REPUBLIC OF ZAMBIA

ZAMBIA'S FOREST REFERENCE EMISSIONS LEVEL SUBMISSION TO THE UNFCCC

January 2016

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List of Acronyms

ABC	Above Ground Carbon
ABG	Above Ground Biomass
AD	Activity Data
AFOLU	Agriculture Forestry and Land Use
BCP	Bio-Carbon Partners
BGB	Below Ground Biomass
BGC	Below Ground Carbon
CEEEZ	Center for Energy, Engineering and Environmental of Zambia
CO	Carbon Oxide
COMACO	Community Markets for Conservation
CP or COP	Conference Of Parties
DBH	Diameter at Breast Height
EF	Emission Factor
FAO	Food and Agriculture Organization of the United Nations
FD	Forestry Department
FRA	Forest Resource Assessments
FREL	Forest Reference Emission Level
FRL	Forest Reference Level
GFOI	Global Forest Observation Initiative
GHG	Green House Gas
GIS	Geographical Information System
GMA	Game Management Areas
ILUA	Integrated Land use Assessment
INDC	Intended Nationally Determined Contribution
IPCC	Inter-Governmental Policy on Climate Change
L	Litter
LC	Land Cover
LDW	Lying Dead Wood
LULUCF	Land use, Land use Change and Forestry
MLNREP	Ministry of Lands, Natural Resources and Environmental Protection
MRV	Monitoring Reporting and Verification
NAMA	Nationally Appropriate Mitigation Actions
NAP	National Agricultural Policy
NEP	National Energy Policy
NFI	National Forest Inventory
NFMA	National Forest Monitoring and Assessment
NFMS	National Forest Monitoring Systems
NFP	National Forestry Policy
NPE	National Policy on Environment
NRSC	National Remote Sensing Center
PA	Protected Areas
PFR	Protected Forest Areas

PMU	Project Management Unit
RCMRD	Regional Center for Mapping of Resource for Development
REDD+	Reduced Emission from Deforestation and Forest Degradation
SD	Survey Department
SDW	Standing Dead Wood
SeNDP	Seventh National Development Plan
SNC	Second National Communication
SNDP	Sixth National Development Plan
SOC	Soil Organic Carbon
tC	Tons of Carbon
TNC	Third National Communication
UNFCCC	United Nations Framework Convention on Climate Change
USGS	United States Geological Survey
WWF	World Wide Fund for Nature
SARPO	Southern African Regional Office

1. Introduction

Zambia welcomes the opportunity to submit a proposed Forest Reference Emissions Level (FREL) to the United Nations Framework Convention on Climate Change (UNFCCC) in response to Decision 1/CP.16 that requests developing country Parties intending to undertake REDD+ activities to develop a national FREL. The submission is presented voluntarily, and in accordance with Decision 12/CP.17 (Guidelines for Submissions of Information on Reference Levels), with a view that it will be technically assessed in the context of results-based payments in accordance with Decision 13/CP.19.

Zambia is adopting a "stepwise" approach to the development of its FREL, according to Decision 12/CP.17, and intends to make improvements over time by incorporating enhanced information, improved methodologies and additional carbon pools and activities. The proposed FREL in this document has been constructed with the best information available to Zambia at the time of submission. The data and information used in the FREL applies, where appropriate, guidance and guidelines provided by the IPCC.

The proposed FREL does not prejudge Zambia's Intended Nationally Determined Contribution or Nationally Appropriate Mitigation Actions in the land and forestry sectors undertaken by Zambia pursuant to the Bali Action Plan. However, Zambia considers that there should be a relationship between measuring such efforts and it's FREL. At this time, Zambia's objective in submitting a proposed FREL is to build capacity and to have a facilitative exchange with technical LULUCF experts from the UNFCCC roster of experts, and through such an effort, to improve the FREL as part of a stepwise approach.

Climate variability and change has become a major threat to sustainable development in Zambia. In response, the Government of Zambia has developed various climate change-related policies that include, among them, strategies and legal frameworks that provide a basis for generating positive results in the forest sector through improved land use planning and forest management. Among them are the National Policy on Environment (NPE, 2007); a new National Forestry Policy (2014); the National Energy Policy (2008); the National Agricultural Policy (2014); a National Strategy for Reducing Emissions from Deforestation and Forest Degradation (REDD+, 2015); a revision of the Forest Act No. 4 (2015); and passage of the Urban and Regional Planning Act No. 3 (2015). These policies, strategies, and laws are aligned with the Revised Sixth National Development Plan and the Vision 2030 which promotes "A prosperous middle income country by 2030", both of which support development of a low carbon and climate-resilient development pathway. The development of the Seventh National Development Plan (SeNDP, 2017-2021) is also underway.

1.1 FREL development process

The Government of Zambia, Ministry of Lands, Natural Resources and Environmental Protection (MLNREP) is the author of, and coordinating ministry for, the construction of the FREL through the project management units (PMU) of the UN-REDD and Integrated Land Use Assessment (ILUA) projects in the Forestry Department. A number of line ministries and institutions were consistently involved in generating the required information used in the construction of the FREL. These include the National Remote Sensing Centre (NRSC); Survey Department (SD); Zambia Environmental Management Agency (ZEMA); Zambia Agriculture Research Institute (ZARI); Regional Centre for Mapping of Resources for Development (RCMRD); Centre for Energy, Environment and Engineering Zambia (CEEEZ).

The technical team for the construction of the FREL is comprised of national foresters, natural and environmental scientists, GIS and remote sensing experts drawn from relevant environmental sectors and the mapping agencies of the Government, technically supported by a team of international experts and consultants from FAO. The technical team spent a considerable amount of time in consultative forums, workshop sessions and e-Communication systems to put together the FREL working document. Many of the data inputs to the FREL were generated as part of capacity development initiatives implemented by both the ILUA and the UN-REDD programs operating in Zambia.

The FREL was also subjected to wider stakeholder consultations and review to ensure that it reflected the expectations of local stakeholders, and to also consider technical inputs from this broader group. Those consulted include:

- Community Markets for Conservation (COMACO)
- Community-based Forest-management Programs (CFP)

2.0 Area Covered by the FREL

The area covered by the FREL is the total land area of Zambia (752,614 km^2) located at an altitude between 2,164 and 350m, geographically located between latitudes 8 and 18 degrees south of the equator (see Figure 1). The climate is humid subtropical, largely on the Central African Plateau, and IPCC (2006) divides the country into two Global Ecological Zones (FAO 2001). These encompass large parts of the Zambezi and Congo drainage systems and it is thus rich in water resources. It is endowed with a wealth of 16 natural ecosystems with landscapes that include extensive forests, grassy plains, hills and steep escarpments; huge lakes and rivers, deep valleys and ecologically rich wetlands together with areas of anthropogenic origin such as cropland, plantation forests and urban settlements. Therefore, the wall-to-wall mapping approach based on Landsat imagery mosaic was made to comprehensively capture the variability in land cover and use of the country.

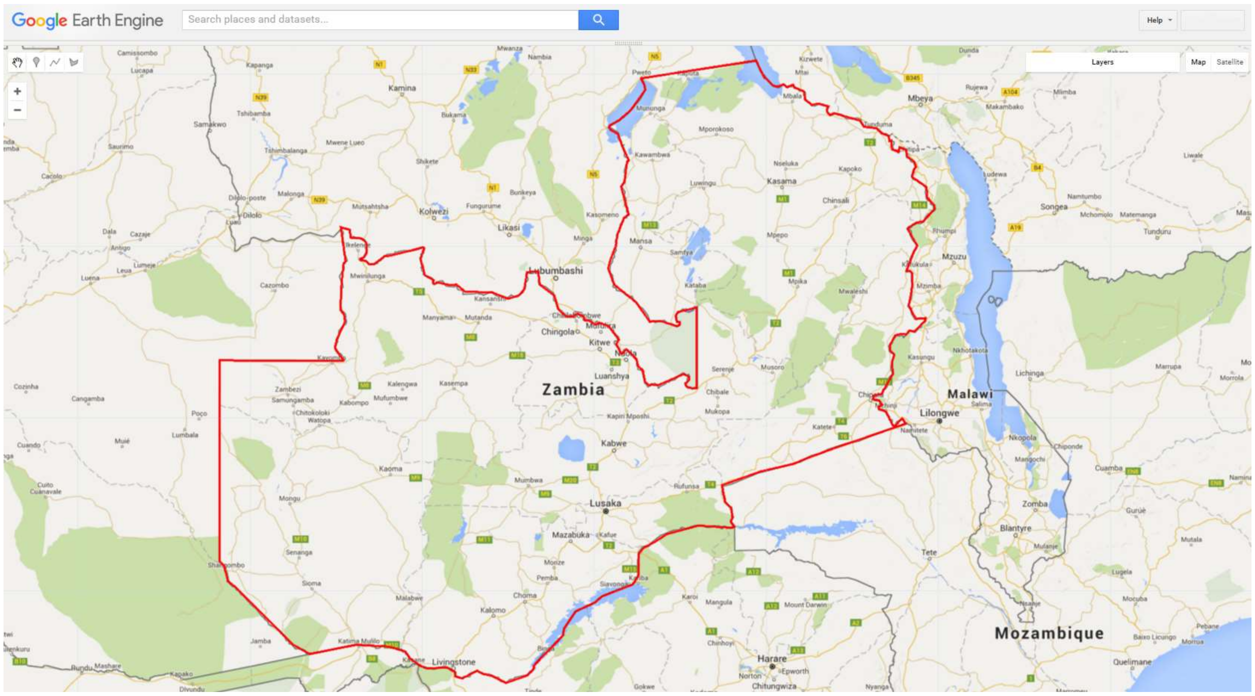

Figure 1 Map of Zambia

Floristically, Zambia is centrally placed within the Zambezian Regional Centre of Endemism, an area of approximately 3,770 million km^2, which extends from the Katanga to the Transvaal. The Zambezian phytochoria is estimated to have a floral richness of 8,500 plant species with approximately 54% endemics (Timberlake & Chidumayo, 2001). Within this regional centre of endemism, major centres of plant biodiversity include the source of the Zambezi River; the Muchinga Escarpment; the Zambian Itigi forest occurring between Lakes Tanganyika and Mweru-wa-Ntipa; the Bangweulu Basin; Copperbelt South; the Kalahari sands which cover much of western Zambia; the middle Zambezi Valley; the Kafue Flats; and the botanical and forest reserves spread across the country. The floristic diversity of Zambia is estimated between 6,000 to 7,000 species, 40% of which are shrubs and wood plants (Dodman *et. al*., 1996).

There are 10 provinces in Zambia and it is the intent of the Government to develop, as data improves, sub-national FRELs at the provincial level -- but to continue monitoring performance at the national level against the national FREL. This means that modifications and considered improvements on both the activity data and emission factors may be proposed as more refined estimates may become available applying the same methodology but possibly intensifying the data collection to be representative at the subnational scale. The sub-national processes shall also follow the step-wise approach by refining the methodologies and techniques acceptable to generate information for constructing the FRELs at that level in a more transparent and organized manner without duplication of efforts and resources.

2.1 SCOPE: ACTIVITIES, POOLS AND GASES INCLUDED

2.1.1 REDD+ activities in the FRL

Zambia's FREL includes gross deforestation only. Deforestation is defined as the conversion of forest land to non-forest land where forest land is any land with a tree canopy cover of more than ten percent and area of more than zero point five hectares and a tree height of five meters (see forest definition section). Non forest land is any other land below these thresholds. Regrowth is not considered in the assessment of deforestation due to the challenges associated with assessing forest regrowth with remote sensing, which is particularly challenging in the Zambian context due to the physiognomy of Zambia's native forest types. For this same reason, i.e. the complexity of assessing forest area gain, Zambia does not include enhancement[1] of forest carbon stocks in this FREL.

Forest degradation is driven by charcoal and firewood extraction, timber extraction, uncontrolled and late bushfires, mining and infrastructure development. Degradation occurs throughout the country in a highly fragmented manner making it difficult to measure and monitor. Due to the present lack of accurate, representative and reliable data on degradation, Zambia intends to include degradation in a future FREL following a stepwise approach. Zambia's national REDD+ strategy includes actions to reduce forest degradation.

2.1.2 Carbon pools in the FRL

Pools included in the estimates used in the FREL include above ground biomass (ABG), below ground biomass (BGB), and standing/lying dead wood (DW). These pools are selected because quality data have been collected on them through ground surveys as part of the National Forest Inventory (NFI) and, importantly, they are considered to represent the most significant pools. The NFI also collected information on litter/grass/twigs, but this data has not yet been analysed and is expected to be a non-significant pool. Furthermore, the NFI collected information on soils, but its inclusion would require a more thorough analysis, including measurements of the soil pool in non-forest land and an improved understanding of the dynamic of soil carbon after forest conversion in the Zambian context. The litter and soil pool may be included at a later stage (see 4.3 Future Improvement).

Carbon pools considered for this FREL are above and below ground biomass as well as the

[1] Enhancement here includes afforestation, reforestation and carbon stock enhancement in forest remaining forest.

dead wood component of the dead wood and litter pool discussed above. Soil organic carbon was not considered for this FREL but may be included in future iterations of this document taking into account the stepwise approach chosen by Zambia. The national forest inventory undertaken in support of this and other management activities in Zambia has conducted a comprehensive sample of soil characteristics including soil organic carbon, however, little is known of soil carbon dynamics in Zambia and as such it is unclear how soil organic carbon behaves within the deforestation activity chosen by Zambia. Given the lack of flux data associated with soils this FREL will not include this pool in the present analyses.

2.1.3 Gases in the FREL

Only CO_2 is included in the FREL at this time. Emissions of non-CO_2 gases from the Zambian forests are mainly associated with forest fires. Forest areas in Zambia are burnt annually (Matakala *et al* 2015) and one of the key features of the miombo eco-region is the frequent occurrence of dry season fires. Low herbivory, high carbon content in the plant biomass, seasonality in litter decomposition and a long dry season (5–7 months) interact to create conditions in which fire plays an important role in nutrient cycling. Annual fires tend to burn grass, leaves and woody litter (herbaceous materials) and therefore do not usually add much to the accumulation of carbon dioxide in the atmosphere as emissions are recaptured the following year by annual re-growth (Chidumayo et al., 2011). Therefore, for the proposed initial FREL, neither emissions from fire, nor regrowth following fire, is included. Fire is considered a natural component of Zambia's forest ecology and trees are adapted to cope with regular burning. However, intensive late bushfires may impede and/or delay re-growth of forest as such affecting removals (Chidumayo, 1994). Current data does not yet allow for an accurate estimate of the emissions impact of this late burning; this could be included in future FRELs as data improves, as part of Zambia's stepwise approach.

2.1.4 Forest Definition used

The Forest Act (Commencement) Order, 2015 provides a definition of forest as below (page 7):

> *"forest" means* ***any land with a tree canopy cover of more than ten percent and area of more than zero point five hectares*** *and includes young stands that have not yet reached, but are expected to reach, a crown density of ten percent and* ***tree height of five metres*** *that are temporarily under stocked areas;*

In practice, the bolded part of the forest definition is used in measurement of forest cover and forest cover loss based on the minimum canopy cover, area and height thresholds provided in the Forest Act. This practice is consistent with the way in which estimates were generated for Zambia's most recent GHG inventory report, the Second National Communications (SNC), submitted December 2014, as well as to report forest and forest area changes to the FAO's Forest Resources Assessment (FRA). The unbolded part of the forest definition is used in accounting for forests managed under cadastral maps for protected forest areas and planted stands for the purpose of conservation, protection and enhancement of the growing biomass and carbon stocks.

2.1.5 Consistency with GHG inventory Reporting

Zambia Environmental Management Agency (ZEMA) is the national regulator and reporter of the GHG inventory for Zambia through the compilation of the national communication reports submitted to the UNFCCC. However, a number of environmental sectors such as forestry, wildlife, agriculture (crop and livestock), water, fisheries and public health provide the required information for the regulator to compile and subsequently report on behalf of the country. This information normally improves with consistent updates as and when respective sectors collect more reliable information across the country.

It should be noted that there are currently observed information inconsistencies between the last National Communications and the information used to construct the FREL. The inconsistencies relate to the data used to compile previous communications and those used to compile the FREL. The first and second communication to the UNFCCC employed data collected between 2000 and 2004 while the FREL presented here makes use of data collected as part of a National Forest Inventory undertaken between 2012 and 2014. As such the FREL employs more up-to-date and accurate information than previous communications. The third national communication (TNC) will use the updated data consistent with that presented here for the FREL.

3.0 Information used for FREL Construction

Zambia has followed the guidelines for the submission of information on reference levels as per the Annex to Decision 12/CP.17. Therefore, the present submission has been developed and is structured accordingly, as follows:

(a) Area covered by the FREL (section 2);

(b) Activities, Pools and gases included as listed in decision 1/CP.16, paragraph 70, which have been included in the FREL and the reasons for omitting a pool and/or activity from the construction of the FREL, noting that significant pools and/or activities should not be excluded (section 2.1);

(c) The forest definition used in the construction of the FREL (section 2.1.4)

(d) Consistent with the national GHG inventory reporting, including methodological information, used at the time of construction of the FREL (section 2.1.5);

(e) Information used in constructing the FREL (section 3);

3.1 Activity Data

3.1.1 Land cover map 2010: Methodology and data used

Activity data used for the construction of Zambia's FREL was generated based on a land cover change analysis conducted between 2000 and 2010 (period 1) and 2010 and 2014 (period 2). The land cover change focused specifically on forest to non-forest changes using the 2010 land cover map (details provided below) as a basis. The change analysis was conducted by MLNREP in collaboration with the FAO (other stakeholders were also involved in this process). Activity data for the construction of Zambia's FREL has been estimated following approach 3 as described in the IPCC's Good Practice Guidance for LULUCF (IPCC, 2003). This approach takes into account geographically explicit land-use and land-cover change for the estimation of activity data. Following this approach, the six IPCC land-cover categories were used in Zambia for the reference year 2010. The classification scheme consisting of the IPCC categories were agreed by a National Team of GIS and Remote Sensing Experts through consultative forums and workshop sessions and are based on Government policies or previous classification schemes. Table 1 provides an outline of these classes along with their national description.

Table 1 Land cover categories consistent with the IPCC Schema I

LAND-COVER CATEGORIES	NATIONAL LAND COVER DESCRIPTIONS
1. FOREST LAND	This is land covered both by natural and planted forest meeting the threshold of 10% canopy cover growing over a minimum area of 0.5 ha with trees growing above 5m height
2. GRASSLAND	Land that include wooded rangeland that may be covered mainly by grasslands, plains, dambos, pans found along major river basins and water channels

3. CROPLAND	Land actively used to grow agriculture (annual and perennial) crops which may be irrigated or rain feed for commercial, peasant and small scale farms around urban and rural settlements
4. WETLAND	Land which is water logged, may be wooded such as marshland, perennial flooded plains and swampy areas that may be recognized and classified as such by RAMSAR
5. SETTLEMENT	Land covered mainly densely populated and organized or irregular settlement patterns surrounding cities, towns, chiefdoms and rural centres commonly referred to as urban and rural built-up areas.
6. OTHER LAND	Barren land covered by natural bare earth / soil such as sandy dunes, beach sand, rocky outcrops and may include old open quarry sites

The workflow used to produce the 2010 land cover map is summarized in Figure 2 of this submission and the methodological steps taken are further described in the document *"GHG Implementation Guide for Zambia"* which is available for download through the website (www.zmb-nfms.org/portal). Information on the accuracy of the land-cover map and changes has been summarized in table 2 of this document. Figure 2 below provides a graphical outline of the workflow used to create the 2010 map for Zambia.

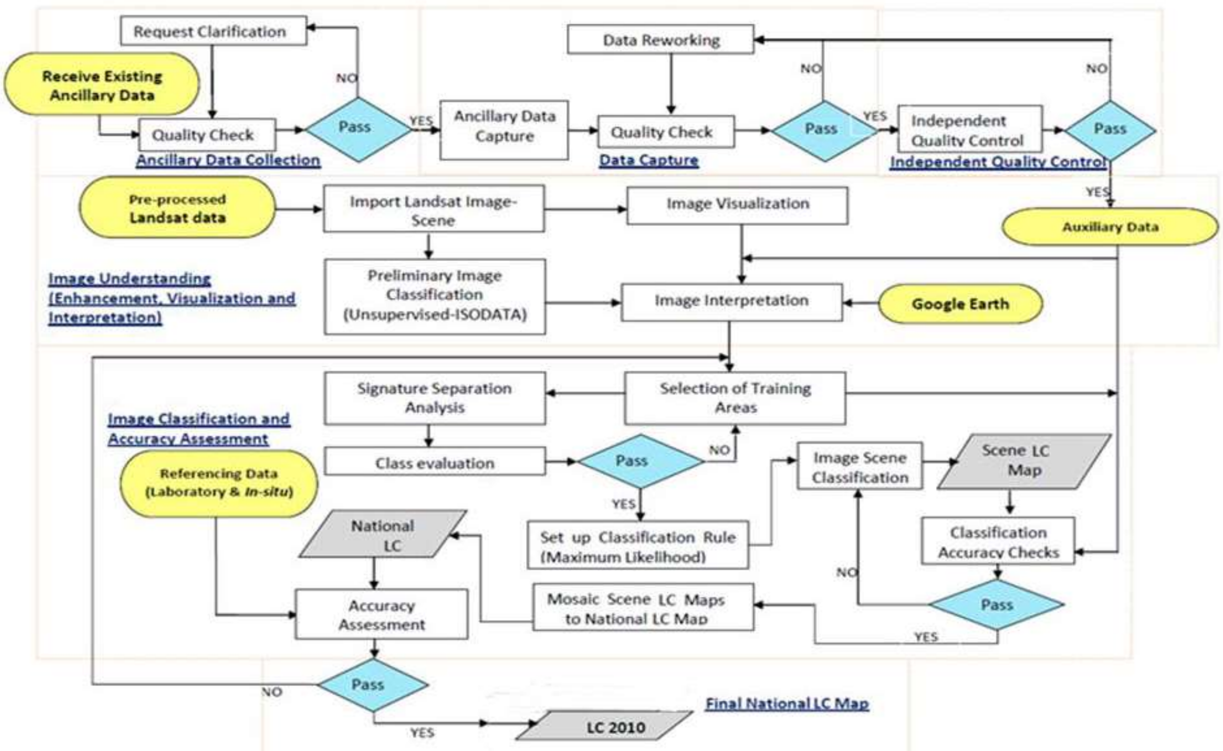

Figure 2 Land cover mapping workflow

3.1.1.1 Accuracy assessment land cover 2010 map

Prior to collecting ground referencing data, the mapping team assessed the overall accuracy, user and producer accuracies including performance of the Kappa coefficient. This was necessary in order to remove bias and systematic errors inherent in maps and also to ensure that the generated maps could provide acceptable accuracies from which to base the additional forest change analyses. An accuracy assessment was done using ground referencing data collected from the field. The point data was overlaid on the classification dataset of the maps and assigned a land cover attribute by the reviewer based on automatic interpretation and comparison. The overall accuracy of IPCC categories in the land cover 2010 map is 85.53% (Kappa Coefficient = 0.7927) with Forestland returning a User Accuracy of 88.92%. Table 1 provides additional information associated with the accuracy assessment of the 2010 land cover map including both Users and Producers accuracies (RCMRD 2012).

Table 2 2010 Land cover map accuracy assessment

		Reference Data						
		Forestland	Grassland	Cropland	Wetland	Settlement	Otherland	*User Accuracy*
Classified Data	Forestland	1099	72	52	13	0	0	*88.92%*
	Grassland	63	480	34	20	0	0	*80.40%*
	Cropland	67	45	337	0	5	1	*74.07%*
	Wetland	6	4	2	327	0	0	*96.46%*
	Settlement	0	0	1	1	56	0	*96.55%*
	Otherland	0	2	0	0	0	13	*86.67%*
	Producer Accuracy	*88.92%*	*79.34%*	*79.11%*	*90.58%*	*91.8%*	*92.86%*	***Overall Accuracy = 85.53%***

3.1.2 Forest loss assessment: Methodology and data used

Forest loss (e.g. deforestation) was assessed on a national scale for Zambia following the Global Forest Observation Initiative guiding principle 1 (GFOI 2013) and in a spatially explicit manner according to Approach 3 of the IPCC Good Practice Guidelines. In order to establish a historical trend of deforestation in Zambia, forest loss was assessed for the periods between 2000-2010 and 2010-2014. Assessment was undertaken using wall-to-wall, single best-pixel Landsat mosaics with nationally collected training data for loss points (Figure 3). The loss detection and mapping was an iterative process consisting of the following steps:

1) Image pre-processing

2) Collection of training data

3) Classification

4) Iterative improvement of training dataset

5) Export, cleansing and area computation

Each of the steps is described in detail in the following sections.

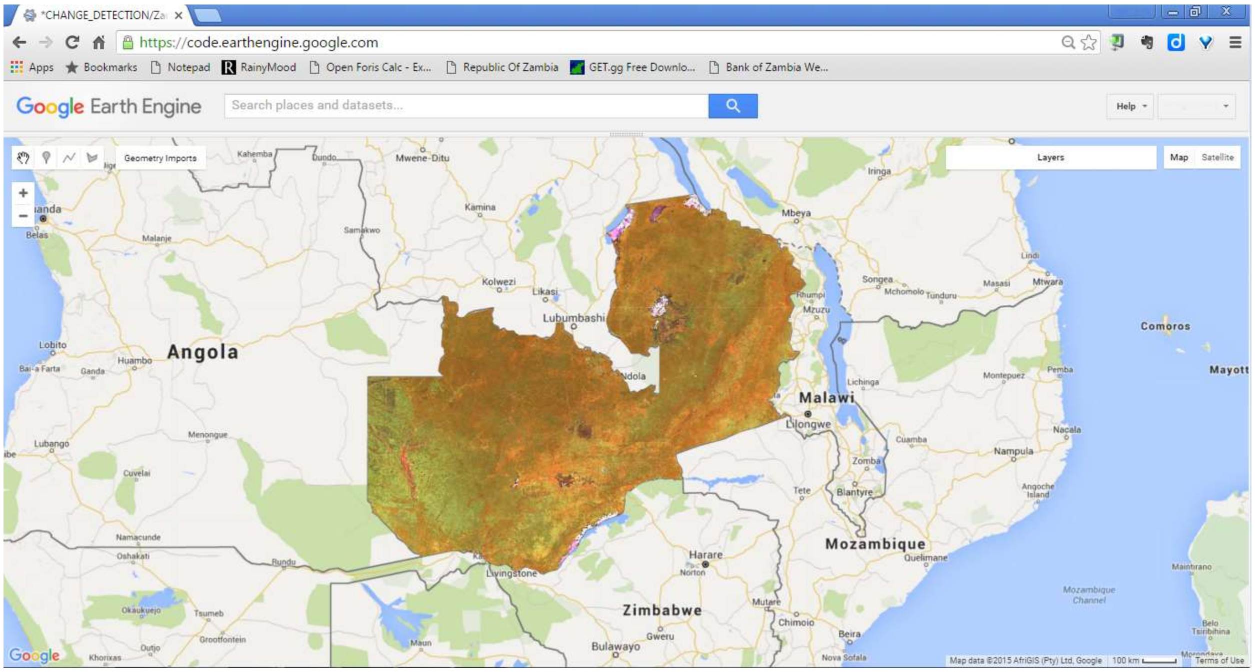

Figure 3 Landsat best pixel mosaic in Google Earth Engine

3.1.2.1 Image pre-processing, compositing, mosaicking

Input data

Landsat satellite imagery data were used as a basis for the Zambian land cover and land cover change assessment. The Landsat program provides an important data source for land monitoring. The combination of Landsat's spatial resolution (30 x 30 m pixel size), ability to detect electromagnetic radiation across the visible, infra-red and thermal wavelengths, 40 year archive of well-calibrated (Markham and Helder, 2012) image acquisitions and free and open, web-based distribution policy (Woodcock et al., 2008; Wulder et al., 2012) has made the data collected by the sensor of high value for classifying and mapping all manner of biophysical properties and alterations of these properties over time of the Earth's surface (Roy et al., 2014).

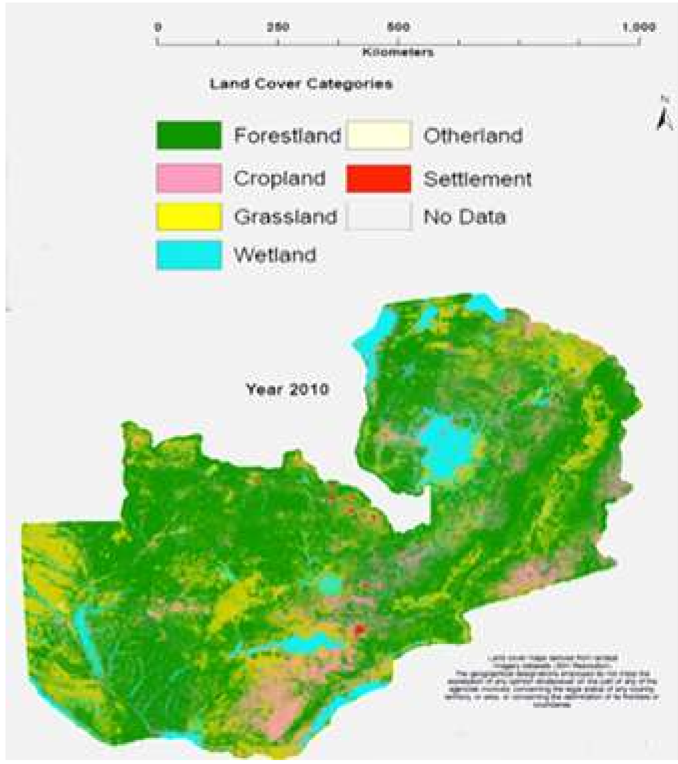

Figure 4 2010 Land Cover Map (RCMRD)

The year 2010 RCMRD map was selected by the Forestry Department of Zambia as an acceptable reference map on which to base new maps for year 2000 and year 2014. The year 2010 RCMRD map was determined to have an overall accuracy of 85.53% (RCMRD, 2012) and was, qualitatively assessed to most closely represent the actual conditions of the biophysical land surface of Zambia.

Year 2000 and year 2014 maps were created by characterizing per-pixel forest cover changes using direct change detection approaches between the base year (e.g. 2010) and year 2000 and 2014. Direct change detection approaches differ from post-classification in that they depend entirely on the spectral information contained in the input imagery to detect changes, not on a classified map product. Post-classification tend to produce less accurate change detection as inherently present errors in classified map products are multiplied when maps are compared (Olofsson et al 2014).

The map classes from the year 2010 map served as the base map from which to label year 2000 and year 2014 maps. No-change pixels were labelled directly using the map classification from the 2010 map. Change pixels (e.g. pixels exhibiting deforestation between year 2000 and 2010 and between year 2010 and 2014, respectively) were labelled as deforestation. Labelling the change pixels as forest or non-forest, appropriately, depending on the year, created updated year 2000 and year 2014 maps. In other words, pixels detected as deforestation between 2000 and 2010 were labelled as forest in the year 2000 map and pixels detected as deforestation between 2010 and 2014 were labelled as non-forest in the year 2014 map.

Google Earth Engine parameterization and corrections

Landsat images covering the entire national territory of Zambia for year 2010, 2000 and 2014 were accessed and processed via the Google Earth Engine (GEE). Single-best-pixel, national mosaics and change detection for Zambia, were carried out using a GEE javascript processing chain. The initial steps of using the GEE processing chain consist of parameterization in order to produce the best possible mosaics for land cover characterization and change detection. The supervised change detection builds two mosaics, one each for the start and end of the monitoring time period, respectively. In the case of Zambia, the script was run once to produce a result for years 2000 and 2010 and a second time to produce a result for years 2010 and 2014. Each mosaic was created from pixels derived from the full Landsat archive filtered using user-supplied parameters for date range, days of year, cloud cover and geographic extent. Each pixel is corrected for the latitudinal component of sun-sensor-target geometry and a 'weight' parameter is created that allows the automatic selection of the single 'best' pixel available to be used in the final mosaics. The 'weight' parameter is created by multiplying the difference in Julian Day of Year (DOY) of the pixel's acquisition date from a selected 'target day' (described below), pixel temperature and pixel wetness. The ultimate goal of the 'weight' parameter is to favour the selection of warm, wet pixels closest to the target date and, thus, to create temporally and seasonally similar, cloud-free mosaics for each time period. The best-pixel mosaics can be tuned using the target day parameter. The target day should be selected according to the time of year corresponding to the highest point of vegetation greenness and, if possible, when cloud cover is low (e.g. the end of rainy season, see Figure 5).

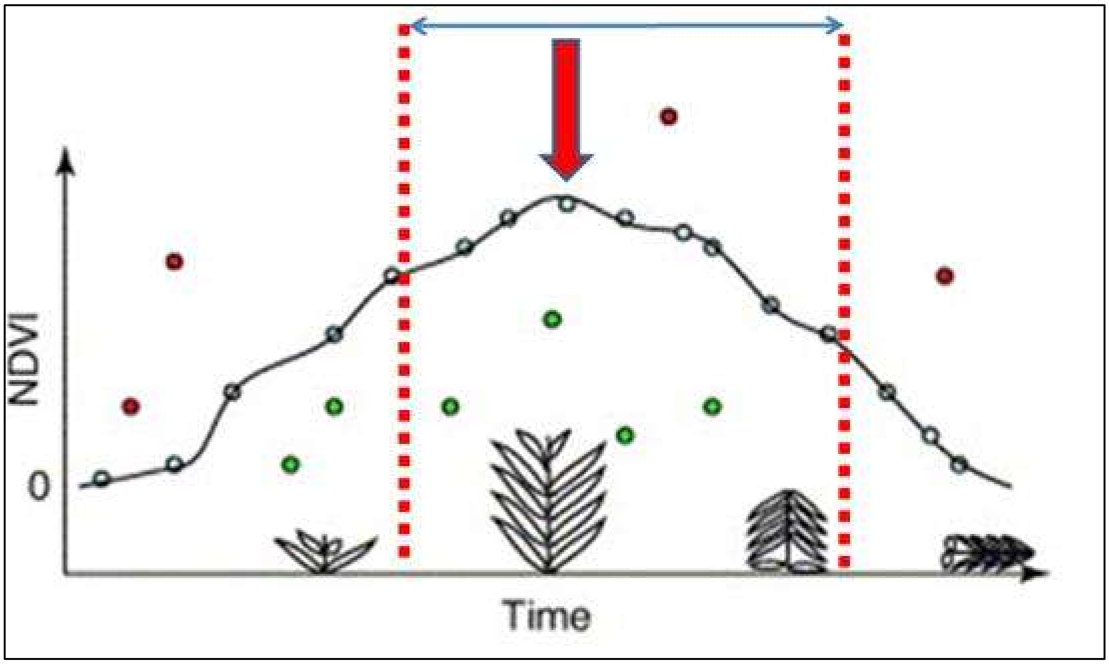

Figure 5 Schematic representation of the target day (red arrow) corresponding to the highest vegetation season, with low cloud cover and the Julian days of the year to include in the mosaic (dotted lines)

Final composites and mosaics

Final, seasonally matched, best-pixel composites were created for years 2000, 2010 and 2014 for the entire national territory of Zambia (Figure 3). These mosaics served as the basis for training data collection and change detection.

3.1.2.2 Classification and training data collection

Supervised classification principles

As previously mentioned, direct change detection approaches were used to characterize forest cover loss between time periods. In this study, supervised classification for deforestation was performed on the best-pixel composites, once for the period between year 2000 and 2010 and another time for the period between year 2010 and 2014. Supervised classification relies on inputs from expert image interpreters during the initial phases of analysis. In the case of Zambia, experts identified known areas of stable forest, stable non-forest and deforestation in and between each of the time periods. The spectral information from the imagery is collected at each of the identified sites, thus relating the known classes with a uniquely identifiable spectral signature. This input data is known as 'training data' because it is used to construct or 'train' models for classifying the unknown pixels in the national mosaics.

Training data collection

Training data was collected as point locations across the national territory of Zambia. Training points for deforestation, stable forest and stable non-forest were derived from several sources including available global datasets of forest cover and change, and from local expert image interpreters and known locations of deforestation. The Global Forest Change (GFC) product (Hansen et al. 2013) aggregated at 5x5 pixel blocks was used to create an initial point training dataset for stable forest, non-forest and deforestation. The GFC dataset is the only global dataset of its kind and serves as a very useful first-step in nationally specific land cover and change characterization, especially if no other data source is available. Expert stakeholders, to refine the overall training dataset, collected additional training points for stable classes and deforestation through an iterative process using, again, the GEE interface.

Random Forest

Training inputs were used in conjunction with Random Forest (RF) algorithms to create a final model for detecting deforestation. The Random Forest algorithm is a classification technique employed in machine learning applications, it is favoured over other techniques as it can be applied to large data sets, is capable of providing estimates of what variables are important in the classification and can handle data-sets with missing data, to name a few. RF is an ensemble learning technique employed in classification and regression problems; during the training phase of the process a large number of decision trees are generated using randomly sampled (with replacement) training data. Approximately 30% of the training data (out-of-bag) is retained and not used for building the decision trees; this data is used to test the error of the decision tree and is also used to determine the variable importance. Once the forest is built, voting methods are employed to select the optimal classification. In the present analyses the RF was trained using user defined training data for the three classes of interest, stable forest, stable non-forest and change (forest to non-forest). The training data (see above section on how this was gathered) was made up of spectral inputs to the RF classifier which included Landsat red, near-infrared and infrared bands (Landsat 7 bands 3, 4 and 5 and Landsat 8 bands 4, 5 and 6) converted to top-of-atmosphere reflectance (TOA) as well as all possible, two-band simple ratios of these bands. The model developed using the training data was then applied to the base data set and all pixels within that data were assigned to one of the three classes depending on which terminal node they fell into. The final map was then assessed for accuracies using the methods outlined below. The present analyses were carried out for both the 2000 - 2010 and the 2010 - 2014 period; outputs from these analysis were used to update the 2000 forest layer as well as create a new 2014 land cover map. The change analyses outputs (forest to non-forest) represented the data used to characterise the activity data reported in this FREL. Figure 6 below provides a map of change.

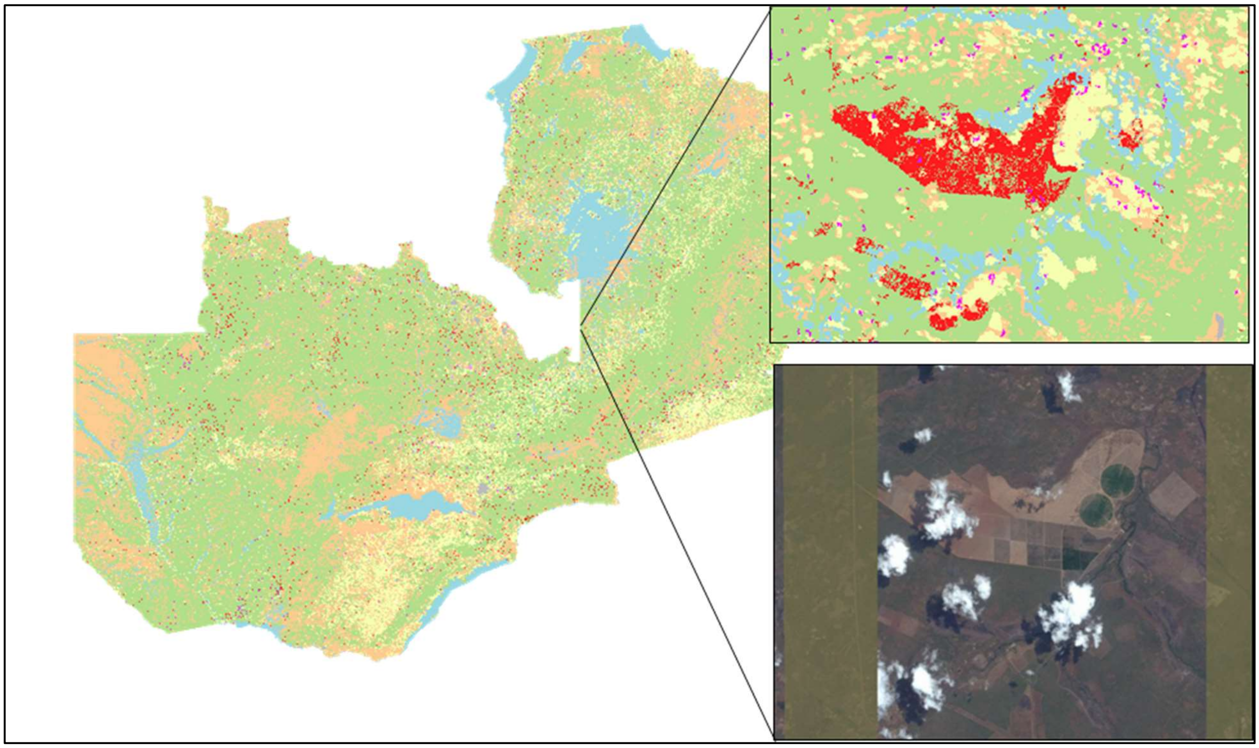

Figure 6 Final change map - 2000 - 2010 - 2014

Accuracy assessment and adjusted area estimates for forest loss

The accuracy assessment was performed using point reference data consisting of higher quality data than that used to make the map. Higher quality data can be obtained from images of higher resolution, or visual interpretation of the Landsat images by a remote sensing expert. The accuracy assessment was performed in conformity with Olofsson *et al* (2013). The accuracy assessment provided a quantification of the map accuracy through the creation of error matrices but also provides forest area and forest area loss estimates that are adjusted for the map bias, thus these estimates can be considered more accurate. Accordingly the precision of the area and area change estimates is quantified through the calculation of confidence intervals. The activity data for deforestation therefore consists of the adjusted forest loss area. It should be noted that the accuracy assessment reported below is taken from a national assessment and stratified according to the classes defined as part of the emissions factors stratification.

3.1.2.3 Results forest area change detection

Forest area change is reported below using the stratification defined in the section covering the emission factors development. The areas reported for each class and each time period are adjusted at this point in time and represent both the actual mapped area of change as well as the adjusted area using the methods described by Olofsson *et al* (2013). The adjusted area estimates were calculated making use of the methods described by Olofsson *et al* (2013) with the adjusted area removing map bias. In addition, the adjusted areas were subjected to one further adjustment which normalised the change between the two time periods. Average percentage change within each strata were calculated using data from both periods and once again used to adjust the change areas. The final adjustment normalised the change between the two periods. Adjusted area estimates as per the discussion above are reported below in Table 3. An additional point to note is that the area estimates for the classes do not include the area covered by water bodies.

Table 3 Forest Area Change

Class	Total Area (ha)	Change 2000-2010 (ha)	Adjusted Change 2000-2010 (ha)	Change 2010-2014 (ha)	Adjusted Change 2010-2014
Stratum 1	1,995,442.11	20,842.56	76,421.87	2,193.12	41,703.43
Stratum 2	13,311,084.96	120,179.52	454,778.10	21,152.70	248,172.51
Stratum 3	32,602,600.35	175,375.44	890,516.42	167,505.57	485,955.00
Stratum 4	11,884,158.90	29,329.74	431,211.57	198,025.83	235,312.25
Stratum 5	14,310,984.33	12,246.84	647,104.04	363,980.34	353,124.81

The periods of analysis are based on the original land cover mapping work undertaken by the Government of the republic of Zambia and represent the most up to date assessment of land cover change. The first period covers 2000 to 2010 while the second period cover 2010 to 2014. The total areas above have been converted to annualised averages in the table below. It is clear to see that the annualised rate of change (forest to non-forest) has increased in the latter period.

Table 4 Annualised Forest Change

Class	Annualised Change 2000-2010 (ha/yr)	Adjusted Annualised Change 2000-2010 (ha/yr)	Annualised Change 2010-2014 (ha/yr)	Adjusted Annualised Change 2010-2014 (ha/yr)
Stratum 1	2,084.26	7,642.19	548.28	10,425.86
Stratum 2	12,017.95	45,477.81	5,288.18	62,043.13
Stratum 3	17,537.54	89,051.64	41,876.39	121,488.75
Stratum 4	2,932.97	43,121.16	49,506.46	58,828.06
Stratum 5	1,224.68	64,710.40	90,995.09	88,281.20
Total	35,797.41	250,003.20	188,214.39	341,067.00

3.2 Emission Factors

3.2.1 Description of National Forest Inventory

Zambia's Integrated Land-use Assessment (ILUA) was implemented by the Government of the Republic of Zambia through the Forestry Department of MLNREP from 2012 to 2014. Technical assistance was provided by FAO while financial support was provided by the Government of the Republic of Finland. The main purpose of ILUA was to build up forest related land use resource inventories, support national planning capacity and contribute to formulating development policies. ILUA II was based on FAO's National Forest Monitoring and Assessment (NFMA) methodology (FAO, NFMA). ILUA data collection informed Zambia's efforts to Measure, Report and Verify (MRV) Greenhouse Gas (GHG) emissions from Deforestation. Therefore, field data collection needed to adhere to land use definitions established by the Intergovernmental Panel for Climate Change (IPCC) for GHG reporting.

The biophysical inventory design was based on a two-phased sampling strategy (Neyman 1938), where for the first phase; 6283 observations were distributed systematically across the country with an interval of 0.1 degrees (approximately equal to 10 km). For each observation, variables such as percentage of tree cover, land use/cover, and vegetation type were evaluated in a 1 hectare square using the OpenForis Collect Earth Tool. Points located on bare land, built-up land, and water was removed from the second phase sampling population.

For the allocation of the secondary and final biophysical sampling plot locations (Phase II), the size of the provinces in the country and the number of primary units per strata were used as ancillary selection variables. Including provincial strata in the selection process helped to capture the variability of forests across both strata and provinces. All plots from previous inventories were also included in the 2nd phase samples. The final sampling data frame consisted of 1087 (986 sampled as some were inaccessible) cluster locations each containing 4 plots where a number of forest biophysical variables were collected during the fieldwork campaign. Full details are provided on the following website (http://www.zmb-nfms.org/portal/).

3.2.2 NFI field sampling of IPCC forest carbon pools

The IPCC (2006) Guidelines Chapter 4, AFOLU sector, identifies three main carbon pools which can be measured for quantifying carbon stock changes: Biomass, Dead organic matter and Soils. The Biomass pool consists of both Above (stems, stumps, branches, bark, seeds and foliage) and Below Ground Biomass (live roots) while Dead organic matter consists of Dead wood (non-living woody biomass not contained in litter) and Litter (non-living organic matter which does not fulfil the requirements for Dead wood). Finally Soils consist of soil organic matter that does not fulfil the requirements for below ground biomass (fine roots with a diameter of less than 2mm as well as decaying organic matter). The present inventory described in this document is based on FAO's NFMA methodology. The details of the inventory can be found in the Biophysical Field Manual prepared in support of the ILUA II and published in 2014. All pools described above were measured as part of ILUA II but not all pools are included in this Forest Reference Emissions Level.

Above Ground Biomass

AGB was measured in all plots selected during the second phase of the inventory. All trees located within the plots (20m wide and 50m long - see Figure 7) with a DBH of greater than 10 cm were sampled, where sampling consisted of measuring the height and diameter at breast height and recording the tree species. Trees with a DBH of between 5 and 10 cm were measured in a rectangular sub plot located in the first 10 m of the larger plot. Regeneration, trees with a DBH of less than 5 cm, was measured in a nested sub-plot within the rectangular sub-plot. Once again, height, DBH and species were recorded for each tree present.

Below Ground Biomass

Below Ground Biomass (BGB) was not measured directly, rather a root:shoot ratio was used to calculate BGB (see section 3.2.3).

Dead Wood

Dead-wood data was recorded on all fallen dead logs and branches with a diameter equal to or above 10 cm and which were found in the plot area (regardless of where they originated). The minimum length of dead-wood to be measured was 1 meter. Combined broken parts (separately shorter than 1 m) from the same tree were counted and measured as one if total length of parts exceed 1 meter. The length and diameter at both ends of all pieces of fallen wood with diameter larger or equal to 10 cm within the plot area were measured. The standard wood density of 619 kg / m^3 was used as per Chidumayo (2012) to convert the volume estimates created to biomass. Section 3.2.3 provides additional information.

Soils and Soil organic matter

On specific clusters identified in the sampling plan, additional information was collected on soil. Soils required additional measurements which are briefly described below. The prescribed location of the soil pits is shown on figure 7, however, this location was not always suitable and in some cases the location had to be modified. GPS location points were recorded for all soil pits dug.

At each soil pit site three types of soil samples were taken. Firstly, the undisturbed core ring sample was collected from the soil pit at 0–10, 10–20 and the 20–30 cm layers, respectively. Secondly, from the same layers in the soil pit, disturbed soil samples were collected for the measurement of soil organic carbon in the laboratory. Thirdly, composite soil samples were prepared having been collected using a soil auger targeting the top soil (0–10 cm), and sub soil (10–30 cm depths) from within the sampling plot (at the biophysical plot centre and at 5m north, east, south and west).

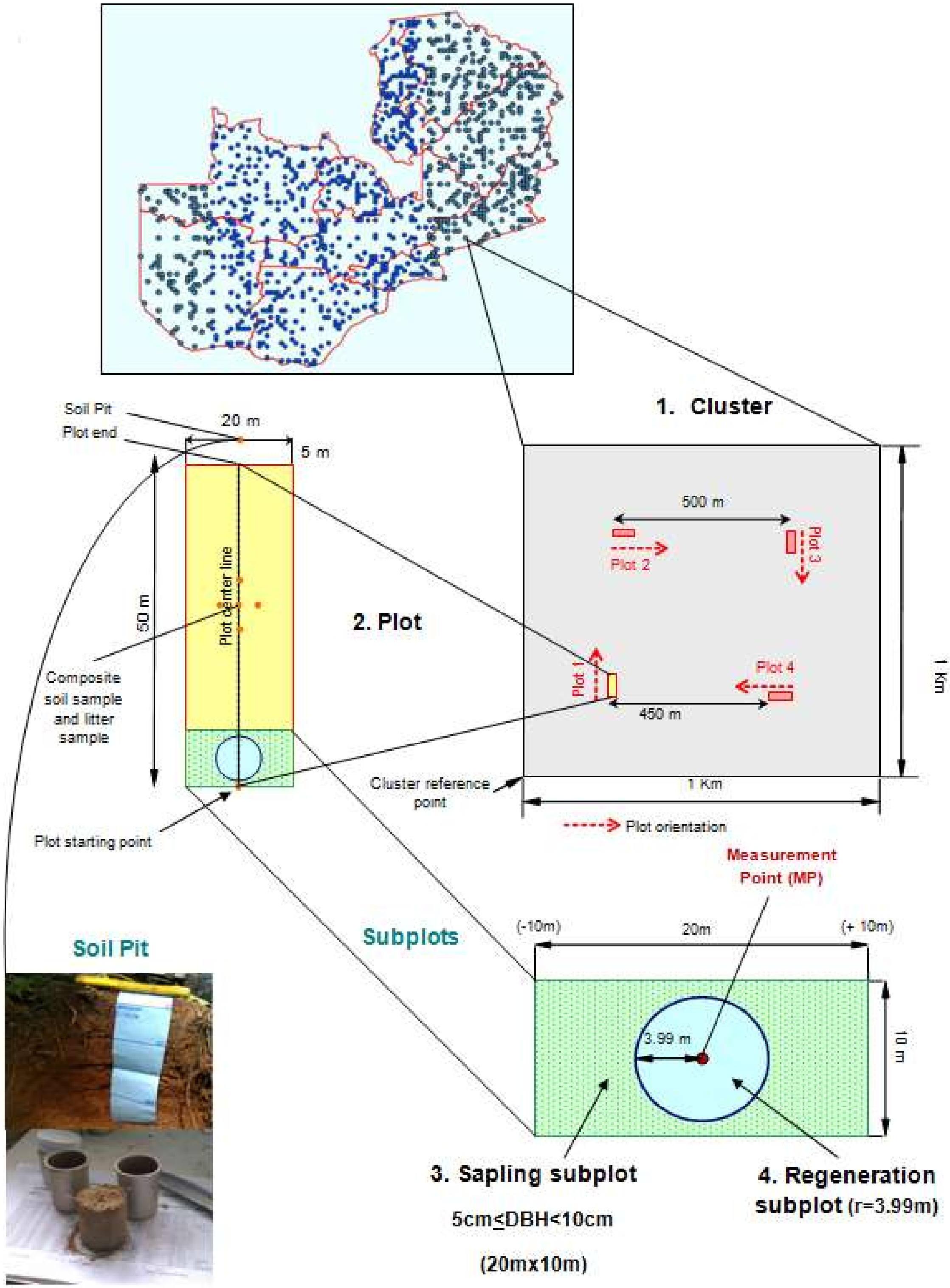

Figure 7 NFI plot layout

3.2.3 Analysis of collected NFI data

To convert tree measurements collected in the ILUA II forest plots, a country specific allometric equation was used. Chidumayo (2012) evaluated different models on prediction performance against volume estimates based on field observations in Miombo woodland. The following models estimating aboveground wood biomass directly from tree diameter measurements were evaluated: (i) log models based on logarithmically transformed data, (ii) polynomial models and (iii) power models. The models that gave the most accurate estimates (< 20% deviation from observed values) were the log and power models. The following log model was identified as the most accurate for Zambia's forest and has been used to undertake the calculation of Above Ground Biomass:

$$AGB\ (kg) = 2.342 * \ln(dbh) - 2.059 \quad (1)$$

A Zambia specific wood density was used in the conversion of plot measured aboveground volume to biomass. To obtain the country specific wood density, 31 tree species from the wetter and drier Miombo were destructively sampled. The specific wood density was calculated by dividing oven-dry weight of 1.0-m long log by the calculated fresh volume of the individual log. A mean specific wood density value for each species was calculated using the data for all the stem logs (from bottom to top of stem) of that species. The overall wood density estimate for the combined data was 618.55 ± 16.81 Kg m-3 (Chidumayo 2012). The carbon fraction used to convert biomass estimates into carbon was 0.49 which is the default value for wood in Table 4.3 (IPCC 2006). Below ground biomass was estimated using a root:shoot ratio to the above ground biomass measured in the NFI. The ratio used is 0.28, which is the default value for above ground biomass which is >20 tonnes per ha in the tropical dry forest ecological zone (Table 4.4 IPCC 2006). Results from destructive sampling of trees in the Zambian Miombo woodlands suggested root:shoot ratios of 0.54 and 0.77 in old-growth and regrowth woodland, respectively (Chidumayo 2014), which may indicate the current ratio applied underestimates the root biomass and can therefore be considered a conservative value.

Zambia has established a digital data management and processing system designed specifically for national forest inventories. OpenForis (http://openforis.org/) is a suite of tools designed specifically for the capturing, cleaning and processing of forest inventory data. The suite of applications includes two inventory management tools, Collect and Calc that are used extensively. Collect and Calc were both employed for the analysis of the inventory data. Hard-copy field data collection sheets containing the raw forest inventory data were entered into the Collect component of the system by trained forestry staff. Once input the data were cleansed, through iterative checks on the various input variables and finally published as being complete and free of errors, data processing and analysis could begin. Data processing and analysis was undertaken using the Calc component of the tool suite where the R statistical programming language was employed to process and analyse the forest inventory data collected. Results from the inventory that were generated at the national and provincial scales using three vegetation type stratifications. For the purposes of the present analysis and the development of suitable emissions factors, plot level data were analysed and used to calculate biomass and carbon estimates.

3.2.4 Stratification

Stratification of emissions factors / carbon stocks associates a given area of deforestation with a specific carbon stock that is relevant to that area, the result is a more accurate and or precise estimate of carbon lost. Zambia has chosen to stratify both its emissions factors and the activity data discussed above using a spatially explicit map of both above and below ground carbon. The spatially explicit map was stratified into classes based on carbon content.

As outlined above, the National Forest Inventory, ILUA II, aimed to sample just over 1000 clusters consisting of four plots each. The final number of clusters sampled (some were inaccessible) was 986 which resulted in approximately 3892 plots. The spatially explicit carbon map was produced using the tree data collected from these plots. Once the data were entered cleansed and published in the Collect database, plot level biomass was calculated using equation (1) above. Once this data were exported from Collect and processed it was imported into the Google Earth Engine where cloud based processing was leveraged to compute the spatially explicit map of both above and below ground biomass. Plot level measures of biomass were used as part of a predictive modelling approach to predict biomass at locations not sampled during the ILUA II campaign. The predictive modelling employed classification and regression trees (CART) to predict biomass using the plot level ILUA II data as independent variables and a combination of both optical and SAR imaging RADAR data[2] as dependent variables. The output from the CART model was a spatially explicit map of total carbon (above and below ground carbon including dead wood) which was then converted into tons/ha. The stratification of this output into emissions factors classes is shown below where the Carbon values used are total carbon (above and below ground including deadwood) and not CO_2 equivalent.

[2] The SAR data used in the production of the map is freely available through the Alaska Satellite Facility (www.asf.alaska.edu)

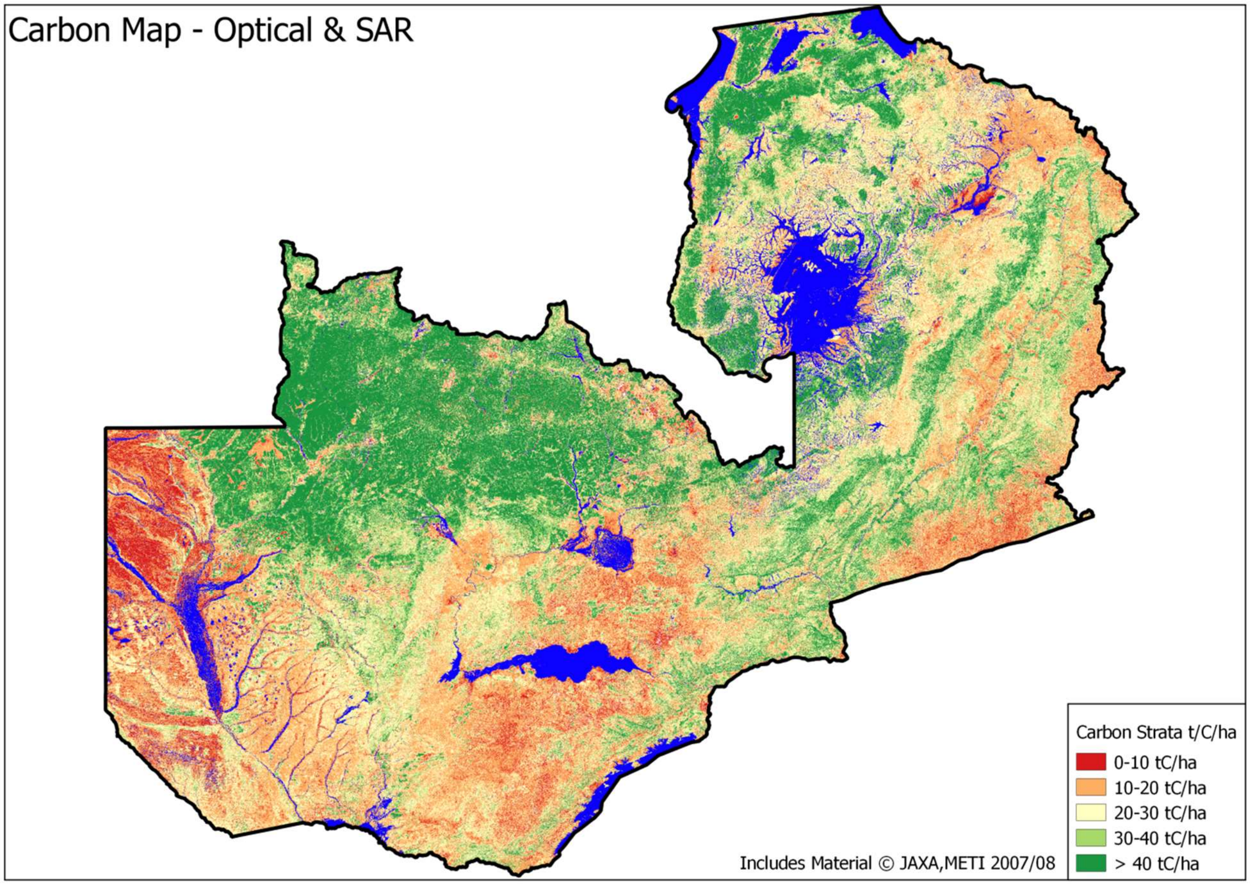

Figure 8 Map of Carbon (tC/ha)

While the carbon map approach was selected as the most suitable stratification for the present FREL, other stratifications were also tested. A vegetation map produced for Zambia in 1976 was one of three additional stratifications tested along with a USGS produced map of terrestrial ecosystems (Sayre et al, 2009) and the World Wildlife Fund map of Terrestrial Ecoregions of the world (Olson et al, 2004). Following discussions among stakeholders the carbon map was chosen as the stratification output that best reflected the variation of forest cover in Zambia and thus would be the most accurate representation of emissions factors data. Five classes or strata were produced using the carbon map (see Figure 8). The strata / classes were defined using tC/ha such that Strata 1 covers areas that have less than 10 tC/ha, Strata 2 contains areas that have between 10 and 20 tC/ha, Strata 3 contains areas that have between 20 and 30 t/C/ha, Strata 4 contains areas that have between 30 and 40 tC/ha and Strata 5 contains areas that have greater than 40 tC/ha.

3.2.5 Results and proposed emission factors

Emissions factors reported below consist of carbon stock associated with the carbon strata discussed above. It is assumed that the biomass directly after deforestation is zero and that no residual biomass is present.

The FREL furthermore assumes that 100% oxidation of both biomass and dead wood occurs at the time of land use conversion.

To estimate historical emissions Zambia proposes to make use of an emissions factors stratification based on a spatially explicit map of total carbon biomass (tons/ha). The map is shown above in Figure 8 and is the basis for the stratification and calculation of emissions factors used in the production of this FREL. Briefly, the NFI sampled just fewer than 1000 clusters with approximately 3128 plots returning a classification which fulfilled the definition of forest and as such were employed in the emissions factors computation. Total carbon was computed for each plot location and over laid on the carbon map such that the relevant carbon map class could be assigned to the plot. Following the class assignment average carbon content was calculated for each of the strata along with standard error estimates as well as the 95% confidence interval. These values are reported in the table below.

Table 5 Emissions factors - Zambian FREL

Class	Emissions Factor (t C/ha)	Standard Error	95% Confidence Interval	Number of Observations (n)
Strata 1	7.49	1.81	2.99	14
Strata 2	13.34	0.93	1.53	281
Strata 3	17.72	0.40	0.67	1326
Strata 4	24.56	0.61	1.01	719
Strata 5	41.20	1.40	2.31	805

3.2.6 Comparison with other studies

Results reported above are significantly lower than the IPCC default values which range from 56 - 200 tC/ha for AGB. The values found by the data analysis of the NFI fall below the low-end of this range however the country specific estimates are considered to be more accurate and more appropriate to use.

3.3 Details on National Circumstances

Zambian forests are vulnerable to factors such as extensive practices of shifting cultivation and slash and burn; ever-increasing demands for wood-based energy (firewood and charcoal); unsustainable commercial utilization of indigenous tree species; over-grazing; and forest fires. In particular, the low productivity of small scale agriculture and degraded agricultural soils create pressure to expand land use for agriculture in forested areas.

Zambia's population is 16.2 million (2015), and has increased more than 150 percent during last 37 years (World Population Prospects 2015). Currently 67 percent of Zambians are poor (National Population Policy. 2007. Ministry of Finance and National Planning. 18 p.). Rural poverty in Zambia is high, even by African standards: it is estimated that 83 percent of the rural population, mainly comprised of semi subsistence farmers, live in poverty. The correlation between poverty and deforestation and forest degradation is high in Zambia, especially in areas near urban centres, and is likely to occur in both directions: a scarce and dwindling natural resource base will be a major contributor to poverty in areas where this is an important element of people's livelihoods, and poverty may encourage activities that threaten the natural resource base.

A growing population has led to increased pressure for agricultural land in order to meet national and subsistence food requirements. Agricultural expansion is caused both by shifting subsistence cultivation and intensification of subsistence and commercial farming.

The demand for timber has over the past few years been exacerbated by the expanding and intensifying construction activities in the country and international demand for valuable timber species existing in the country such as *Pterocarpus chrysothrix*, *Pterocarpus angolensis Guibourtia coleosperma* (Rosewood), *Colophospermum mopane*, and *Baikiaea plurijuga* (Zambezi teak) which has contributed to illegal harvesting leading to Forest degradation.

Charcoal and firewood make up over 70% of the national energy consumption in Zambia as only about 22% of the population has access to electricity. Firewood is in high demand especially in rural areas for cooking and heating needs at household level and also among tobacco farmers especially those producing Virginia tobacco which requires smoke curing as well as for brick burning in the booming construction of houses in the rural and peri-urban areas of rural towns. It is also in high demand by fisher folks in rural areas for fish smoking to dry the fish. Electricity is mainly sourced by hydropower and low rainfall in the recent years has resulted in a shortage in electricity and subsequently an increase in the consumption of charcoal as alternative energy source which may have contributed to the increased forest loss in recent years detected in the activity data (section 3.1,2). Rainfall has also been low this year (due to the el niño climatological feature) therefore an increased extraction of charcoal is also expected for the year to come. Charcoal extraction usually results in degradation but as it helps open up the forest for agriculture and thus the increased charcoal collection is expected to result in increased deforestation.

4 Proposed FREL

The approach to generate the actual emissions estimates follows the guidance provided by the IPCC GPG on LULUCF (2003), multiplying the activity data computed, by a carbon stock emissions factor calculated based on information collected as part of a National Forest Inventory.

The method used to construct the FREL is to calculate the average historical emissions for the period 2005-2014, a 9-year period. Because emissions have been rising in more recent years, it is unclear if the proposed FREL is; in fact, an estimate of future "business as usual" emissions, i.e. what the country believes would be expected emissions in the absence of REDD+ activities. It may be that emissions associated with land use change (forest to non-forest) will continue at recent high rates, or even potentially increase in the future (See section on national circumstances). The historical data highlights a marked increase in the rate of land use change (forest to non-forest) in the latter period of the analyses. However, Zambia is not submitting a proposed adjustment to the historic average FREL because data is not available at this time to quantify an appropriate adjustment, and considers the average historic FREL based on a 9-year period to be conservative.

4.1 FREL calculation/method applied

As noted above, the proposed FREL is calculated using an historical average approach whereby annualised rates of change are computed based on the analysis of historical land use change (forest to non-forest) through the analysis of remote sensing data (see section 3.1). This historical change information is then coupled to the emissions factors generated and used to calculate annualised total emissions for the historical period. Table 6 below provides a breakdown of the annualised change calculated above coupled to the emissions factors produced. The annualised emissions are reported for both periods with the 2000-2010 period returning annual emissions of **21,879,122.18** tons CO_2e per year while the second period, 2010-2014 returned **29,848,604.19** tons CO_2e.

Table 6 Annualised Emissions

Stratification	t/C/ha	t/CO2e/ha	Annualised Change 2000-2010 (ha/yr)	Total Annual Emissions 2000 - 2010 (t/CO2e/yr)	Annualised Change 2010-2014 (ha/yr)	Total Annual Emissions (t/CO2e/yr)
Stratum 1	7.49	27.46	7,642.19	209,879.93	10,425.86	286,328.81
Stratum 2	13.34	48.91	45,477.81	2,224,471.27	62,043.13	3,034,736.12
Stratum 3	17.72	64.97	89,051.64	5,785,982.02	121,488.75	7,893,529.09
Stratum 4	24.56	90.05	43,121.16	3,883,203.94	58,828.06	5,297,663.06
Stratum 5	41.2	151.07	64,710.40	9,775,585.01	88,281.20	13,336,347.11
Total			250,003.20	21,879,122.18	341,067.00	29,848,604.19

The difference between the two periods highlights the growing challenges Zambia faces with regards to deforestation and the need for urgent action in terms of emissions reductions activities. The difference between the two periods also has an impact on the construction of the FREL, Zambia has chosen to use a historical average to quantify its emissions, which in cases where there is a clear trend either up or down in terms of deforestation could be problematic. In Zambia's case, the upturn in deforestation measured between 2010 and 2014 may well reflect the current state of land use change in Zambia; however, the period is not long enough to concretely say that this is indeed the business as usual case. The proposed FREL therefore at the end of 2005 (midway through the initial period) and ends in 2014. Figure 9 provides a graphical interpretation of the FREL and its proposed construction. Values presented in the graphic are in Megatons and represent the annual emissions calculated for the two time periods as well as the average for the period 2005 to 2014 (shown in red).

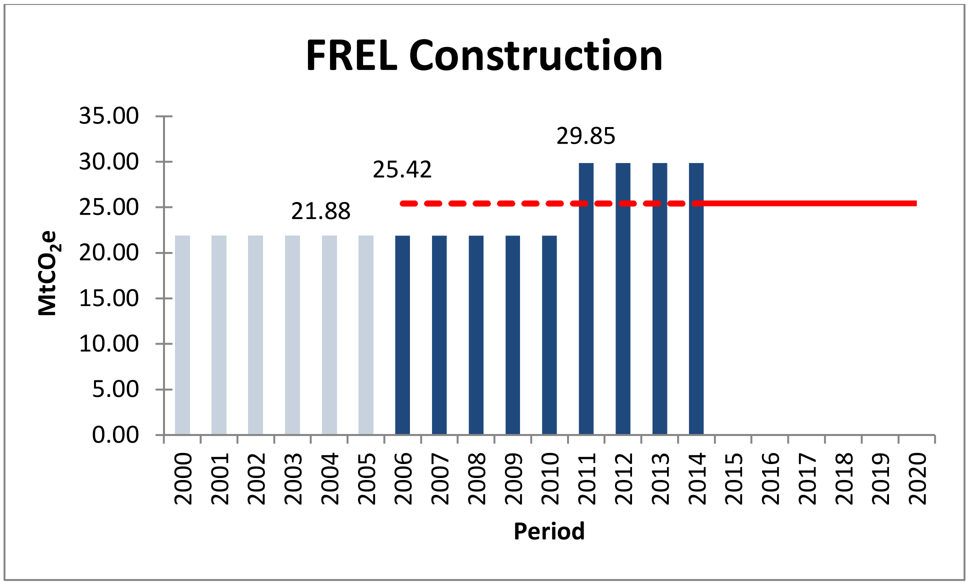

Figure 9 Zambia's FREL

Therefore, this submission of a proposed FREL suggests the best estimate at this time of emissions associated with land use change (forest to non-forest) in Zambia, for the near future, amount to an annual rate of 25.42 $MtCO_2e/yr^{-1}$.

4.2 Updating frequency

The update frequency of the present FREL will be determined at a later date based on the inputs received from the Technical Assessment Team. In addition, Zambia intends to develop and refine its FREL based on three guiding goals or motivations, the first is for domestic purposes whereby Zambia will make use of the FREL to measure the impacts of policies and measures to protect forests. The second is to seek international finance within the context of results based finance and finally the third, Zambia seeks to contribute to global mitigation activities. As such, the update frequency will be determined based on these three goals, and how Zambia would like to measure, report and verify results against its FREL.

4.3 Future Improvements

Zambia has chosen to develop its FREL using a stepwise approach which allows for iterative updates and improvements to FREL as and when new data and or updated methods become available. As such, the present FREL, while comprehensive, will see improvements in the future that enhance the FREL's ability to capture the emissions in Zambia that are associated with new activities taken to reduce deforestation. The Zambian government recognises the following five areas where the FREL could be improved on in the future.

Additional Land Use Assessment (2005-2006)

The historical reference period for the FREL currently starts in 2005 and ends in 2014. This period was chosen as it captures the recent increase in deforestation (2010 - 2014) while also being cognisant of the past rates of deforestation measured between 2000 and 2010. The limitation of this approach is that the period of assessment for the period before 2010 runs from 2000 to 2010 and not 2005 to 2010. As such the FREL would benefit from an additional forest change assessment in 2006. Zambia intends to conduct this analysis in the near future and to update the FREL using the activity data calculated during the new time period.

Measuring Degradation

The present iteration of the FREL includes only the deforestation activity. Data collected as part of the National Forest Inventory and the forest cover change analysis are suitable for quantifying the emissions associated with deforestation but are not suitable for degradation purposes. In Zambia, degradation is defined as changes within the forest class affecting the forest stand quality or site negatively. A well-known degradation activity in Zambia is the production of charcoal. Primary forests are usually clear felled and the larger branches and stems are used to burn the timber into charcoal, which is then sold for cooking and general energy needs. The impact on the forest is severe but, over a period of 15 - 20 years the forest will return to its previous state, provided the area is not converted to agriculture. Measuring the emissions associated with degradation in Zambia is very difficult as reliable records on charcoal production are not available and the land use was not sampled during the National Forest Inventory. In addition to the challenges of quantifying the emissions associated with degradation the tools used to measure activity data are not accurate enough to reliably quantify the areal area affected by degradation. As such the activity was not included in the present FREL but the Zambian government does recognise that this is an important activity that should be quantified in future iterations of this FREL.

Including gain and regrowth

Gains and regrowth within Zambia have not been included in this FREL. The reasons for their exclusion are similar to those mentioned above in the case of degradation. While it is acknowledged that areas that have undergone degradation and or deforestation may experience a certain amount of re-growth over a particular period, reliably quantifying these gains is difficult at present. In the future Zambia will endeavour to collect data that may be used for quantifying gains and may also benefit from the development of advanced analytical tools that allow for the mapping of gains and regrowth.

Additional Pools

Within the present FREL both the soil and litter carbon pools are not included. Little is known about soil carbon dynamics following deforestation activities; as such the lack of empirical information on the losses from this pool makes it problematic to report accurate emissions. Soil data has however been collected throughout the country and additional soils analyses will be undertaken in the future. Once confidence in the data is improved the pool will be included in the FREL. Litter will also be included once more is known about the dynamics of CO_2 in litter following deforestation.

Including emissions from Fires

Emissions associated with fires will be included in future iterations of this FREL. The quantification of these emissions is possible by combining spatial data capturing fire occurrence (MODIS Burn Scar Maps) with emissions factors data collected as part of the recently completed National Forest Inventory (ILUA II).

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ANNEX: Summary of main features of the proposed FREL

The following table is a summary of the information contained in this submission:

Main features of the FREL		*Remarks*
Proposed FREL (in tCO_2eq/yr)	25,863,863.19 tCO_2eq/yr^{-1}	
Type and duration of FREL	Historical Average – 9 years	
Adjustment for national circumstances	None	
National/subnational [a]	National	
Activities included	Deforestation	
Pools included [b]	Above Ground Biomass, Below Ground Biomass, Dead Wood	
Gases included	CO_2	
Forest definition [c]	0.5 ha – 10% Canopy Cover – 5 m height	
Relationship with latest GHG inventory	GHGi to be updated shortly	
Description of relevant policies and plans [d]		
Description of assumptions on future changes in policies [d]		
Description of changes to previous FREL		
Future improvements identified	• Additional land use assessment 2006	

	• Measure degradation • Include gain and regrowth • Additional pools • Include emissions from fires	

Abbreviations: AB = aboveground biomass, BB = belowground biomass, DW = dead wood, FREL = Forest reference emission level, GHG = greenhouse gas, L = litter, t CO2 eq/yr = tonnes of carbon dioxide equivalent per year.

[a] If subnational, comments should include information on the treatment of displacement of emissions.

[b] In the case of omitted pools or activities, comments should include the justification provided by the country.

[c] The forest definition should be summarized, and it should be stated if it differs from the definition used in the greenhouse gas inventory or in reporting to other international organizations.

[d] May be relevant to the description of national circumstances, which is required in the case of adjustment.