THE UNITED REPUBLIC OF TANZANIA

TANZANIA'S FOREST REFERENCE EMISSION LEVEL SUBMISSION TO THE UNFCCC

NOVEMBER 2017

SUMMARY

Approach	Historical average of emissions associated with gross-deforestation between the years 2002-2013
Scale	• National: As a sum of two sub-national FRELs: Main land Tanzania and Zanzibar covers 94.76 million ha • Reserved Area Strata covers 26,250,525 ha
Scope	• REDD+ activities: Deforestation • Carbon pools: Above-ground biomass, Below-ground biomass and Dead wood • Gases: CO_2
Data sets used for Activity data	Landsat 7 ETM+, Landsat 8 OLI; Landcover maps; Ortho-photographs; RapidEye
Emissions Factor (EF) **Tier**	Based on National Forest Inventory (NFI) (NAFORMA and ZWBS) Three (Based on NFI and local Allometric Equations)
Reference period	Mainland: 11 years, two data points (2002–2013) Zanzibar: 8 years, two data points (2004–2012)
Forest definition	Crown cover (%): ≥10 Tree height (m): ≥3 Area (ha): ≥0.5
Adjustment for national policy or economic growth	None
National FREL	43,736,974 ± 5,337,463 t CO_2e
Reserved Area FREL	7,183,038 ± 861,653 t CO_2e
Areas for improvement	• Additional REDD+ activities: Degradation, Enhancement of carbon stock, Sustainable Management of Forest and Forest Conservation • More data points • Additional carbon pools: Litter and Soil Carbon • Technical capacity

ACKNOWLEDGEMENTS

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ACRONYMS/ABBREVIATIONS

AD	Activity Data
AGB	Above-ground biomass
BGB	Below-ground biomass
CDM	Clean Development Mechanism
CO_2e	Carbon Dioxide equivalent
CoP	Conference of the Parties
DFNR	Department of Forestry and Non-Renewable Natural Resources
DWB	Deadwood biomass
EF	Emission Factor
ETM+	Enhanced Thematic Mapper Plus
FBD	Forest and Beekeeping Division
FREL	Forest Reference Emission Level
FRL	Forest Reference Level
GHG	Green House Gas
GFC	Global Forest Change
ha	hectare
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature and Natural Resources.
INC	Initial National Communication
LEDAPS	Landsat Ecosystem Disturbance Adaptive Processing System
LULUCF	Land Use- Land Use Change and Forestry
LULC	Land Use-Land Cover
MANRLF	Ministry of Agriculture Natural Resources Livestock and Fisheries
MRV	Measuring, Reporting and Verification
MNRT	Ministry of Natural Resources and Tourism
NAFORMA	National Forest Resources Monitoring and Assessment
NCMC	National Carbon Monitoring Center
NFI	National Forest Inventory
NIBIO	Norwegian Institute of Bioeconomy Research
REDD+	Reducing Emissions from Deforestation and forest Degradation; and the role of conservation, sustainable management of

	forests, and enhancement of forest carbon stocks in developing countries.
RCMRD	Regional Centre for Mapping and Resource Development
RGoZ	Revolutionary Government of Zanzibar
SUA	Sokoine University of Agriculture
SNC	Second National Communication
TAFORI	Tanzania Forestry Research Institute
TFS	Tanzania Forest Services Agency
TFCG	Tanzania Forest Conservation Group
TNC	Third National Communication
tC	Tonnes of Carbon
tCO_2e	Tonnes of CO_2 equivalent
UNFCCC	United Nations Framework Convention on Climate Change
UN-REDD	The United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation
VPO	Vice President's Office
ZWBS	Zanzibar Woody Biomass Survey

1. INTRODUCTION

1.1 Background

The United Nations Framework Convention on Climate Change (UNFCCC), invited developing country Parties to submit voluntarily Forest Reference Emissions Level (FREL) for a technical assessment (Decisions 12/CP.17 and 13/CP.19). This is in the context of results-based payments for reducing emissions from deforestation and forest degradation; and the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks in developing countries (REDD+).

Tanzania has been a party to the UNFCCC since 1996 and accordingly, presents a proposal of her national FREL for her possible participation in the REDD+ activities (Paragraph 70, Decision 1/CP.16, paragraph 71(b) (UNFCCC, 2011). The purpose of the proposed Tanzania's FREL is to facilitate access to international and regional funding related to REDD+, expand the forest resources base for domestic and export needs under public, private partnerships, to meet sustainable development goal and to assess and monitor achievements in forest resource management practices at all levels. This submission entails the FREL technical assessment in accordance with the guidelines and procedures adopted in decision 13/CP.19 (UNFCCC, 2014). Further, the information regarding methodologies used in constructing the FREL, that is, activities, pools, gases and the forest definition are provided following the guidelines of the Inter-governmental Panel on Climate Change (IPCC) (IPCC, 2003; 2006). The preparation and submission of proposed FREL is voluntary and it is mainly for the purpose of benefiting from the results-based payment, as per Decisions 9/CP.19, 13/CP.19 and 14/CP.19 (UNFCCC, 2014). According to Decision 12/CP.17, this submission will follow a stepwise approach, which allows incorporating better data, improved methodologies and adding more pools, where appropriate overtime.

1.2 Forest Reference Emission Level development process for Tanzania

Tanzania started REDD+ readiness process in 2008. This was possible through a generous support of the Government of the Royal Kingdom of Norway among others, where the two countries agreed to cooperate for five years (2008 - 2013) on

climate change issues. During the REDD+ readiness phase, Tanzania undertook the following activities:

- Prepared the National Framework for REDD+;
- Prepared the National REDD+ Strategy and Action Plan;
- Conducted various researches and capacity building programmes in support of REDD+;
- Carried out nine REDD+ pilot projects;
- Prepared draft of REDD+ Social and Environmental Safeguards and Standard; and
- Raised awareness on REDD+ among different stakeholders.

Moreover, Tanzania is in the process of establishing a National Carbon Monitoring Centre (NCMC). The NCMC is currently operating at a transitional phase and expects to be operational by 2019. This is a strategy of preparing the country for a result based payment mechanism under REDD+. In the result based payment mechanism, countries are required to quantify their achievements by establishing a robust and transparent forest carbon Measurement, Reporting and Verification (MRV) system. MRV provides a system on how to account for forest carbon, including changes over time. This system establishes the FREL against which the REDD+ achievements will be determined over time. NCMC started its activities in January 2016 where one of its initial tasks was to establish the MRV system for the estimation of FREL for the country. The first technical meeting on FREL for Tanzania was held at NCMC on 12th April 2016 and attended by experts from the Government, higher learning and research institutions, and the private sector. The meeting reached a common understanding and a way forward on the national forest definition; the scale; scope; activities, and data points for the REDD+ FREL of Tanzania. The following technical working groups were established to take up the process of FREL development:

- Technical working group on forest definition: This group worked on forest definition and came up with a proposed forest definition to be used in FREL process;
- Technical working group on activity data: This group worked on issues related to historical data, reference year for land cover-land use changes, and suggested future projections;

- Technical working group on emission factors: This group worked on possible emission factors to be included in the FREL process, taking into consideration the country circumstances;
- Technical working group on FREL: This working group reviewed other countries' FREL submissions to UNFCCC for drawing experiences, and practices relevant to Tanzania. The group suggested the content and layout of the FREL document, compiled activity data and emission factors and finally computed FREL.

The working groups were facilitated by NCMC to undertake their tasks. The groups presented their findings and suggestions to the second technical meeting held on 5th May 2016. This technical meeting reached a consensus on the proposed forest definition, proposed data and methodological approaches for estimating emission factors, activity data and the choice of REDD+ activity to be used for the FREL process. Having these deliverables from the technical meetings, NCMC organized a first FREL multi-stakeholder consultation meeting, which was held on 19th - 20th May 2016. The stakeholders who attended the meeting were from the Government, Government agencies, universities, research institutions, NGOs and the private sector.

The outcomes of the four-national technical working groups and workshops/meetings included:

- A proposed forest definition for the REDD+ and CDM processes, which was later endorsed by the Government;
- Consensus on the use of the National Forest Resource Monitoring and Assessment (NAFORMA) data for Mainland Tanzania and Zanzibar Wood Biomass Survey (ZWBS) data for Zanzibar in estimating emission factors. The NAFORMA and ZWBS are comprehensive national forest inventories in Tanzania. NAFORMA was carried out from 2009 to 2013 (MNRT, 2015) while ZWBS was carried out in 2012 (RGoZ, 2013). While NAFORMA was the first NFI for Mainland Tanzania, ZWBS of 2012 was preceded by ZWBS of 1997;
    - Consensus on the adoption of Approach 3 of the IPCC 2006 Good Practice Guidelines (spatially explicitly) in the development of activity

data for deforestation based on the available data and country circumstance; and

- Consensus on the inclusion of a stratum for reserved areas[1].

The preliminary results from this national process, which involved multiple stakeholders (Appendix 1) were then presented to the side meeting at the Oslo REDD+ exchange workshop held on 16th to 17th June 2016 in Ås, Norway. The team from Tanzania presented the country's expert views on how the FREL for the country would be developed. This was followed by presentations and discussions from and among international experts including Land Use Land Use Changes and Forestry (LULUCF) experts who had revised the previously submitted FREL from other countries, methodological experts in forest carbon monitoring and change estimations, and experts who had been involved in the development of other countries' FREL. The main goal of the side meeting was to share experiences with other experts on FREL development. Recommendations from the meeting were as follows:

- Based on the assessment of the available data, expertise and capacity, it is possible for Tanzania to submit her FREL in early December 2016, and have it reviewed by the UNFCCC technical assessment experts in March 2017. Accordingly, Tanzania should target to have the FREL document ready by October 2016, scrutinized by stakeholders in November 2016 and ready for submission by early December 2016. For this to be practical, it was advised that the FREL technical group should start working on the draft document, which would have details of all the procedures, processes and methodologies followed and plans for the future. Thus, each technical working group on FREL should clearly document all the procedure and methods used in detail to ensure transparency, accuracy, consistency and compatibility and that it is confined with the UNFCCC guidelines on the development of FREL; and
- Develop the emission factor from the NAFORMA and ZWBS classification of forest types. The historical activity data for forest change detections used the

[1] Reserved areas are: Conservation Areas i.e. National Parks, Game Reserves, and Nature Forest Reserves (protective) and National Forest Reserves/forest reserves (Protective and/ Productive).

2002 Landsat 7 and the 2013 Landsat 8 data for Mainland Tanzania. This was based on the availability of both Landsat 7 (year 2002) and Landsat 8 (year 2013). Data collection for NAFORMA and ZWBS was finalized in 2013 and 2012, respectively; thus, it would be appropriate to link NAFORMA and ZWBS data with the remote sensing data (*see section 4.3 for details on the choice of data and years of data collection*).

The second and final formal stakeholder consultation and validation workshop was held on 20th December 2016 at NCMC, SUA - Morogoro. The workshop was officiated by the Permanent Secretary, Vice President's Office and attended by participants representing Government institutions, Government Agencies, NGOs and the private sector. The workshop participants reviewed and discussed the FREL document and provided comments and inputs aiming at improving the FREL document.

1.3 Consistency with GHGs Inventory reporting

The United Republic of Tanzania has been reporting on the GHGs inventory through her national communication reports submitted to the UNFCCC. The Initial National Communication (INC) was submitted in 2003 based on the GHGs inventory carried out in 1993. The Second National Communication (SNC) submitted in 2014 was based on the GHGs inventory carried out between 1995 and 2005, using 2000 as the base year. Both national communications used IPCC 2006 guidelines Tier 1 approaches.

These previous GHGs inventories employed outdated data, which were collected between 1993 and 2005, and since data for some sectors were missing, in such cases default global values were applied. This FREL used emission factors based on the recent data from the National Forest Inventories (NFI) in Mainland Tanzania and Zanzibar. The emission factors, which were derived from the NFI data in this submission, are therefore, considered as up-to-date and more detailed (Tier 3) compared to the previous GHGs inventories. Hence, data generated in the FREL development process will benefit the Third National Communication (TNC) and first biennial update report (BUR1).

2. SCALE: AREA COVERED BY THE FOREST REFERENCE EMISSION LEVEL (FREL)

2.1 National FREL

This FREL submission considered the country circumstance, that Tanzania is a Union of Mainland Tanzania and Zanzibar. A national FREL for gross deforestation was developed as a sum of FREL for Mainland Tanzania and that of Zanzibar as per UNFCCC Decision 12/CP.17. The national FREL therefore, covers a total area of 94.76 million ha of the United Republic of Tanzania (Figure 1) that is, 94.51 million ha in Mainland Tanzania and 250,000 ha of land area in Zanzibar.

Tanzania is located between 1° 00' S and 12° 00' S and between 30° 00' E and 41°00' E at an altitude between 358 m a.s.l. and 5,950 m a.s.l. Mainland Tanzania is characterized by tropical climate, which can be divided into four distinct climatic zones, namely, the hot humid coastal plain, the semi-arid zone of the central plateau, the high-moist lake regions, and the temperate highland areas. The country has mean maximum day-time temperatures ranging from 10°C to 31°C and a mean annual rainfall ranging from 500 to 2,500 mm across the four zones. Zanzibar is characterized by tropical and humid climate with mild temperatures, with an average annual temperature of 31.5°C, and a mean annual rainfall ranging from 1,000 to 2,500 mm.

The total forested land in Mainland Tanzania is 48.1 million ha, which is equivalent to 54.4% of the total land area of 88.3 million ha. Broadly, forested land in the country is comprised of forest and woodlands. Forests include montane, lowland, mangrove, and plantation forests, while woodlands include open and closed woodlands, and thickets. Woodlands occupy 44.7 million ha (~93.0% of the total forested land and 50.6% of total land area in Mainland Tanzania), followed by cultivated land (25.2%), bushland and grassland (16.6%) and forests (3.5%). In Zanzibar, forest cover is about 106,458 ha, which is equivalent to 43% of the total land area. This includes bush and tall trees in coral rag areas (81%), mangroves (15%), and forest plantations (4%). Other land cover types are a mixture of trees and agricultural crops, clove plantation, coconut plantation, and mixed wood vegetation (RGoZ, 2013).

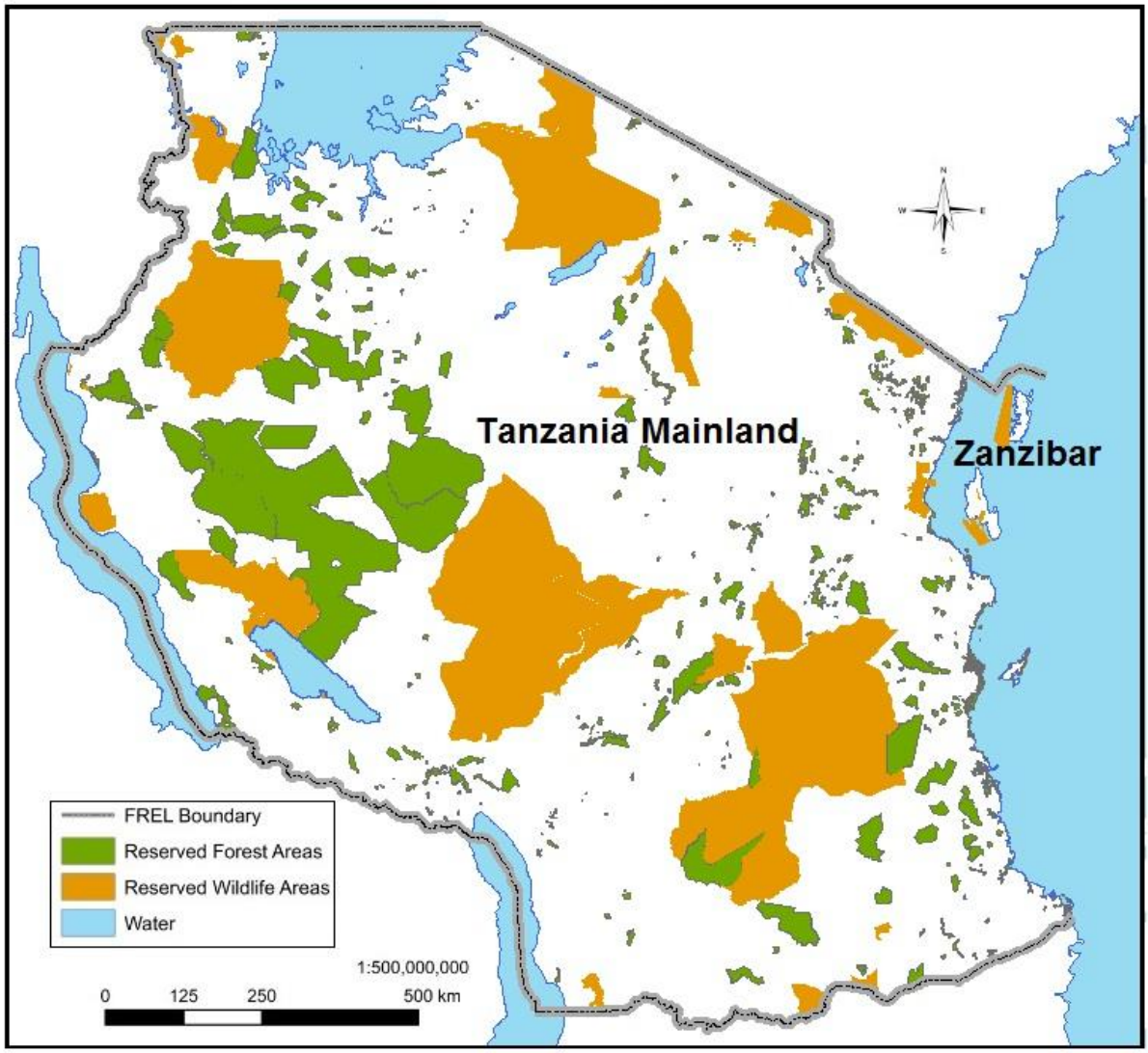

Figure 1: Area covered by the FREL - Mainland Tanzania and Zanzibar and Reserved Areas

Forests in Tanzania play an important role in the daily livelihoods. They are an important source of energy for cooking, building timber, traditional medicine, tourism, fodder, water catchments, shelter for wildlife and estuaries for fish breeding areas. Furthermore, these forests also have high biodiversity, containing over 10,000 plant species, hundreds of which are nationally endemic, 724 species of flora and fauna identified as threatened in the IUCN Red List, and 276 species of flora and fauna classified as endangered (IUCN, 2013).

2.2 FREL for Reserved Areas

Reserved areas in Tanzania (Mainland and Zanzibar) include (a) Conservation Areas, namely, National Parks, Game Reserves, and Nature Forest Reserves (Protective); and (b) Forest Reserves (Protected and Production). The forest reserves are managed by either the Central Government or the Local Government Authorities. All reserved areas are included in this submission except the village land forest reserves and Wildlife Management Areas (WMA), due to inadequate spatial coverage data. The combined size of the considered reserved areas is 26,250,525 ha, of which 26,236,030 ha are in Mainland Tanzania and 14,495 ha are in Zanzibar. The reserved area FREL is a sub-set of the national FREL.

The reserved area occupies more than 50% of the forested area in Tanzania. These reserved areas are legally protected, and therefore, it is easier to reverse the current forest losses with interventions such as forest boundary consolidations, enhancing law enforcement and management.

3. SCOPE: ACTIVITIES, POOLS AND GASES INCLUDED IN THE CONSTRUCTION OF THE FREL

3.1 REDD+ Activities

REDD+ activities, which are referred to in the Decision 1/CP.16, paragraph 70 of the UNFCCC, include reducing emissions from deforestation and forest degradation; and the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks in developing countries. Deforestation is the only REDD+ activity considered in this submission; this is because of the availability of deforestation data and inadequate data for the other REDD+ activities. Deforestation in this submission is defined as a change of forest cover to non-forest cover. Temporary un-stocked areas of natural forests are also considered as deforested areas (Appendix 6).

The total area of forest reserves in Tanzania is *ca* 14 million ha. Apart from their high carbon storage capacity, these forests have a unique biodiversity potential. In this submission, conservation of carbon stock is not included due to lack of past continuous forest inventory data for the conserved forest to depict both area and carbon stock changes. The presence of NAFORMA and ZWBS will largely mitigate this challenge and allow inclusion of conservation of forest carbon stock in the future submissions. The emphasis will be on the managed forest areas that include national parks, game reserves, nature forest reserves, local Government authority forest reserves, national forest reserves, community conserved forest areas, private, sacred forests and Wildlife Management Areas (WMA).

Forest degradation is not included in this submission although it is considered as a significant source of emission. The main drivers of forest degradation are extraction of wood fuel (charcoal and firewood), logging, grazing and wild fires. Forest degradation is taking place all over the country in a fragmented manner and degraded forests frequently maintain a closed canopy. This poses a significant challenge to the assessment and monitoring of forest degradation by means of remote sense techniques. However, NAFORMA and ZWBS have included assessment of harvesting or natural mortality through stumps measurements, which can be used to determine forest degradation. Moreover, there have been national

wild fire monitoring projects, which have been coordinated by Tanzania Forest Services (TFS) Agency and Tanzania Forestry Research Institute (TAFORI); these and other ongoing case studies can also be used to determine forest degradation. However, these datasets are of limited spatial coverage and are therefore not included in this submission.

The enhancement of carbon stock has not been included in this submission. The assessment of enhancement of carbon stock should consider forest growth and area gain. Tanzania has a potential to include the enhancement of carbon stock in the future as one of the activities since there is a large number of afforestation, reforestation, and natural-regeneration programs coordinated by the Government and the private sector, including smallholders' tree growers. However, accurate national data on the past reforested and afforested areas and the annual tree survival rate are missing. Future monitoring of afforestation and reforestation programs through institutions such as NCMC will provide data for the enhancement of carbon stock.

Sustainable management of forest has also not been included in this submission despite the efforts on implementing sustainable forest management in Tanzania and different policy reforms, which go back to the colonial eras. However, the inclusion of sustainable management of forest in this submission is limited by inadequate data on the following, which should be addressed in future:

- Removals and emissions associated with forest management;
- Growing stock under different forest management regimes;
- Relevant historical data on forest management and governance at national level;
- The existing forest areas set for sustainable forest management and their monitoring plans;
- New areas subjected to sustainable forest management; and
- Inadequate and outdated forest management plans.

3.2 Carbon pools

The carbon pools included in this FREL submission are:

- Above-ground biomass (AGB);
- Below-ground biomass (BGB); and
- Deadwood biomass (DWB).

These pools are included because of their significant size in Tanzania, the expected high rate of change, and most importantly, the availability of appropriate data and accurate methods of estimation.

Soil organic carbon (SOC) pool is not included in this submission. Soil data was only partially collected by NAFORMA and ZWBS. Moreover, FREL requires not a current carbon stock, but change in the carbon stock. The change of carbon in the SOC when Forest is converted to grassland, or cropland or settlement or commercial agriculture is not known and hard to obtain. Furthermore, the uncertainty in the data from literature is large for SOC due to large natural variation. In future NAFORMA, this data will hopefully be available and included.

The litter carbon pool is not included in this submission. Data on litter was not collected by NAFORMA and ZWBS because of frequent fires that burn the litter layer in the woodlands, which is the most dominant forest type in Tanzania constituting 93% of forested land. The litter carbon pool dynamics in the woodland is shaped by the amount of litter accumulation and fire occurrences; currently this information is lacking.

3.3 Gases

This FREL submission considered carbon dioxide (CO_2) gas only. In this submission, the focus is on reducing emission from forest related activities whereby CO_2 is the most emitted gas. Other GHGs may be considered in the future when accurate methods and reliable data become available.

4. INFORMATION USED AND METHODS FOR FREL CONSTRUCTION

4.1 Forest definition

In defining forest, this submission considered internationally agreed parameters (height, crown cover, and area) and the technological capability to monitor change in the forest area and carbon stocks, and ensure social, economic and cultural aspects. Accordingly, the choice of the forest definition for Tanzania considered that (1) Tanzania is capable of measuring and monitoring carbon stocks using moderate and affordable data such as LandSat imageries; (2) the forest definition incentivize rehabilitation of degraded forests since large area of reserved forests are degraded yet with potential to recover following interventions; (3) the forest definition ensure conservation of dry forests (including those with short trees) such as open woodlands and thickets with tree crown cover > 10% trees with height of 3m; (4) the definition also ensure conservation of sacred forests. Apart from carbon storage, both dry and sacred forests ensure conservation of biodiversity and soils. Moreover, sacred forests are important for social and cultural dimensions. Based on such considerations, the following definition is adopted:

'Forest' means an area of land with at least 0.5 ha, with a minimum tree crown cover of 10% or with existing tree species planted or natural having the potential of attaining more than 10% crown cover, and with trees which have the potential or have reached a minimum height of 3m at maturity in situ.

This definition, which is accessible through the following link http://www.ncmc.sua.ac.tz/wp-content/uploads//2017/07/National%20Definition%20of%20Forest%20for%20REDD+%20and%20CDM%20in%20Tanzania.pdf, was developed through a stakeholder's consultative process as shown in Section 1.2. The current definition is different from the one used in other previous national reporting such as national communications and FRA and is meant to cater for REDD+ and Clean Development Mechanism (CDM) programs under UNFCCC. Therefore, Tanzania will use the current forest definition in all future reporting.

4.2 The Reference Period

The historical reference period is defined as the period from which the data for estimating past changes in forest areas are obtained. Both the initial and the last data point of the reference period for the current FREL are largely dictated by the availability of activity data and additional data for comparison.

For Mainland Tanzania, the reference period is 2002-2013. Year 2002 was chosen as the start of the reference period because of the availability of Landsat 7 ETM+ prior to the failure in line scanner of Landsat 7 Satellite in 2003. The year 2013 was selected because Landsat 8 OLI is available, with an improved image quality, and the year coincides with the period of NAFORMA measurements that are used as a reference for forest classification and for stratification.

For Zanzibar, the reference period is 2004-2012. Year 2004 was chosen as the start of the reference period because of the availability of ortho-photographs covering the two islands (Unguja and Pemba). These ortho-photographs were also the basis for the Land Cover Map that was used in ZWBS in 2005. The year 2012 was selected because of the availability of RapidEye data and coincided with the second phase of ZWBS, which was used as a background for forest classification or activity data stratification. Landsat data were not used for Zanzibar, because in most parts of the islands, Landsat images were covered by clouds.

4.3 Activity Data

4.3.1 Activity data for Mainland Tanzania and Zanzibar

Activity data used for the construction of Tanzania's FREL were generated using land use and land cover (LULC) change analysis for the period between 2002 and 2013 for Mainland Tanzania, and 2004 and 2012 for Zanzibar Islands. The analysis of the LULC change focused on changes from forest to non-forest. The classification scheme followed closely the approach described in the IPCC 2006 Good Practice Guidance for LULUCF (IPCC, 2006). Using consultative workshops and considering the existing forest definition, the LULC changes were categorized into seven classes. These classes were later grouped into four broad classes. Table 1 provides a list of these classes along with their descriptions.

The forest cover change detection entailed an iterative process consisting of the following steps:

- Image acquisition and pre-processing;
- Collection of training data and classification;
- Post-classification processing; and
- Area estimation and accuracy assessment.

Table 1: Land Use Land Cover classes for Activity Data

LULC Classes	LULC Classes for mapping	National Land Cover Description
Forest land	Forest	An area of land with at least 0.5 ha, with a minimum tree crown cover of 10% or with the existing tree species planted or natural having the potential of attaining more than 10% crown cover, and with trees which have the potential or have reached a minimum height of 3 m at maturity in situ. It includes montane, lowland, mangrove and plantation forests, woodlands, thickets, cultivated land mixed crops and cultivated land with wooded crops
Bushland	Non-forest	Bushland predominantly comprises of wooded plants, which are multi-stemmed from a single root base. It includes dense and open bushland except thickets
Grassland		For the most part, grassland occurs in combination with either limited wooded or bushed component, or with scattered subsistence cultivation.
Cultivated land		Land, which is actively used, and grows agriculture crops including agroforestry systems, herbaceous crops and grain crops
Other lands		Land that includes settlement, bare land and rock outcrop, Costal bare lands, Ice cap / snow
Wetland	Wetland	Land which is water logged, may be wooded such as marshland, perennial flooded plains and swampy areas.
Water	Water	Indian Ocean and inland water

Image acquisition and pre-processing

Bi-temporal analyses of LULC change requires an extensive data selection and preparation to ensure comparability of the imagery. Appropriate selection of imagery acquisition dates is as crucial to the change detection method as is the choice of the sensor(s), change categories, and change detection algorithms. In consideration of cloud cover, the seasonality and phenological effects, better Landsat 7 and 8 images were selected for image processing from a large number of images. The images targeted were those acquired during the dry seasons (July-November) of the years 2002 and 2013 with cloud cover ≤ 10%. However, getting all the images conforming to the criteria proved to be challenging in some areas. Owing to this constraint, for some places, the images acquired in the wet season were used. Landsat 7 and 8

OLI images were the major source of data for forest change assessment in Tanzania Mainland. The images were downloaded from freely available USGS and Earth Explorer websites (http://earthexplorer.usgs.gov/ and http://glovis.usgs.gov/). More than 50 Landsat 7 ETM+ (for 2002) and Landsat 8 (for 2013) images were downloaded (Appendix 2). The Landsat 7 ETM+ scenes were pre-processed to surface reflectance level using the Landsat Ecosystem Disturbance Adaptive Processing System (LEDAPS) atmospheric and topographic correction algorithm. The Landsat 8 OLI scenes had already been processed to surface reflectance level by the USGS internal L8SR algorithm. Details of the pre-processing approach used by the USGS are provided in:
http://landsat.usgs.gov/documents/cdr_sr_product_guide_ee.pdf and
http://landsat.usgs.gov/documents/Provisional_Landsat_8_SURFACE_REFLECTANCE_EE.pdf.).

Due to heavy cloud cover, it was difficult to find appropriate Landsat images for Zanzibar Islands. As a result, the processed ortho-photographs of 2004 at a scale of 1:10,000 and images from the RapidEye satellite of the year 2012 were used. Details of the ortho-photographs and the RapidEye images used are described in the ZWBS of 2005 and 2012 (RGoZ, 2013).

Collection of training data and classification

The collection of training data and classification were iterative processes whereby the quality of training data was assessed using generated variables, i.e. internally generated confusion matrix and signature plot, from the Random Forest (RF) (Figure 2a and 2b) and adjusted accordingly to produce better results.

```
Confusion matrix
> print(randfor$confusion)
    1   2  3  4   5   6   7   8   9 10  11  12  13  14  15 16  17  18 19
1  96   2  0  0   0   0   0   1   0  2   0   0   0   0   0  0   0   0  1
2   1 102  0  0   0   0   0   0   0  0   0   0   0   0   0  0   0   0  0
3   0   0 89 12   0   0   0   0   0  0   0   1   0   0   0  0   0   0  0
4   0   0 16 83   0   2   0   0   0  0   0   0   0   0   0  0   0   0  0
5   0   0  0  0 103   0   0   0   0  0   0   0   0   1   0  0   0   0  0
6   0   0  0  0   0 102   0   0   0  0   0   0   0   0   0  0   0   0  0
7   0   0  0  0   0   0 101   0   0  0   0   0   0   0   0  0   0   0  0
8   0   0  0  0   0   0   0 102   0  0   0   0   0   0   0  0   0   0  0
9   0   0  0  0   0   0   0   0 100  0   3   0   0   0   0  0   0   0  0
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15  0   0  0  0   0   0   0   0   0  0   0   0   0   0 102  0   0   0  0
16  0   0  0  0   0   0   0   0   0  0   0   0   0   1   0 99   0   0  0
17  0   0  0  0   0   0   0   0   0  0   0   0   0   0   0  0 100   0  0
18  0   0  0  0   0   0   0   0   0  0   0   0   0   0   0  0   0 103  2
19  0   0  0  0   1   0   0   0   0  0   0   0   0   1   0  0   0   2 97
```

Figure 2a: Internally generated confusion matrix (out-of-bag error) generated after running the RF algorithm (path 167, row 64)

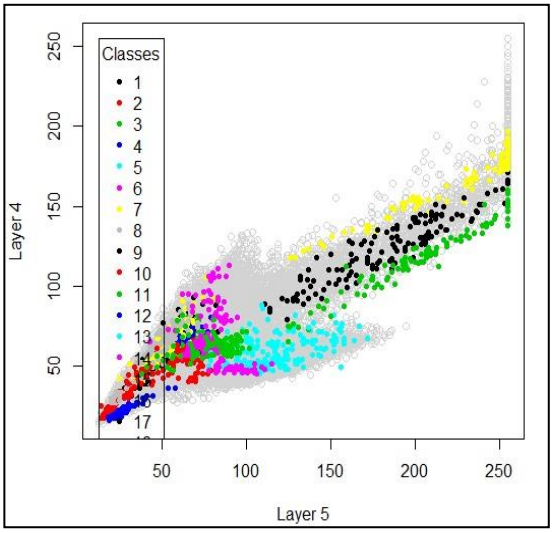

Figure 2b: Spectral signature plot generated by the RF classifier (path 167, row 64)

The collection of training data was done for each Landsat scene separately using a layer of stacked bi-temporal images (from 2002 and 2013), meaning six bands from each image (bands 1, 2, 3, 4, 5 and 7 from Landsat 7 and bands 2, 3, 4, 5, 6 and 7 from Landsat 8). This process was carried out in order to minimize classification errors due to seasonality between scenes. Training polygons for LULC changes, including deforestation, stable forest, and other lands remaining other lands, were digitized using image interpretation expertise and the Global Forest Change (GFC) product (Hansen et al., 2013). Examples of training data showing different LULC changes are shown in Appendix 3.

The stacking of bi-temporal images increases the efficiency at which spectral information can be extracted because it eliminates the need for two separate classifications and improves accuracy by eliminating the misinterpretation of classes between dates.

The classification of the bi-temporal stacked scenes was carried out using the RF algorithm. The RF algorithm is a machine learning technique whereby an ensemble of decision trees was created based on bootstrapped data and the response is calculated based on the outcome of all the decision trees. According to Ned (2010), RF has several advantages when compared with other image classification methods:

it is non-parametric, it is easy to parameterize, it is not sensitive to over-fitting; it is good at dealing with outliers in training data, and it is able to calculate useful information about errors, variable importance, and data outliers. This information can be used to evaluate the performance of the model and make changes to the training data if necessary. The RF model, which was developed using the training data, was then applied to the stacked images to generate a forest change map for each scene. The initial assessment of the classification output was done by overlaying the output on the color composite and was visually checked for classification accuracy.

Post-classification processing

Post-classification processing included recoding, majority filtering, clumping, elimination, and mosaicking. The classified images were recoded to the five classes namely; stable forest (forest remaining forest), deforestation (forest to non-forest), non-forest (including bushland, bare land, croplands, grasslands, and settlements), wetland, and water. Then, a 3 by 3 majority filter was applied to the recoded image to reduce the salt and paper effect; and lastly, the classes were filtered to a minimum mapping unit of about 0.5 ha to conform to the forest definition, that is, the minimum size is 0.5 ha.

Final interpretations from all scenes were mosaicked to produce a wall-to-wall forest change map for the entire country (Figure 3a and 3b). This was the basis for area estimation (Table 2a and 2b) and accuracy assessment.

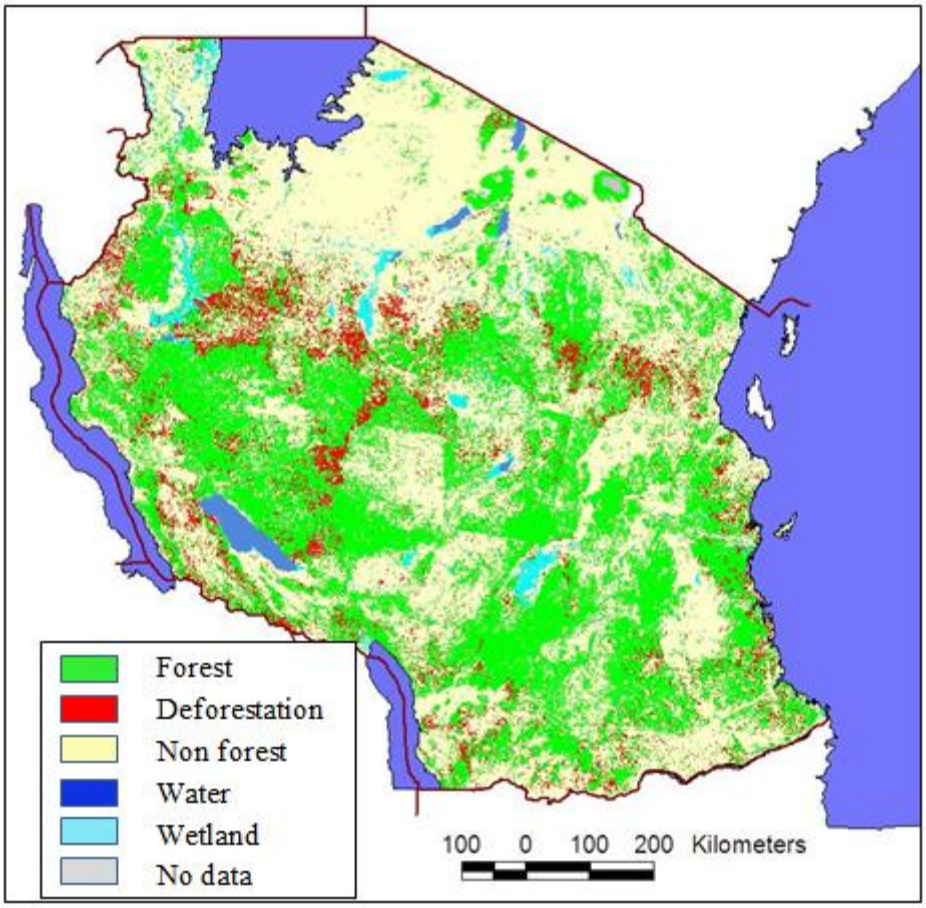

Figure 3a: Forest change maps for the Mainland Tanzania

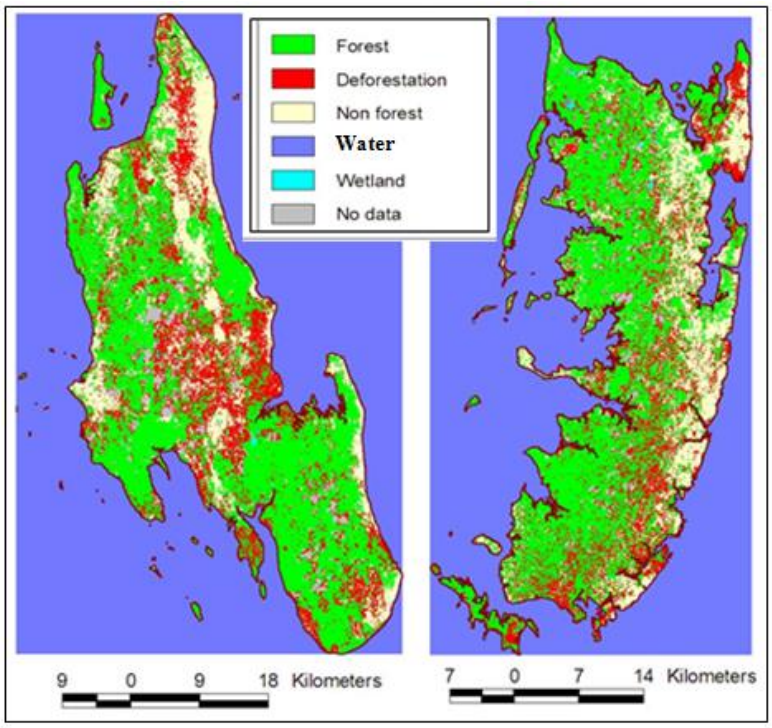

Figure 3b: Forest change maps for the Zanzibar islands Unguja (left) and Pemba (right)

Table 2a: Mapped areas and area changes (2002 – 2013) for the Tanzania Mainland

No.	Change class	Area (1,000 ha)	% Total Area
1	Forest remaining forest	32,001	35
2	Deforestation	6,407	7
3	Other lands remaining other lands	53,800	58
4	No data (clouds/shadow)	305	0
Total		92,513	100

Note: Other lands remaining other lands include all non-forest covers.

Table 2b: Mapped areas and area changes (2004 – 2012) for the Zanzibar Islands

No.	Change class	Area (x 1,000 ha)	% Total Area
1	Forest remaining forest	151	58
2	Deforestation	44	17
3	Other lands remaining other lands	55	21
4	No data (clouds/shadow)	12	4
Total		262	100

Note: Other lands remaining other lands include all non-forest covers

Area Estimation and Accuracy Assessment for LULC Change

The IPCC 2006 Good Practice requires inventories that neither over- nor under-estimates LULC changes and their uncertainties reduced as far as is practicable. According to GFOI (2013), to achieve these criteria, compensation should be made for classification errors when estimating activity areas from maps and uncertainties should be estimated using robust and statistically rigorous methods. In this document, we adopted the approach described by Olofsson et al. (2013) and GFOI (2013) to estimate deforestation areas in the Tanzania mainland and the Zanzibar Islands.

Accuracy of the produced LULC change map was evaluated using a combination of NAFORMA plots and the 2000 Regional Centre for Mapping and Resource Development (RCMRD) LULC map for the Mainland Tanzania. For Zanzibar Islands, we used a combination of Zanzibar Woody Biomass Survey (ZWBS) plots and random points, obtained from a visual interpretation of the ZWBS plots on the 2004 and aerial photographs by a remote sensing expert.

Due to the two different reference systems used, this description is split into two subsections to increase transparency.

Mainland Tanzania

The NAFORMA sample plots were distributed following a stratified systematic cluster sampling (Tomppo et al., 2014; MNRT, 2015). The country was divided into 18 strata based on predicted growing stock, accessibility and slope. Samples were then randomly distributed, with different sampling intensities in each stratum. Higher sampling intensity was allocated to strata with high variation and high predicted growing stock and less sampling intensity to strata with low variation and low predicted growing stock. This resulted in a total of 3,419 clusters with 32,660 plots. The RCMRD map was developed from supervised classification of Landsat imagery (30m by 30m) and was found to represent the LULC classes in Tanzania with an overall accuracy of about 86% (RCMRD, 2012).

The combination of NAFORMA and RCMRD was necessary because NAFORMA only contains the status and not the change of land use categories (including deforestation) during the reference period. The resulting reference data set consisted of 2,836 NAFORMA clusters with a total of 27,091 sample plots. The remaining NAFORMA sample plots were not available because they were not measured in the field due to inaccessibility.

Procedures:

a) The datasets, namely; NAFORMA plots and 2000 RCMRD LULC map were combined using ArcGIS spatial analyst tool “extract value to points” to produce LULC change reference data for Mainland Tanzania.

b) The error matrix in terms of sample counts and the areas computed from the map categories was constructed as shown in Table 3a.

Table 3a: Error matrix for the Mainland Tanzania

Class	Number of NAFORMA sample plots (n)				Map area (1,000 ha)	W_i
	FF	D	OO	Total		
FF	15313	262	277	15,852	32,001	0.35
D	557	951	202	1,710	6,407	0.07
OO	2345	189	6995	9,529	53,800	0.58
Total	18,215	1,402	7,474	27,091	92,208	1.00

Note:

- FF is forest remaining forest
- D is deforestation
- OO is other lands remaining other lands (including settlements, cropland, grasslands, wetland and inland water).
- The total map area excludes area covered by clouds and shadow, thus it looks smaller than the one in Table 2a.
- Map categories are presented by rows, and columns present the reference categories (NAFORMA observations).
- W_i is the proportion of area for mapped category.

c) The error matrix was then expressed in terms of estimated area proportions p_{ij} (Olofsson et al., 2013) and derived using equations 1 to 4. The estimated error matrix for Mainland Tanzania is presented in Table 3b.

$$p_{ij} = W_i\left(\frac{n_{ij}}{n_i}\right) \quad \text{.....(1)}$$

$$U_i = \frac{p_{ii}}{p_i} \quad \text{.....(2)}$$

$$P_j = \frac{p_{jj}}{p_j} \quad \text{.....(3)}$$

$$O = \sum_{j=1}^{a} p_{jj} \quad \text{.....(4)}$$

Where U_i denotes user's accuracy, P_i denotes producer's accuracy, O denotes overall accuracy, subscript *i* denotes the row (map categories) and the subscript *j* denotes the column (reference categories) in the error matrix,

Table 3b: Error matrix of estimated area proportions (p_{ij}) for the Mainland Tanzania

Class	FF	D	OO	Total	Accuracy		
					User's	Producer's	Overall
FF	0.34	0.01	0.01	0.35	0.97	0.67	
D	0.02	0.04	0.01	0.07	0.56	0.69	0.80
OO	0.14	0.01	0.43	0.58	0.73	0.97	
Total	0.50	0.06	0.44	1.00			

Note: Differences in total are due to rounding.

Therefore, the estimated proportion of deforestation based on the reference classification for Mainland Tanzania is:

$$P_D = \sum W_i \left(\frac{n_{i1}}{n_i} \right) = \frac{0.347(262)}{15852} + \frac{0.069(951)}{1710} + \frac{0.583(189)}{9529} = 0.056$$

d) Equation 5 presents an estimator of the total area of deforestation:

$$A_D = A_{tot}(P_D) \quad \text{..... (5)}$$

Where A_{tot} is the map total area.

Therefore, the estimate of the area of deforestation for the Mainland Tanzania is:

$A_D = 0.056\ (92{,}208.00 \times 10^3) = 5{,}163.65 \times 10^3$ ha

e) The estimated standard error of the estimated area proportion for Mainland Tanzania was computed using Olofsson et al. (2013)'s equation (6a and 6b):

$$S(P_D) = \sqrt{\sum_{i=i}^{q} W_i^2 \times \left[\frac{\frac{n_{ij}}{n_i}\left(1 - \frac{n_{ij}}{n_i}\right)}{n_i - 1} \right]} \quad \text{.....(6a)}$$

In order to accommodate the clustered nature of NAFORMA plots, equation (6a) was adjusted:

$$S(P_D) = \sqrt{\sum_{i=i}^{q} W_i^2 \times \left[\frac{\frac{n_{ij}}{n_i}\left(1 - \frac{n_{ij}}{n_i}\right)}{\frac{n_i}{c} - 1} \right]} \quad \text{.....(6b)}$$

where *c=8* is the average number of plots within a cluster.

Hence:

$$S(P_D) = \sqrt{0.3472^2 \left(\frac{\frac{262}{15852}\left(1-\frac{262}{15852}\right)}{\frac{15852}{8}-1} \right) + 0.0692^2 \left(\frac{\frac{951}{1710}\left(1-\frac{951}{1710}\right)}{\frac{1710}{8}-1} \right) + 0.5832^2 \left(\frac{\frac{189}{9529}\left(1-\frac{189}{9529}\right)}{\frac{9529}{8}-1} \right)} = 0.00349$$

f) The standard error for the error-adjusted estimated area of deforestation for Mainland Tanzania was computed using equation 7:

$SE(A_D) = S(P_D) \times A_{tot}$ .....(7)

Hence:

$SE(A_D) = 0.00349 \times 92{,}208.00 \times 10^3$

$= 321.81 \times 10^3$ ha

This gives a final deforestation estimate with an approximate 95% confidence interval of:

$A_D \pm 1.96\ SE(A_D) = 5{,}163.65 \times 10^3$ **$\pm$ 630 x 10^3 ha** for the Mainland Tanzania.

The relative confidence interval is 100 x (630/5,163.65) = **12.2%.**

The annual deforestation estimate is 5,163,650 ha/11 years = **469,420 ha/year**.

The observed deforestation rate in this submission differs from previous studies because of the differences in forest definition, approaches used, different window periods considered and lack of accuracy and uncertainty assessment in the previous estimates.

The results suggest that the map area of deforestation for Mainland Tanzania (6,407 x 10^3 ha) was an overestimate; that is outside 95% confidence region of the error-adjusted area estimator.

The mapped and the adjusted activity data for each forest cover sub-class are shown in Table 4c. These sub-classes are only those where deforestation has taken place.

Zanzibar

The ZWBS sampling design was based on stratified sampling (RGoZ, 2013). The sample plots were distributed within 18 strata, which are the LULC classes visually delineated from 2012 RapidEye imagery. This resulted in 267 and 301 plots for the Zanzibar Islands i.e. Pemba and Unguja, respectively.

The same procedures used for Mainland Tanzania were applied to Zanzibar; the datasets, namely; ZWBS plots and random points were combined using ArcGIS spatial analyst tool "extract value to points to produce LULC change reference data for Zanzibar, respectively.

The error matrix in terms of sample counts and the areas computed from the map categories for the Zanzibar Island was constructed as shown in Table 4a.

Table 4a: Error matrix for the Zanzibar Island

Class	FF	D	OO	Total	Map Area (ha) x 1,000	Wi
FF	326	2	6	334	151.322	0.61
D	12	26	12	50	43.885	0.18
OO	106	4	40	150	54.895	0.22
Total	444	32	58	534	250.102	1

The error matrix was then expressed in terms of estimated area proportions P_{ij} (Olofsson et al., 2013) as shown in Table 4b. (See equations 1,2,3 and 4).

Table 4b: Error matrix of estimated area proportions for the Zanzibar Island

Class	FF	D	OO	Total	Accuracy		
					User's	Producer's	Overall
FF	0.59	0.00	0.01	0.61	0.98	0.75	
D	0.04	0.09	0.04	0.18	0.52	0.91	0.74
OO	0.16	0.01	0.06	0.22	0.27	0.52	
Total	0.79	0.10	0.11	1.00			

Therefore; the estimated proportions of deforestations based on the reference classification for Zanzibar Island:

$$P_D = \sum W_i \left(\frac{n_{i2}}{n_i} \right) = 0.605 \left(\frac{2}{334} \right) + 0.175 \left(\frac{26}{50} \right) + 0.219 \left(\frac{40}{150} \right) = 0.15$$

An estimator of the total area (based on the reference classification) of category j was computed from column total ($p_{.j}$) and map total area (A_{tot}) same as for Mainland Tanzania (equation 5). Therefore, the post-stratified estimators of the area of deforestation for the Zanzibar Island:

$A_D = A_{tot} \times P_D = 250{,}102 \times 0.15 = 37{,}515.30$ ha

The estimated standard error of the estimated area proportion for Mainland Tanzania was computed using Olofsson et al. (2013) equation (Equation 6a). For Zanzibar no adjustment to Olofsson et al. (2013) equation was needed because Zanzibar plots didn't have clusters.

Therefore, for the Zanzibar Island:

$$SE(P_D) = \sqrt{0.605^2 \left(\frac{\frac{2}{334}\left(1-\frac{2}{334}\right)}{334-1} \right) + 0.175^2 \left(\frac{\frac{26}{50}\left(1-\frac{26}{50}\right)}{50-1} \right) + 0.219^2 \left(\frac{\frac{40}{150}\left(1-\frac{40}{150}\right)}{150-1} \right)} = 0.01501$$

The standard error for the error-adjusted estimated area of deforestation for Zanzibar Island was also computed using Olofsson et al. (2013) standard error equation (7):

$SE(A_D) = SE(P_{.D}) \times A_{tot}$

$SE(A_D) = 0.01501 \times 250{,}102 = 3{,}754$ ha

This gives a final deforestation estimate with a margin of error (at approximate 95% confidence interval) of:

$A_D \pm 1.96\ SE\ (A_D)$ = **37,515.30 ± 7360 ha**

Therefore, the uncertainty value is:

100 x (7360/**37,515.30**) = **19.62%**

The annual deforestation is 37,515.30 ha/8 years = **4,689 ha/year**

The observed deforestation rate in this submission differs from previous studies because of the differences in forest definition, approaches used, different window periods considered and lack of accuracy and uncertainty assessment in the previous estimates.

The mapped and the adjusted Activity data for each forest cover sub-classes are shown in Table 5. These sub-classes are only those where deforestation has taken place.

Table 5: Mapped and Adjusted deforestation (Activity data) for each forest cover sub-Classes

Sub-national coverage	Land cover name	Map Change (2002-2013)		Area estimates (Adjusted Map Change)	
		Area ha (2002-2013)	Annual Deforestation (ha/year)	Area ha (2002-2013)	Annual Deforestation (ha/year)
Mainland Tanzania	Closed woodland	632,233	57,476	509,565	46,324
	Mangrove forest	19,454	1,769	15,679	1,426
	Montane & Lowland	40,964	3,724	33,016	3,001
	Open woodland	5,341,483	485,589	4,305,112	391,371
	Thickets	40,079	3,644	32,303	2,937
	Wooded crops	332,484	30,226	267,974	24,361
	Total	**6,406,697**	**582,427**	**5,163,650**	**469,420**
Zanzibar Islands	Coral rag vegetation	16,025	2,003	19,719	2,464
	High forest	281	35	346	43
	Mangrove forest	1,081	135	1,330	166
	Mixture of tree and agricultural crops	9,062	1,133	11,151	1,394
	Wooded crops	4,038	505	4,969	621
	Total	**30,487**	**3,811**	**37,515**	**4,689**

4.3.2 Activity data for reserved areas

Reserved areas in Tanzania constitute about half of the forest area of the country. Since they are formally managed, it is much easier to change the trend of emissions by interventions. The REDD+ activity, which is considered in this submission for the reserved areas, is deforestation only. Shapefiles for wildlife reserves were obtained from the United Nations Environment programme and shapefiles for nature forest reserve and forest reserves were obtained from Tanzania Forest Service Agency. The shapefile polygons for the reserved areas were overlaid with land cover change maps of the entire Tanzania. The approach of obtaining activity data within the reserved areas with total area of 26,250,525 ha are therefore the same as the approach used to obtain activity data for Mainland Tanzania or Zanzibar. The annual deforestation for reserved areas is 97,101.46 ha/year for Mainland Tanzania and 3,251 ha/year for Zanzibar.

4.4 Emission factors

Emission factors were obtained from NAFORMA and ZWBS. As pointed out in Chapter one, NAFORMA was carried out from 2009 to 2013 while ZWBS was carried out from 2012. NAFORMA was the first NFI for Mainland Tanzania, while the 2012 ZWBS was preceded by the previous inventory carried out in 1997.

Emission factors used in this submission were based on Land Cover Classification that is consistent with the Activity data (Table 1). The four primary classes of land cover are, Forest, Non-Forest, Water and Wetlands. Each primary class consists of several land cover sub-classes, which are based on the land cover classification used by NAFORMA and ZWBS. Each primary class and its corresponding land cover sub-class for Mainland Tanzania and Zanzibar are presented in Tables 6 and 7 respectively.

Table 6: Classification of land cover types in Mainland Tanzania

Land cover sub-class	**Primary class**
Woodland: Closed (>40%)	Forest: Closed woodland
Forest: Plantation	Forest: Forest plantation
Forest: Mangrove	Forest: Mangrove forest
Forest: Humid Montane	Forest: Montane and lowland
Forest: Lowland	Forest: Montane and lowland
Bushland: Dense	non forest
Bushland: Emergent trees	non forest
Bushland: Open	non forest
Bushland: Scattered cultivation	non forest
Cultivated land: Agro-forestry system	non forest
Cultivated land: Grain crops	non forest
Cultivated land: Herbaceous crops	non forest
Grassland: Bushed	non forest
Grassland: Open	non forest
Grassland: Scattered cropland	non forest
Grassland: Wooded	non forest
N/A	non forest
Open land: Bare soil	non forest
Open land: Rock outcrops	non forest
Open land: Salt crusts	non forest
Other areas	non forest
Woodland: Open (10-40%)	Forest: Open woodland
Bushland: Thicket	Forest: Thickets
Bushland: Thicket with emergent trees	Forest: Thickets
Water: Inland water	Wetland
Water: Swamp	Wetland
Cultivated land: Mixed tree cropping	Forest: Wooded crops
Cultivated land: Wooded crops	Forest: Wooded crops
Woodland: Scattered cropland (Unspecified density)	Forest: Wooded crops

Table 7: Classification of land cover types in Zanzibar

Land cover sub-class	Primary class
Low coral rag vegetation	Forest: Coral rag vegetation
Intermediate coral rag vegetation	Forest: Coral rag vegetation
High coral rag forest	Forest: Coral rag vegetation
High forest	Forest: High forest
Other native bushland	Non forest
Mangrove	Forest: Mangrove
Forest tree plantations	Forest: plantation
Rubber plantations	Forest: Wooded crop
Clove plantations	Forest: Wooded crop
Coconut plantations	Forest: Wooded crop
Mixture of trees and agricultural crops	Forest: Mixture of trees and agricultural crops
Large-scale field assortments	Non forest
Subsistence agriculture	Non forest
Paddy fields (rice / sugar cane)	Non forest
Mixed woody vegetation	Non forest
Towns and villages	Non forest
Other built-up areas	Non forest
Bare land areas	Non forest

Emission factors for the current FREL is defined as the difference between the total carbon densities (t/ha) before and after deforestation. The total carbon stock density (t/ha) is the sum of the carbon in the AGB, BGB and DWB pools associated with the land cover primary classes from NAFORMA and ZWBS. It was assumed that the carbon density after deforestation would not be zero. Accordingly, after deforestation, carbon density was derived from non-forest land cover primary classes using NAFORMA and ZWBS data. Details of the NAFORMA are presented in MNRT (2015), available at http://www.tfs.go.tz/resources/view/naforma-report-2015 and those for ZWBS are presented in RGoZ (2013) available at http://www.indufor.fi/zanzibar-woody-biomass-survey-tanzania-2012-2013).

Procedures used to estimate emission factors (EF) for the respective land cover classes are as follows:

(i) Estimating the AGB and BGB values of each tree measured in the NAFORMA/ZWBS plots, using appropriate allometric equations, developed for different vegetation types in Tanzania and obtaining plot levels values scaled up to per ha level (Appendix 4 and see also Malimbwi et al., 2016).

DWB was estimated as the product of volume and specific wood density. Volume was computed using Smalian formula (the average of the cross section area at the top and bottom of the dead wood log multiplied by its length). Species-specific wood density values from the Global Wood Density database (Chave et

al., 2009; Zanne et al., 2009) were applied. For cases where species-specific wood density values were missing from the database, a default wood density value of 500 kg m^{-3} (MNRT, 2015) was applied. Irrespective of species, a wood density reduction factor of 0.97 was used for solid woods and 0.45 was used for the more decayed wood (Harmon and Sexton, 1996 in IPCC, 2006);

(ii) Stratifying the NAFORMA/ZWBS plots into appropriate land cover sub-classes. The subclasses for non-forest land cover were further aggregated into primary land cover classes (Tables 1) that are consistent with activity data classification;

(iii) Estimating the average biomass stock per unit area for each of the land cover sub-class; and

(iv) Estimating emission factors of each primary land cover class as a mean of the land cover sub-class estimates, which were weighted by their corresponding areas. The emission factor of a given primary land cover class was therefore computed using equation (8).

$$Y_i = \frac{\sum_{i=1}^{n} (X_i \times a_i)}{\sum_{i=1}^{n} a_i} \quad \ldots\ldots (8)$$

Where Y is the weighted estimate of AGB, BGB or DWB per ha, *a* is the area of land cover sub-class *i*, X is AGB, BGB or DWB per ha of the land cover sub-class and *n* is the number of land cover sub-classes in the primary land cover class.

(v) Calculating Emission Factors for each primary land cover class as the sum of AGB, BGB and DWB, and then multiplied by a factor of 0.47 to convert the biomass to carbon (IPCC, 2006).

(vi) Calculation of uncertainty of the EFs in each land cover class followed the procedure described in equation 3.2 of IPCC (2006) (Equation 9). Errors were weighted and propagated for parameters with the same units of measurement.

$$U_{total} = \frac{\sqrt{(U_1 \times X_1)^2 + (U_2 \times X_2)^2 + \ldots + (U_n \times X_n)^2}}{|X_1 + X_2 + \ldots + X_n|} \quad \ldots\ldots (9)$$

Where:

U_{total} = percentage uncertainty of the sum of quantities (half the 95% confidence interval, divided by the total (i.e. the mean) and expressed as a percentage). The term “uncertainty” is based on the 95% confidence interval.

x_i and U_i = uncertainty quantity and the associated percentage uncertainties, respectively.

Uncertainty associated with allometric equations was not considered. Estimation of error propagation requires errors of the parameter estimates of the allometric equations. Such errors have not been reported for most of the allometric equations used in estimation of EF. To generate such errors would require re-fitting of the allometric equations. This will be considered in future submissions. In this case, the quality of data and the method, which were used to obtain EF is high and correspond to Tier 3 (for details see Table 8).

Table 8: Emission factors for each Land cover sub-Class

Location	Land cover sub-Classes	Carbon (ton/ha)	CI (ton/ha)	Uncertainty (%)
Mainland Tanzania	Closed woodland	47.82	0.30	0.62
	Forest plantation	25.19	0.36	1.44
	Mangrove forest	78.86	0.62	0.78
	Montane and lowland	66.90	1.04	1.56
	Open woodland	29.93	0.37	1.24
	Thickets	12.40	0.17	1.34
	Wooded crops	14.77	0.64	4.34
	Overall for forest	**33.35**	**0.31**	**0.93**
	Wetland	4.28	0.48	11.3
	Non forest	5.81	0.10	1.8
Zanzibar	Coral rag vegetation	3.56	0.09	2.6
	Forest plantation	6.50	2.08	32.0
	High forest	19.42	2.51	13.0
	Mangrove	7.88	2.16	27.4
	Mixture of trees and agricultural Crops	11.66	2.76	23.7
	Wooded crop	15.82	2.25	14.2
	Overall for forest	**12.26**	**0.91**	**7.46**
	Non forest	5.73	1.23	21.4

5. THE FREL CALCULATION AND RESULTS

The national FREL consists of two sub-national FRELs namely, Mainland Tanzania and Zanzibar (Fig. 1). Each sub-national FREL was computed as shown in equation 10.

$$FREL = Area_{Activity}\, x\left(EF_{Forest} - EF_{Non-Forest}\right) \quad \text{(10)}$$

For reserved areas, activity data were obtained as shown in section 4.3.2 and for the emission factor as shown in the procedure under section 4.4, and were estimated by applying equation 10 for Mainland Tanzania and Zanzibar (See Tables 9 and 10). To obtain the carbon dioxide equivalent (tCO_2e) the FREL generated using equation 10 was multiplied by a factor of 3.667.

Uncertainty of FREL was obtained by combining uncertainty of EF and that of AD using equation 11 (i.e. equation 3.1 in IPCC 2006 guideline).

$$U_{total} = \sqrt{U_1^{\,2} + U_2^{\,2} + ... + U_n^{\,2}} \quad \text{(11)}$$

Where U_{total} = percentage uncertainty of the product of quantities (half the 90% confidence interval, divided by the total and expressed as a percentage); U_i = percentage uncertainty associated with each of the quantities.

Table 9: The Tanzanian Forest Reference Emission Level

Scope	Annual Activity Data (ha/year)	FREL (tCO_2e/year)	Overall Uncertainty %
Mainland Tanzania (Sub-National 1)	469,420	43,673,924 ± 5,337,447	12
Zanzibar (Sub-National 2)	4,689	63,050 ± 13,234	21
Total National FREL		**43,736,974 ± 5,337,463**	**12**

Table 10: Activity data, Emission Factors and FREL for Reserved Areas

Scope	Annual Activity Data (ha/year)	FREL (tCO_2e/year)	Overall Uncertainty %
Mainland Tanzania (Sub-National 1)	97,101.46	7,179,786 ± 861,263	12
Zanzibar (Sub-National 2)	170.62	3,251 ± 848	26
Total FREL		**7,183,038 ± 861,653**	**12**

The current FREL for Tanzania is therefore estimated at 43,736,974 tCO_2e/year. This is about 0.69% of the total amount of 6,327,717,997 tCO_2e stock in the forested land of Tanzania (MNRT, 2015).

6. EXPECTED IMPROVEMENTS

Tanzania will take advantage of stepwise approach to improve the current FREL overtime by incorporating more REDD+ activities, better data, improved methodologies and, where appropriate, additional pools. Furthermore, Tanzania will update her FREL periodically incorporating new knowledge, trends, or any modification of scope and methodologies.

To-date, in REDD+-MRV the assessment of forest degradation is one of the challenges. In this submission, we used landsat for determination of activity data which cannot detect degradation sufficiently. Ideally, degradation could be detected through long term ground observations on permanent sample plots in combination with the use of very high resolution remote sensing data.

As an effort to generate ground observations, the first NAFORMA was concluded and reported in 2015. This was just a one-time inventory, which needs future data for the detection of change, which could be degradation. Repeated measurements from NAFORMA and ZWBS will provide data not only for forest degradation but also for enhancement and conservation of carbon stocks. These inventory data together with anticipated decreasing costs and availability of remote sensing data of higher spatial and temporal resolution will allow inclusion of the remaining REDD+ activities in future FREL. However, availability of data for sustainable forest management is still a challenge, which may be addressed in the distant future.

Soil data were partially collected and analyzed by NAFORMA and ZWBS and thus, they could not be used. Monitoring of soil organic carbon will be possible in the future when the analysis of soil data is completed and repeated measurement from NAFORMA and ZWBS made available.

Ideally, the number of data points should be sufficient to understand the dynamics and possible trends in historical emissions. This would enhance a country's capacity in identifying key national circumstances to be considered, and choose the most appropriate FREL/FRL construction approach. However, the choice of data points in this submission was constrained by availability of historical data. In the future, with

availability of promising remote sensing sensors and ground re-measurement more data point will be included.

Tanzania has started the process of establishing her National Carbon Monitoring Centre (NCMC). This centre will harness human and technical capacity that will improve and implement a robust MRV system in order to improve the future FREL.

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APPENDICES

Appendix 1: List of technical institutions, experts and stakeholders who participated in the development of the FREL

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12.	Ms. Namkunda Johnson	National Carbon Monitoring Centre
13.	Dr. Belachew G. Zeleke	Norwegian Institute of Bioeconomy Research

Appendix 2: List of Landsat 7 ETM+ and Landsat 8 OLI that were downloaded for the activity data

Landsat 7 Images	Landsat 8 Images
LE71640672002205SGS00	LC81650652013282LGN00
LE71650652002276SGS00	LC81650652013346LGN00
LE71650662001209EDC00	LC81650662013154LGN00
LE71650662001257SGS00	LC81650662013186LGN00
LE71650662002132SGS00	LC81650662013282LGN00
LE71650662002212EDC01	LC81650672013154LGN00
LE71650672002228JSA00	LC81650672013170LGN00
LE71650672002244EDC00	LC81650682013170LGN00
LE71650682002244EDC00	LC81650682013218LGN00
LE71660632002203SGS00	LC81650682013250LGN00
LE71660632002315SGS00	LC81660632013145LGN00
LE71660642001200SGS00	LC81660632013337LGN00
LE71660642001264SGS00	LC81660642013193LGN00
LE71660642002203SGS00	LC81660642013257LGN00
LE71660642002219JSA00	LC81660642013353LGN00
LE71660642002315SGS00	LC81660652013193LGN00
LE71660652002219JSA00	LC81660652013257LGN00
LE71660662002219JSA00	LC81660662013145LGN00
LE71660672001248SGS00	LC81660662013209LGN00
LE71660672001264JSA00	LC81660662013241LGN00
LE71660672001312SGS00	LC81660662013257LGN00
LE71660672002203JSA00	LC81660672013209LGN00
LE71660672002203JSA00	LC81660672013257LGN00
LE71660672002219JSA00	LC81660682013257LGN00
LE71660682002267SGS00	LC81670632013184LGN00
LE71670622002194SGS00	LC81670632013360LGN00
LE71670632002194SGS00	LC81670642013168LGN00
LE71670642001239EDC00	LC81670642013184LGN00
LE71670642002274SGS00	LC81670642013360LGN00
LE71670642002322SGS00	LC81670652013168LGN00
LE71670652001191SGS00	LC81670652013184LGN00
LE71670652001239EDC00	LC81670652013312LGN00
LE71670652002274SGS00	LC81670662013168LGN00
LE71670662001239EDC00	LC81670662013296LGN00
LE71670662002274SGS00	LC81670662013312LGN00
LE71670672002274SGS00	LC81670672013200LGN00
LE71670682002274SGS00	LC81670672013296LGN00
LE71680622002153SGS00	LC81670682013296LGN00
LE71680622002345SGS00	LC81680622013271LGN00
LE71680632002249SGS00	LC81680632013271LGN00
LE71680642002249SGS00	LC81680642013271LGN00
LE71680652002249SGS00	LC81680652013191LGN00
LE71680662002169SGS01	LC81680652013271LGN00
LE71680662002249SGS00	LC81680662013271LGN00
LE71680662002265JSA00	LC81680672013271LGN00
LE71680672002169SGS01	LC81680682013271LGN00
LE71680672002249SGS00	LC81690612013246LGN00
LE71680672002265JSA00	LC81690612013278LGN00
LE71680682002249SGS00	LC81690622013278LGN00
LE71690612002256SGS00	LC81690622013294LGN00
LE71690622002192SGS00	LC81690632013294LGN00
LE71690632002256JSA00	LC81690642013262LGN00
LE71690642002256JSA00	LC81690642013294LGN00

LE71690652002256JSA00	LC81690652013262LGN00
LE71690662002192JSA00	LC81690652013294LGN00
LE71690662002208JSA00	LC81690662013294LGN00
LE71690662002240JSA00	LC81690672013294LGN00
LE71690662002256EDC00	LC81700612013205LGN00
LE71690662002272JSA00	LC81700632013285LGN00
LE71690672002240JSA00	LC81700642013285LGN00
LE71690672002272JSA00	LC81700662013253LGN00
LE71700612002247SGS00	LC81710612013196LGN00
LE71700622002183JSA00	LC81710622013196LGN00
LE71700622002247SGS00	LC81710632013196LGN00
LE71700632002231SGS00	LC81710642013228LGN00
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LE71710642002270SGS00	
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LE71710662002270SGS00	
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LE71720612001274SGS00	
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LE71720612002325EDC01	
LE71720622002229EDC00	
LE71720632002229EDC00	
LE71720632002245JSA00	
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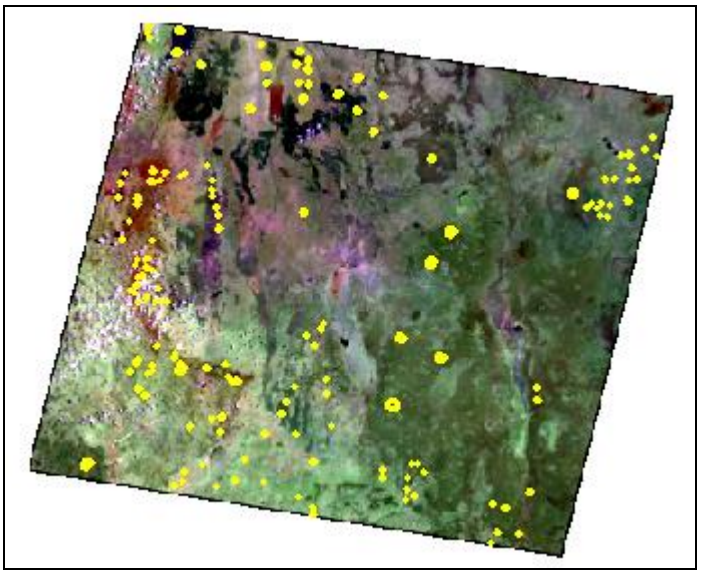
LE71720642002261JSA00	
LE71720652002245JSA00	
LE71720652002261JSA00	

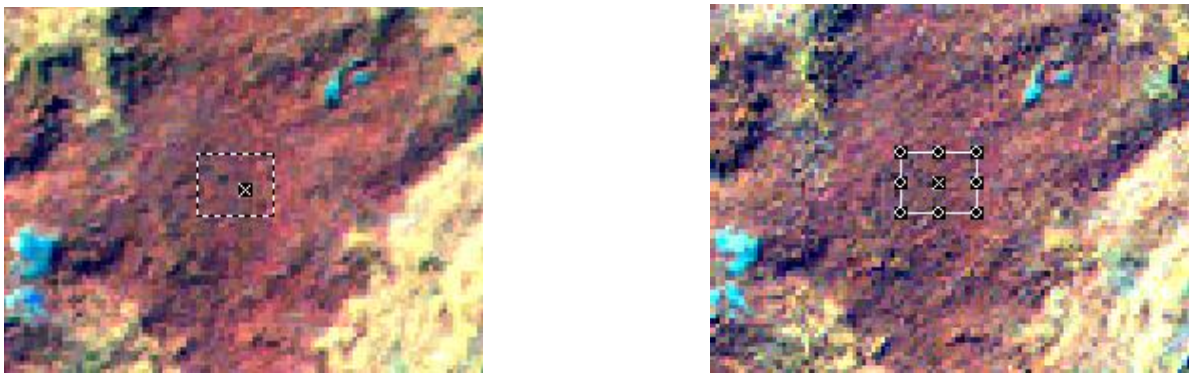
Appendix 3: Additional text to clarify the image processing approach

For each class a handful of training site polygons even distributed over the image scene were digitized. Appendix 3-Figure 1 gives an example on how the training data was distributed over the image scene.

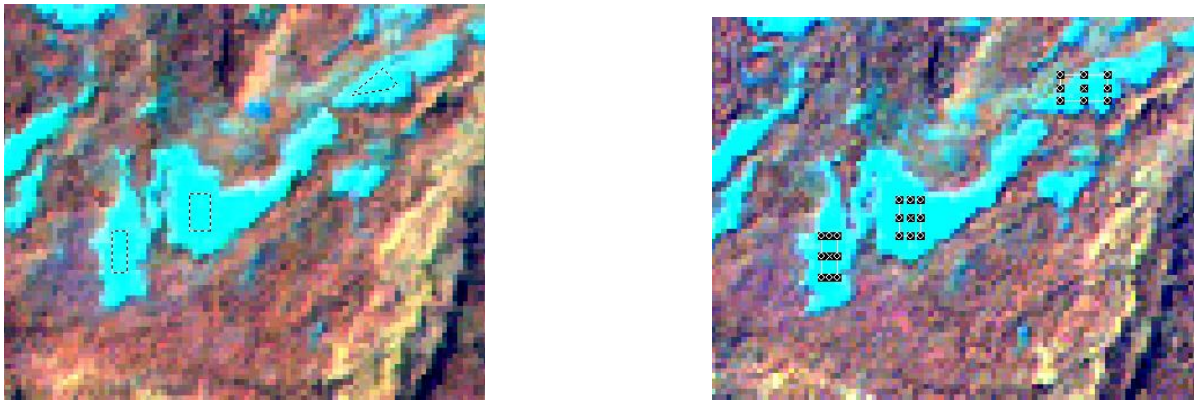


Appendix 3-Figure 1: Distribution of training data over the scene (p168r63_2002-2013)

The size and number of the training areas varied depending on several factors including the complexity of the landscape. It was important to include the range of spectral patterns that thoroughly represent each class, and this meant collecting signatures from throughout the scene. It was also important to have sub-classes for each class. For example, mangrove, woodland and montane forests were trained separately and combined (recoding) later to form the classes “forest-forest and forest-non”. Similarly, a number of subclasses for non-non-class were introduced during training phase. Appendix 3-Figures 2a-2d provide an example of how forest-forest, non-non, and forest-non-classes appear on a colour composite (RGB 453) image. Forest-forest indicates an area that was forest in 2002 and also in 2013, non-non-indicates an area that was non-forest on both dates, and forest-non-indicates an area that experienced deforestation between the two dates.

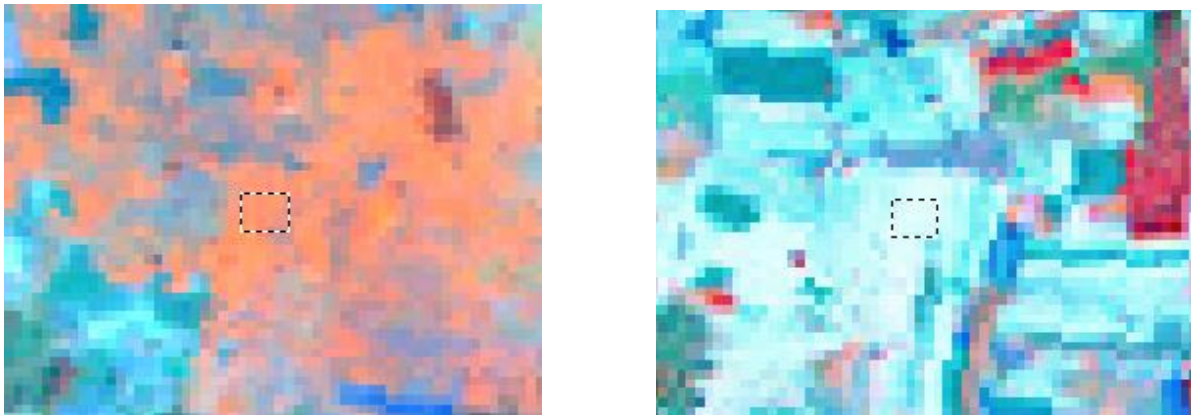


Appendix 3-Figure 2a: Forest in both dates (deep reds are indicators of mature, closed-canopy forest)

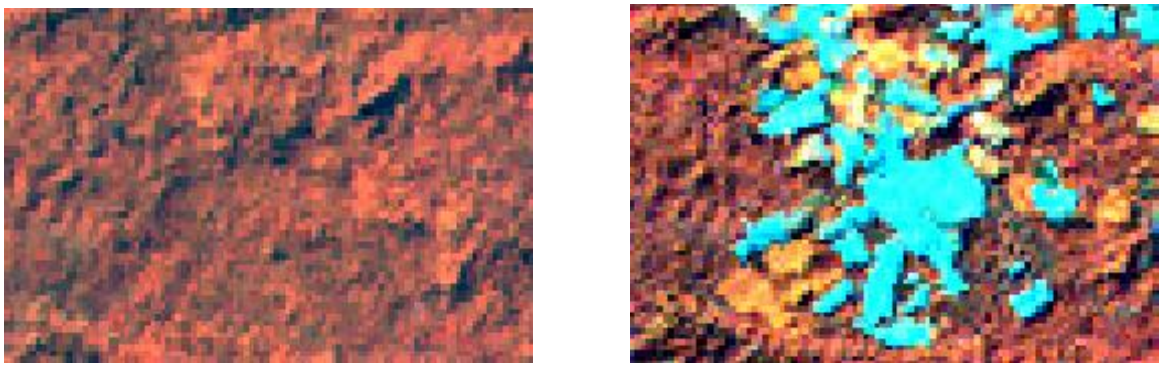


Appendix 3-Figure 2b (i): Non-forest in both dates - blue (bright blue is usually a cleared area or field)

Another important non-to non-class to capture was vegetated fields or secondary growth that changed to dry fields. These can be tricky because the signature sometimes looks like bright forest, which may result in a misclassification of deforestation. (Similarly, secondary growth forest that is logged would cause the same problem.) In the example below, vegetated fields appear orange in the early date while dry fields appear blue in the later date.



Appendix 3-Figure 2b (ii): Non-forest in both dates



Appendix 3-Figure 2c: Forest loss or deforestation (generally indicated by a change from red in the first scene to either blue or yellow in the second scene).

Appendix 4: Allometric biomass and volume equations for different vegetation types in Tanzania

Veg Type	Species	AGB	Source	BGB	Source	Volume (m^3)	Source
Forest: Humid Montane	All	$0.3571 \times dbh^{1.744} \times ht^{0.4713}$	Mugasha et al., 2016	AGB×0.25	MNRT, 2015		
Forest: Lowland	All	$0.3571 \times dbh^{1.744} \times ht^{0.4713}$	Mugasha et al., 2016	AGB×0.25	MNRT, 2015		
Forest: Mangrove	*Avicenia marina*	$0.25128 \times dbh^{2.24351}$	Njana et al., 2015	$1.42040 \times dbh^{1.44260}$	Njana et al., 2015		
	Soneratia alba	$0.25128 \times dbh^{2.21727}$	Njana et al., 2015	$1.42040 \times dbh^{1.65760}$	Njana et al., 2015		
	Rhizophora mucronata	$0.25128 \times dbh^{2.26026}$	Njana et al., 2015	$1.42040 \times dbh^{1.68979}$	Njana et al., 2015		
	Others	$0.19633 \times dbh^{2.010853} \times ht^{0.29654}$	Njana et al., 2015	$1.42040 \times dbh^{1.59666}$	Njana et al., 2015		
Forest: Plantation	*Tectona grandis*	$0.1711 \times dbh^{2.0047} \times ht^{0.3767}$	Mugasha et al., 2016	$0.0279 \times dbh^{1.7430} \times ht^{0.7689}$	Mugasha et al., 2016		
	Pinus patula	$0.0550 \times dbh^{2.5968}$	Mugasha et al., 2016	$0.0027 \times dbh^{3.0579}$	Mugasha et al., 2016		
	Eucalyptus spp	volume×843×1.4	IPCC, 2006; MNRT, 2015	AGB×0.25	Petro et al., 2015	$0.000065 \times dbh^{1.633} ht^{1.137}$	Malimbwi and Mbwambo, 1990
	Grevillea robusta	volume×609×1.4	IPCC, 2006; MNRT, 2015	AGB×0.25	Petro et al., 2015	$0.000065 \times dbh^{1.633} ht^{1.137}$	
	Others	volume×500×1.4	IPCC, 2006; MNRT, 2015	AGB×0.25	MNRT, 2015	$0.5 \times 3.14 \times (0.01 \times dbh/2)^2 \times ht$	Haule and Munyuku, 1994
Woodland: Closed (>40%)	All	$0.0763 \times dbh^{2.2046} \times ht^{0.4918}$	Mugasha et al., 2013	$0.1766 \times dbh^{1.7844} ht^{0.3434}$	Mugasha et al., 2013		
	Baobab	$2.234966 \times dbh^{1.43543}$	Masota et al., 2016	AGB×0.25	Masota et al., 2016		
	Dalbergia melanoxylon	Volume×1060×1.4	IPCC, 2006; MNRT, 2015	AGB×0.25	MNRT, 2015	$0.00023 \times dbh^{2.231}$	Malimbwi, 2000
Woodland: Open (10-40%)	All	$0.0763 \times dbh^{2.2046} \times ht^{0.4918}$	Mugasha et al., 2013	$0.1766 \times dbh^{1.7844} ht^{0.3434}$	Mugasha et al., 2013		
	Baobab	$2.234966 \times dbh^{1.43543}$	Masota et al., 2016	AGB×0.25	Masota et al., 2016		
	Dalbergia melanoxylon	Volume×1060×1.4	IPCC, 2006; MNRT, 2015	AGB×0.25	MNRT, 2015	$0.00023 \times dbh^{2.231}$	Malimbwi, 2000
Bushland: Thicket, dense	*Pseudoprosopis fischeri*	$0.4276 \times dbh^{2.4053}\ st^{0.5290}$	Makero et al., 2016	$0.1442 \times dbh^{4.1534}\ st^{0.4117}$	Makero et al., 2016		
	Combretum celastroides	$0.7269 \times dbh^{2.6710} \times ht^{0.5737}\ st^{0.2039}$	Makero et al., 2016	$0.1006 \times dbh^{4.0062}\ st^{0.33499}$	Makero et al., 2016		
	Baobab	$2.234966 \times dbh^{1.43543}$		AGB×0.25	Masota et al., 2016		
Bushland: Emergent trees	All	$1.2013 \times dbh^{1.5076}$	Makero et al., 2016	$1.3803 \times dbh^{1.1671}$	Makero et al., 2016		
Bushland: Thicket with emergent trees	All	$1.2013 \times dbh^{1.5076}$	Makero et al., 2016	$1.3803 \times dbh^{1.1671}$	Makero et al., 2016		
Bushland: Open	others	$0.0763 \times dbh^{2.2046} \times ht^{0.4918}$	Mugasha et al., 2013	$0.1766 \times dbh^{1.7844} ht^{0.3434}$	Mugasha et al., 2013		

Veg Type	Species	AGB	Source	BGB	Source	Volume (m^3)	Source
	Acacia and Commiphora spp	$0.0292 \times dbh^{2.0647} \times ht^{1.0146}$	Mugasha et al., 2016	$0.0593 \times dbh^{1.4481} \times ht^{1.0210}$	Mugasha et al., 2016		
Grassland: Wooded	Others	$0.0763 \times dbh^{2.2046} \times ht^{0.4918}$		$0.1766 \times dbh^{1.7844} ht^{0.3434}$	Mugasha et al., 2013		
	Acacia and Commiphora spp	$0.0292 \times dbh^{2.0647} \times ht^{1.0146}$	Mugasha et al., 2016	$0.0593 \times dbh^{1.4481} \times ht^{1.0210}$	Mugasha et al., 2016		
	Baobab	$2.234966 \times dbh^{1.43543}$	Masota et al., 2016	AGB×0.25	Masota et al., 2016		
Grassland: Bushed Grassland: Open	Others	$0.0763 \times dbh^{2.2046} \times ht^{0.4918}$	Mugasha et al., 2013	$0.1766 \times dbh^{1.7844} ht^{0.3434}$	Mugasha et al., 2013		
	Acacia and Commiphora spp	$0.0292 \times dbh^{2.0647} \times ht^{1.0146}$	Mugasha et al., 2016	$0.0593 \times dbh^{1.4481} \times ht^{1.0210}$	Mugasha et al., 2016		
	Baobab	$2.234966 \times dbh^{1.43543}$	Masota et al., 2016	AGB×0.25	Masota et al., 2016		
Woodland: Scattered cropland (Unspecified density)	All	$0.0763 \times dbh^{2.2046} \times ht^{0.4918}$	Mugasha et al., 2016	$0.1766 \times dbh^{1.7844} ht^{0.3434}$	Mugasha et al., 2013		
	Baobab	$2.234966 \times dbh^{1.43543}$	Masota et al., 2016	AGB×0.25	Masota et al., 2016		
Bushland: Scattered cultivation	All	$1.2013 \times dbh^{1.5076}$	Makero et al., 2016	$1.3803 \times dbh^{1.1671}$	Makero et al., 2016		
	Baobab	$2.234966 \times dbh^{1.43543}$	Masota et al., 2016		Masota et al., 2016		
Grassland: Scattered cropland	All	$1.2013 \times dbh^{1.5076}$	Makero et al., 2016	$1.3803 \times dbh^{1.1671}$	Makero et al., 2016		
Cultivated land: Agro-forestry system	All	$0.051*(dbh^2*ht)^{0.93}$	Henry et al., 2009	AGB×0.25			
Cultivated land: Wooded crops	Coconuts trees	$3.7964 \times ht^{1.8130}$		$13.5961 \times ht^{0.6635}$	Zahabu et al., 2016		
	Cashewnuts	$0.3152 \times dbh^{1.7722} ht^{0.5003}$		AGB×0.25	Zahabu et al., 2016		
	Others	$0.0763 \times dbh^{2.2046} \times ht^{0.4918}$		$0.1766 \times dbh^{1.7844} ht^{0.3434}$	Mugasha et al., 2013		
Cultivated land: Herbaceous crops	All	$0.051*(dbh^2*ht)^{0.93}$	Henry et al., 2009	AGB×0.25	MNRT, 2015		
Cultivated land: Mixed tree cropping	All	$0.051*(dbh^2*ht)^{0.93}$	Henry et al., 2009	AGB×0.25	MNRT, 2015		
Cultivated land: Grain crops	All	$0.051*(dbh^2*ht)^{0.93}$	Henry et al., 2009	AGB×0.25	MNRT, 2015		
Open land: Bare soil	All	volume×500×1.4	IPCC, 2006; MNRT, 2015	AGB×0.25	MNRT, 2015	$0.5 \times 3.14 \times (0.01 \times dbh/2)^2 \times ht$	Haule and Munyuku, 1994
Open land: Salt crusts	All	volume×500×1.4	IPCC, 2006; MNRT, 2015	AGB×0.25	MNRT, 2015	$0.5 \times 3.14 \times (0.01 \times dbh/2)^2 \times ht$	Haule and Munyuku, 1994
Open land: Rock outcrops	All	volume×500×1.4	IPCC, 2006; MNRT, 2015	AGB×0.25	MNRT, 2015	$0.5 \times 3.14 \times (0.01 \times dbh/2)^2 \times ht$	Haule and Munyuku, 1994
Water: Inland water	All	volume×500×1.4	IPCC, 2006; MNRT, 2015	AGB×0.25	MNRT, 2015	$0.5 \times 3.14 \times (0.01 \times dbh/2)^2 \times ht$	Haule and Munyuku, 1994
Water: Swamp	All	volume×500×1.4	IPCC, 2006; MNRT, 2015	AGB×0.25	MNRT, 2015	$0.5 \times 3.14 \times (0.01 \times dbh/2)^2 \times ht$	Haule and Munyuku, 1994
Other areas	All	volume×500×1.4	IPCC, 2006; MNRT, 2015	AGB×0.25	MNRT, 2015	$0.5 \times 3.14 \times (0.01 \times dbh/2)^2 \times ht$	Haule and Munyuku, 1994

Remarks: For Thicket and dense bushland, the variable ST stands for number of stems in a clump. This variable should be “1”.

Appendix 5: Differences in national deforestation estimates between current FREL submission and previous estimates (i.e. NAFORMA, FAO-FRA etc.).

The observed rate of deforestation in this submission is different from previous deforestation estimates in Tanzania because:

(i) The approaches used are different,
(ii) The years considered are also different,
(iii) Lack of accuracy assessment in the other deforestation estimation approaches. In this submission, accuracy assessment employed ground data collected by NAFORMA.

Differences in the approaches: For example, NAFORMA compared forest statistics from two LULC classifications, i.e. NAFORMA and Huntings, while FREL in this submission used a wall-to-wall pixel comparison. According to literature, pixel-to-pixel comparison produces better results than post-classification comparison, which tends to accumulate errors from the two independently classified layers. Moreover, NAFORMA Team used a sampling approach where 860 sample sites were used while this submission was based on wall-to-wall pixel comparison.

For the Hansen Global Forest Maps, global dataset usually tends to over or underestimate areas of land cover classes because of scale and limited local knowledge. Furthermore, Hansen global forest maps are difficult to compare to FREL, when the tree-cover does not necessarily mean Forest cover and that our crown cover does not necessarily translate into tree-cover percentage of Hansen. In the current estimation, accuracy assessment employed ground data collected by NAFORMA, which is better compared, to FRA that was limited to expert opinion.

The land cover sub classes used in the FRA and their relation with the classes used in the FREL are as shown in Appendix 5-Table 1. It appears that most of the Primary Classes in the two cases are similar. The noted differences were on:

- The Bushland: Thicket and Woodland: Scattered cropland; were considered as other wooded land in the FRA while in the FREL they are forest because they have a minimum height of 3 m.
- Cultivated land: Wooden crops and Cultivated land: Mixed tree cropping; were considered as other land in the FRA while in the FREL they are forest because they cover large area in the country with a distinct continuous cover.

- The approach we adopted in the FREL did not put emphasis on the land use after deforestation. Instead the focus was on Land cover change, i.e., a cover change that is from forest to non-forest.
- Pixel to pixel and not post-classification comparison
- In the revised submission only the forest primary class was disaggregated, it was not possible therefore to disaggregate the non-forest sub-classes since the activity chosen is Gross deforestation.

Nevertheless, the forest definitions used for FREL and FAO-FRA are different. FRA definition considered a minimum tree height of 5 m while the new forest definition used in the FREL has a minimum tree height of 3 m.

Appendix 5-Table 1: Land Cover Sub Classes used in the FAO-FRA and their relation with the classes used in the FREL

Land cover sub-class	**FREL Primary class**	**FRA sub-class**	**FRA primary class**
Bushland: Thicket	Forest	Bushland	Other wooded land
Bushland: Thicket with emergent trees	Forest	Bushland	Other wooded land
Woodland: Scattered cropland	Forest	Cultivated land	Other land
Forest: Humid Montane	Forest	Forest	Forest
Forest: Lowland	Forest	Forest	Forest
Forest: Mangrove	Forest	Forest	Forest
Forest: Plantation	Forest	Forest	Forest
Woodland: Closed (>40%)	Forest	Woodland	Forest
Woodland: Open (10-40%)	Forest	Woodland	Forest
Bushland: Dense	Non forest	Bushland	Other wooded land
Bushland: Emergent trees (<10%)	Non forest	Bushland	Other wooded land
Bushland: Open	Non forest	Bushland	Other wooded land
Bushland: Scattered cultivation	Non forest	Bushland	Other wooded land
Grassland: Scattered cropland	Non forest	Cultivated land	Other land
Cultivated land: Agro-forestry system	Non forest	Cultivated land	Other land
Cultivated land: Wooded crops	Forest	Cultivated land	Other land
Cultivated land: Herbaceous crops	Non forest	Cultivated land	Other land
Cultivated land: Mixed tree cropping	Forest	Cultivated land	Other land
Cultivated land: Grain crops	Non forest	Cultivated land	Other land
Grassland: Wooded	Non forest	Grassland	Other land
Grassland: Bushed	Non forest	Grassland	Other land
Grassland: Open	Non forest	Grassland	Other land
Open land: Bare soil	Non forest	Open land	Other land
Open land: Salt crusts	Non forest	Open land	Other land
Open land: Rock outcrops	Non forest	Open land	Other land
Other areas	Non forest	Other areas	Other land
Water: Inland water	Wetland	Water	Inland water bodies
Water: Swamp	Wetland	Water	Inland water bodies

Appendix 6: Considerations for temporary un-stocked areas

In the Tanzanian FREL document, deforestation is defined as change from forest cover to non-forest cover (Section 3.1). Therefore, in the change analysis any change from forest to non-forest cover was considered as deforestation except in forest plantations where replanting is guaranteed and therefore considered as stable forest areas. The locations of forest plantation are known (See details in Forest plantations and Woodlots in Tanzania report, African Forest Forum Working Paper Series Vol. 1, Issues 16, 2011 by Y. M. Ngaga). Therefore, provided locations are clearly defined/known, temporary un-stock plantation areas were not treated as deforestation due to their potential of attaining the status of a forest. Temporary loss of forest status to areas with unknown location and boundaries were treated as deforestation. However, at a later stage, if such lands fulfill the forest definition, they would be included as forest gain (non-forest converted to forest cover). In future, clear methodology of identifying such areas as re-stocked will be devised.

In the current FREL submission the conversion of natural forest to forest plantation is not considered as gross deforestation. In relation to the future need to provide information related to paragraph 2e in the Appendix 1 of Decision 1/CP.16, i.e. that REDD+ activities should not be used for the conversion of natural forests, but are instead used to incentivize the protection and conservation of natural forests, Tanzania will develop a system that is able to identify any area of conversion of natural forest to plantations in its future reporting system. Moreover, the country is currently in process of developing REDD+ safeguard information system, environmental standards, forest program and policy guidelines that will safeguard the natural forests.