying drivers	• *Are there experience in decoupling deforestation and degradation from economic activities?* • *Is relevant legal and regulatory environment conducive to REDD+ objectives?*	***5%***	*Risk is considered high: 0% discount;* ***OR***	***5%***
			Risk is considered medium: 2% discount; ***OR***	***3%***
			Risk is considered low: 5% discount	***0%***
D. Exposure and vulnerability to natural disturbances	• *Is the Accounting Area prone to fire, storms, droughts, etc?* • *Are there capacities for preventing natural distur-bances or mitigating their impacts?*	***5%***	*Risk is considered high: 0% discount;* ***OR***	***5%***
			Risk is considered medium: 2% discount; ***OR***	***3%***
			Risk is considered low: 5% discount	***0%***
Actual Set-Aside Percentage: 10+(Result A+ Result B+ Result C+ Result D) = 10 to 40%				

Table 20. Reversal Risk assessment tool.

From the actual set-aside percentage for Reversal Risks, as determined in accordance with table above, half of the Default Risk percentage of 10% (i.e. 5% of Contract ERs and Additional ERs) should be deposited as Buffer ERs into the Pooled Reversal Buffer account while the remainder of the actual set-aside percentage for Reversal Risks should be deposited as Buffer ERs into the Reversal Buffer account.

In determining the actual set-aside percentage for Reversal Risks after each reporting period, the Trustee and the Buffer Manager, as applicable, should take into account the results of any related assessment done by another entity or body authorized by and acting on behalf of the CF (e.g.; Technical Advisory Panel assessments).

Cancelation in case of Reversal

The Trustee determines whether a Reversal has occurred and, if so, notifies the Buffer Manager accordingly. A Reversal can only occur if ERs have been transferred to the CF, as Contract ERs and Additional ERs, for at least one prior ER Program reporting period .If a Reversal occurs, then Buffer ERs should be cancelled from the Reversal Buffer account to compensate for the Reversal. The quantity of Buffer ERs cancelled from the Reversal Buffer account should be equal to the amount of ERs that have been previously transferred to the CF, as Contract ERs and Additional ERs, and are proportionally affected by the Reversal. The amount of previously transferred Contract ERs and Additional ERs affected by the Reversal should be calculated as follows:

$$R_c = {}^{C}/_{T_0} \times (T_1 - T_0)$$

R_c= Quantity of Buffer ERs cancelled from the Reversal Buffer account
C = Quantity of Contract ERs and Additional ERs
T_0 = Quantity of Total ERs estimated for prior reporting period
T_1 = Quantity of Total ERs estimated for current reporting period (as an aggregate of ERs accumulated since beginning of the ERPA)

If the amount of Buffer ERs in the Reversal Buffer account does not suffice to fully compensate for the Reversal, then the shortfall amount of Buffer ERs in the Reversal Buffer account should be covered through an equivalent amount of Buffer ERs from the Pooled Reversal Buffer, provided that the Reversal event, as determined by the Trustee, has been a non-human induced Force Majeure Event, impacting at least 25% of the ER Program Accounting Area.

Buffer ERs should be cancelled by removing them from the Reversal Buffer and Pooled Reversal Buffer account, as applicable, and permanently retiring their associated serial numbers.

The ER Program Entity, Trustee or Buffer Manager should instruct, or help instruct, as applicable, the ER Transaction Registry administrator to cancel such Buffer ERs in the Reversal Buffer and Pooled Reversal Buffer account, as applicable.

Update reversal risks

Reversal Risk assessments after subsequent ER Program reporting periods may, in accordance with Table above, determine a reduced risk exposure than was determined after the previous ER Program reporting period (e.g., from high to medium risk or from medium to low risk). Such reduced risk exposure should reduce the required actual set-aside percentage for Reversal Risks and allow for a release of a corresponding amount of Buffer ERs from the Reversal Buffer.

If the required amount of Buffer ERs set aside for the Reversal Buffer for the current ER Program reporting period was reduced below the required amount of Buffer ERs set aside in prior ER Program reporting periods, then the Buffer Manager should release Buffer ERs from the Reversal Buffer account in an amount equal to the difference of such required amounts of Buffer ERs and transfer those released Buffer ERs into an account designated to hold ERs, following the instructions of the ER Program Entity or Trustee, as applicable. The quantity of Buffer ERs to be released from the Reversal Buffer account should be determined using the following formula:

$$Q_r = (R_0 - R_1) \times N_0$$

Q_r =The quantity of Buffer ERs to be released from the Reversal Buffer account
R_0=The actual set-aside percentage for the Reversal Buffer applied to all reporting periods prior to the current reporting period 2
R_1=The actual set-aside percentage for the Reversal Buffer applicable to the current reporting period
N_0=The cumulative total of Contract ERs and Additional ERs for all reporting periods prior to the current reporting period

If is greater than the number of Buffer ERs currently in the Reversal Buffer account, then the quantity of Buffer ERs remaining in the Reversal Buffer account may be released.

The required set aside for the current reporting period is calculated following the procedure described above. The respective quantity of Buffer ERs is transferred to the Reversal Buffer account after the quantity of Buffer ERs to be released were transferred out of the Reversal Buffer account.

If the ER Program Entity wishes to continue maintaining a buffer reserve serving the same function as the Reversal Buffer beyond the end of the ERPA term, then the Buffer Manager should, prior to the end of the ERPA term:

a) Transfer all Buffer ERs remaining in the Reversal Buffer account in the ER Transaction Registry to such other buffer reserve account designated and controlled by the ER Program Entity or any other entity designated by the ER Program Entity, and

b) Transfer a portion of the Buffer ERs remaining in the Pooled Reversal Buffer account in the ER Transaction Registry (equivalent to the ER Program's proportional share of any amount of Buffer ERs in the Pooled Reversal Buffer remaining at the end the ER Program's ERPA term, but not exceeding the ER Program's original contribution) to such other buffer reserve account designated and controlled by the ER Program Entity or any other entity designated by the ER Program Entity.

If the ER Program Entity chooses to manage Reversal Risks using policies or mechanisms other than a buffer reserve, then the Buffer Manager should, prior to the end of the ERPA term:

a) Cancel all Buffer ERs remaining in the Reversal Buffer account in the ER Transaction Registry, and

b) Cancel a portion of the Buffer ERs remaining in the Pooled Reversal Buffer account in the ER Transaction Registry (equivalent to the ER Program's proportional share of any amount of Buffer ERs in the Pooled Reversal Buffer remaining at the end of the ER Program's ERPA term, but not exceeding the ER Program's original contribution)

Buffer ERs should be cancelled by removing them from the Reversal Buffer and Pooled Reversal Buffer account and permanently retiring their associated serial numbers.

Alternatively, subject to agreement between the Trustee and the ER Program Entity, the Buffer Manager may, instead of cancelling such Buffer ERs from the Reversal Buffer and Pooled

Reversal Buffer account, release and transfer them into an account designated to hold ERs, following instructions by the ER Program Entity or Trustee, as applicable

If the ER Program will not continue past the ERPA term, then the Buffer Manager should:

a) Cancel all Buffer ERs remaining in the Reversal Buffer account in the ER Transaction Registry, and

b) Cancel a portion of the Buffer ERs remaining in the Pooled Reversal Buffer account in the ER Transaction Registry (equivalent to the proportional share of any amount of Buffer ERs in the Pooled Reversal Buffer remaining at the end of the ER Program's ERPA term).

ERs should be cancelled by removing them from the Reversal Buffer account and permanently retiring their associated serial numbers.

The ER Program Entity or Trustee should instruct, or help instruct, as applicable, the ER Transaction Registry administrator **to transfer from the remaining serialized ERs an amount of ERs contracted for under an ERPA and designated for transfer to the CF, as Contract ERs or Additional ERs**, into one or more account(s) designated to hold ERs.

MRV Workflow

As we have explained MRV system considers a multi-scale (three different levels: National, Provincial and Local) system where selected activities (deforestation, forest degradation and enhancement carbon stocks; A/F) are integrated into an accounting scheme of a larger jurisdiction (top-down approach with integration of low level data at the high level). There must be consistent monitoring datasets at national level but these also must gather on field information from the lower levels. Provincial and Local levels may also account additional activities or additional pools.

MRV system is centralised at national level in line with UNFCCC decisions relying on existing systems, ensuring the sustainability of the system, and avoiding the creation of duplicities.

The reported results (GHG emissions) must be consistent with UNFCCC communications. Any results reported at sub-national level have to be fully consistent with the UNFCCC communications, meaning consistent with the reported results by the national MRV system.

It is presented below a workflow for the MRV system consisting of three different levels defined in the overall framework.

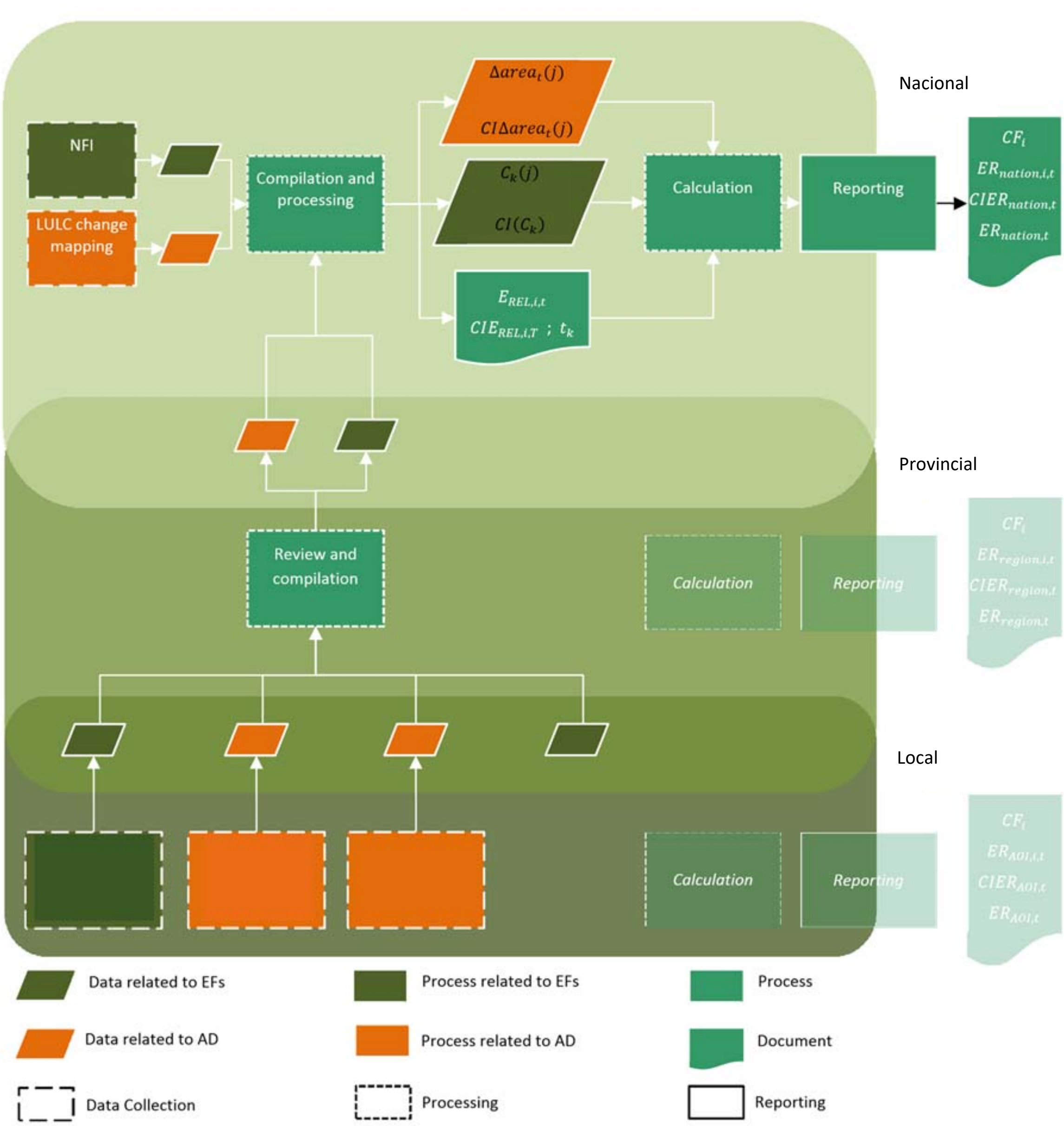

Figure 9. MRV Workflows. Integration of the National, Regional and Project Level.

The lowest level of this MRV system consists of projects or interventions that will have their own monitoring systems to collect relevant information for feeding the Provincial and National MRV systems. The information will include for instance data reported by REDD+ projects (i.e. forest inventories, project areas, detailed mapping of LULC classes, etc.), data reported by M&E systems (e.g. planted areas, etc.) or other data (e.g. biomass surveys, etc.). It is necessary to ensure that all these data is generated and reported in a consistent manner, following certain standards so that they can be incorporated to the national level (e.g. setting guidelines for projects to conduct data collection and reporting).

The provincial level, would not collect data directly (except information from relevant provincial programs), but would compile all primary and secondary data from the project level and would check and ensure that all data has been collected and reported following the defined standards or guidelines. The compiled data would be communicated to the National level, where it would be processed. The resulting parameter values from this processing at the National level will then be used by the provincial level for reporting purposes.

The National level, would collect primary data and would compile primary and secondary data coming from the Provincial level or directly from the Project Level. Additionally, two specific relevant national tasks would be implemented by the National MRV Unit at FNDS; (i) LULC and LULC changes mapping, and the (ii) NFI & National net of permanent plots. With these data the MRV Unit (FNDS) will produce official Activity Data, Emission Factors, revised RELs and related uncertainties at National, Provincial and Project Level. These processed data would then be used to calculate the Emission Reductions in collaboration with the Provincial or Project level (it depends on the Program/Project). Provincial or Project entities would then include these calculations in their program monitoring report, calculating the Emission Reductions that are assigned to each project/intervention area, depending on the benefit sharing mechanisms that will be established.

Higher MRV levels should be fully operational and the specific standards or guidelines for data collection and reporting should be clear and consistent with the national level procedures, for implementing this workflow. While these tasks are carried out, project and program entities are responsible for collecting, processing, analysing, and reporting all required information, following the standards and guidelines that are currently being developed.

Organizational structure, responsibilities and competencies

In this section we will try to provide an overview of the organization structure, responsibilities and competencies of the various MRV levels that we defined before. So far, the only institutions with a defined MRV function have been defined at National level:

1. **MRV Unit** at FNDS (Fundo Nacional de Desenvolvimento Sustentável, Ministério da Terra, Ambiente e desenvolvimento Rural): it is a technical unit with 5 specialists with background in Remote Sensing & GIS and Forest Resources assessment. It is the technical Unit directly involved in AD analysis (reporting deforestation, forest degradation and enhancement of carbon stocks A/R), LULC and LULC Change maps preparation, and EFs analysis (technical support, logistics and data processing for the National Forest Inventory, EFs calculation and updating process).They are also responsible of compiling and processing all relevant information from lower levels and operationalize the geographic information management system and databases, MRV platform, hosted in the two servers located in the offices of FNDS. Any General Directorate of the MITADER or other Ministries to which the corresponding permissions are granted can have direct access to this information for consultation and editing through the MRV web platform. They will also have access from the provincial and local levels.

On the other hand it is planned to design on this platform of information, specific tools and applications for groups of users.

All technical design features of this information portal and production unit are detailed in Annex 4.

2. **MRV Task Force:** We consider that should be created. It would be a technical group monitoring and providing support and technical advice for the main components of the system. The Task Force would be composed of representatives of MITADER Directorates, Other Ministries, Statistical Agencies, CENACARTA, several academic and research institutions (UEM, IIAM,…), NGOs, and international organizations (WB, FAO, etc.).

   There are many institutions with which the flow of information and services must remain open: some examples are: DINAT (Land Delimitation, Land DUAT's), CENACARTA (Topography maps, Satellite Imagery), IIAM (Soils, Permanent Plots), INE (Human Settlements), MOPH (Infraestructures, Hidrology), ANAC (Conservation areas), MMAI (Hidrology), DINAF (Forest data), etc.

At provincial level, the department that has been mandated with a REDD MRV functions is the UT-REDD+. In the near future a small MRV team will be established and will be assigned with MRV responsibilities:

3. **Provincial MRV team** with two specialists at the UT-REDD+ Provincial Coordination Units will coordinate the MRV functions that are responsibility of the provincial level;

4. **Project/Program implementer** will develop its own monitoring system to collect relevant information of the project (forest inventory, project areas, detailed mapping of LULC classes and changes), reporting to the Provincial/National Units in a consistent manner, following certain national standards.

   At Local Level, both systems PMRV and SIS, as we have explained before, will stand by the participation of local communities through selected agents

The responsibilities of each of these parties and how they would interact is provided in the following table:

Activities	National Level	Provincial Level	Project Level / Communities
Measurement	▪ MRV Unit at FNDS will produce the LULC map and disaggregate it into adequate forest classes and will implement the AD analyses. ▪ MRV Unit regularly will collect primary and secondary data (AD/EFs) from lower MRV levels, will analyze and compile this data. ▪ The MRV Unit elaborates the GHG emission calculation at national, provincial and project level.	▪ MRV team at provincial UT-REDD+ will collect, compile and analyze primary and secondary data on project interventions, e.g. emission factors, boundaries of activities, lulc changes, etc. This includes databases, GIS and remote sensing data.	▪ Project implementer will design its own monitoring system (following national guidelines) and will collect and analyze primary and secondary data within project boundaries; e.g. forest inventory data, boundaries of activities, lulc changes mapping, etc. This information includes databases and GIS data. Relevant forest information and socio-economic and environmental information will be collected at Community level.
Reporting	▪ MITADER? (appropriate directorate) is responsible for reporting at international (UNFCCC) and National Level and also for generating the information in collaboration with provincial institutions and project implementers for program and project reports. ▪ MITADER? (appropriate directorate) reports to UNFCCC.	▪ UT-REDD+ is responsible for compiling results from the Provincial MRV Unit for the province and reports in form of a Monitoring Report.	▪ Project implementer is responsible for compiling results from the Federal MRV Unit and Regional MRV Unit for the project and reports in form of a Monitoring Report.
Verification	▪ Third party national or international (accredited agency)		

Table 21. MRV Institutional arrangements and roles.

Subcomponent: 4b. Information System for Multiple Benefits, Other Impacts, Governance, and Safeguards

It is explicitly referred to in the National Strategy that the standards, procedures and guidelines for monitoring and measuring REDD + activities and results in Mozambique should be prepared considering the strategic objective that aims to ensure the **active participation of local communities** (participatory or community-based MRV; PMRV), and include useful information for the definition of **environmental indicators** related to the reduction of deforestation and forest degradation and related emissions, **economic and social indicators** linked to integrated rural development, as well as the specific indicators of **environmental and social safeguards**, as set out in the Environmental and Social Management Framework (ESMF) of REDD+.

Safeguards instruments, elaborated during the preparation of the REDD + process, are the Strategic Environmental and Social Assessment (SESA), the Environment and Social Management

Framework (ESMF) and the Resettlement Policy Framework (RPF), which includes the Complaints Mechanism (Mario Souto, 2016).

In compliance with the principles of REDD + implementation, and within the framework of the UNFCCC, a Safeguards Information System (SIS) will be developed and implemented to provide information on how safeguards are handled and respected. This is a necessary requirement to obtain payment by results.

The SIS is expected to be simple, accessible, inclusive, transparent, auditable, comprehensive and according to national legislation. The process of collecting information involves various partners from base community organizations, government and civil society organizations.

The implementation of safeguards and the creation of the REDD + Safeguards Information System (SIS) should be gradual and following a participatory approach. It is still a incipient process in Mozambique that demands a coordinated structure to enable the full participation of stakeholders (community, private sector, government and civil society).

Principles:

• Compliance with legislation and good governance,
• Promoting transparency and public / social responsibility,
• Respect for local culture and traditions,
• Ensure the significant participation of affected people and stakeholders (especially the most vulnerable)
• Ensure "auscultation" functions as conflict resolution mechanisms
• Protect and conserve forests, contribute to the improvement of the multiple functions of the forests.

The list of SIS indicators presented below, is a proposal prepared after consulting with various institutions involved in the process, reviewing the technical notes for preparing the Project Appraisal Document (PAD) of MozFIP and the MozDGM project, as well as bibliographical revision with special attention to the guide of good practices to identify areas of high conservation value. This list must be harmonized through planned seminars with stakeholders.

The methodology to be used for the monitoring process of indicators includes interviews, questionnaires, direct observation and public consultations whenever necessary. Continuous dissemination programs will be part of the process to enable stakeholders to be actively involved, making an efficient and transparent implementation of REDD + projects and initiatives in the region.

Item	sub-item	Description	Scale (National, Landscape, Community)	Responsible
Environmental / Ecological	Forests	Reforested Area (Increase of coverage percentage)	National, Landscape	DINAS, DINAF
		Reforested areas (New planting areas established)	National, Landscape	DINAS, DINAF
		Rehabilitated forest area	Landscape	DINAF e DINAS
		Information on existing management plans (updated)	Landscape	DINAF; ANAC;

Item	sub-item	Description	Scale (National, Landscape, Community)	Responsible
		Burned areas	National, Landscape	DINAF; ANAC
		Environmental Management Plan	Landscape	DINAF; ANAC
		Fires	Nacional, Landscape	DINAF; ANAC
	Biodiversity	Registration of fragile ecosystems	Landscape	
		List of endangered species (fauna and flora)	Nacional, Landscape	DINAF, ANAC
		Protected species (fauna and flora) survey	Nacional, Landscape	DINAF, ANAC
		Percentage of native area preserved in the concession (20% conservation law)	Landscapes	DINAF, PS (Service provider)
		Census faunistico (2 in 2 years in the conservation area)	Landscapes	ANAC
	Soils	Soil quality information	Landscapes	IIAM
		Areas of sustainable agriculture (agroforestry and conservation systems)	Landscapes	DINAS, SP
		Registration of use of agrochemicals	Landscapes	DINAS, SP
	Water resources	Pollution registry of water lines (agrochemicals)	Landscapes	DINAS, SP
		Pollution registry of water lines (sediments)	Landscapes	DINAS, SP
Socio cultural/Economicos	Cultural heritage	Registry of existing cultural rituals	Landscapes, Comunidades	CGRN´s , SP, SIDAE
		Registry of sacred sites	Landscapes, Comunidades	CGRN´s , SP, SIDAE
		Number of complaints attended	Landscapes, Comunidades	CGRN´s , SP, SIDAE
	Land tenure	Number of DUAT's holders	Landscapes, Comunidades	DINAT, SPGC
		Number of informal certificates issued	Landscapes, Comunidades	DINAT, SPGC
		Number of individuals with "occupation of good faith and customary practices"	Comunidades	DINAT, SPGC, SIDAE, CGRN, SP
		Number of disputes submitted and resolved (including complaint channels used)	Landscapes, Comunidades	CGRN´s , SP, SIDAE
	Land Use Changes	Grassland areas acquired for forest plantations	Landscapes	DINAT, SPGC
		Areas of Agriculture Purchased for Forest Plantations	Landscapes	DINAT, SPGC
		Number of community members involved in forest plantations / Partnerships and / or employment	Comunidades	SP
	Training	Number of community members involved in REDD + / FIP / DGM capacity building (by sex)	Comunidades	SP/FNDS
		Number of supported associations and forums	Landscapes, Comunidades	SP/FNDS

Item	sub-item	Description	Scale (National, Landscape, Community)	Responsible
		Number of operators involved in training	Landscapes	SP/FNDS
		Number of charcoal workers involved in training	Landscapes, Communities	SP/FNDS
		Number of trained institutions and technicians	National, Landscape	SP/FNDS
		Number of villages and beneficiaries (disaggregate)	Landscapes, Communities	SP/FNDS
	Other beneficiaries	Number of community members with access / information on sustainable technologies for biomass energy use (dissemination programs)	Landscapes, Communities	SP/FNDS
		Community projects: Number of Community projects / initiatives supported	Landscapes, Communities	SP/FNDS
		Number of workers employed in forestry plantations	Landscapes, Communities	DINAF, DINAS, SP/FNDS

Table 22. Proposal of SIS indicators

After the International/National review of PMRV practices, we drafted the following key points that now we should define in this document:

Key findings for PMRV design

Scope The main objective of the *'participatory'* component of a PMRV is to collect local carbon stock data to improve carbon accounting at national level (in compliance with international standards) and increase the participation of local communities to maximize the co-benefits of REDD+. But information has to be carefully defined and complemented: **carbon stocks** (main component but **pools** must be specified), **additional forest variables** (**non-carbon data**), variables on **drivers of deforestation and forest degradation**, **activity data** (**activities** must be established), **environmental and social information and impacts** of REDD+ implementation (safeguards information system, SIS). Information must be **simple** to measure and report, **accurate** (according to national and international standards), based on **robust and proven methods**, **cost and time-effective** avoiding high opportunity costs and **useful to the community**.

Methods Monitoring and measuring methods should be **simple** but scientifically **robust** and unbiased to provide accurate and reliable data. The use of **new technologies** (e.g. forest surveys or remote sensing mapping using digital devices; tablets or smartphones, drones, etc.) should first be tested in areas where communities are already involved in monitoring.

Training program It is a key point in a PMRV system for feasibility and sustainability purposes to strength local capacities and autonomy because in many cases the monitoring and reporting skills reside in intermediary organizations instead of the communities themselves. That's why it is necessary to design a complete program to conduct Training of Trainers (ToT) on data collection, data processing and data reporting for project staff, local representatives and key roles in the local MRV system developed (considering all information and data processing levels: **National Level**: Unidade de MRV - Unidade Técnica do REDD+, UTREDD+; **Provincial Level**: Coordenação Provincial de REDD+, Ponto focal ao nível de província da Unidade Técnica de REDD+ para as questões de MRV, **District Level**: Ponto focal ao nível de distrito da Unidade Técnica do REDD+ para as questões de MRV).

Scaling up monitoring program A remote sensing analysis will be necessary to compare the gap between local and national approaches. The methods to integrate the local information into the national system should be tested and ready to be used.

Validation A reliable verification process needs to be designed and implemented for national data integration consistency and for international reporting (direct requirement in a project or nested approach).

Environment and incentives The system needs to be **embedded into community based forest management** so the information can be used to improve management decisions as well as MRV purposes (see above; information useful to the community). This combination can easily deliver economic, social and environmental benefits for the local communities (livelihoods, organizational capacities, negotiating skills, environmental awareness, ecosystem services and conserving biodiversity) (Hawthorne & Boissière, 2014). Nevertheless a social analysis to probe the enabling conditions for local participation, including **a priori detailed incentives analysis**, is needed to motivate individual involvement in PMRV (financial, social and personal incentives).

PMRV as a cog in the wheel It should be incorporated into community based forest management system and into the multilevel MRV system (including into the national forest inventory) taking advantage of the existing local management systems with standardized practices and methods. A **governance analysis to understand data flow** (roles of members of local communities) is also needed.

PMRV & SIS It should be considered the potential contribution of PMRV to maximize the co-benefits of REDD+ and implement REDD+ safeguards information system (SIS).

Financing PMRV We should think about what the function of the collected data will be regarding the way that benefits are to be distributed, providing protocols for the PMRV. Experiences suggest that the best solution might be a hybrid system in which forest enhancements (stock increases) are rewarded on an output basis at the level of the individual forest parcel, while the financial returns from reductions in emissions from deforestation and degradation (assessed at regional level) would be used to fund input-based incentives.

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MRV Road Map Presentation

M&MRV Nacional

Moçambique

Programa de atividades do MRV em Moçambique financiadas com fundos adicionais FCPF CF

Unidade MRV

Aristides Muhate, Credencio Maunze, Hercilo Odorico,
Alismo Herculano, Delfio Esmenio Mapsanganhe, Julian Gonzalo

Fundo Nacional de Desenvolvimento Sustentável (FNDS)
Ministério da Terra, Ambiente e Desenvolvimento Rural
Governo de Moçambique

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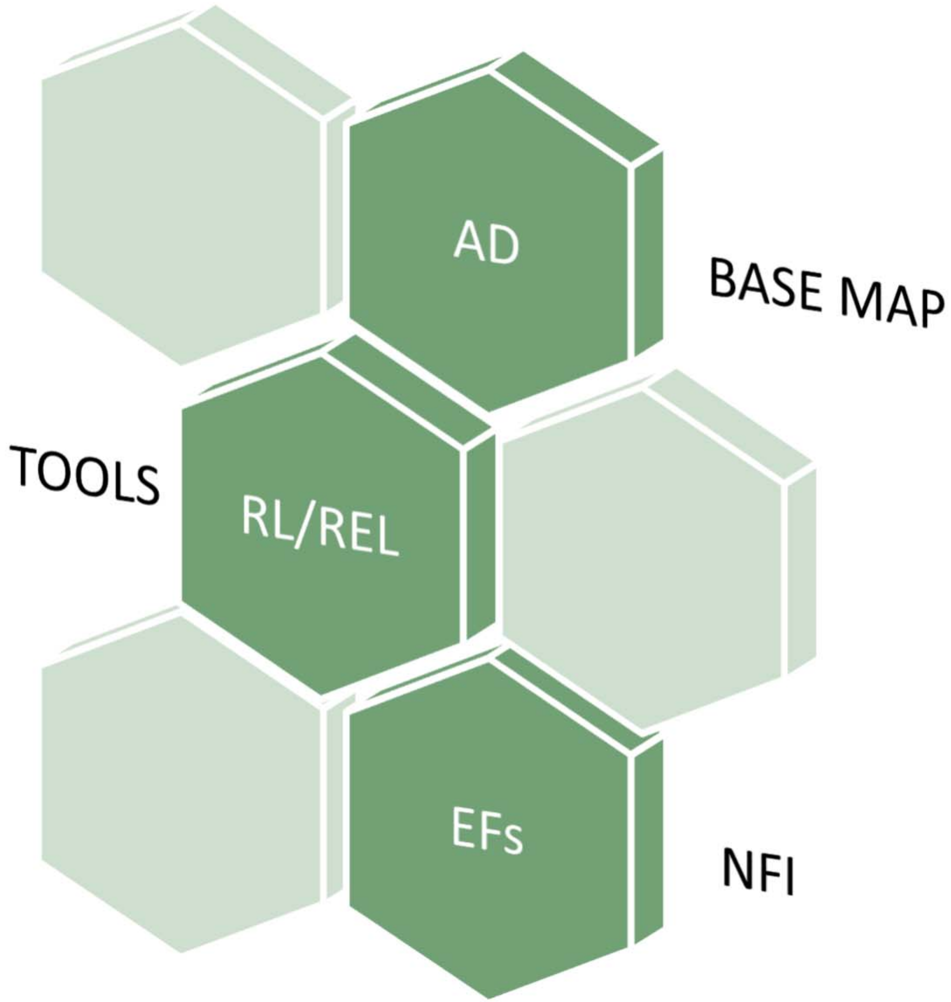
Component 3 REL/RL Scheme



MRV Activities

Component 3
Reference Emissions Level/ Reference Levels (REL/RL)

1,700,000 USD

3.1. Development of an updated national LU/LC base map	
Aim	To develop an updated and recent land cover map to assess the extent of forest cover (by vegetation types) prior to initiating REDD+
Ongoing	i) Preparation of a 2016 LULC Map based on Sentinel-2 Mosaic (same LULC classification) JICA & consultancy companies will continue with the preparation of the 2012 LULC Map based on Landsat 2012 Imagery
Justification	i) High Resolution (10 m), Free available (sustainability), Starting point for a NFMS based on it, Mozambique is part of ESA project based on sentinel-1,2 about degradation in dry forests ii) Historical analysis to establish the FRL (last point in time with the vegetation types classification) iii) Strata map (a posteriori) to process NFI data.
Who	i) New MRV Unit, as a 'learning-by doing' activity, whereby national experts will be trained and supervised by the MRV specialist. ii) Consultancy service: GMV AEROSPACE AND DEFENSE SAU - Mosaic preparation and Training: $42.708,43
Timeframe	i) Sentinel-2 2016: Q1-2017
Budget FCPF CF	200.000 USD

MRV Activities

Component 3
Reference Emissions Level/ Reference Levels (REL/RL)

1,700,000 USD

3.1. Development of an updated national LU/LC base map

Aim	To develop an updated and recent land cover map to assess the extent of forest cover (by vegetation types) prior to initiating REDD+

Timeframe

	2016				2017				2018			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
LULC Map Landsat 2012 JICA					Mo/ Ma/ G 6P			Mo/ Ma/ G 2P	Mo/ Ma/ G 2P			
LULC Map Sentinel-2 2016 MRV-Unit		Mo1 T1	Mo2 T2	Mo GT3	T4 Ma W							

(i) Mosaics (Mo); CS GMV: May/August – Completed in November 2016 (28/11/16)
(ii) Ground Truth Survey completition (G); AD analysis – Collect Earth GT
(iii) RS trainings: MRV Unit (T1, T2, T3, T4); T1 (June) - FAO-Univ. Sapienza Collect Earth training; T2(Sept) – Int. (DIRF) Collect Earth Forms AD-GT; T3(Nov) – GMV- ENVI & Sentinel
(iv) Supervised classification and refinement; (v) LU/LC map (First Version); (vi) Validation (desk and field checking), and refinement; (vii) LU/LC map (Final Version, Ma); (viii) 1 workshop (W) presenting results to stakeholders.

MRV Activities

Component 3
Reference Emissions Level/ Reference Levels (REL/RL)

1,700,000 USD

3.1. Development of an updated national LU/LC base map	
Aim	To develop an updated and recent land cover map to assess the extent of forest cover (by vegetation types) prior to initiating REDD+

Geração dum mosaico baseado em sentinel-2a adequado para a classificação LULC de Moçambique. MOZ-MOSAIC V 1.0

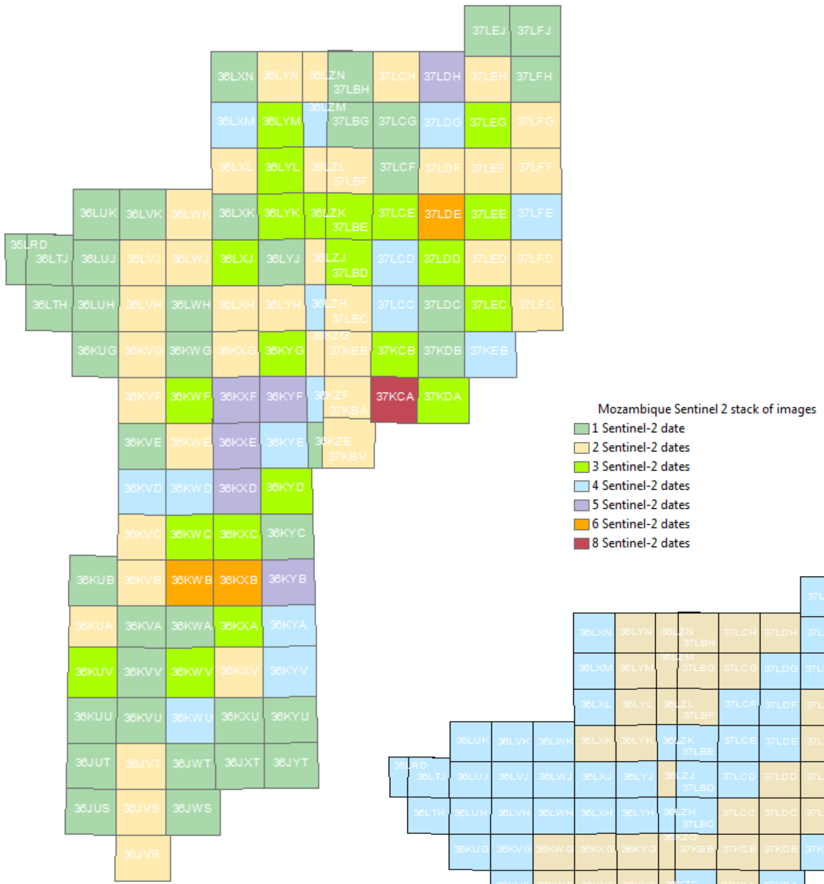
Project outputs (28/09/16-28/11/16-31/03/2017)

1. Two Sentinel-2 mosaics (may/june 2016 and agust/sept 2016).
2. LULC Classification of an AoI; Inhambane (NFI 2016) that will be used as training material.
3. Report with methodological approach.
4. Training session agenda (Nov 2016) and didactic material.
5. 2016 LULC Map of Mozambique (Validation, Refinement, R, WS).

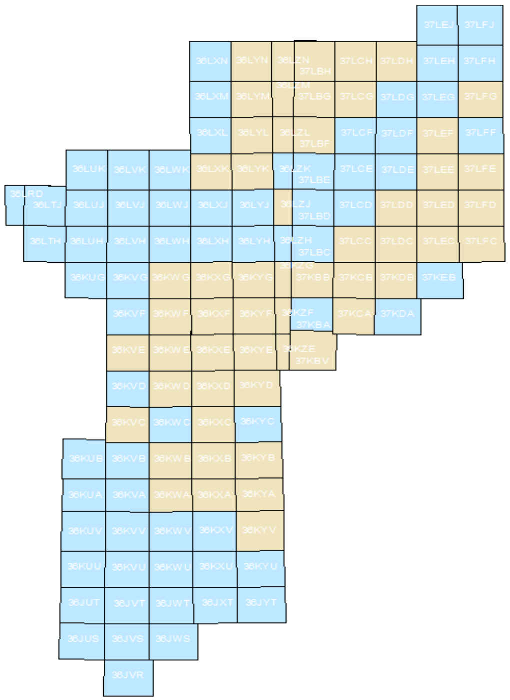
Proposta LULC2016

Contrato MOZMOSAIC

Concept	Technical specifications
Source data	Sentinel-2 A Level and Landsat-8 data
Bands in the outcome product	BLUE, GREEN, RED and NIR at 10 m resolution; RED-EDGE and SWIR at 20 m resolution
Reflectance	Bottom of the atmosphere (BOA) reflectance for each individual band
Delivery format	Format GeoTiff and jp2
Mosaic- 1 (Period with leaves on) dates	May 2016 to June 2016
Mosaic- 2 (Period with leaves off) dates	Mainly August 2016 (Septemeber)
Tile size	100X100 km2, following S-2 A tiling (granules)
Reference System	EPSG: 3036; Moznet / UTM zone 36S
Procedure to eliminate remaining clouds from the Sentinel 2 multi-temporal stack of images	If cloud coverage threshold is exceeded over any granule considering the Sentinel 2 multi-temporal stack of images built, remaining clouds (and shadows) will be detected, clipped and the affected pixels substituted byLandsat-8 data of the same season. Note that Landsat 8 does not have Red-Edge neither SWIR channels
Auxiliary data	Approx. location of deciduous and/or semi-deciduous forests on a geospatial layer (Map from 'Zoneamiento Agroecológico de Moçambique' project) will be provided by the client. Sampling ground truth dataset (4 x 4 km National Grid), will be prepared using Collect Earth Tool by the MRV-Unit and provided to the Service Provider.
Maximum allowed cloud coverage	5-10% depending on the abundance of clouds over the granule in the period/area.



Mozambique Sentinel 2 stack of images
1 Sentinel-2 date
2 Sentinel-2 dates
3 Sentinel-2 dates
4 Sentinel-2 dates
5 Sentinel-2 dates
6 Sentinel-2 dates
8 Sentinel-2 dates



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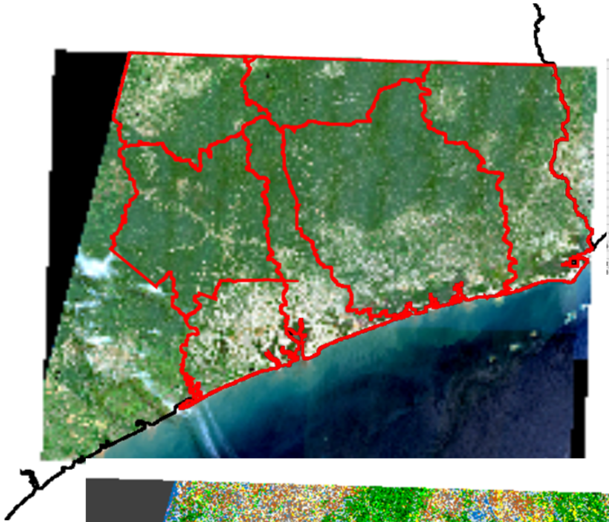
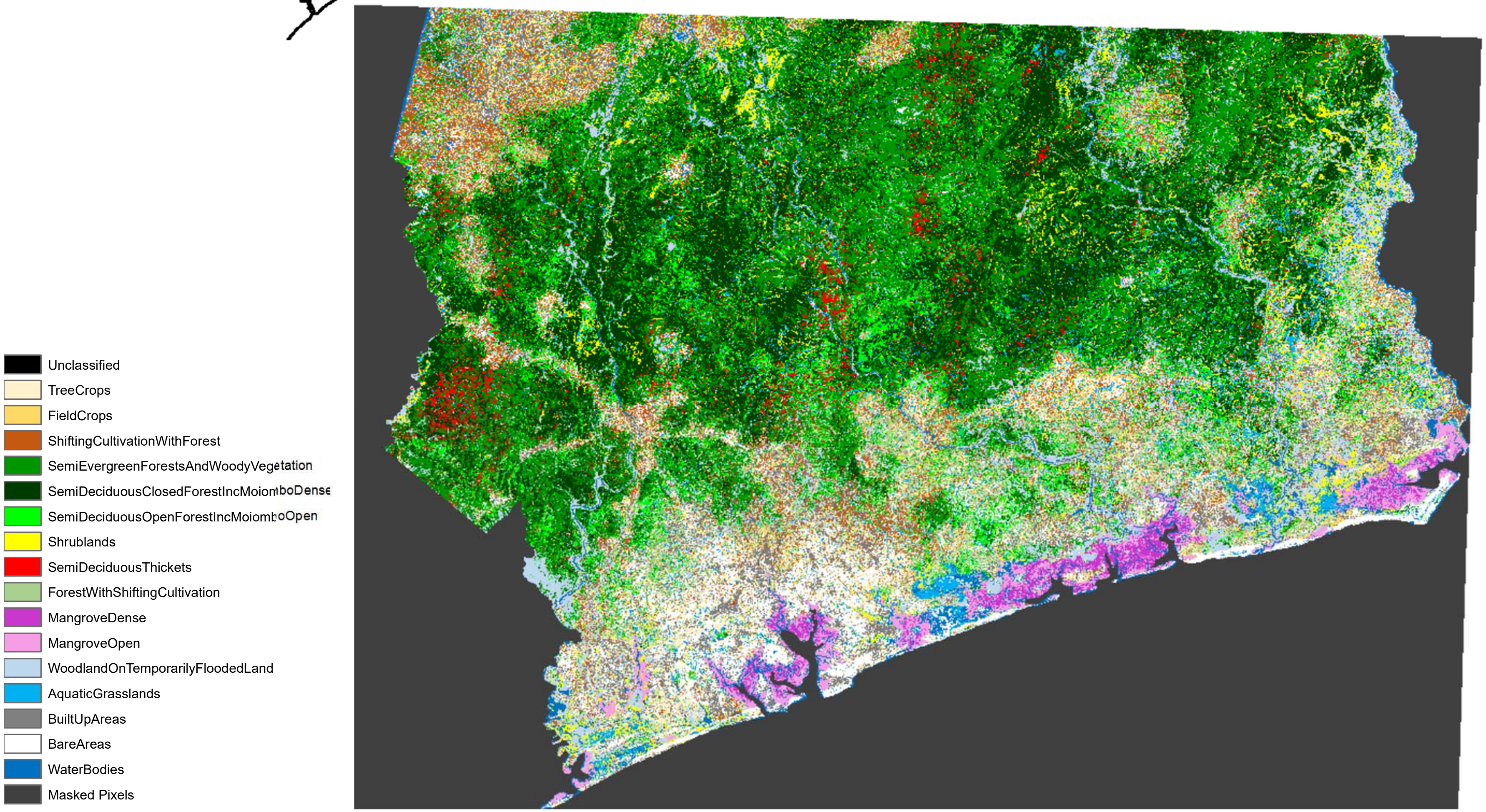


Classes	Tree crops	Field crops	Shifting cultivation with open to closed forested	Semi-evergreen forests and woody vegetation	Semi-deciduous closed forest (incl. Miombo	Semi-deciduous open forest (incl. Miombo	Shrublands	Semi-deciduous thickets	Forest with shifting cultivation	Mangrove dense	Mangrove open	Woodland on temporarily flooded land	Aquatic grasslands	Built-up areas	Bare areas	Natural water bodies	TOTAL
	Ground Truth (Pixels)																
Tree crops	283	29	4	0	0	0	0	3	6	0	0	5	0	29	2	0	361
Field crops	10	276	9	1	0	0	0	0	16	0	0	0	0	39	3	0	354
Shifting cultivation with open to closed	0	51	215	0	0	0	2	3	17	0	0	1	0	16	0	0	315
Semi-evergreen forests and woody vegetation	0	2	0	154	3	22	12	41	1	0	0	22	0	0	0	0	257
Semi-deciduous closed forest (incl. Miombo	0	0	0	39	167	20	3	19	0	0	0	0	0	0	0	0	248
Semi-deciduous open forest (incl. Miombo	0	3	30	32	0	126	1	71	17	0	0	11	0	0	0	0	290
Shrublands	0	4	0	18	1	11	122	3	1	0	3	5	19	0	0	4	191
Semi-deciduous thickets	0	2	3	20	0	22	0	39	4	0	0	2	1	0	0	0	93
Forest with shifting cultivation	14	39	32	1	0	13	0	8	189	0	0	6	0	0	0	0	342
Mangrove dense	0	0	0	0	0	0	0	0	0	224	35	0	0	0	0	0	259
Mangrove open	1	0	0	1	0	0	4	0	0	1	222	0	6	0	0	3	237
Woodland on temporarily flooded land	11	5	25	31	0	11	6	10	3	0	0	109	2	5	0	0	218
Aquatic grasslands	0	0	0	2	0	0	25	1	5	0	1	4	295	0	0	0	333
Built-up areas	17	42	6	0	0	0	0	0	0	0	0	0	0	148	8	0	221
Bare areas	9	5	10	0	0	0	0	0	4	0	0	3	0	22	185	3	241
Natural water bodies	0	0	0	1	0	0	4	0	0	0	0	3	2	0	0	197	207
TOTAL	333	522	342	360	171	225	180	190	243	225	261	171	324	261	198	207	4221

Global accuracy 70%:

complete provincial legend & 1 mosaic & NFI 2007 GT



MRV Activities

Component 3
Reference Emissions Level/ Reference Levels (REL/RL)

1,700,000 USD

3.2. Development of historic land cover change maps 3.5. Development of FREL/FRL	
Aim	To conduct the historical LULC change analysis to calculate the average emissions during the reference period (FREL)
Ongoing	Supervised classification over a multitemporal landsat mosaic (2001-2016). Using Collect Earth tool (FAO free available tool) and all the High/Medium Resolution Imagery free available in the web (Google Earth -Digital Globe and SPOT-, Bing and Here maps), to visually assess the forest change category and establish a training dataset. This training data will be plugged into a supervised classification routine to perform forest/non - forest change detection within the Google Earth Engine API.
Justification	Only reliable statistics and a map of LULC changes is needed (adjustment to 2016 LULC Map). Tools, Historical High and Medium resolution imagery are free available.
Who	New MRV Unit, as a 'learning-by doing' activity, whereby national experts will be trained and supervised by the MRV specialist.
Timeframe	Q1 2017 National approach. First Version R-Package
Budget FCPF CF	150.000 USD (historical analysis) + 140.000 USD (FREL)

MRV Activities

Component 3
Reference Emissions Level/ Reference Levels (REL/RL)

1,700,000 USD

3.2. Development of historic land cover change maps 3.5. Development of FREL/FRL	
Aim	To conduct the historical LULC change analysis to calculate the average emissions during the reference period (FREL)

	Timeframe											
	2016				2017				2018			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Hist. LULC Maps JICA					LULC M FREL 2P			LULC M 4P	FREL 4P		LULC M 4P	FREL 4P
Multitemporal Mosaic MRV-Unit		T1	T2	T3 G	T4 M FREL	**Comparison exercise**						

(i) A 'learning by doing' training activity will be developed (T1, T2, T3, T4): T1 (June) - FAO-Univ. Sapienza Collect Earth training; T2(Sept) – Int. (DIRF) Collect Earth Forms AD-GT; T3(Nov) – GMV- ENVI & Sentinel
(ii) Grid sampling points for deforestation, forest gain and forest degradation (first test) will be prepared and allocated (G); (iii) Supervised classification over a multitemporal landsat mosaic (eg. 2005-2010, 2010-2012) and refinement (iv) Provisional maps of forest change detection; (v) Validation and refinement; (vi) Maps of forest change detection and statistics (M); (vii) FREL calculation

MRV Activities

Component 3
Reference Emissions Level/ Reference Levels (REL/RL)

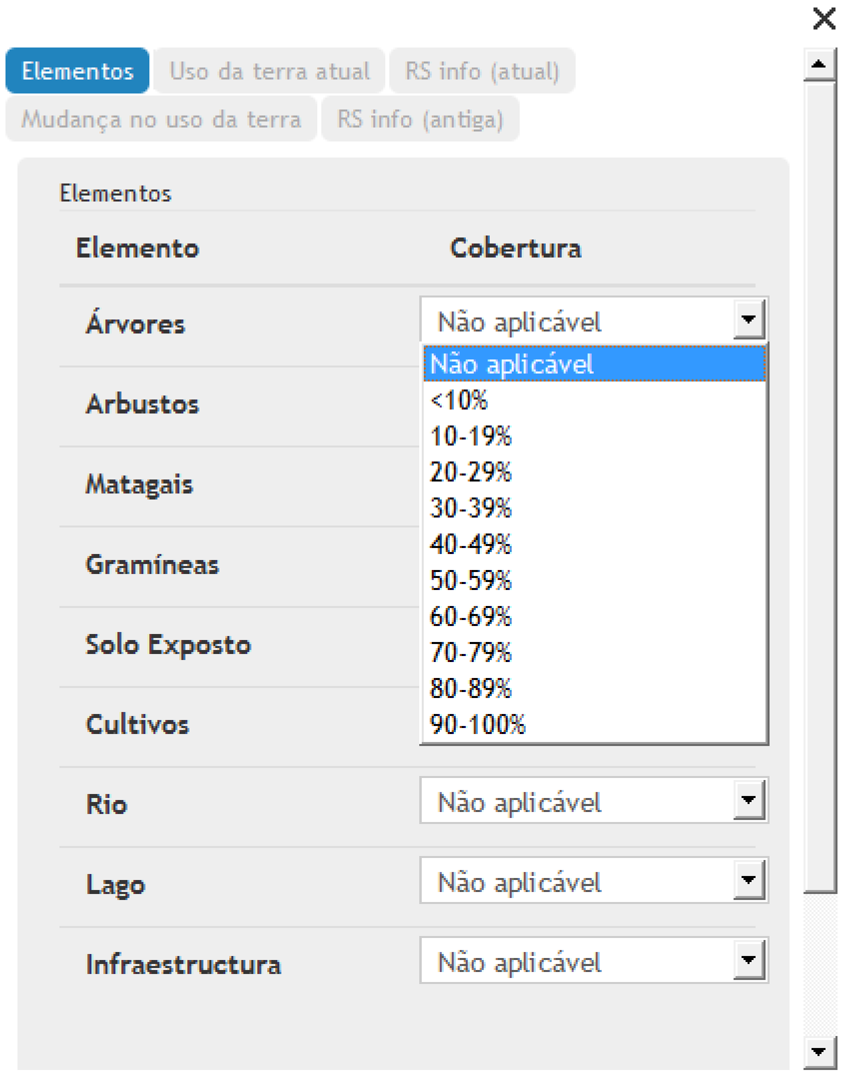
1,700,000 USD

3.2. Development of historic land cover change maps **3.5. Development of FREL/FRL**	
Aim	To conduct the historical LULC change analysis to calculate the average emissions during the reference period (FREL)

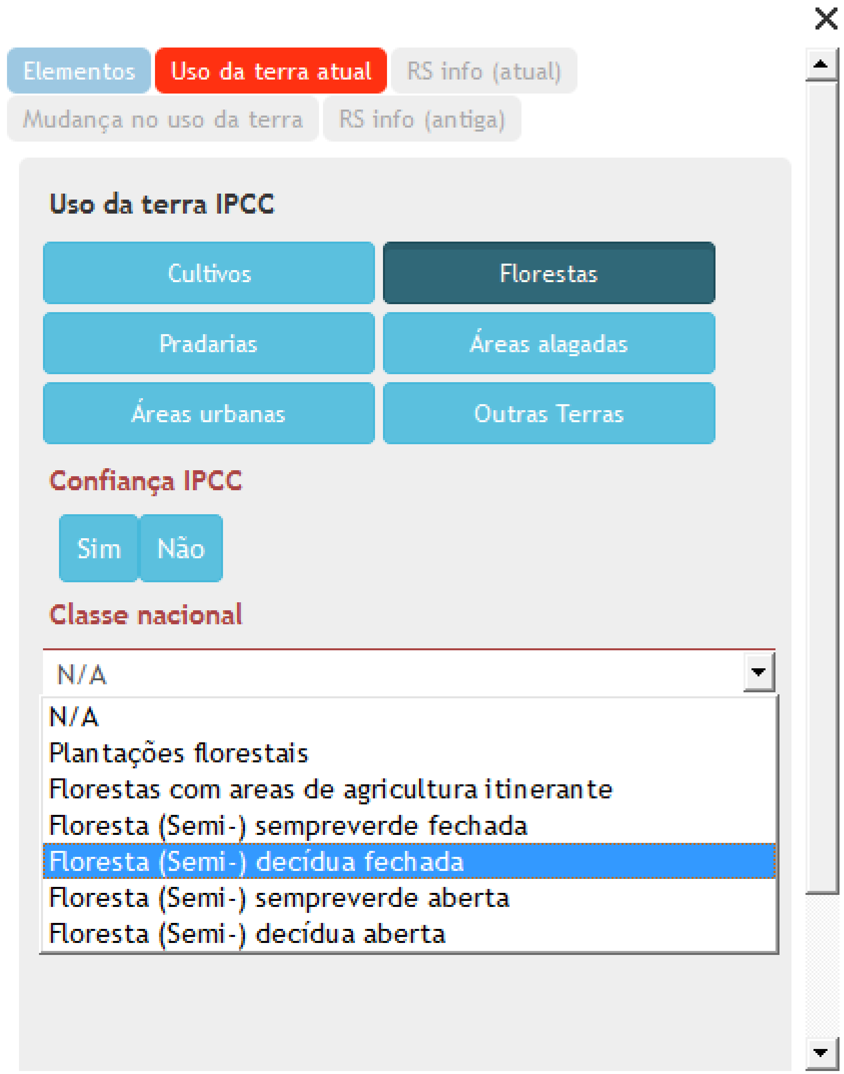
Geração duma base de dados de atividade (LULC changes) sobre a grelha nacional de 4 x 4 km baseada em interpretação visual de imagens de alta e média resolução espacial

Project outputs (01/10/16-28/02/17)

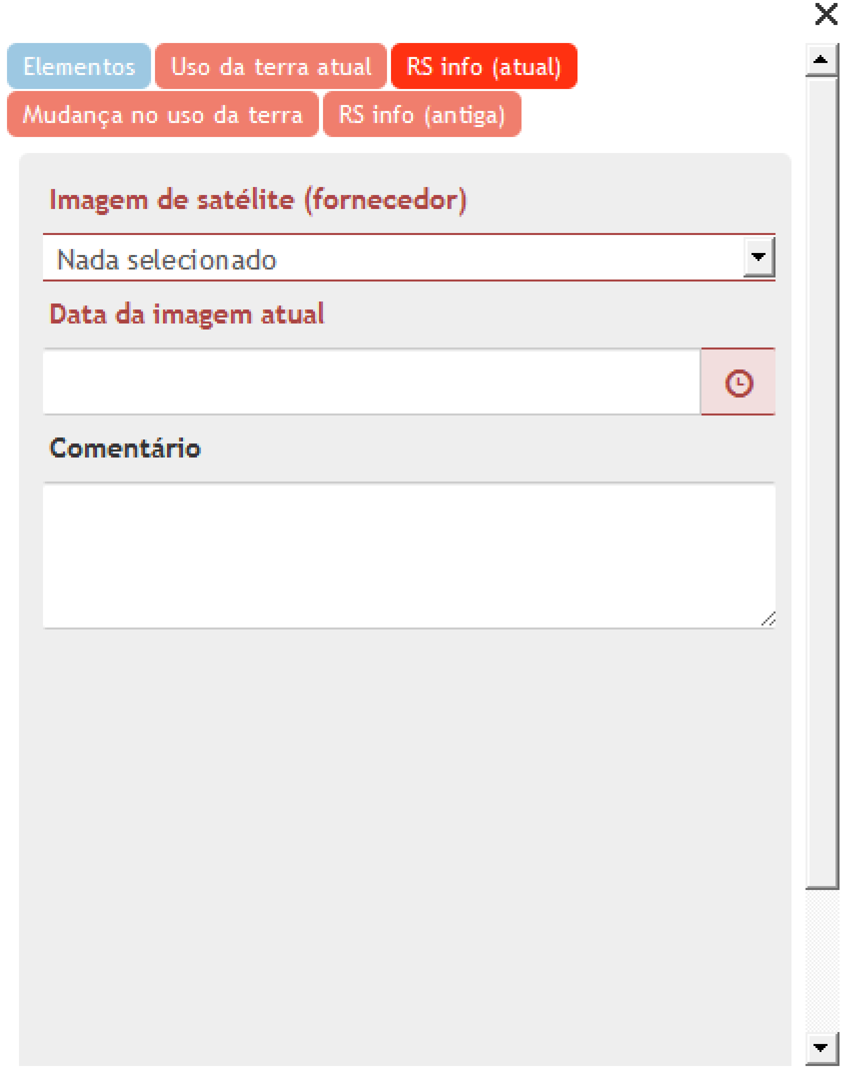
1. 2016 LULC (4 x 4 km) training dataset for the 2016 LULC Sentinel2 supervised classification.
2. 2001-2016 LULC changes dataset (4 x 4 km): deforestation data set, forest degradation data set, forest gain data set.
3. 2001-2016 LULC changes Map (deforestation, forest degradation and forest gain).
4. Report with methodological approach and results.
5. Preparation of a first version of the national FREL/FRL (R-Package and UNFCCC).



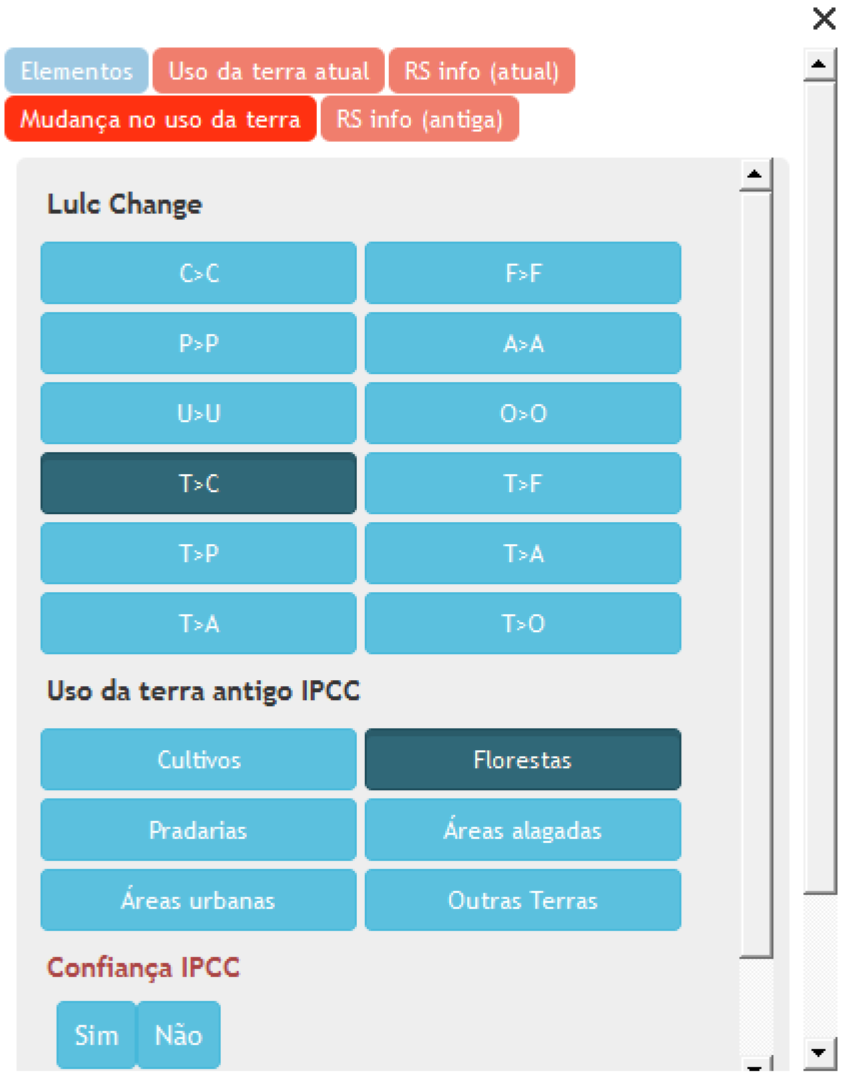
Elements coverage (5 x 5 grid 1 ha)



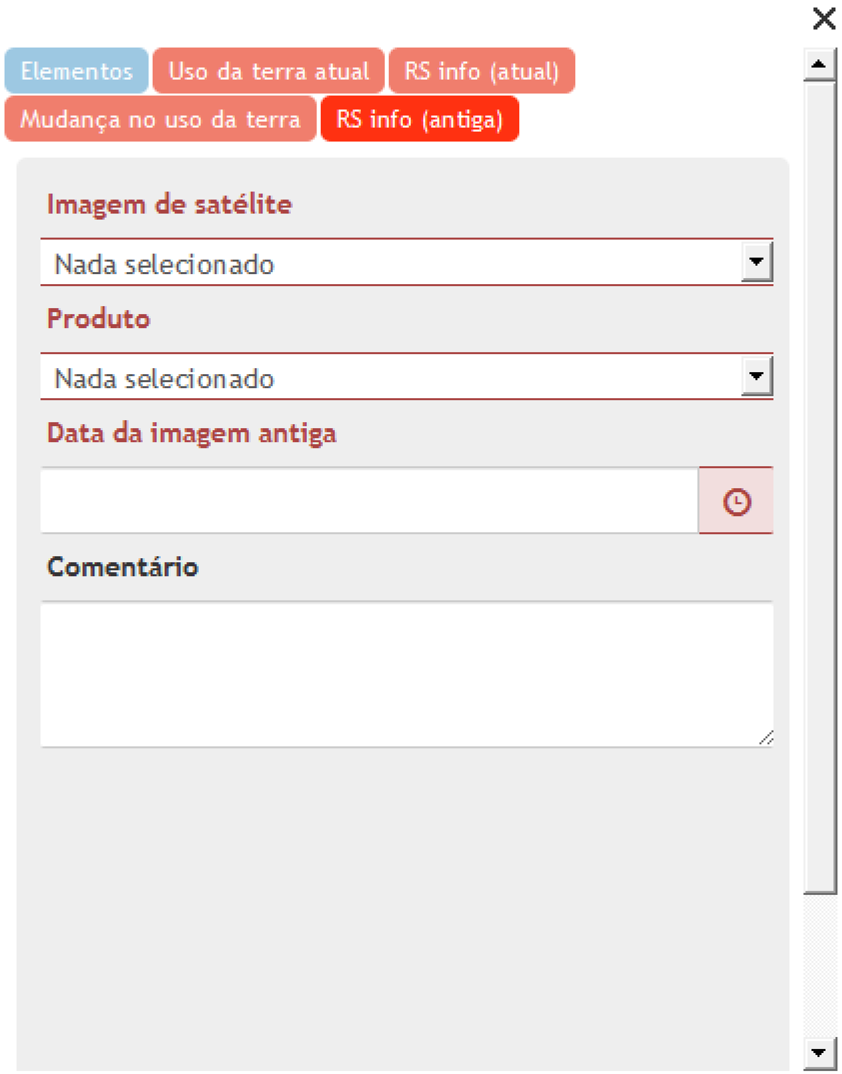
Current LULC: IPCC/National (class/subclass)



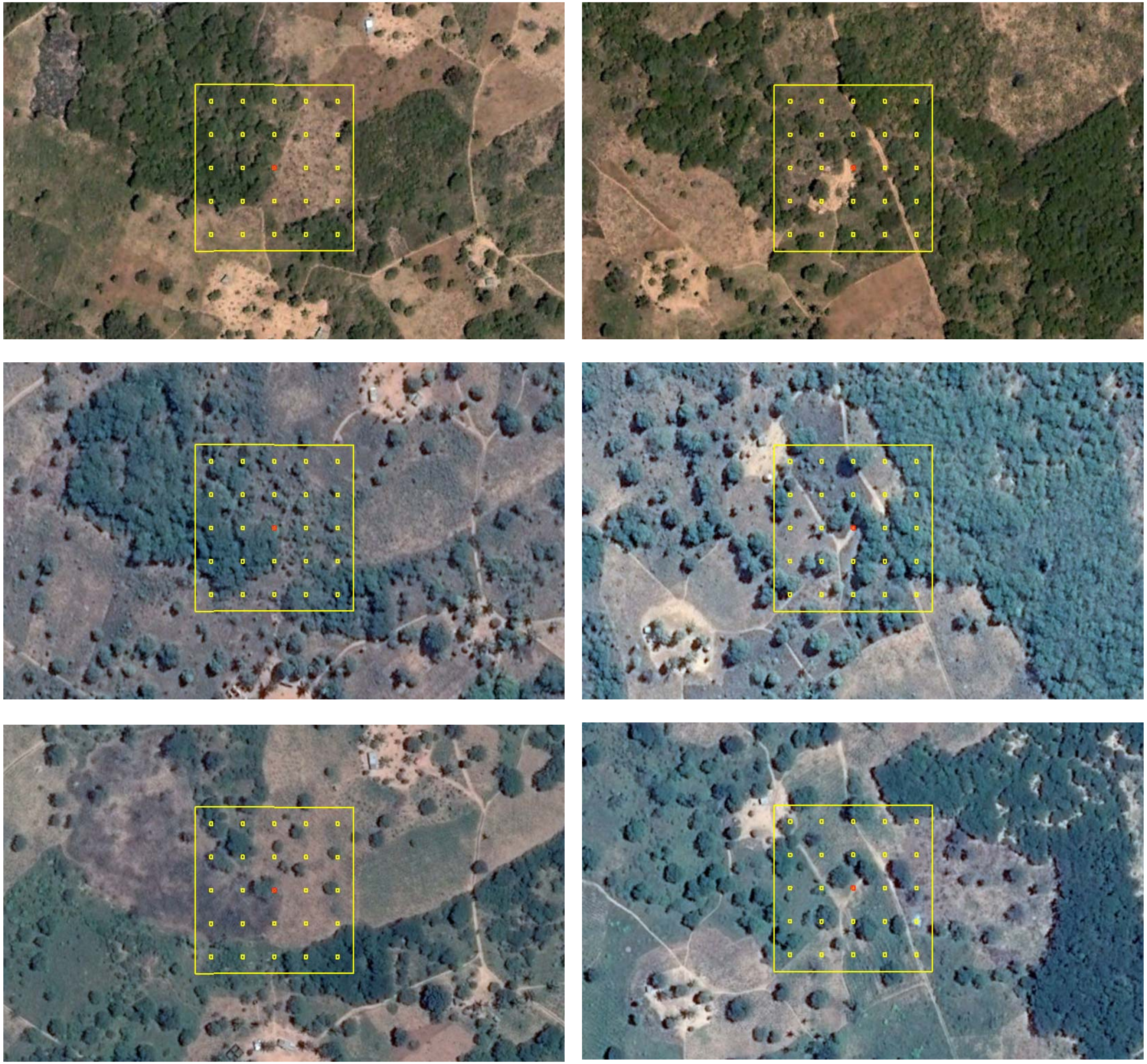
Current RS Image Info: provider/date



LULC change info: IPCC class, prior LULC IPCC class, prior LULC national (class/subclass)



Prior RS Image Info: product/date



Google Earth Pro Historical Imagery

Bing maps

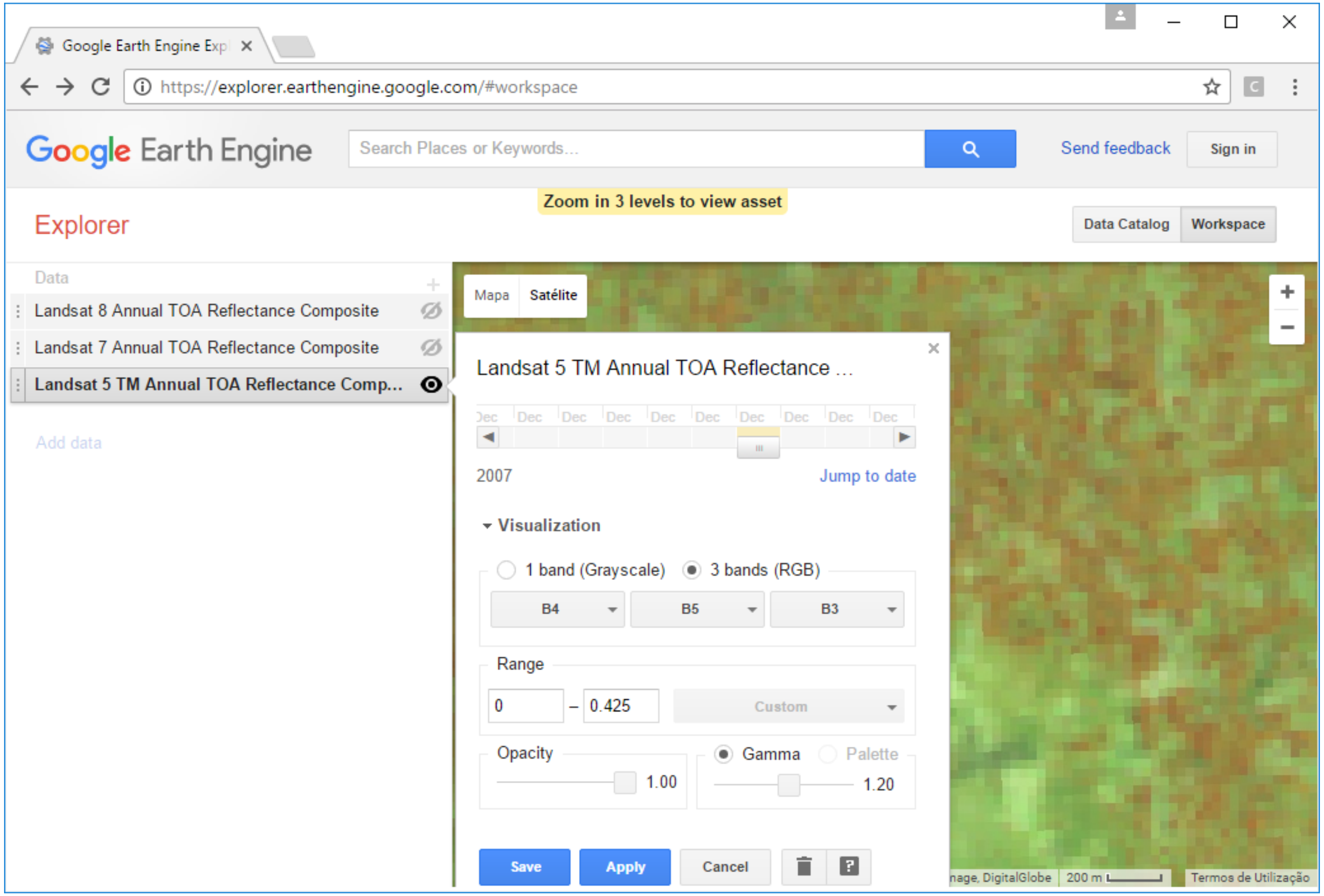
17/12/2005

27/07/2013

12/02/2016

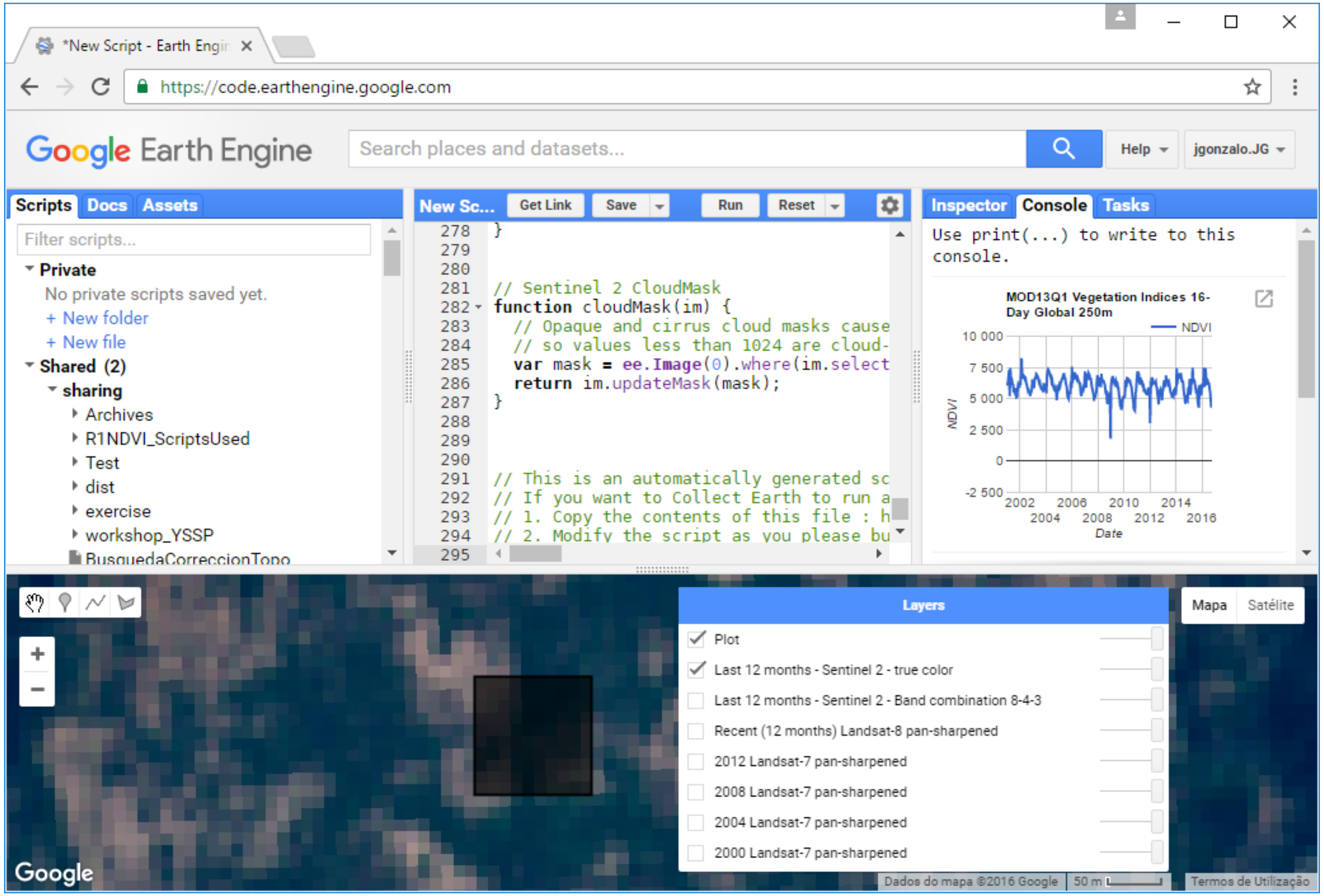
Google Earth Engine

Historical Imagery and Products



Google Earth Engine Code

NDVI series
Sentinel2
Landsat8
....



MRV Activities

Component 3
Reference Emissions Level/ Reference Levels (REL/RL)

1,700,000 USD

3.3. Design and implementation of the national forest inventory	
Aim	To conduct a NFI that meets REDD+ requirements and collect complete information on forests
Ongoing	DINAF – DIRF in col. with MRV Unit (FNDS) (and IIAM, Serviços Provinciais de Florestas e Fauna Bravia, UEM) is implementing the NFI using FCPF CF additional funds with a national design approach (7 strata / 620 clusters (x4 plots) + 10% add + 10% QA/QC)
Justification	A national level inventory is required. Estimates (vars and errors) valid at national stratum level. Relevant information for forest sector and REDD+ Program. Sustainability of the NFI updating process: NFI (low sampling intensity: updating process 10 years) + permanent plots: 2-3 (5) years (36+60=96)
Who	DINAF-DIRF / MRV Unit (FNDS) (in col. IIAM, Serviços Provinciais de Florestas e Fauna Bravia, UEM).
Timeframe	National approach. 8 provinces: Q4-2017
Budget FCPF CF	960.000 USD (8 provinces)

MRV Activities

Component 3
Reference Emissions Level/ Reference Levels (REL/RL)

1,700,000 USD

3.3. Design and implementation of the national forest inventory	
Aim	To conduct a NFI that meets REDD+ requirements and collect complete information on forests

	Timeframe											
	2016				2017				2018			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Provincial design (JICA)				Gaza	Cabo Delga -do							Ou- tras
National design	D		Maputo Nampu- la	Inham- bane		Niassa Zambe -zia ?	Mani -ca Tete Sofa- la ?					

WB Draft report

(i) NFI Design: DINAF: MRV Unit e col. DIRF: ToRs, Diretrizes
(ii) NFI Implementation: DINAF: MRV Unit/DIRF/SPFFB/IIAM/UEM

MRV Activities

Component 3
Reference Emissions Level/ Reference Levels (REL/RL)

1,700,000 USD

3.3. Design and implementation of the national forest inventory	
Aim	To conduct a NFI that meets REDD+ requirements and collect complete information on forests

Project outputs (23/03/16-01/07/16-21/11/16-31/12/17)

1. NFI Design Document - ToRs
2. NFI Guidelines
3. NFI Databases (row and processed) province by province: Maputo and Nampula (01/10/16), Inhambane (31/12/16), Niassa, Zambézia, Tete, Sofala, Manica (31/12/2017)
4. Interim Report (Maputo and Nampula 21/11/16) with methodological approach and results.
5. NFI Reports (methodological approach and results), Database, Maps.
6. National EFs by Stratum and LULC change.

ToRs

Diretrizes IFN

MRV Activities

Component 3
Reference Emissions Level/ Reference Levels (REL/RL)

1,700,000 USD

3.4. Improved tools and methodologies for estimating carbon pools	
Aim	Support new research activities and collaborations to improve biomass estimates and Identify potential technologies to detect forest degradation
Ongoing	After a compilation database of existing EFs and tools for biomass calculation in Mozambique and an assessment analysis to detect gaps, we have prepared jointly with IIAM a plan to complete the National Net of Permanent Plots
Justification	To design and implement a network of permanent plots to allow REDD+ MRV system periodic reports (EFs updated): expand the national network of permanent plots (IIAM) to complete the representation in all types of forests. Need of models and methods to improve biomass estimates and forest degradation detection. Strength national research capabilities.
Who	IIAM / MRV Unit
Timeframe	01/01/2017-31/12/2018
Budget FCPF CF	250.000 USD

MRV Activities

Component 3
Reference Emissions Level/ Reference Levels (REL/RL)

1,700,000 USD

3.4. Improved tools and methodologies for estimating carbon pools	
Aim	Support new research activities and collaborations to improve biomass estimates and Identify potential technologies to detect forest degradation

Timeframe											
2016				2017				2018			
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
			Efs Eqs DB /R	ToR Dz				ToR Dz	S	S	R

EFs Database (i) Preliminary assessment document on gaps in available tools and methodologies to estimate carbon pools and to detect forest degradation (R); (ii) Elaboration of ToRs for the design and implementation of a permanent plot net in Mozambique (ToR), (iv) Elaboration of the Guidelines to collect Forest Information at the National Net of PP (Dz), (v) Plot Survey (S), (vi) Reporting (R)

MRV Activities

Component 3
Reference Emissions Level/ Reference Levels (REL/RL)

1,700,000 USD

3.4. Improved tools and methodologies for estimating carbon pools	
Aim	Support new research activities and collaborations to improve biomass estimates and Identify potential technologies to detect forest degradation

Project outputs (01/01/17-31/12/18)

1. PP Design Document - ToRs
2. PP Guidelines
3. PP Databases (row and processed)
4. PP Reports (methodological approach and results), Database, Maps.
5. National EFs by Vegetation Type and LULC change.

Projecto Parcelas Permanentes

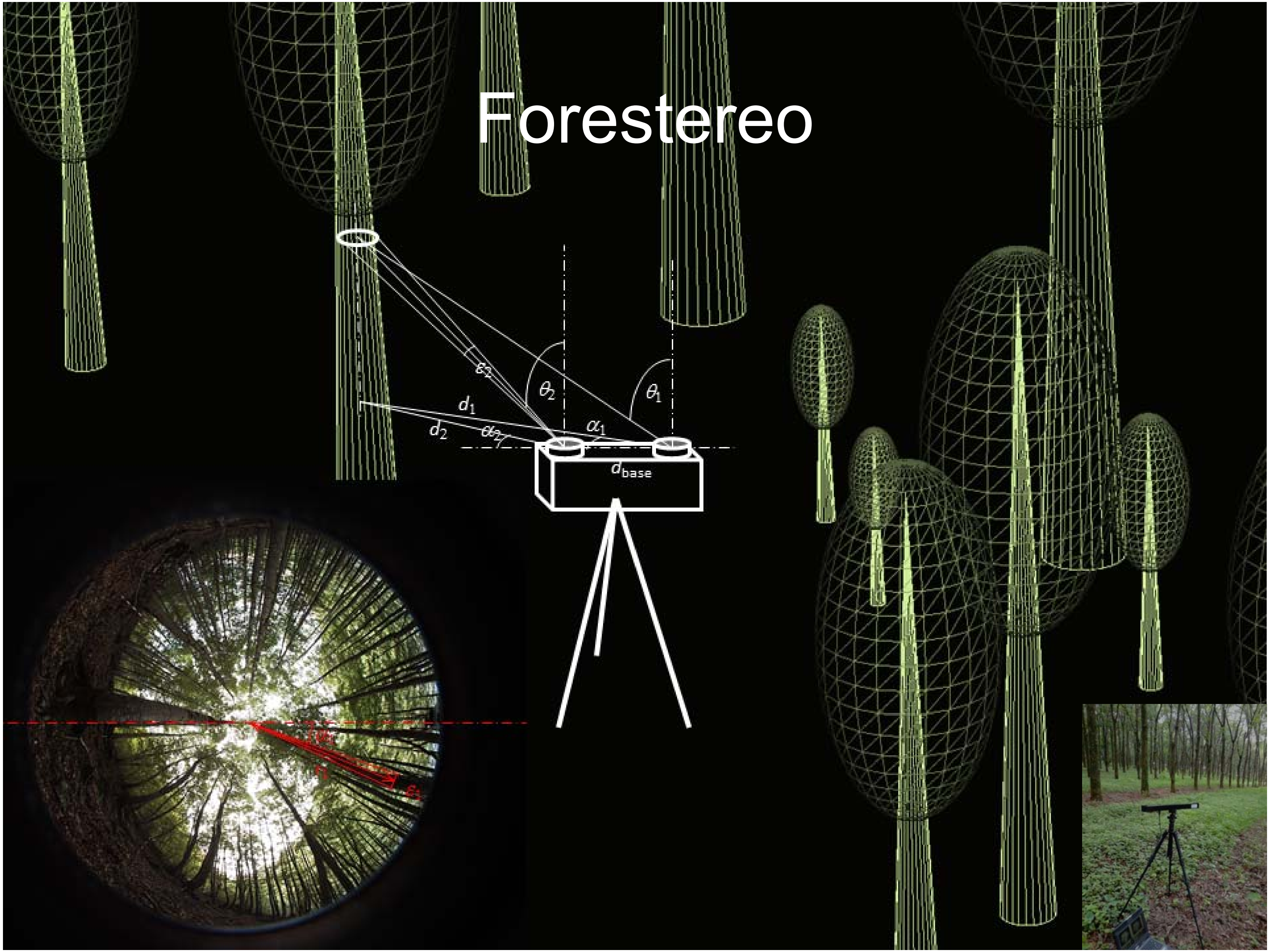
Representatividade de parcelas permanentes nos ecossistemas florestais em Moçambique

Tipos florestais	Variáveis existentes	Variáveis adicionais	Ppermanentes existentes	Ppermanentes adicionais no âmbito do MRV
Floresta sempre verde	DAP, Ht, Hcomercial, qualidade, sanidade e altitude	A. solo, M. orgânica e Biomassa	5	10
Floresta sempre verde de montanha	DAP, Ht, Hcomercial, qualidade, sanidade e altitude	A. solo, M. orgânica e Biomassa	0	12
Floresta semi decidua	DAP, Ht, Hcomercial, qualidade, sanidade e altitude	A. solo, M. orgânica e Biomassa	0	12
Miombo	DAP, Ht, Hcomercial, qualidade, sanidade e altitude	A. solo, M. orgânica e Biomassa	19	3
Mopane	DAP, Ht, Hcomercial, qualidade, sanidade e altitude	A. solo, M. orgânica e Biomassa	9	6
Mecrusse	DAP, Ht, Hcomercial, qualidade, sanidade e altitude	A. solo, M. orgânica e Biomassa	3	7

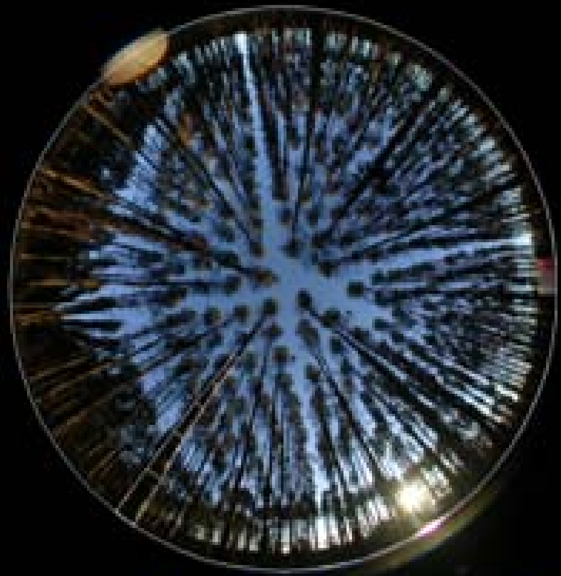
Representatividade de parcelas permanentes nos ecossistemas florestais em Moçambique

Tipos florestais	Variáveis existentes	Variáveis adicionais	Ppermanentes existentes	Ppermanentes adicionais no âmbito do MRV
Mangal	DAP, Ht, Hcomercial, qualidade, sanidade e altitude	A. solo, M. orgânica e Biomassa	0	10
Galeria	DAP, Ht, Hcomercial, qualidade, sanidade e altitude	A. solo, M. orgânica e Biomassa	0	0
Savana	DAP, Ht, Hcomercial, qualidade, sanidade e altitude	A. solo, M. orgânica e Biomassa	0	0
Total			**36**	**60**
Grande total				**96**

Forestereo



Estimativa do volume

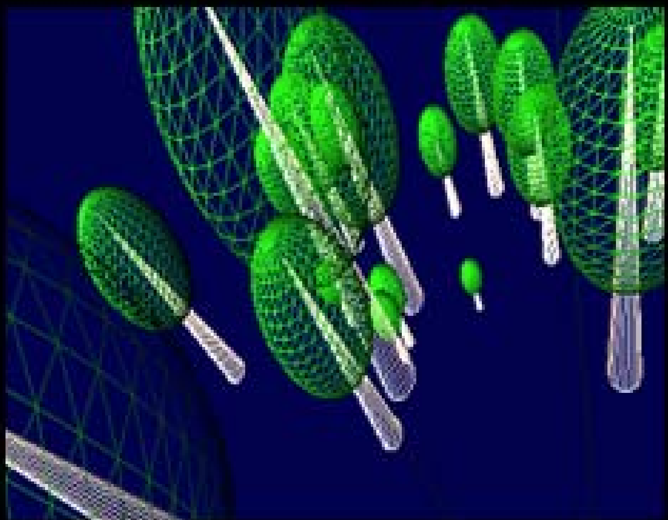


Correspondência

Distância, direção, diâmetro, altura

Equações de perfil

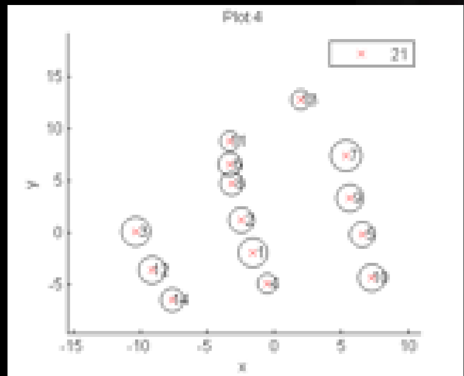
Variáveis de árvores: Posição, DAP, o volume

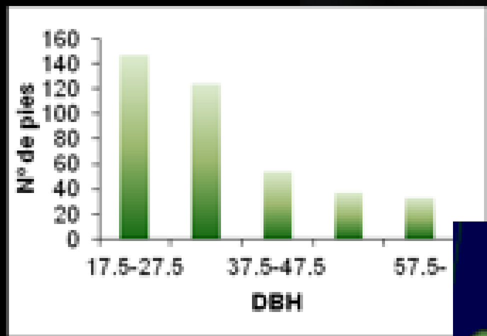


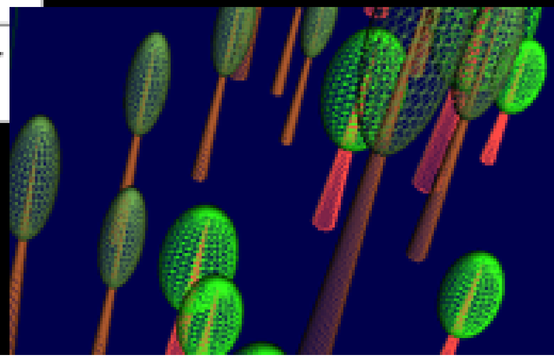
Probabilidade de seleção

Variáveis de floresta: área basal, N, distribuição de diâmetros

Índices de estrutura

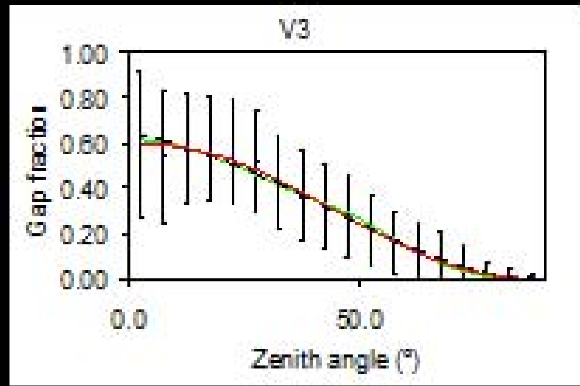


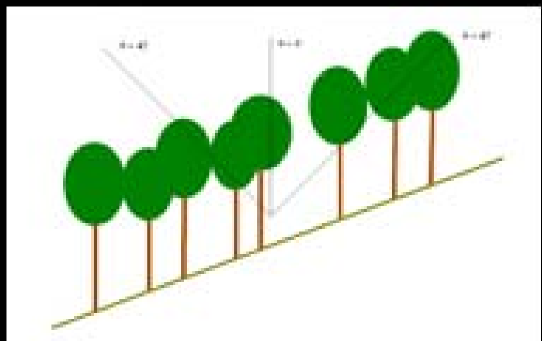


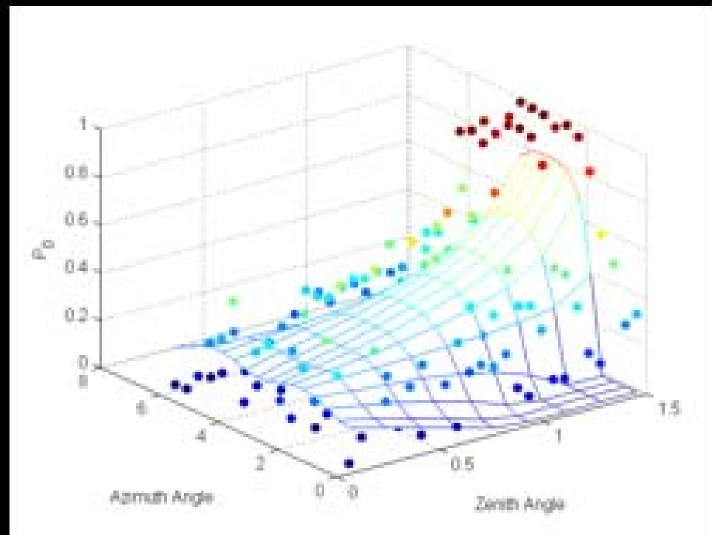


- Distribuição espacial
- Diferenciação
- Mistura de espécies

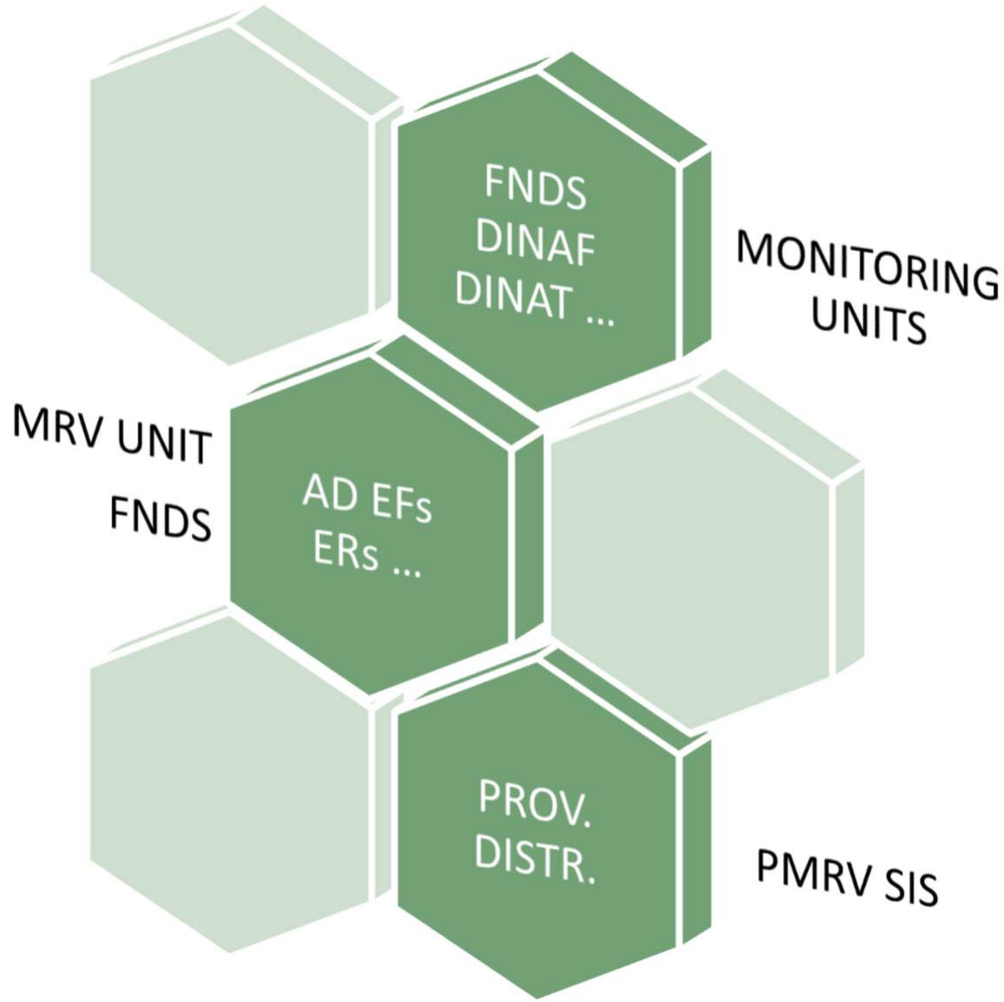
Estimativa do LAI







Component 4 Monitoring Systems Scheme



MRV Activities

Component 4
Monitoring Systems for Forests

800,000 USD

4.1. Preparation of MRV	
Aim	Design and implementation of a complete PMRV system for the country.
Ongoing	Considering four levels of implementation: (i) National Level with an operational remote-sensing/GIS forest/land-use monitoring unit (MRV Unit FNDS), (ii) Provincial Level (iii) District Level and (iv) Community Level. It will be elaborated a Review of International/National MRV/SIS Practices, Designed the community based MRV/SIS system, Developed an operational manual for MRV/SIS tasks. It will be conducted a training of trainers on the designed system and tested its applicability on field in selected communities of 15 districts of Zambezia and Cabo Delgado (ERs Programmes).
Justification	MRV Tasks, Forest Monitoring and management, SIS Tasks, other opportunities.
Who	MRV Unit, Safeguards specialist, P&P…
Timeframe	Q4 2018
Budget FCPF CF	500.000 USD

MRV Activities

Component 4
Monitoring Systems for Forests

800,000 USD

4.1. Preparation of MRV

Aim	Design and implementation of a complete PMRV system for the country.

Timeframe											
2016				2017				2018			
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	H1 R5	R6	R1,R2, R3	H2 R7	R4 P1 T1	P1	R8				

(i) Needs assessment for training and capacity building on MRV (R1), (ii) Assess existing data storage and management systems relevant for MRV (R2) and design and implement management solutions for key elements of the MRV system (R3), (iii) Develop a data sharing policy for internal and external usage (R4), (iv) Technical Staff Recruitment for the MRV Unit under UT-REDD (H1), (v) Procurement of IT expertise to provide system management and IT (H2), Review of International/National MRV Practices (R5), Design the community based MRV system (R6), Develop an operational manual for MRV tasks (R7), Conduct training of trainers on the developed MRV system (T1) and Support testing of the applicability of the local MRV system on field level in selected communities of 15 districts of Zambezia and Cabo Delgado (ERs Programmes) (P1, R8).

MRV Activities

Component 4
Monitoring Systems for Forests

800,000 USD

Int_Nat PMRV practices

Draft PMRV System

4.1. Preparation of MRV	
Aim	Design and implementation of a complete PMRV system for the country.

Project outputs (01/01/17-31/12/18)

1. Design reports: Needs assessment for training and capacity building on MRV, Assess existing data storage and management systems relevant for MRV, design and implement management solutions for key elements of the MRV system, Develop a data sharing policy for internal and external usage.
2. Technical Staff Recruitment for the MRV Unit: 4 qualified specialists.
3. Recruitment of an IT expert (specialist in database management) to provide system management and IT maintenance: FIP.
4. Guidelines: Review of International/National MRV Practices, Design the community based MRV system, Operational manual for MRV tasks.
5. Training of trainers on the developed MRV system.
6. Reporting the test. Results, discussion, conclusions and feedback.

MRV Activities

Component 4
Monitoring Systems for Forests

800,000 USD

4.2. Acquisition of equipment and others	
Aim	Support the purchase of all furniture, material and equipment necessary to prepare the REL and the MRV system
Ongoing	This activity would support the purchase of all furniture, material and equipment necessary to prepare the MRV Unit . Basically: 4 workstations, 1 GIS Server, 1 DB Server, GIS and RS software for these 6 computers, 1 printer, 1 plotter, wireless net, 6 desks, 6 chairs.
Justification	Operational MRV Unit to launch the system
Who	UT-REDD+
Timeframe	Q4 2016
Budget FCPF CF	300.000 USD

MRV Activities

Component 4
Monitoring Systems for Forests

800,000 USD

4.2. Acquisition of equipment and others	
Aim	Support the purchase of all furniture, material and equipment necessary to prepare the REL and the MRV system

Timeframe											
2016				2017				2018			
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	R1		P1								

(i) Needs assessment for the MRV Unit under UT-REDD (procurement plan, R1), (ii) Purchase all equipments and furniture included in the procurement plan (P1). It is very urgent to design and implement this activity for the proper operation of the MRV Unit and the performance of all tasks. It should also cover the maintenance costs for the equipment, software, and furniture; that's why the timeframe covers all project implementation period.

MRV Activities

Component 4
Monitoring Systems for Forests

800,000 USD

4.2. Acquisition of equipment and others	
Aim	Support the purchase of all furniture, material and equipment necessary to prepare the REL and the MRV system

Project outputs (01/04/16-31/12/16)

1. MRV Unit – Procurement Plan.
2. MRV Unit operational (service provider to FNDS, DINAF,…) at FNDS.
3. MRV information & services site (MRV Blog).

ToRs
Procurement MMRV

MRV Activities

Component 4
Monitoring Systems for Forests

800,000 USD

Geospatial information architecture in three levels: Integrated Web GIS Platform:

- **DATA:** Geographic Database in which geospatial data is stored; **Database, Online content and services, Server extensions.**

- **ACCESS AND SERVICES:** Geospatial Server, where GIS services (mapping, analysis, data management) are created and where the web site (MRV web site) will be hosted; **Portal.**

- **APPS:** Tools for creating maps, templates and administration, together with customers' desktop applications, web and mobile devices, including additional modules required for the project: **Desktop apps (GIS & RS), Web, Devices.**

MRV Activities

Component 4
Monitoring Systems for Forests

800,000 USD

Architecture Components:

- **GIS Server**: should provide the client with the GIS capacity in a service-based architecture. It will be possible to deploy geospatial data and features, images, geoprocessing models, through web services that can be shared throughout MITADER or the Web.

- **DB Server**: the platform will provide the necessary tools to storage effectively and efficiently geographic information in centralized repositories accessible by GIS professionals and other users through services. Database Management System of (e.g.) PostgreSQL.

- **Portal Web**: It is a collaborative platform based on the cloud that will allow MITADER members to create, share and access maps, applications and data…

MRV Activities

Component 4
Monitoring Systems for Forests

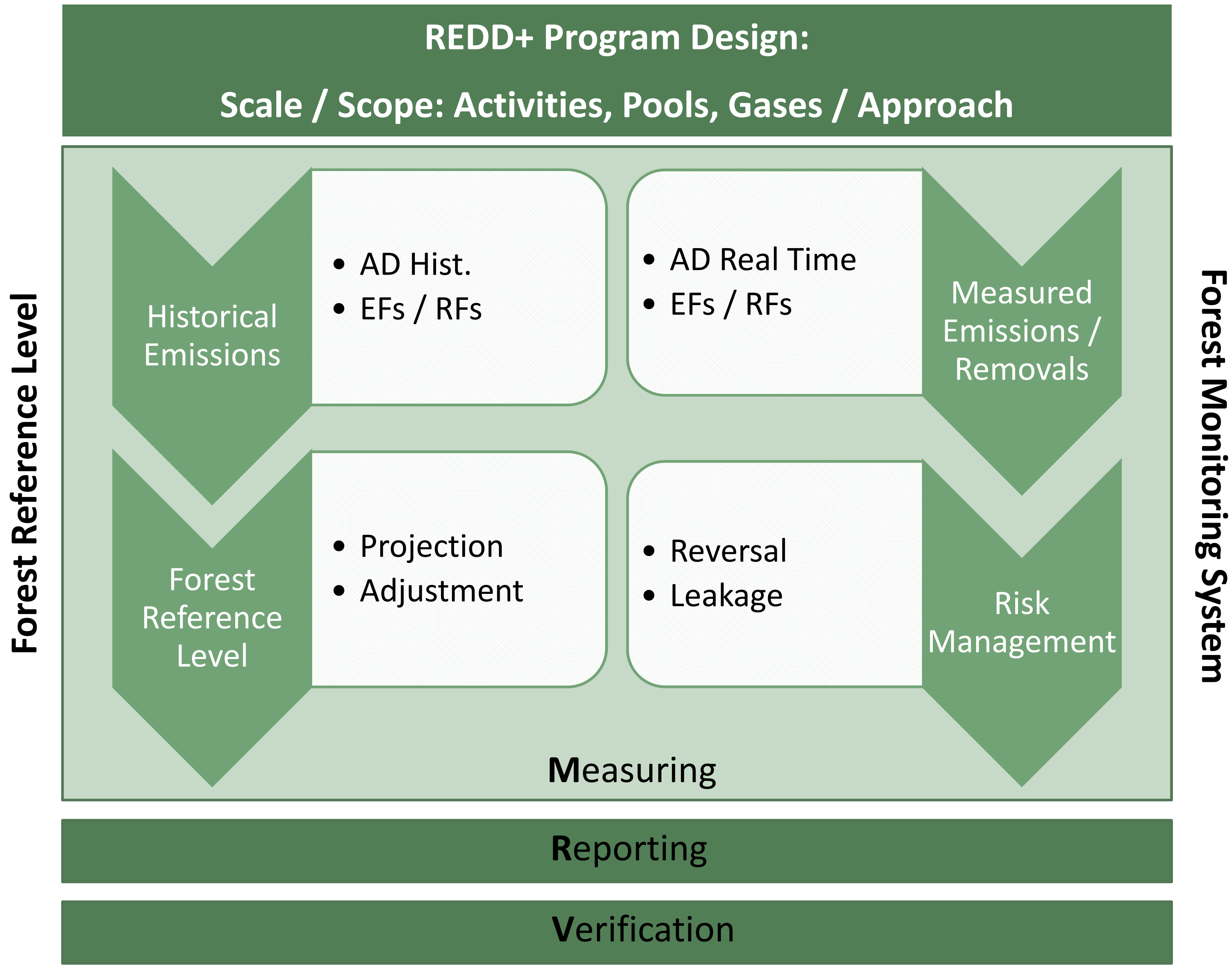
800,000 USD

Architecture Components:

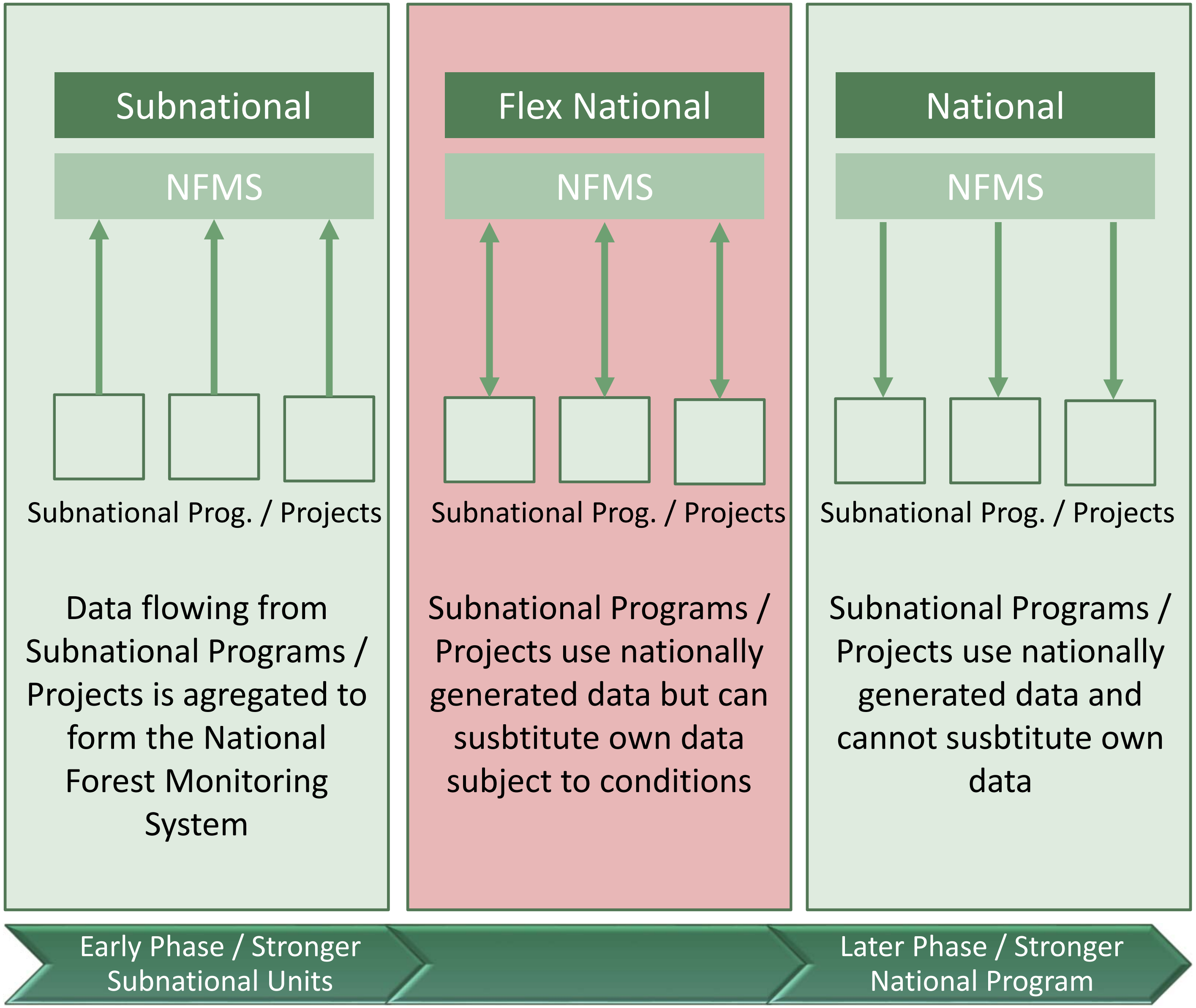
- **Desktop GIS**: This level platform will provide MITADER with the tools needed by GIS professionals to create, edit, manage and analyze geographic information within their own environment.

- **Desktop for image processing**: this level platform will include the tools that provide expert-level results in analysis and image processing.

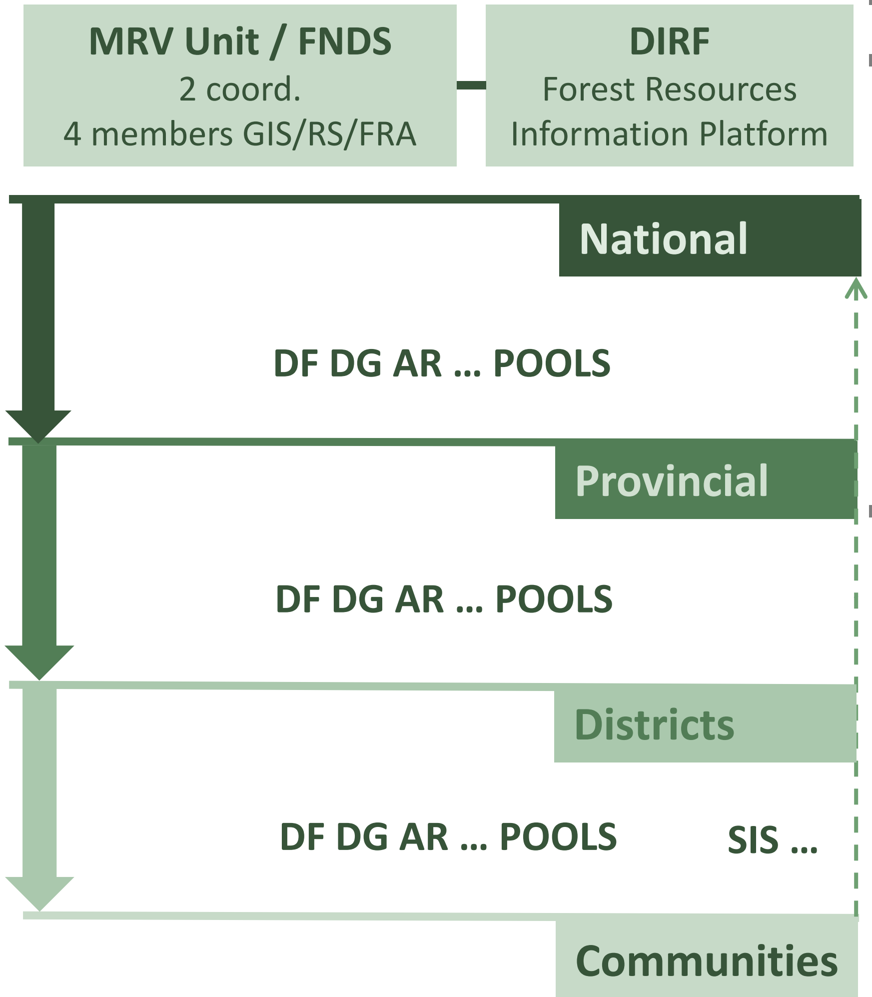
Overall accounting framework



Overall accounting framework



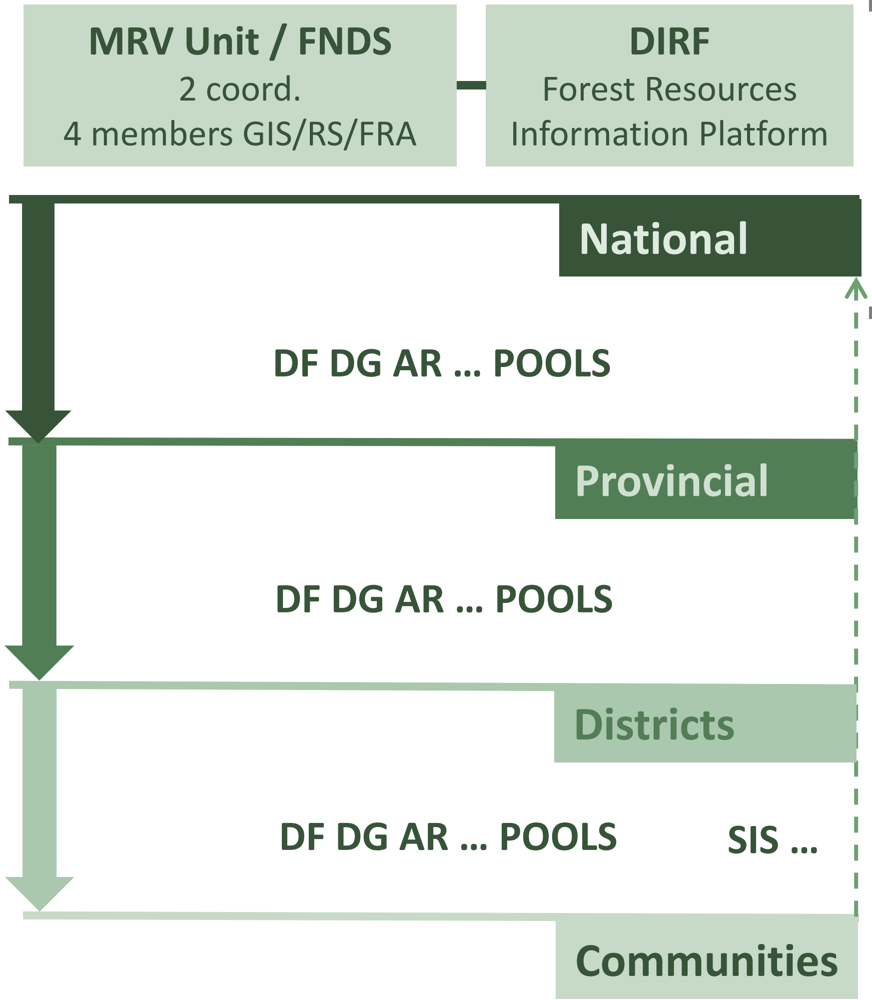
Overall accounting framework



- Basic principles of FREL/RL and MRV:
- **National Forest Definition**: MMU 1 ha, TH >5 m, CC 30%
- **Scale**:
  - **National** to **Provincial** to **… Community:** Flex National. Integration of ongoing or planned REDD+ projects/ programmes
  - **REDD+ Activities:** Deforestation, Forest degradation and Enhancement of forest carbon stocks (A/R).
  - **Pools:** AGB, BGB …SOC
- **Approach:**
  - Vegetation type strata. Historical **annual average** over a **15 year period (FCPF MF)**: continuous analysis (2001-2016).

Reference Period:
End date: the most recent date prior to **two years before the TAP starts the independent assessment of the draft ER Program Document and** for which forest-cover data is available to enable IPCC Approach 3. Exceptions allowed.
Start date: Is about 10 years before the end-date. Exceptions allowed but not more than 15 years.

Overall accounting framework



- Basic principles of FREL/RL and MRV:
- **Activity Data:** (/uncertainties)
  - **FREL/FRL: Statistical sampling analysis 2001-2016**

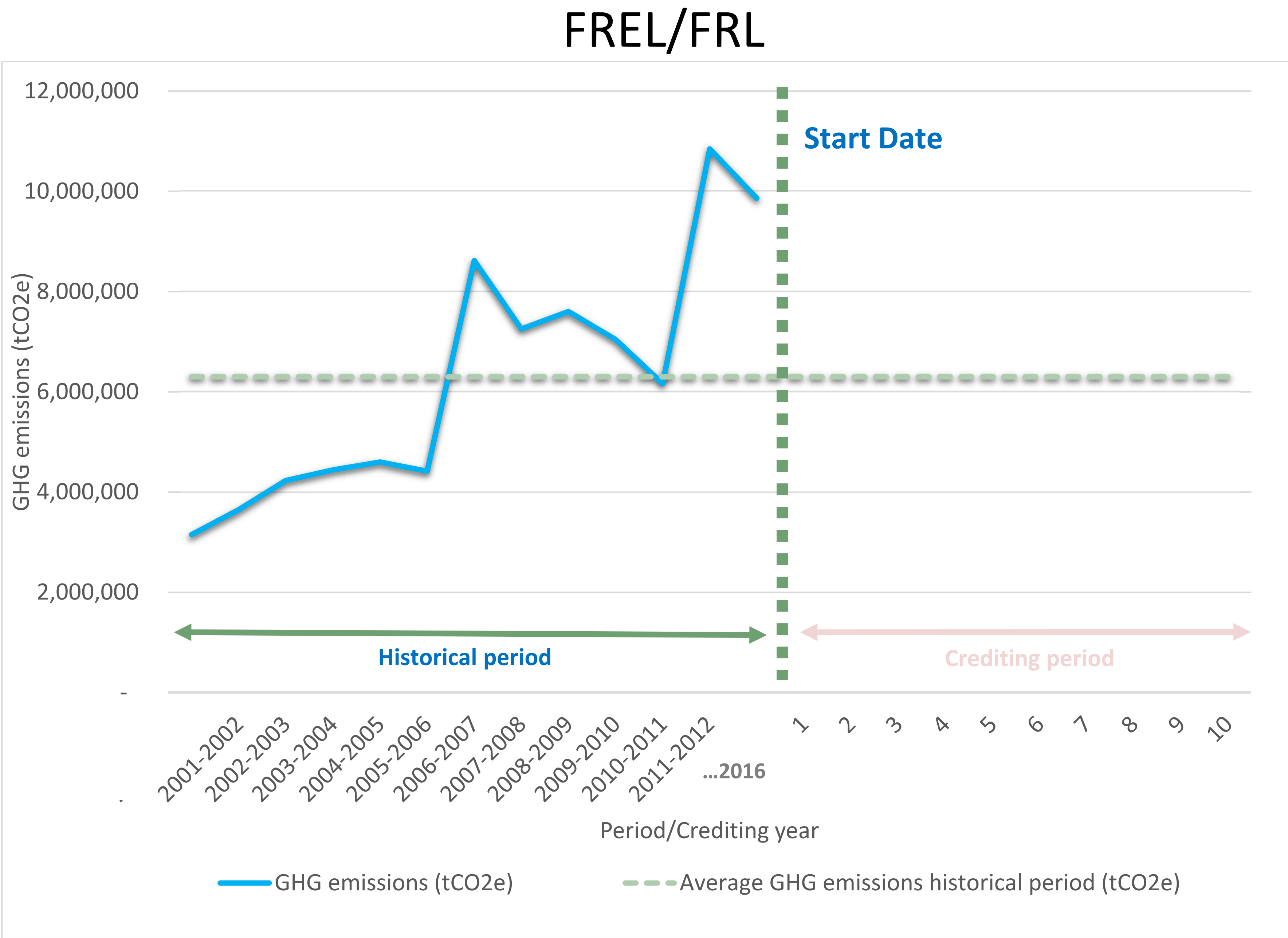
    Activity 3.2 /3.5
  - **MRV: Statistical sampling analysis every year**.
- **Emission Factors**: (/uncertainties)
  - Corresp. to changes in LULC all significant pool:

    IPCC Tier 2 (country specific data)

    IPCC Tier 3 (NFI **every 10 years**

    PP FI every **2 years**)

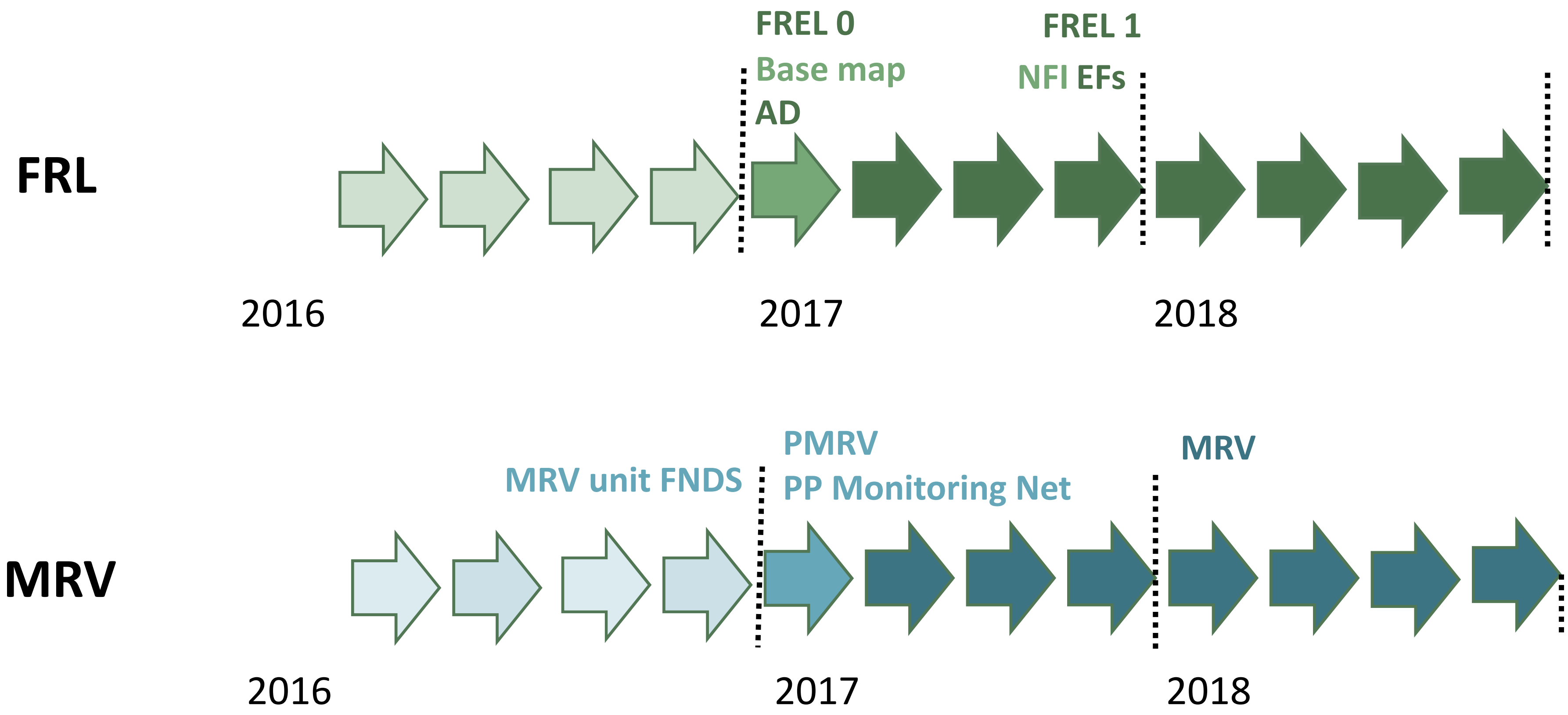
    Activity 3.3 /3.4



FREL/FRL
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
-
GHG emissions (tCO2e)
Start Date
Historical period
Crediting period
2001-2002
2002-2003
2003-2004
2004-2005
2005-2006
2006-2007
2007-2008
2008-2009
2009-2010
2010-2011
2011-2012
...2016
1
2
3
4
5
6
7
8
9
10
Period/Crediting year
GHG emissions (tCO2e)
Average GHG emissions historical period (tCO2e)

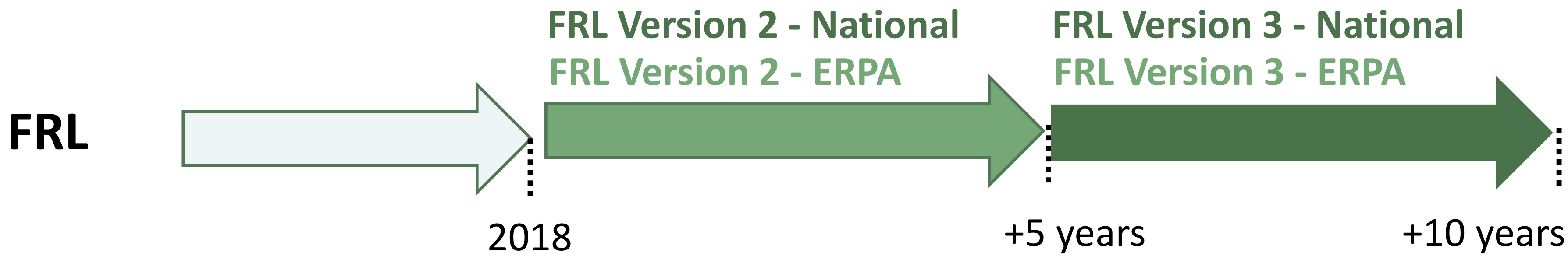
MRV Time frame

- Temporal dimension

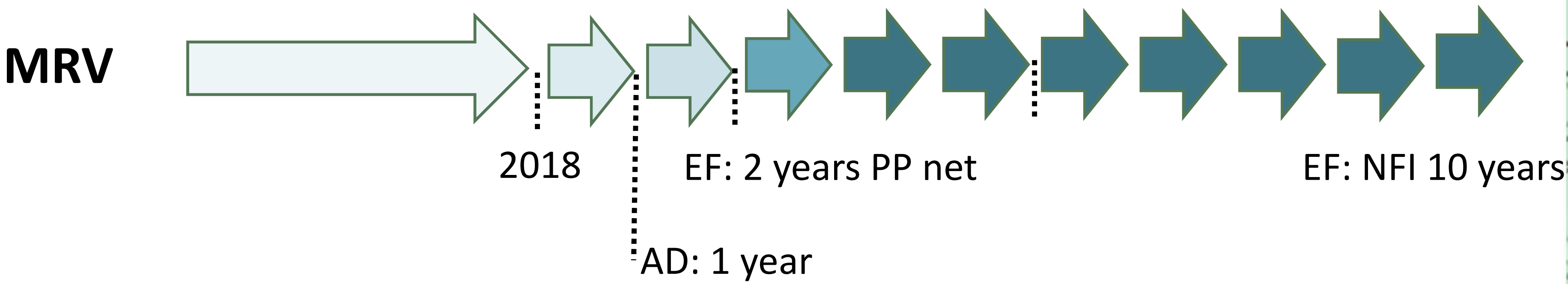


MRV Time frame

- Temporal dimension
  - RL updated every 5 years



  - MRV - AD updated every year
  - MRV - EFs updated every 2 years



Summary

Activities	Geographic coverage	Timeline completion	Budget	Technical Notes
Development of an updated national LULC base map: 2016 LULC (Sentinel-2)	Whole country	Q1 2017	200,000	• High Resolution (10m) • Free Available • NFMS Sustainability • ESA/WB proj. Forest Deg. in Tropical Dry Forests
Development of historic land cover change maps: Historical AD analysis Collect Earth + EE	Whole country	Q1 2017	150,000	• No historic LULC maps • Accurate change statistics (LULC changes map) • Can be compared with JICA products for Gaza and CD
Forest Inventory (National design)	National based inventory	Q4 2017	960,000	• National coverage but lower intensity: trusty estimations at national strata level (instead provincial level) • NFMS Sustainability
FREL/ FRL	Whole country	Q1 2017 FREL-1v Q4 2017	140,000	• National approach based on accurate change statistics by Vegetation Type to be applied to lower levels: provinces, programs…

Summary

Activities	Geographic coverage	Timeline completion	Budget	Technical Notes
Improved tools and methodologies for estimating carbon pools: EFs Database, PP Net (MRV)	Whole country in pre-identified vegetation types and areas	Q4 2018	250,000	• Complete gaps in biomass estimates and forest degradation detection tools and methods • Strengthen National Research Capability • Engage Research Institutions in REDD+ Process

Summary

Activities	Geographic coverage	Timeline completion	Budget	Technical Notes
Acquisition of equipment and others: procurement plan, purchase equipments and furniture.		Q4 2016	300,000	• 4 workstations and 1 GIS Server/DB, GIS and RS software for these 6 computers, 1 printer, 1 plotter, wireless net, 6 desks, 6 chairs.
Preparation of MRV: Design and implementation of a complete PMRV system for the country (i) National Level – MRV Unit (NFIS-DIRN) (ii) Provincial Level (iii) District Level and (iv) Community Level.	National Test: 15 districts of Zambezia and Cabo Delgado (ERs Programmes).	Q4 2018	500,000	• Review of International/National MRV/SIS Practices, • Design the community based MRV/SIS system, • Develope an operational manual for MRV/SIS tasks. • ToTs • Tested its applicability on field in selected communities of 15 districts of Zambezia and Cabo Delgado (ERs Programmes).

Annex 1. Generation of a mosaic based on sentinel-2a suitable for the LULC classification of Mozambique. MOZ-MOSAIC V 1.0

Annex 2. Designing and implementing an accuracy assessment of a change map and estimating area based on the reference sample data

Annex 3. National Forest Inventory Guidelines

Annex 4. M & MRV Unit Design