Republic of Kenya

Ministry of Environment and Forestry

The National Forest Reference Level for REDD+ Implementation

December 2019

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LIST OF ACRONYMS

AD	Activity Data
AGB	Above Ground Biomass
BGB	Below Ground Biomass
CBD	Convention on Biological Diversity
CF	Carbon Fraction
CO_2	Carbon Dioxide
EF	Emission Factor
EMCA	environmental Management and Conservation Act
FAO	Food and Agriculture Organization of the United Nations
FLEGT	Forest Law Enforcement, Governance and Trade
FPP	Forest Preservation Program
FRA	Forest Resources Assessment
FREL	Forest Reference Emission Level
FRL	Forest Reference Level
GFOI MGD	Global Forest Observation Initiative Methods and Guidance Document
GHG	Green House Gases
IPCC	Intergovernmental Panel on Climate Change
ITTA	International Tropical Timber Agreement
JICA	Japan International Cooperation Agency
KEFRI	Kenya Forestry Research Institute
KFS	Kenya Forest Service
LAPSSET	Lamu Port South Sudan Ethiopia Transport Corridor
LCC	Land Cover Change Mapping
MEF	Ministry of Environment and Forestry
MMU	Minimum Mapping Unit
NCCRS	National Climate Change Response Strategy
NDC	Nationally Determined Contribution
NFI	National Forest Inventory
NFMS	National Forest Monitoring System
NIR	National Inventory Report
NRS	National REDD+ Strategy
REDD+	Reducing Emissions from Deforestation and Forest Degradation, and the role of Conservation, Sustainable management of forests and Enhancement of forest carbon stock.

SDG	Sustainable Development Goals
SIS	Safeguard Information System
SLEEK	System for Land-based Emissions Estimation in Kenya
UNCCD	United Nations Convention to Combat Desertification
UNFCCC	United Nations Framework Convention on Climate Change

EXECUTIVE SUMMARY

Kenya is a low forest cover country with a total forest area of 3,462,536 ha or about 5.9% of the total national area. The government of Kenya has a goal of enhancing forest cover to a minimum of 10 % of the National area by 2030. As a party to the UNFCCC, Kenya has committed to contribute to Global climate change mitigation and adaptation and has submitted its Nationally Determined Contribution (NDC) in line with the requirements of the Paris Climate change Agreement. The forest sector was identified as key to the realization of the national goals due to its comparatively high abatement potential. Based on data collected as part of this process, deforestation in the country is estimated at 103,368 ha per year (0.17% of the national area) but conservation efforts achieve about 90,477ha of reforestation annually (0.15% of national area).

Kenya is establishing a Forest Reference Level (FRL) for REDD+ to; 1) exploit opportunities for reducing current emissions arising from deforestation and forest degradation, and 2) take advantage of opportunities for enhancement of carbon stock arising from afforestation, reforestation and restoration of degraded forest areas. The various building blocks for establishing the FRL were comprehensively discussed and agreed by a Technical Working Group that was established purposely to offer technical guidance for FRL development. An overview of the decisions is as follows:

- Forest definition: a minimum 15% canopy cover; minimum land area of 0.5 ha and minimum height of 2 meters.
- Scale: National
- Scope: REDD+ Activities include Reducing emissions from deforestation, Reducing emissions from forest degradation, Sustainable management of forest and Enhancement of forest carbon stocks.;
- Gases: covers only CO_2.
- Pools: Above Ground Biomass (AGB) and Below Ground Biomass (BGB).
- Reference period: 2002-2018
- Construction method: Historical Average of emissions and removals between 2002 and 2018, monitored at 4 year intervals

Using an approach 3 mapping and a combination of local and IPCC defaults, Kenya proposes a FRL of 52,204,059 t CO_2/year. This FRL is derived from average annual historical emissions from deforestation, forest degradation, sustainable management of forests, and enhancement of forest carbon stocks in the period 2002-2018 monitored at 4 year intervals. The FRL for each of the REDD+ Activities has been calculated as 48,166,940 t CO_2/year for Deforestation, 10,885,950 t CO_2/year for forest degradation, 2,681,433 t CO_2/year for sustainable management of forests and -9,530,264 t CO_2/year for enhancement of carbon stocks.

Based on national circumstances, the projected future Emissions are based on an extrapolation of the average trend from the historical analysis for the net Emissions and for each of the REDD+ Activities. Since Kenya is in the process of developing a National REDD+ Strategy, the FRL provides an opportunity to monitor emission reductions based on the proposed Policies and Measures and their specific interventions.

The FRL process identifies a number of improvements for the future which include; enhancing the land cover mapping process to improve accuracy of Activity data, implementing an NFI to improve on Emission Factors and research to capture the variety of non CO_2 emissions from REDD+ activities and involve more pools.

1. INTRODUCTION

1.1. Relevance

In response to UNFCCC decision 1/CP.16 paragraph 71 (b) and decision 12/CP.17 paragraph 8 and 10, Kenya wishes to voluntarily submit to the United Nations Framework Convention on Climate Change (UNFCCC) the proposed National Forest Reference Level (FRL) for contribution to mitigation actions in the forest sector. In this context, this submission is premised on the consideration that the submission is subject to a technical assessment in accordance with decision 13/CP.19; decision 14/CP.19; and decision 12/CP.17. In preparing the FRL, Kenya has used a stepwise approach consistent with decision 12/CP.19; on the modalities for FRLs and FRELs; including the right to make adjustments to the proposed FRLs/FRELs based on national circumstances. This stepwise approach is strongly informed by availability of data, financial resources and capacities within the country for establishing the FRL.

1.2. The National Context

1.2.1. Country Profile

Kenya is one of the East African countries lying across the equator at latitude of 4° North to 4° South and Longitude 34° East to 41° East. The country is bordered by South Sudan and Ethiopia in the north, Somalia to the east, Indian Ocean to the south-east, Tanzania to the south and Uganda to the west (Fig. 1). The country has a total area of 592,038. km^2 including 13,400 km^2 of inland water and a 536km coastline.

Kenya's geography is diverse and varied. The terrain gradually changes from the low-lying coastal plains to the Kenyan highlands reaching a peak of 5,199m above sea level at Mt Kenya. The Great Rift Valley located in the central and western part of the country basically dissects the Kenyan highlands into east and west. Further west, the altitude decreases towards Lake Victoria while northwards, there are vast drylands which are gradually being colonized to support livelihoods for the pastoralist communities and game ranchers. Kenya has six drainage patterns based on the direction of the waters and the majority of inland water bodies are found in the Rift Valley.

Kenya is divided into seven agro-climatic zones ranging from humid to very arid. Less than 20% of the land is suitable for cultivation, of which only 12% is classified as high potential (adequate rainfall) agricultural land and about 8% is medium potential land. The rest of the land is arid or semi-arid.

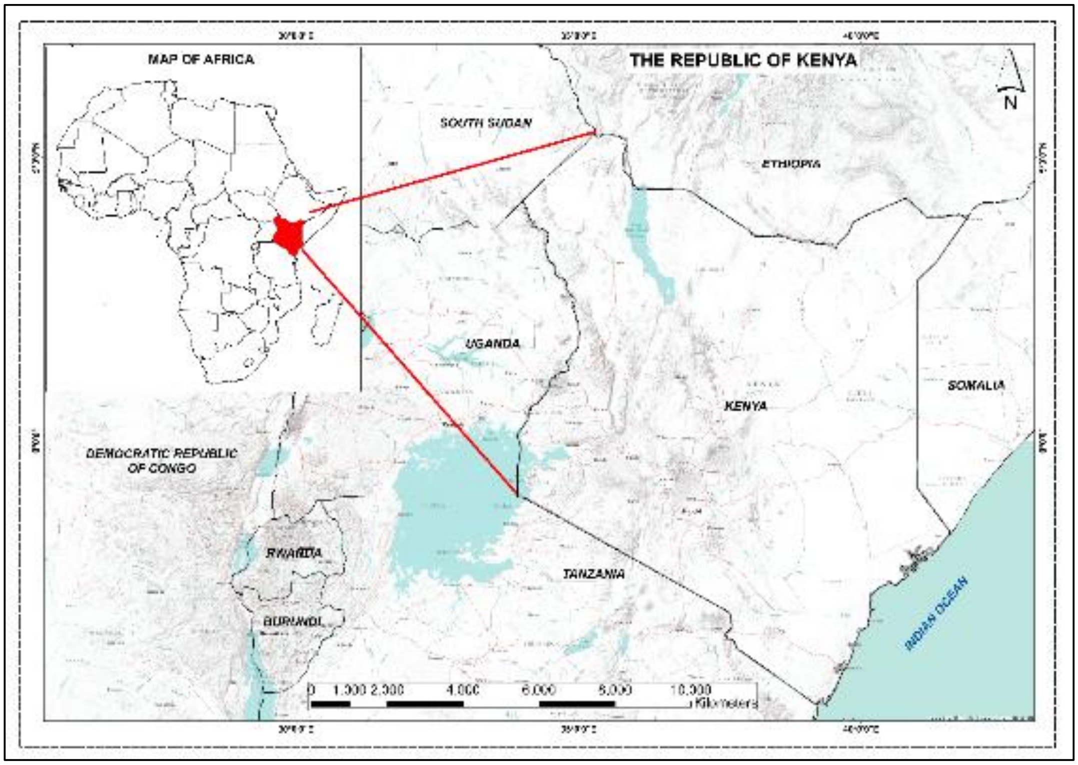

Figure 1: Location Map of Kenya

Kenya is a low forest cover country. The 2018 Land cover mapping shows a forest cover of 3,462,536 ha or about 5.9% of the country's total area, which has slightly declined from about 6.2% in the year 2002. Enhancing forest cover to a minimum of 10% is a key priority of the Government of Kenya. The Constitution (GoK, 2010) obliges the government to work and achieve a forest cover of at least 10% while the national development blueprint (Vision 2030) and the National Climate Change Response Strategy (NCCRS) aim to achieve this goal by 2030. As a party to the UNFCCC, Kenya has committed herself to contribute effectively to global climate change mitigation and adaptation efforts including a renewed resolve to conserve all available carbons stocks and enhancing its forest carbon. The country has signed the **Paris Agreement** and developed a **Nationally Determined Contribution (NDC)** to global climate change efforts. The success of the NDC will strongly be influenced by the forest sector due to its comparatively high abatement potential.

A Climate Change Strategy was developed in 2010 and this has led to the passing of the Climate Change Act in 2016. The Climate Change Act defines an institutional arrangement under the Ministry in charge of Environment to spearhead implementation of climate change activities and recognizes the need to mainstream climate change issues in all developmental programmes in the country. In addition, Climate Change Action Plans have been developed for the period 2013-2017 and also 2018-2022 to support implementation of pertinent and upcoming issues regarding climate change. The **Forest Act** of 2005 has also been reviewed into the Forest Conservation and Management Act of 2016 (GoK, 2016) to further strengthen the country's responses to protect forested landscapes and to provide opportunities for increasing the forest cover in line with national development aspirations. In mainstreaming Climate change in various sectors, additional policies in the land, agriculture and energy sectors have also been developed. In addition to this, Kenya has a National Development Plan which seeks to achieve the Vision 2030 targets through aggressive afforestation and reforestation and rehabilitation programs.

All these policy documents and Specifically the NDC regard the forestry sector as a priority area to move Kenya towards a low-carbon, climate-resilient development pathway. Specifically, in response to a global call for action contained in the **New York Declaration of forests, the Bonn Challenge and the Africa 100 million ha of forests (AFR100) commitment**, the Government of Kenya has committed to restore 5.1 million ha by 2030 equivalent to an average of 392,000 ha per year. The opportunities for restoration have been identified and current discussions revolve around the best strategies for restoration.

1.2.2. The Forest Sector

Kenya's economy is strongly dependent on natural resources including forestry. The Forest sector is the backbone of Kenya's Tourism since forests provide habitats for wild animals, offer dry season grazing grounds and protect catchments that provide water downstream. Forests maintain water catchments (defined as water towers) which support agriculture, industry, horticulture, and energy sectors contribute more than 3.6 per cent of GDP. In some rural areas, forests contribute over 75% of the cash income and provide virtually all of household's energy requirements. It is estimated that economic benefits of forest ecosystem services exceed the short-term gains of deforestation and forest degradation and therefore justify the need to conserve the forests.

In spite of these important functions, deforestation and forest degradation have continued to pose challenges driven by among others pressure for conversion to agriculture, urbanization and other developments, unsustainable utilization of forest resources, inadequate forest governance and forest fires. The country is exploring a wide range of options, including policy reforms and investments, to protect the existing forests and to substantially restore forest ecosystems across the country.

Forests in Kenya are managed under three tenure systems: public, community and private. Public forests are managed by both national government agencies (mainly Kenya Forest Service and

Kenya Wildlife Service) and County Governments. Public forests are mainly managed for provision of environmental goods and services but they also contain a belt that is managed for timber, poles and fuelwood. Community forests are owned by communities or held in trust by county governments and where forest management rights and responsibilities are transferred from the Public Administration to local communities through long-term leases or management agreements. Private forests are owned or managed by individuals, institutions or corporate entities as freehold or leasehold. The Kenya Forest Service remains the foremost institution charged with the responsibility and mandate to ensure all forests in the country are sustainably managed.

1.3. REDD+ in Kenya

Past attempts to increase forest cover and address the problem of deforestation and forest degradation in the country have not been very successful. This can be attributed to among other factors; increasing demand for land for agriculture, urbanization and other developments, high energy demand and inadequate funding to support investments in the forestry sector. Unresponsive policy and poor governance in the forestry sector have often in the past compounded these problems.

In the year 2012, Kenya developed a consultative REDD+ readiness proposal which identified priorities in the National REDD+ implementation process. The National REDD+ strategy is currently being developed. It is noted that REDD+ presents a great opportunity to reverse the negative trends of forest loss by providing innovative approaches, including incentives from carbon finance that support implementation of a comprehensive strategy that effectively supports sustainable management and conservation of forests and at the same time reduce carbon emissions. In Kenya, REDD+ is evolving as an attractive means to reduce forest sector carbon emissions. Kenya's participation in REDD+ is premised on the conviction that the process holds great potential in supporting:

- Realization of constitutional requirement and vision 2030 objectives of increasing forest cover to a minimum of 10%;
- Government efforts in designing policies and measures to protect and improve its remaining forest resources in ways that improve local livelihoods and conserve biodiversity;
- Access to international climate finance to support investments in the forestry sector;
- Realization of the National Climate Change Response Strategy (NCCRS) goals.
- Contribution to global climate change mitigation and adaptation efforts as illustrated in Kenya's NDC.

Priority areas of focus in REDD+ include the following:

- Reducing pressure to clear forests for agriculture, settlements and other land uses;
- Promoting sustainable utilization of forests by promoting efficiency and energy conservation;
- Improving governance in the forest sector -by strengthening national capacity for Forest Law Enforcement, Governance (FLEG)- advocacy and awareness;
- Enhancement of carbon stocks through afforestation /Reforestation, and fire prevention and control.

2. THE FOREST REFERENCE LEVEL

2.1. Objectives of developing a National FRL

Kenya is establishing a Forest Reference Level as an objective benchmark for assessing performance of REDD+ activities. The FRL has been established in consistence with the country's greenhouse gas inventory process guided by the IPCC reporting principles of Transparency, Accuracy, Consistency and Comparability. In this report, Kenya focuses on four REDD+ activities; reducing emissions from deforestation, reducing emissions from forest degradation, sustainable management of forests and enhancement of forest carbon stocks.

2.2. The Building Blocks of the Forest Reference Level

2.2.1. Forest definition

A national forest definition for REDD+ has been agreed through a broad stakeholder consensus as a minimum 15% canopy cover; minimum land area of 0.5 ha and potential to reach a minimum height of 2 meters at maturity in situ. Perennial tree crops like coffee and tea are not considered as forests under this definition irrespective of whether they meet the definition of forests.

This definition was informed by five basic considerations;

- Provision of opportunity to many stakeholders within the country to participate in incentivized forestry activities that reduce deforestation and forest degradation, support conservation and those that enhance carbon stocks;
- Inclusion of the variety of forest types in the country ranging from montane forests to western rain forests, coastal forests and dryland forests, all of which have been constrained by ecological conditions but are a priority for conservation by Kenya's national development programmes;
- Possibility of providing consistent data for establishing the reference level and for monitoring of performance based on available technology;
- Need to balance the costs of implementation and monitoring and the result-based incentives
- Consistency with the national forest agenda to optimize, manage and conserve Kenya's forests.

While the Second National Communication (SNC) to the UNFCCC used the FAO forest definition to provide information on forest cover in the country, it has since been agreed that the Third National Communication will be harmonized with the forest definition which is used for setting this FRL. This definition will also be used to inform monitoring of forest sector performance and reporting to other international treaties and protocols to which Kenya has subscribed.

2.2.2. Identification of REDD+ Activities

Kenya has classified forests in the country based on four strata (Figure 2). Three strata (Montane and Western rain. Coastal and Mangrove and Dryland) are based on Kenya's broad ecological zones based on climate and altitude. They define the major biomes/ecological zones in which forests grow and align to the IPCC ecological zones[1] The 4th strata is a management zone and covers the public plantation forests which are managed by the Kenya Forest Service. These strata were used to define the scope of REDD+ Activities.

Kenya has decided on the following scope of REDD+ activities with their definitions:

- Reducing emissions from deforestation (Deforestation)

  Deforestation is defined as the conversion of Forest to Non-Forest land use across all management systems in Montane and Western rain, Mangrove and coastal, and Dryland forest strata. Deforestation does not include planned and periodic felling of public plantation forests and associated carbon stock fluxes.

- Reducing emissions from forest degradation (Forest Degradation)

Forest degradation is defined as the degradation of forest canopy which changes from dense canopy coverage to moderate and open canopy coverage and from moderate to open canopy coverage in Montane and Western rain, Mangrove and Coastal, and Dryland forest strata.

- Sustainable management of forests

Sustainable management of forests which is limited to the public Plantation Forests managed by Kenya Forest Service (KFS), is defined as the conversion of non-planted forest area to planted forest area. This is based on a backlog in replanting of areas designated for public commercial plantations. Kenya notes that any variations in canopy cover among plantation forests may not be associated to degradation and enhancement and adopted a single canopy cover for plantation forests. Sustainable management of forests aims at ensuring a balance between harvests and replanting activities of the public plantation forests in which case the net emissions will be equal to zero.

[1] Table 4.4. of the 2006 IPCC guidelines for GHGI. Volume 4: Agriculture, Forestry and Other Land Use

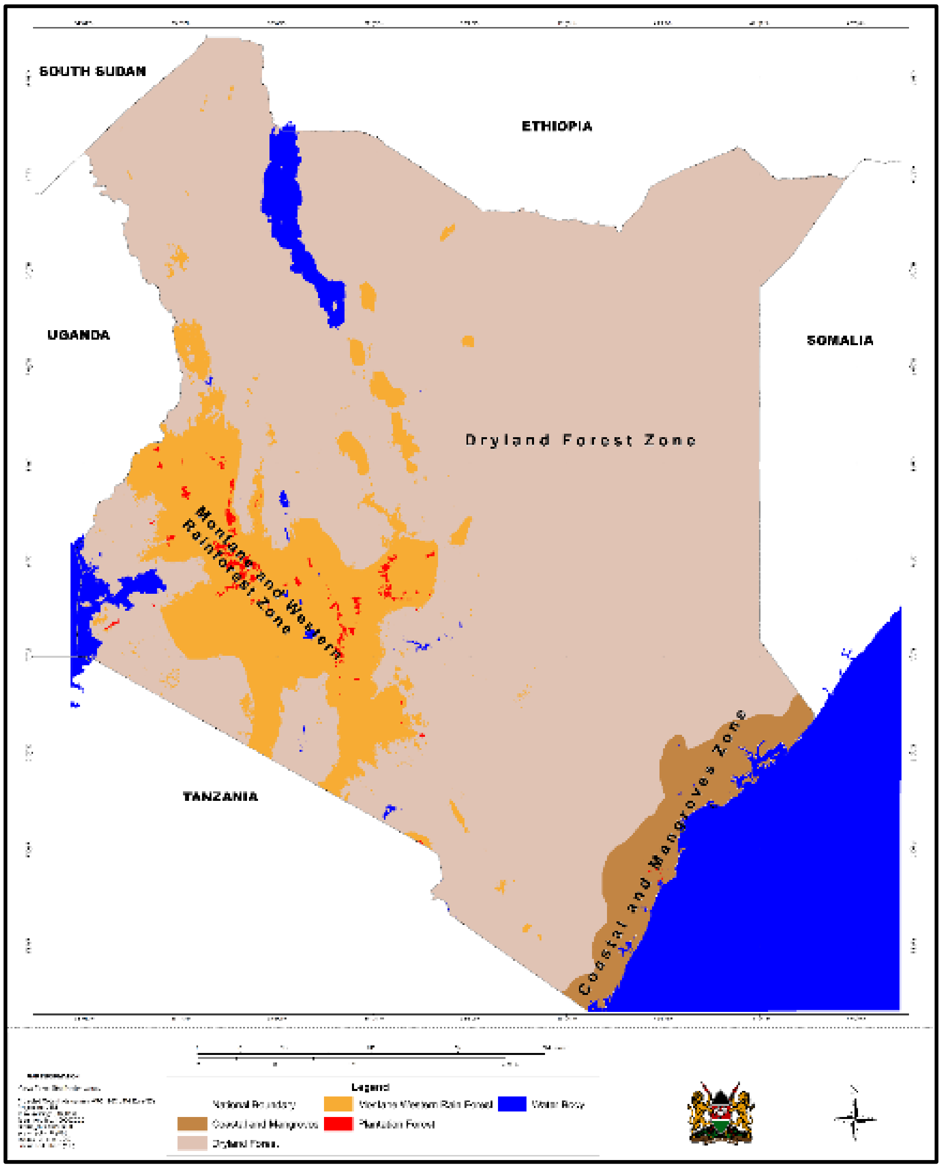

Figure 2: The Ecozones used to create forest strata

- Enhancement of forest carbon stocks

This refers to activities that increase carbon stocks in Montane and Western rain, Coastal and Mangrove, and Dryland forest strata through rehabilitation of degraded areas, reforestation and afforestation efforts.

2.2.3. Carbon pools

Kenya selected the carbon pools as follows:

- Above-ground biomass
- Below-ground biomass

The carbon pools shown below were not considered when establishing the FRL:

- Soil organic carbon
- Litter
- Deadwood

The reasons of omission from the carbon pools are as shown below:

a) Soil organic carbon

Kenya notes the requirements for Tier 1 reporting of the soil carbon stocks (2006 IPCC Guidelines) which require a land-use factor (FLU), a management factor (FMG) an input factor (FI), all that require a variety of information which is lacking in Kenya. In line with the stepwise approach and based on data availability, this pool can be included in Kenya's monitoring of GHGs from the forest sector in future.

b) Litter

There is limited information and research data in Kenya to support inclusion of this carbon pool. In the future, this pool will be researched further to support a more accurate estimation based on a stepwise approach.

c) Deadwood

There has not been enough research on the deadwood carbon pool. Data from a pilot forest inventory showed inconclusive results. Further research and collection of more data has been proposed to support its inclusion in future.

2.2.4. Scale

Kenya has chosen to establish a national FRL. This decision is informed by current forest management practices and evolving policies, legislation and institutional frameworks for forest sector reforms. There is broad consensus that REDD+ will be implemented through strong policies and other measures by the national government and county governments. Kenya's decision was also informed by the need to provide broad sectoral technical guidance and monitoring framework to support jurisdictional and project-level REDD+ activities.

2.2.5. Green House Gases (GHG)

Kenya's FRL only covers Carbon dioxide gas (CO_2). Non-CO_2 emission Gas such as Methane (CH_4), Carbon Monoxide (CO) and Nitrous Oxide (N_2O) have not been considered because Kenya does not have quantitative spatial data for Non-CO_2 emission Gases (such as emissions from forest fires and emissions from forests in wetlands). Nethertheless, forest fires and mangrove forests are major sources of non- CO_2 gases and may be considered in subsequent estimation.

2.3. Selection of Reference Period

The forest sector in Kenya has undergone a number of changes over the historical period. It started during the colonization of Kenya where white highlands were created and areas of forest plantation established from existing natural forests (Ochieng *et al.,* 1992). In 1957 under the then CAP 385 Laws of Kenya, a National Forest Policy was published to support the management of forests. The policy was further revised in 1968 with the objective of enhancing biodiversity conservation. However, the suspension of the "Shamba" system[2] in the 1980s and 1990s due to an increasing forest adjacent community, massive excisions of public forests and poor enforcement of conservation recorded large scale destruction of forests. In the year 2001, a partial implementation of the proposed excision of 167,000 ha of forests was done taking away 71,000 ha of forests mainly in the Mau Forest Complex, and converting it into agricultural land (Ministry of Lands, 2001).

The Kenya Indigenous Forest conservation Programme (KIFCON) of 1990-1994 (Wass, 1995) provided a first glimpse of the situation of forests in Kenya, illustrated poor stocking in natural forests due to massive human encroachment. Agitation for revision of the Forest Act started in 2002 culminating in enactment of the Forest Act 2005 which has further been revised to the Forest Conservation and Management Act of 2016. The First National Land cover maps were actualized under the Forest Preservation Program (FPP) (KFS, 2013) which produced Land Cover / Land Use Map for 1990, 2000 and 2010 based on imageries of LANDSAT4, 5, 7 and ALOS. The maps illustrated a declining forest cover in the period 1990- 2000 and then a slight increase in the forest cover past year 2000 corresponding to improved forest policies. However, an improvement in forest policies of conservation may have favored only the forests of the white highlands (in this report described as Montane and Western Rain forests exposing the other forests to further degradation.

[2] Under the Shamba system, communities were allowed to reside inside forests and they actively participated in supporting forest plantation programmes

2.3.1. Aligning Reference period to changes in the Forest Sector

Policy has advised the selection of the reference period as **the period 2002 – 2018**. Such policies have been detailed in the introductory chapter of this document and are summarized below

1. The implementation of recent forest Acts i.e. Forest Act 2005 and Forest Conservation and Management Act of 2016 is expected to affect forest area changes positively. The agitation for a change in the forest act peaked in the year 2002 when a new government was elected and there was a general consensus that governance of forests should change. The forest act brought changes on management including community participation and made forest excisions more difficult than they were previously. The year 2002 is just after major excisions of montane forests that were done in 2001 (Ministry of Lands 2001) and no further excisions have been done. It implies a period of clearance of the excised forests but also a recovery of degraded forests next to excisions.

2. The coming of a new government in the year 2002 brought in planning of large scale development under the Vision 2030 targets. This came with urbanization and infrastructural growth, improved access into formerly pristine vegetation which exposes the dryland forests. By 2010, a new constitution was enacted and governance structures under devolved governments instituted. These changes have affected management and conservation of forests both positively and negatively. For example, proposals to increase agricultural land encroaches into former marginal lands where dryland forests existed. Similarly, developmental targets in the construction industry expose forests to further degradation because they are a major source of construction material

3. The period after the year 2002 has experienced enactment of many environmentally friendly policies that may favour forest conservation. The climate change related policies include The National Climate Change Strategy of 2010, Kenya Climate Change Act 2016, National Climate Change Framework Policy 2016 and Climate Change Action Plan 2018 among others. Land related polices include the Kenya Land Registration Act of 2012, The National Land Use policy of 2016 and the Kenya Land Act of 2016. Similarly, the Farm Forestry Rules of 2009, the gazettement of the Kenya Water Towers Agency in 2012 and the Enactment of the Wildlife Conservation and Management Act 2016 are some of the recent policies that favour forest conservation.

2.3.2. Selecting a Reference period based on mapping tools

Activity data for Estimating Green House Gases from the Land sector which has been used in the National Inventory Report for 2019 and the FRL is based on Wall to Wall land cover mapping using LANDSAT imagery. The detailed procedures used to develop the maps are explained in chapter three of this report. To develop a time series set of maps, the 34 LANDSAT images that make a wall-to-wall map of Kenya were available for the period 1990 to 2018. The land cover products are available for the years 1990, 1995, 2000, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015 and 2018. However, analyzing land cover change associated with each available epoch e.g. on annual basis is a complex process. Under the System for Landbased Emission Estimation for Kenya (SLEEK) programme that supported the development of the land cover maps, an Integration Tool (FLINT) is proposed to provide an annual monitoring of emissions from the Land sector based on annual land cover maps. However, the integration tool is still under development.

It is noted that the National Inventory Report for Kenya's 3rd NC has adopted the period 1995 – 2015 due to availability of data from other sectors while the FRL has adopted the period 2002 – 2018 to capture the period of implementation of recent forest sector policy decisions. The NIR adopted a 5 year interval of monitoring emissions (1990-2000, 2000-2005, 2005-2010 and 2010-2015). To harmonise emissions from the two processes and allow comparability, the FRL has adopted 4 year intervals in the period 2002-2018 (2002-2006, 2006-2010, 2010-2014 and 2014-2018).

3. ACTIVITY DATA AND EMISSION FACTORS

3.1. Activity data

3.1.1. Kenya's Land Cover mapping programme

In 2013, Kenya launched the System for Land-Based Emission Estimation in Kenya (SLEEK) programme to support the National GHG inventory process. The SLEEK has done an extensive mapping using a semi-automated method and produced the Land Cover / Land Use Map for the year 1990, 1995, 2000, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015 and 2018 based on imagery of LANDSAT4, 5, 7 and 8.

The map production methodology applied by SLEEK is pixel based – supervised classification using Random forest algorithm. The SLEEK Land Cover Change Mapping (LCC) Process aims to create a consistent, sustainable and technically rigorous process for providing land cover and change information required for national land based greenhouse gas (GHG) estimation. The programme seeks to provide a nationwide, time series consistent land cover maps for Kenya. These maps allow analysis of land cover and cover change through time based on IPCC land cover categories and their subtypes based on local requirements. In addition to supporting SLEEK, the maps and statistics generated by the program are recognized as official Government documents for informing Government processes across the land sector – such as land use planning, tracking deforestation, and landscape restoration. These maps have also been used to support the REDD+ process in construction of the Forest Reference Level and the National Forest Monitoring System.

The methodology employed for the SLEEK mapping process and which is described in Annex 1 allows creation of Land Cover / Land Use Map in a short period at low cost without requiring manual interpretation and editing. The site training data for supervised classification was extracted through a ground truth survey supplemented by Google Earth in areas with poor accessibility. The minimum mapping unit (MMU) of Land Cover / Use class was 0.09ha due to pixel basis image classification methodology. However, filtering process was applied to ensure that forest mapping met the forest definition (0.5ha as minimum area) as agreed in the country. The detailed process of developing these maps is available in a Technical Manual (SLEEK, 2018). An illustration of the map products from this process is shown in Figure

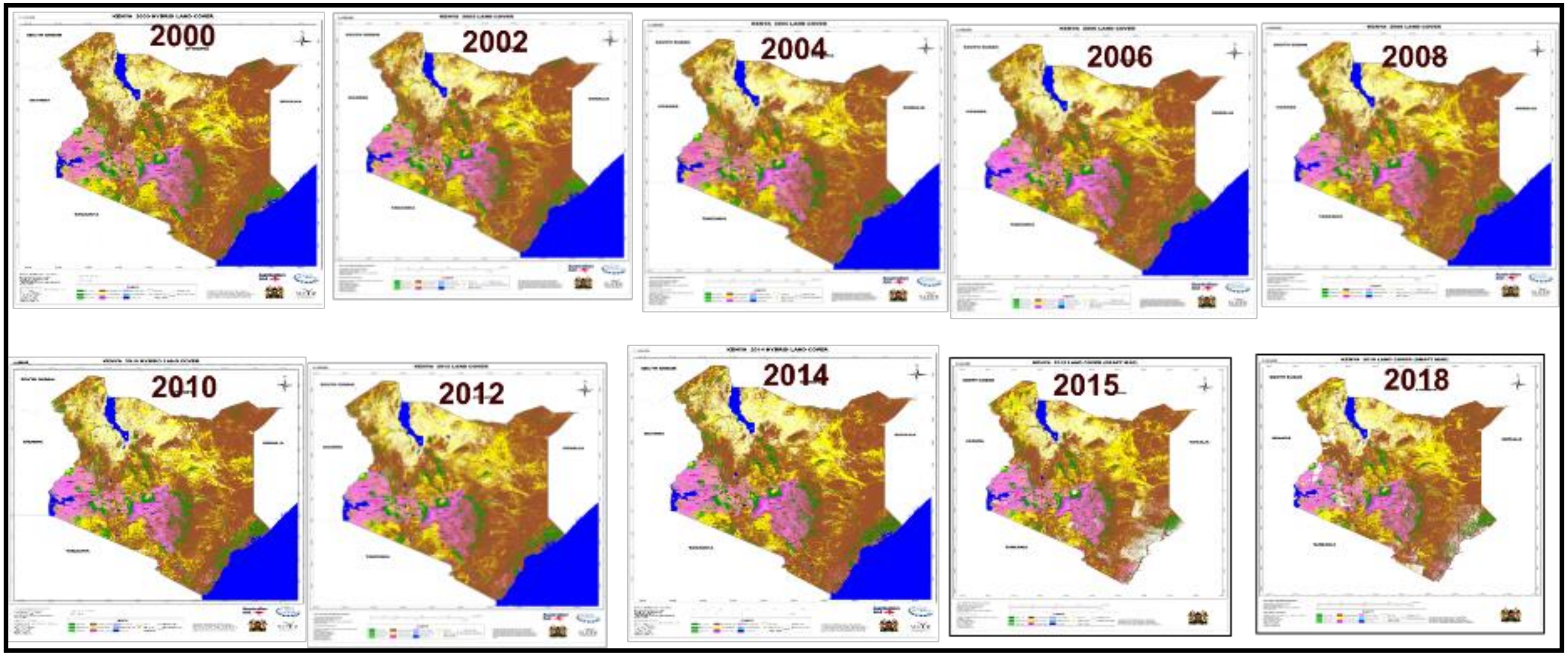

Figure 3: Some of the Wall-Wall time series Landcover maps from the SLEEK programme

Based on the complete time series mapping, the trend of forest cover for the period 2002-2018 is shown in percentages in Figure4. The figure shows a decline in forest cover from 6.2% (3,669,768 ha) in 2002 to 5.9% (3,462,536 ha) in 2018.

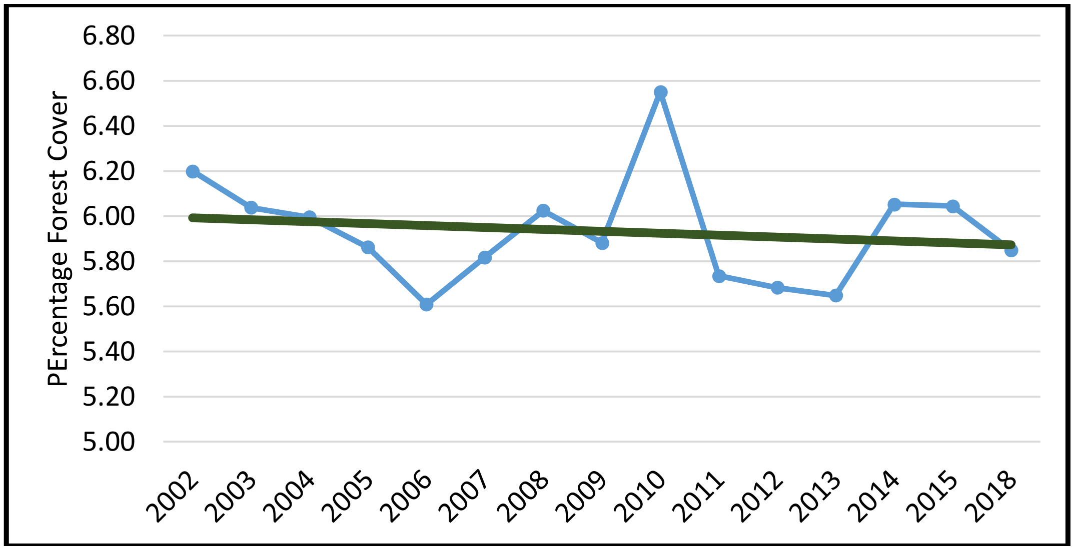

Figure 4: The Trend of forest cover change (%) (2002 – 2018) (SLEEK maps)

3.1.2. Stratification of forests

The land cover maps stratify forests into four strata (Figure 2) which have been adopted for assigning emission factors to different forest types. These strata are described in Chapter 2 of this report and follow the three forest ecozones of Kenya (Dryland forest areas, Montane & Western Rain forest areas and Coastal & Mangrove forest areas) defined by altitude and climate (Wass, 1995). The specific characteristics of the forests in each stratum are described in Annex 2. The fourth stratum is a management stratum comprising of commercial plantation forest areas managed by Kenya Forest Service (KFS), which spread across the ecozones. Non forest areas refer to Cropland, Grassland, Wetland, Settlement and Other land corresponding to the IPCC guidelines[3].

A second level stratification on the three strata based on ecozones (Dryland forest areas, Montane & Western Rain forest areas and Coastal & Mangrove forest areas) was done on the basis of canopy closure. The resultant canopy classes are: 15-40 % (Open), 40-65 % (Moderate), and

[3] Note that the SLEEK mapping system has not allowed separation of settlement (built up areas) and Otherlands as described by the IPCC guidelines

above 65 % (Dense). However, for the Plantation forest category managed by Kenya Forest Service (KFS), no subdivisions were done by canopy closure. This results to a total of 10 forest strata (Table 1). A conversion of a forest in a lower canopy class (e.g. open forest) to a higher canopy class (e.g. dense forest) results to Enhancement of Carbon stocks. Similarly a conversion of higher canopy forest to a lower canopy forest results to reduction in carbon stocks and is a forest degradation activity.

Table 1: Classification of Land Cover/Land uses for mapping under SLEEK

Land Category	First level stratification	Second level stratification
Forest	Montane/western rainforest/bamboo	Dense (canopy cover ≥65%)
		Moderate (Canopy cover 40-65%)
		Open (Canopy cover 15-40%)
	Coastal and Mangrove forests	Dense (canopy cover ≥65%)
		Moderate (Canopy cover 40-65%)
		Open (Canopy cover 15-40%)
	Dryland forest	Dense (canopy cover ≥65%)
		Moderate (Canopy cover 40-65%)
		Open (Canopy cover 15-40%)
	Plantation forest	Plantation forest
Non forest	Cropland	
	Grassland	
	Wetland	
	Settlement and Other lands[4]	

Table 2 below shows a product of the mapping process. It illustrates the specific areas of land uses mapped for the years 2002 and 2018. The table gives an illustration of the coverage of the various land uses identified in Table 2. Forestlands comprise a small percentage of the total land area of Kenya at approximately 6% (ranging from 6.2% in 2002 to 5.9% in 2018) while grasslands dominate at about 70% of the total land cover in Kenya. Croplands show a slight increasing trend from 8.9% to 11.4% in the years 2002 and 2018 respectively. These numbers are important because they describe Kenya's national circumstances affecting the forest cover and how this is expected to change over time. A decline in forest cover in the period 2002 – 2018 provides an opportunity for REDD+ implementation not only to reverse this trend but also to increase the forest cover towards the constitutional target of 10%. Similarly, an expansion in the Cropland area may be attributed to decreasing grasslands and forestlands and is one of the challenges

[4] The SLEEK land cover automated mapping does not separate Settlements and otherlands. Settlements are manually digitized on each maps based on ancillary data

affecting conservation of forestlands.

Table 2 also shows that most of the forests in Kenya are found in the dryland areas and the Montane forest areas. Each of these strata is faced by different drivers of deforestation but in spite of this, there is potential for enhancement of carbon stocks. The plantation forests managed by Kenya Forest Service (KFS) have the least area among the four strata and the areas have decreased over time. However, the area of plantation forests presented in Table 2 is only half of what is set aside for plantation forestry in Kenya[5] and this provides an opportunity for increasing the forest cover within the plantation zones.

[5] KFS maps show the area set aside for public plantation forestry as approximately 137,000 ha

Table 2: Land Cover statistics generated for each year used in the reference period

Land Use Strata	2002		2006		2010		2014		2018	
	Area (ha)	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**
Dense Forest	2,057,649	3.5	2,139,703	3.6	2,463,674	4.2	2,558,363	4.3	2,205,189	3.7
Moderate Forest	1,021,083	1.7	657,767	1.1	889,327	1.5	609,436	1.0	816,174	1.4
Open Forest	591,035	1.0	522,508	0.9	525,469	0.9	415,061	0.7	441,173	0.7
Sum Forests	**3,669,768**	**6.2**	**3,319,978**	**5.6**	**3,878,470**	**6.6**	**3,582,861**	**6.1**	**3,462,536**	**5.8**
Wooded Grassland	33,447,438	56.5	32,286,628	54.5	31,742,295	53.6	32,388,566	54.7	32,271,452	54.5
Open Grassland	8,985,269	15.2	9,299,024	15.7	9,331,841	15.8	8,821,893	14.9	8,980,656	15.2
Sum grassland	**42,432,707**	**71.7**	**41,585,652**	**70.2**	**41,074,136**	**69.4**	**41,210,459**	**69.6**	**41,252,109**	**69.7**
Perennial Cropland	281,755	0.5	299,776	0.5	261,821	0.4	299,727	0.5	284,357	0.5
Annual Cropland	4,995,761	8.4	5,798,968	9.8	5,800,963	9.8	5,901,652	10.0	6,455,816	10.9
Sum cropland	**5,277,516**	**8.9**	**6,098,743**	**10.3**	**6,062,784**	**10.2**	**6,201,378**	**10.5**	**6,740,173**	**11.4**
Vegetated Wetland	29,327	0.0	40,541	0.1	45,956	0.1	38,868	0.1	40,212	0.1
Open Water	1,212,707	2.0	1,177,785	2.0	1,215,342	2.1	1,223,689	2.1	1,227,320	2.1
Sum Wetland	**1,242,034**	**2.1**	**1,218,326**	**2.1**	**1,261,298**	**2.1**	**1,262,557**	**2.1**	**1,267,532**	**2.1**
Settlements & Otherland	**6,581,764**	**11.1**	**6,981,089**	**11.8**	**6,927,099**	**11.7**	**6,946,533**	**11.7**	**6,481,438**	**10.9**
Grand Total	**59,203,788**	**100**	**59,203,788**	**100**	**59,203,788**	**100**	**59,203,788**	**100**	**59,203,788**	**100**

3.1.2. Mapping land use transitions

The process of mapping land use transitions involved comparing change in maps from 2 time periods sequentially (e.g. 2002 vs 2006, 2006 vs 2010, 2010 vs 2014, and 2014 vs 2018). This resulted in a change map with areas remaining in the same land use type and areas changed to different land use types between 2-time periods (e.g. as shown in Figure 5) for the specific REDD+ activities. The process was repeated for each of the 4 time intervals (epochs) to generate activity data which was used to calculate emissions.

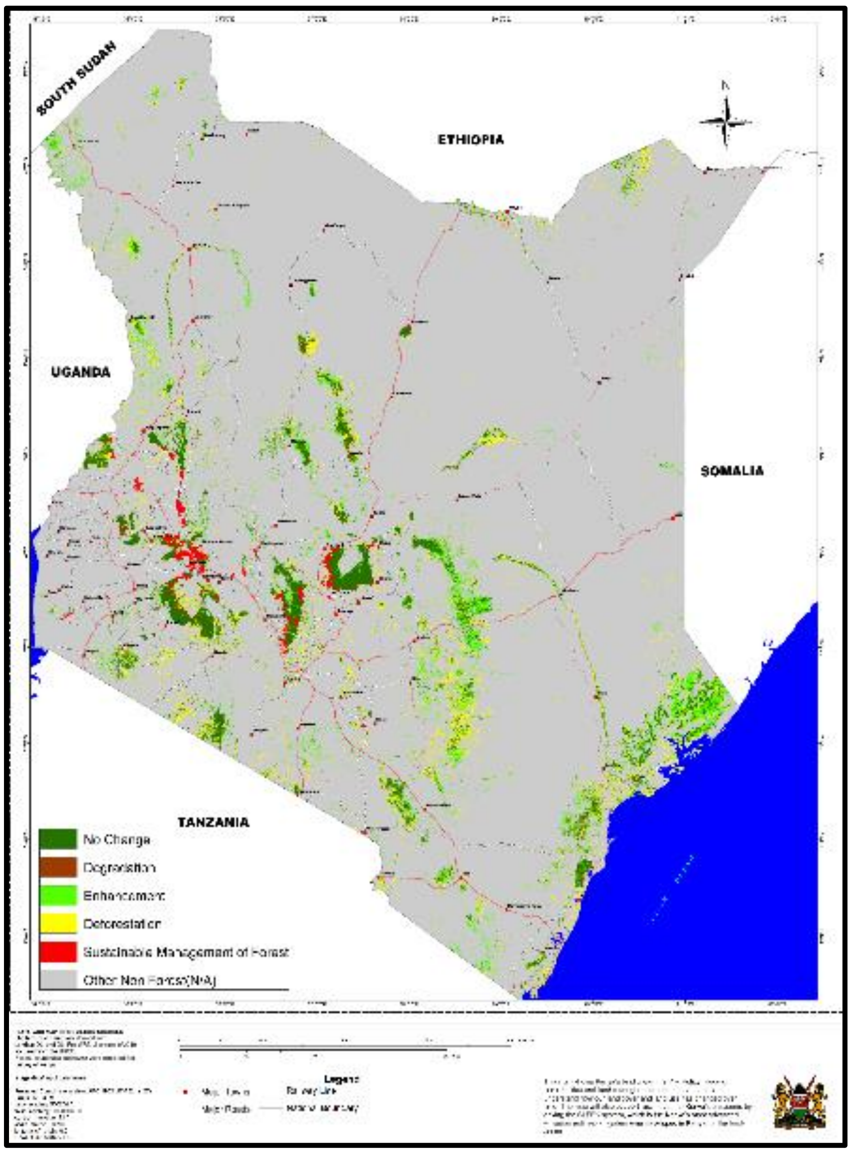

Figure 5: A Change maps (for year 2002-2006) used to generate activity data

3.1.3. Assigning Activity Data to REDD+ Activities

Based on the identified forest strata, Activity data on land use changes were assigned to each REDD+ activity to allow calculation of area change. A matrix was prepared to facilitate assigning the REDD+ activities to the different land use transitions, identify the specific areas of transition, with their specific Emission Factors and facilitate calculation of the overall emissions. The matrix below (Table 3) provides an explanation how each REDD+ Activities will be accounted for while setting the FRL. This information is summarized below

1. Deforestation is conversion of Forests to Non forests in all canopy classes of Montane/Western Rain forest, Coastal and mangrove forests and Dryland forests and is indicated by Red colour
2. Degradation is conversion of a forest from a higher canopy class to a lower canopy class for all forests in the strata/ecozones of Montane/Western Rain forests, Coastal and mangrove forests and Dryland forests and is indicated by yellow colour
3. Enhancement of Carbon stocks is the conversion of Non forests into forests (afforestation and reforestation) and the improvement of forests from a lower canopy class to a higher canopy class in the strata/ecozones of Montane/Western Rain forests, Coastal and mangrove forests and Dryland forests and is indicated by green colour.
4. Sustainable management of forests is the conversion of non-forests into forests and sustainable harvesting (forests into non forests) in public plantation forest areas managed by Kenya Forest Service (KFS) and is indicated by blue colour. This aims at reducing backlogs by replanting and increasing productivity of the public plantation forests.
5. Forestlands remaining forestland in the strata/ecozones of Montane/Western Rain forests, Coastal and mangrove forests, Dryland forests and Public Plantation Forests, which were mapped with a canopy remaining in the same canopy level in the two mapping years (e.g. 2002 and 2006) do not imply any carbon stock changes and have not been assigned any colour.
6. Conversions among non-forests e.g. cropland converted to wetland do not imply any emissions and have not been assigned any colour.

Table 3: Matrix for Allocating REDD+ activities to land use changes

				Area in 20XX+(X)													
				Forest										Non Forest			
				Montane Forest/ Western Rain Forest/ Bamboo			Costal Forest and Mangroves			Dryland Forest			Plantation Forest	Crop Land	Grass land	Wet land	Settlement and Other land
				D	M	O	D	M	O	D	M	O					
Area in 20XX	Forest	Montane Forest/ Western Rain Forest/ Bamboo	D	n	dg	dg								df	df	df	df
			M	e	n	dg								df	df	df	df
			O	e	e	n								df	df	df	df
		Costal Forest and Mangroves	D				n	dg	dg					df	df	df	df
			M				e	n	dg					df	df	df	df
			O				e	e	n					df	df	df	df
		Dryland Forest	D							n	dg	dg		df	df	df	df
			M							e	n	dg		df	df	df	df
			O							e	e	n		df	df	df	df
		Plantation Forest											n	s	s	s	s
	Non Forest	Cropland		e	e	e	e	e	e	e	e	e	s	NA	NA	NA	NA
		Grass land		e	e	e	e	e	e	e	e	e	s	NA	NA	NA	NA
		Wetland		e	e	e	e	e	e	e	e	e	s	NA	NA	NA	NA
		Settlement and Other land		e	e	e	e	e	e	e	e	e	s	NA	NA	NA	NA

df Deforestation (F→NF)
dg Forest Degradation (F→F(Degraded))
e Enhancement (F→F(Improved) ,NF→F)
n No Change (F→F)
s Sustainable Management of Forest (F→NF, NF→F)
NA Not Available

3.1.4. Land cover change areas between years

The proposed land cover change matrix was populated with data based on the proposed epochs; 2002 - 2006, 2006 -2010, 2010 -2014, and 2014-2018 as illustrated in Table 4. Calculations of area change are based on aforementioned strata (Montane & Western Rain forest areas, Coastal and mangrove forest areas, Dryland forest areas and Plantation forest zones) and their specific canopy classes (for Montane & Western Rain forests, Coastal and mangrove forests and Dryland forests). The area of each land use transition is illustrated and the colour on the table used to assign each change to a REDD+ activity as described in Table 3.

3.1.5. Transitions of forests based on land cover change matrices

A summary of land over transitions affecting the forest sector illustrates that

1. Most of the forests of Kenya are found in the Montane and Western Rain forest strata
2. The Montane dense forests are stable and have been increasing over the time series from 773,672ha in 2002 to 834,862 ha in 2018. This is unlike the dryland dense forests that have large fluctuations from 303,805ha in 2006, 425,505ha in 2010, 450,388ha in 2014 and 344,985ha in 2018
3. The largest conversions of forests occur in the dryland forest strata and the conversion is mainly from forests into grasslands and the reverse
4. The plantation forest has not exceeded 65,000ha in all the years implying that the plantation forests occupy only half of the designated public plantation forest areas

Table 4: Land use Change (No of ha) for each forest strata in the 2002-2006 epoch

Forest strata			2006													
			Montane & Western Rain Forest			Costal & Mangrove Forest			Dryland Forest			Plantation forest	Cropland	Grassland	Wetland	Settlement & Otherland
			Dense	Moderate	Open	Dense	Moderate	Open	Dense	Moderate	Open					
2002	Montane Forest & Western Rain Forest /	Dense	773,672	75,916	27,963								110,685	127,283	251	445
		Moderate	36,857	75,670	14,739								17,071	71,895	154	248
		Open	25,105	10,533	27,186								8,333	82,848	18	267
	Costal & Mangrove Forests	Dense				114,602	11,053	3,190					2,458	36,401	490	623
		Moderate				100,716	77,558	22,429					9,195	130,990	431	1,039
		Open				12,055	4,378	1,861					1,509	18,267	22	128
	Dryland Forest	Dense							303,805	32,124	21,397		38,529	301,166	1,933	2,465
		Moderate							107,414	84,438	21,236		17,244	220,465	2,309	1,868
		Open							43,048	22,420	62,831		8,668	248,377	1,452	10,672
	Plantation forest											62,292	4,248	12,622	9	9
	Cropland		37,067	3,719	2,655	300	583	102	16,223	1,679	5,441	5,520				
	Grassland		103,916	73,048	33,153	52,514	41,374	40,874	343,099	132,028	228,734	5,515				
	Wetland		205	61	23	513	576	368	2,229	1,768	1,835	10				
	Settlement & Other land		462	64	48	266	156	115	1,707	1,360	4,005	4				

Table 5: Land use Change (No of ha) for each forest strata in the 2006-2010 epoch

Forest strata			2010													
			Montane & Western Rain Forest			Costal & Mangrove Forest			Dryland Forest			Plantation forest	Cropland	Grassland	Wetland	Settlement & Otherland
			Dense	Moderate	Open	Dense	Moderate	Open	Dense	Moderate	Open					
2006	Montane Forest & Western Rain Forest /	Dense	749,295	38,797	18,012								57,504	111,178	256	2,243
		Moderate	74,676	79,707	9,679								4,647	70,133	44	125
		Open	29,698	13,517	20,443								4,500	37,492	16	101
	Costal & Mangrove Forests	Dense				215,356	29,039	333					713	34,769	581	176
		Moderate				19,875	77,651	1,166					521	35,589	726	149
		Open				3,352	27,627	1,329					205	35,722	473	230
	Dryland Forest	Dense							425,505	39,428	26,851		28,583	291,829	2,881	2,449
		Moderate							62,214	76,621	17,783		3,653	112,795	1,870	881
		Open							28,938	28,669	68,159		9,935	200,598	2,053	7,129
	Plantation forest											61,183	4,178	7,968	11	0
	Cropland		67,138	8,536	8,401	2,485	2,573	298	27,969	4,497	12,733	3,819				
	Grassland		132,713	78,280	40,850	59,719	122,443	9,292	485,917	230,353	276,515	11,970				
	Wetland		222	39	28	402	552	18	2,850	1,283	1,359	17				
	Settlement & Other land		882	962	138	507	945	185	4,230	21,324	10,939	13				

Table 6: Land use Change (No of ha) for each forest strata in the 2010-2014 epoch

Forest strata			2014													
			Montane & Western Rain Forest			Costal & Mangrove Forest			Dryland Forest			Plantation forest	Cropland	Grassland	Wetland	Settlement & Otherland
			Dense	Moderate	Open	Dense	Moderate	Open	Dense	Moderate	Open					
2010	Montane Forest & Western Rain Forest /	Dense	811,460	35,478	29,991								67,820	109,131	215	529
		Moderate	70,180	76,226	10,964								8,986	53,130	107	244
		Open	20,994	12,731	13,395								8,378	41,885	43	123
	Costal & Mangrove Forests	Dense				221,815	20,895	768					1,186	55,669	460	902
		Moderate				59,002	59,199	1,835					4,427	135,127	912	327
		Open				623	926	646					978	9,361	15	72
	Dryland Forest	Dense							450,388	48,329	26,540		31,316	475,519	2,748	2,782
		Moderate							68,735	78,685	23,421		4,150	220,502	1,454	5,230
		Open							31,273	17,404	75,590		11,696	268,363	1,887	8,126
	Plantation forest											64,384	5,889	6,707	12	9
	Cropland		62,635	6,649	3,452	2,606	460	15	28,717	4,707	3,493	5,109				
	Grassland		118,181	70,500	46,412	137,075	37,087	2,216	385,810	134,613	168,121	11,987				
	Wetland		330	11	10	1,126	344	2	4,112	1,266	412	15				
	Settlement & Other land		1,938	128	239	368	194	3	2,708	1,202	6,554	11				

Table 7: Land use Change (No of ha) for each forest strata in the 2014-2018 epoch

Forest strata			2018													
			Montane & Western Rain Forest			Costal & Mangrove Forest			Dryland Forest			Plantation forest	Cropland	Grassland	Wetland	Settlement & Otherland
			Dense	Moderate	Open	Dense	Moderate	Open	Dense	Moderate	Open					
2014	Montane Forest & Western Rain Forest /	Dense	834,862	49,209	19,734								88,835	91,840	416	821
		Moderate	40,248	83,235	12,899								11,406	53,825	78	33
		Open	9,843	10,324	26,260								6,435	51,566	10	25
	Costal & Mangrove Forests	Dense				164,282	87,918	1,363					6,422	160,174	1,632	825
		Moderate				22,023	40,366	2,040					3,565	50,419	458	233
		Open				1,116	989	452					110	2,797	9	12
	Dryland Forest	Dense							344,985	97,928	42,170		24,559	455,918	3,874	2,307
		Moderate							57,877	60,223	33,164		4,763	127,932	1,229	1,018
		Open							21,221	20,412	66,984		4,012	185,783	1,445	4,274
	Plantation forest											56,315	17,880	7,263	26	23
	Cropland		78,641	8,156	6,568	1,689	2,567	438	21,204	9,163	10,163	3,886				
	Grassland		85,367	48,885	38,956	76,856	82,563	13,417	377,850	207,559	158,441	4,834				
	Wetland		267	176	12	343	316	38	1,648	1,083	1,877	14				
	Settlement & Other land		866	107	1,702	398	470	15	1,667	2,424	3,279	6				

3.1.6. Annual and percentage areas of change

The tables 8-12 illustrate annual areas of change for each stratum based on the land use change matrices presented in tables 4-7. Figure 4 compares the contribution of the forest strata to deforestation

1. Table 8 shows that the area of deforestation in Kenya (average 338,863ha) has slightly exceeded the area of reforestation (average 326,794ha) and therefore there has been a net loss of forests. The greatest transition of forests to non forests and the reverse occurs in the dryland forest strata. A REDD+ programme to reduce deforestation is expected to reverse this trend
2. Table 9 shows that the process of degradation of forests is slightly less than that of canopy improvement at 59,736ha versus 69,813ha. This implies that afforestation programmes have been on an improvement trend. A continuous improvement of the planted forests enhances their stocks and justifies this as a REDD+ activity
3. Table 10 shows that in public plantation forest areas, the process of harvesting forests has slightly exceeded the process of planting implying that the plantation forests have more planting backlogs and their forest area has been reducing. A sustainable management programme is expected to reverse this trend.
4. Table 11 gives the average deforestation rate in Kenya as 0.58% of the total land area which implies an area of 9.27% of the total land area was deforested in the 2002-2018 reference period. This is against an afforestation area of 8.83% of the total land area. In effect a net area of 0.44% of Kenya's total land area was deforested in the reference period. Figure 6 shows the specific deforestation areas among strata in the different mapping epochs
5. Table 12 illustrates the rates of forest degradation and enhancement of forest canopy in conserved areas. The table shows that the areas under canopy improvement are slightly more (at 0.12% of the national land area) than the areas undergoing forest degradation (at 0.1% of the national land area).

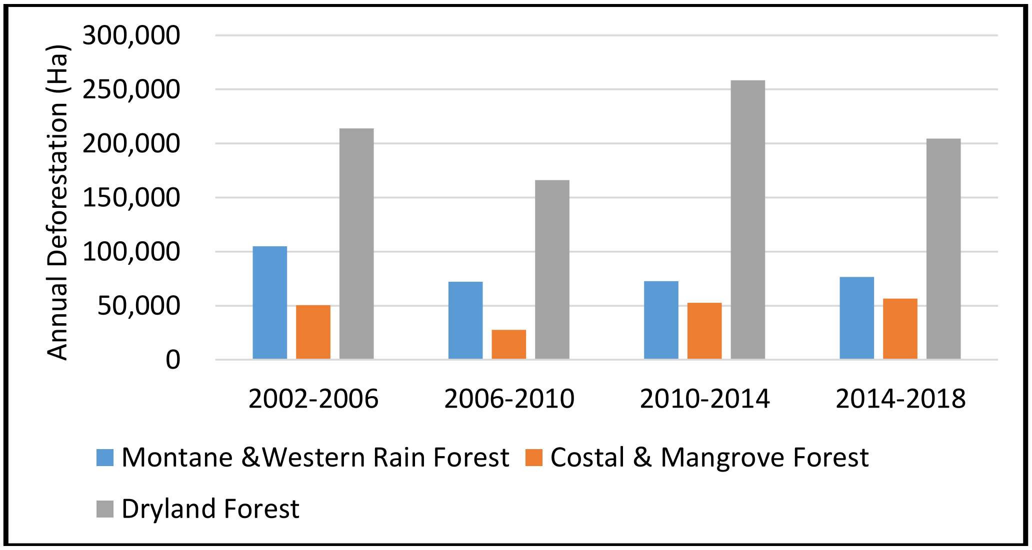

Figure 6: The contribution of strata to the annual deforestation in the reference period

Table 8: Annual transitions (No of ha); Deforestation and Afforestation among forest strata

Forest strata	Area (ha/yr) of Deforestation					Area (ha/yr) of Afforestation				
	2002-2006	2006-2010	2010-2014	2014-2018	Average	2002-2006	2006-2010	2010-2014	2014-2018	Average
Montane &Western Rain Forest	104,874	72,059	72,648	76,322	81,476	63,605	84,547	77,621	67,426	73,300
Costal & Mangrove Forest	50,388	27,463	52,359	56,664	46,719	34,435	49,855	45,374	44,777	43,610
Dryland Forest	213,787	166,164	258,443	204,279	210,668	185,027	269,992	185,429	199,089	209,884
Total	369,049	265,687	383,450	337,265	338,863	283,068	404,394	308,424	311,292	326,794

Table 9: Annual transitions (No of ha); Forest degradation and Canopy improvement

Forest strata	Area (ha/yr) of Forest Degradation					Area (ha/yr) of Forest enhancement by Canopy improvement				
	2002-2006	2006-2010	2010-2014	2014-2018	Average	2002-2006	2006-2010	2010-2014	2014-2018	Average
Montane &Western Rain Forest	29,655	16,622	19,108	20,461	21,461	18,124	29,473	25,976	15,104	22,169
Costal & Mangrove Forest	9,168	7,634	5,874	22,830	11,377	29,287	12,714	15,138	6,032	15,793
Dryland Forest	18,689	21,016	24,572	43,316	26,898	43,220	29,955	29,353	24,878	31,852
Total	57,512	45,272	49,555	86,607	59,736	90,631	72,142	70,467	46,013	69,813

Table 10: Annual transitions for sustainable management in public Plantation forests

Forest strata	Area (ha/yr) of Sustainable Management of forests				
	2002-2006	2006-2010	2010-2014	2014-2018	Average
Harvested area	4,222	3,039	3,155	6,298	4,178
Afforested area	2,762	3,955	4,280	2,185	3,296
Net (Deficit/backlog)	-1,460	916	1,125	-4,113	-882

Table 11: Annual transitions (% of national area); Deforestation and Afforestation

Forest strata	Percentage of national area Deforested					Percentage of national area Afforested				
	2002-2006	2006-2010	2010-2014	2014-2018	Average	2002-2006	2006-2010	2010-2014	2014-2018	Average
Montane &Western Rain Forest	0.18	0.12	0.12	0.13	0.14	0.11	0.14	0.13	0.11	0.12
Costal & Mangrove Forest	0.09	0.05	0.09	0.10	0.08	0.06	0.08	0.08	0.08	0.07
Dryland Forest	0.36	0.28	0.44	0.35	0.36	0.31	0.46	0.31	0.34	0.35
Total	0.63	0.45	0.65	0.58	0.58	0.48	0.68	0.52	0.53	0.55

Table 12: Annual transitions (% of national area); Forest degradation and Canopy improvement

Forest strata	Percentage of national area with Forest Degradation					Percentage of national area with Canopy improvement				
	2002-2006	2006-2010	2010-2014	2014-2018	Average	2002-2006	2006-2010	2010-2014	2014-2018	Average
Montane &Western Rain Forest	0.05	0.03	0.03	0.03	0.04	0.03	0.05	0.04	0.03	0.04
Costal & Mangrove Forest	0.02	0.01	0.01	0.04	0.02	0.05	0.02	0.03	0.01	0.03
Dryland Forest	0.03	0.04	0.04	0.07	0.05	0.07	0.05	0.05	0.04	0.05
Total	0.10	0.08	0.08	0.15	0.10	0.15	0.12	0.12	0.08	0.12

Table 13: Area of forestland remaining forestland in the reference period

Forest strata	Area (ha) of Forestland that remained forestland					Percentage of forestland (based on national land area) that remained forestland				
	2002-2006	2006-2010	2010-2014	2014-2018	Average	2002-2006	2006-2010	2010-2014	2014-2018	Average
Montane &Western Rain Forest	1,067,639	1,033,823	1,081,420	1,086,615	1,067,374	1.80	1.75	1.83	1.84	1.80
Costal & Mangrove Forest	347,841	375,728	365,710	320,549	352,457	0.59	0.63	0.62	0.54	0.60
Dryland Forest	698,714	774,168	820,364	744,965	759,553	1.18	1.31	1.39	1.26	1.28
Plantation	62,292	61,183	64,384	56,315	61,044	0.11	0.10	0.11	0.10	0.10
Total	**2,176,487**	**2,244,903**	**2,331,878**	**2,208,444**	**2,240,428**	**3.68**	**3.79**	**3.94**	**3.73**	**3.78**

3.1.7. Area of stable forests

The area of forests that remained forests between two mapping years is shown in table 13. An area of slightly over 2 million hectares has remained forest in the reference period and averages at 2,240,428ha. The Montane and Western Rain forest stratum has the biggest contribution to the stable forest maintaining an area slightly over 1 million hectares (average 1,067,374ha) in the reference period. The Dryland forests and the Coastal and Mangrove strata have also significantly stable forests. The table shows that an area of 3.78% of Kenya's land area has remained forestland in the reference period. This area of stable forests and the area that underwent afforestation and the reduction of areas that have been undergoing deforestation contribute towards meeting the country's target of 10% forest cover.

3.1. Emission Factors (EF)

Two sets of data were used to generate Emission Factors; stock change and growth rates.

3.2.1. Emission factors from stock change

Emission Factors for changes in forest carbon stocks were based on 1st level and 2nd level stratification of forests described in Table 1 above. Stratified sampling was used and forest stock data collected in a Pilot Forest Inventory by ICFRA (KFS, 2016) and CADEP-SFM (JICA, 2017) was used to assign biomass stock to each strata and sub strata. It is noted that Kenya has not conducted a comprehensive National Forest Inventory (NFI) that would have effectively supported the establishment of emission factors. According to the step-wise approach, it is expected that the NFI will be implemented in future[6]. Therefore, data from the pilot inventory that covered all the forest strata was used. The data was collected from a total of 121 plots and is illustrated in Annex 3. A simple average of the field data for each stratum was used as the Biomass stock for each sub strata.

The EFs were estimated for Deforestation (conversion of forests into non forests) by the following process. Firstly, the values of AGB in each plot were computed (Table 14), using the forest inventory data described above and locally acceptable allometric equations (Table 15). The values of BGB were calculated by applying the R/S ratio per forest strata based on IPCC 2006 guidelines for each stratum (Table 16). Forest biomass calculated as the sum of AGB and BGB was converted into Carbon using the IPCC carbon fraction of 0.47. Further, the conversion to CO_2 is based on the ratio of molecular weights (44/12) (IPCC 2006). Finally, Emission Factors were estimated as the differences in carbon stocks in an area at two points in time (e.g. 2002 and 2006).

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[6] The ICFRA project developed technical manuals for Biophysical assessment of Forest resources and also developed a design for an NFI. However, the NFI has not been implemented

In conversions of forests into non-forests, the Carbons stocks were assumed to go through immediate oxidation and IPCC 2006 guidelines used for Tier 1 default factors[7] used in calculating stock changes.

3.2.2. Emission Factors due to forest growth

Emission Factors due to forest growth were classified into two as shown below

3.2.2.1. Conversion of non-forests into forests

The EFs due to afforestation (conversion of a non-forest into a forest) shown in Table 17 were calculated using a growth rate for each of the forest strata for trees < 20yr, because in the 4 year change period such the forests have not attained 20 years. Choice of EF was based on the fact that a forest undergoes a process of growth after planting and does not immediately achieve the carbon stock of the forest it is mapped into but attains a carbon stock value described by its growth rate and the number of years of growth. The growth rates were calculated based on IPCC 2006 guidelines as shown in Table 17.

3.2.2.2. Improvement of forest stock due to canopy enhancement

The EFs for Enhancement (improvement of Carbon stocks where a canopy improvement was noted between two years of mapping are shown in Table 18. They were calculated using a growth rate associated to each of the forest strata for trees >=20 yr. The >=20 yr is selected on the basis that these are already grown forests which had previously been degraded and are undergoing stock enhancement. Choice of EF was based on the fact that a forest undergoes a process of growth after conservation measures are initiated and a canopy improvement (as in the case of an open forest converting to a dense forest) does not result to the carbon stock of the forest it is mapped into, but attains a carbon stock value described by its growth rate and the number of years of growth typical to such a forest stratum.

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[7] Table 4.7of vol 4 chapter 4 of IPCC 2006 guidelines

Table 14: Emission Factors from NFI for forest type class

Forest strata	Canopy Cover	ABG	BGB	TOTAL		
		Biomass Tonnes/ha)[8]	Biomass Tonnes/ha)[9]	Biomass (Tonnes/ha)[10]	Carbon (Tonnes/ha)[11]	CO_2 (Tonnes/ha)[12]
Montane & Western Rain	Dense	244.80	90.57	335.37	157.62	577.95
	Moderate	58.43	21.62	80.05	37.62	137.96
	Open	18.31	6.77	25.08	11.79	43.23
Coastal & Mangrove	Dense	94.63	18.93	113.55	53.37	195.69
	Moderate	52.75	10.55	63.30	29.75	109.08
	Open	24.01	4.80	28.81	13.54	49.64
Dryland	Dense	42.43	11.88	54.31	25.53	93.60
	Moderate	34.52	9.67	44.19	20.77	76.15
	Open	14.26	3.99	18.26	8.58	31.47
Plantation		324.79	87.69	412.48	193.87	710.84
Cropland Wetland &Settlements/ Otheralands		0	0	0	0[13]	0
Grassland				8.7[14]	4.09	14.99

[8] Stock obtained from Pilot NFI and allometric equations as simple average of plot data for each stratum
[9] Calculated using the IPCC root/shoot Ratio shown in table 9
[10] Sum of ABG and BGB
[11] Calculated using Carbon fraction of 0.47
[12] Calculated using CO_2 molecular formula of 44/12
[13] The Cropland Carbon Factor obtained from IPCC default values for tier 1 reporting: 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4: Chapter 5 (Cropland) Table 5.8: Default Biomass Stocks Present On Cropland , After Conversion From Forestland
[14] The Grassland Carbon Factor obtained from IPCC default values for Tropical Dry Grasslands: 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4: Chapter 6 (Grassland) Table 6.4: Default Biomass Stocks Present On Grassland , After Conversion From Other Land Use

Table 15: List of allometric equations used for AGB Estimation

Type	Volume (m^3)	Reference	Equation for AGB (kg)	Reference
Common for natural forests and plantations	$\pi \times (DBH/200)^2 \times H \times 0.5$	Henry et al. 2011	$0.0673*(0.598*D^2H)^{0.976}$	Chave et al. 2009, 2014
Rhizophora sp. in mangroves	$\pi \times (DBH/200)^2 \times H \times 0.5$	Henry et al. 2011	$0.128 \times DBH^{2.60}$	Fromard et al. 1998, Komiyama et al. 2008
Bamboo in montane forests	$d^2-(d*0.7)^2/4*\pi*h*0.8$	Dan et al. 2007	$1.04+0.06*d*GW_{bamboo}$ $GW_{bamboo}=1.11+0.36*d^2$ (bamboo diameter > 3 cm) $GW_{bamboo}=1.11+0.36*3.1^2$ (bamboo diameter ≤ 3 cm)	Muchiri and Muga. 2013
Climbers in natural forests	-	-	$e^{(-1.484+2.657*\ln(DBH))}$	Schnitzer et al. 2006

Table 16: Specific Shoot/Root ratios for the different strata

Forest strata	Root shoot ratio	Source in table 4.4 of IPCC 2006 guidelines V4.4
Montane	0.37	for Tropical rainforest
Dryland	0.28	Above-ground biomass >20 tonnes ha^{-1} for Tropical Dryland forests
Coastal and Mangrove	0.20	Above-ground biomass <125 tonnes ha^{-1} for Tropical moist deciduous forest
Plantation	0.27	For Tropical Mountain systems

Table 17: Emission factors for calculating forest growth due to afforestation

Forest strata	Biomass gain (Tonnes/ha)			Carbon from Biomass	CO_2 sequestered (Tonnes/ha)		Reference AGB value from IPCC V4.4
	AGB value	BGB[15]	Total		One year	4 years	
Montane and Western rain	10	3.70	13.70	6.44	23.61	94.44	Table 4.9 for Africa tropical rain forests for forests <20 yrs
Dryland	2.4	0.67	3.07	1.44	5.29	21.16	Table 4.9 for Africa tropical dry forests for forests< 20 yrs
Coastal and Mangrove	5	1.00	6.00	2.82	10.34	41.36	Table 4.9 for Africa tropical moist deciduous forests for forests < 20 yrs
Public Plantation	10	2.70	12.70	5.97	21.89	87.56	Table 4.10 for Africa Tropical mountain systems plantation forests

[15] EF used as in table 16 for shoot/root rations

Table 18: Emission factors used for calculating forest growth due to enhancement

Forest strata	Biomass gain (Tonnes/ha)			Carbon from Biomass	CO_2 sequestered (Tonnes/ha)		Reference AGB value from IPCC V4.4
	AGB value	BGB[16]	Total		One year	4 years	
Montane and Western rain	3.1	1.15	4.25	2.00	7.32	29.28	Table 4.9 for Africa tropical rain forests for forests >20 yrs
Dryland	1.8	0.50	2.30	1.08	3.97	15.88	Table 4.9 for Africa tropical dry forests for forests > 20 yrs
Coastal and Mangrove	1.3	0.26	1.56	0.73	2.69	10.76	Table 4.9 for Africa tropical moist deciduous forests for forests > 20 yrs
Public Plantation	10	2.70	12.70	5.97	21.89	87.56	Table 4.10 for Africa Tropical mountain systems plantation forests

[16] EF used as in table 16 for shoot/root rations

3.2.3. Generating Emission factors from land use transitions

Using Carbon stock data (Tables 14 to 18), the EF associated with each land use transition, were calculated and assigned to each REDD+ activity as illustrated in Table 19. These calculations were done as follows

1. Deforestation which is conversion of a forest to a non-forest in Montane &Western Rain forests, Coastal & mangrove forests and Dryland forests;
    a. Instantaneous Oxidation[17] was assumed for all deforestation. Therefore, the EF is the difference between the CO_2 value of the initial forest strata/canopy class and the CO_2 value of the non-forest
    b. All forest conversions into Croplands, Wetlands and Settlements& Otherlands attain a CO_2 value of Zero after conversion. The EF is the difference between the CO_2 of the former forest and zero
    c. All forest conversions into Grasslands attain a CO_2 value of 14.99 Tonnes/ha after conversion. The EF is the difference between the CO_2 of the former forest and 14.99 Tonnes/ha
2. Forest Degradation which is the conversion of a forest from a higher canopy class to a lower canopy class in Montane &Western Rain forests, Coastal & mangrove forests and Dryland forests
    a. Instantaneous Oxidation was assumed for all degradation[18]. Therefore, the EF is the difference between the CO_2 value of the initial forest canopy class and the CO_2 value of the new forest canopy class within a stratum
3. Enhancement of Carbon stocks due to conversion of non-forests into forests in Montane & Western Rain forests, Coastal & mangrove forests and Dryland forests was calculated as follows
    a. A growth factor was adopted for each stratum (Table 17) to give the amount of CO_2 gained in a planted/young forest (in this case a forest that is less than 20 years) in the 4 year period. In case the calculation of growth results to a stock which is more than the stock factor of the specific canopy class, a capping was done to retain the stock of the specific canopy class.
    b. The EF for conversion of Croplands, Wetlands and Settlements & Otherlands into forestlands was the difference between zero and the CO_2 value after growth of 4

17.There is no data on harvested wood products. Most of the activities that convert forests to non-forests in the specified strata may result to instantaneous oxidation

18.Data on drivers of degradation is not reliable enough to estimate emissions as shown in a preliminary study to this work - Options for Estimating GHG Emissions/Sinks from Forest Degradation, Forest Fires and Forest Revegetation. A Report To Support Establishment of Kenya's Forest Reference Level years

c. The EF for conversion of grasslands into Forestlands was the difference between a CO_2 value of 14.99 Tonnes/ha and the CO_2 value of the forest after 4 years of growth

4. Enhancement of Carbon stocks due to improvement of Canopy in forests from a lower canopy class to a higher canopy class in Montane and Western Rain forests, Coastal and mangrove forests and Dryland forests was calculated as follows
   a. A growth factor was adopted for each stratum (Table 18) to give the amount of CO_2 gained in an existing forest (in this case a forest that is more than 20 years[19]) in the 4 year period
   b. The EF was calculated as the difference between the previous CO_2 value (for the starting year) and the new CO_2 value after forest enhancement (end year). In case the calculation of growth results to a stock which is more than the stock factor of the specific canopy class, a capping was done to retain the stock of the specific canopy class.
5. In Sustainable management of forest which is the conversion of non-forests into forestlands in areas designated as Plantation zones[20], EF were calculated as follows
   a. A stock change method was applied and the EF calculated as the difference between the CO_2 value of the previous non-forest to the CO_2 value of a plantation based on growth rate (Table 16).
   b. A Conversion of a Cropland, Wetland and Settlements & Otherlands into a forestland changes carbon stocks from a zero CO_2 value to a CO_2 value to 87.56 Tonnes/ha
   c. A conversion of a grassland to a forestland changes carbon stocks from a CO_2 value of 14.99 Tonnes/ha to a CO_2 value of 87.56 Tonnes/ha

[19] IPCC Table 4.9 classifies forests into less than 20 years or more than 20 years to determine Growth rate Factors

[20] NB: future Definitions of sustainable management of forests may include plantation forests remaining plantations where stock improvement is considered. This requires periodic inventories

Table 19: Matrix of EF setting for various land use changes and REDD+ activities

Forest strata			End Year													
			Montane & Western Rain Forest			Coastal & Mangroves Forest			Dryland Forest			Plantation	Cropland	Grassland	Wetland	Settlement & Other land
			Dense	Moderate	Open	Dense	Moderate	Open	Dense	Moderate	Open					
Start year	Montane & Western Rain Forest	Dense	0	440.00	534.72								577.95	562.96	577.95	577.95
		Moderate	-29.28	0	94.73								137.96	122.96	137.96	137.96
		Open	-29.28	-29.28	0								43.23	28.24	43.23	43.23
	Coastal & Mangroves Forest	Dense				0	86.61	146.04					195.69	180.69	195.69	195.69
		Moderate				-10.75	0	59.44					109.08	94.09	109.08	109.08
		Open				-10.75	-10.75	0					49.64	34.65	49.64	49.64
	Dryland Forest	Dense							0	17.44	62.13		93.60	78.60	93.60	93.60
		Moderate							-15.88	0	44.69		76.15	61.16	76.15	76.15
		Open							-15.88	-15.88	0		31.47	16.47	31.47	31.47
	Plantation											0	710.84	695.85	710.84	710.84
	Cropland		-94.44	-94.44	-43.23	-41.36	-41.36	-41.36	-21.18	-21.18	-21.18	-87.55				
	Grassland		-79.45	-79.45	-28.24	-26.37	-26.37	-26.37	-6.18	-6.18	-6.18	-72.55				
	Wetland		-94.44	-94.44	-43.23	-41.36	-41.36	-41.36	-21.18	-21.18	-21.18	-87.55				
	Settlement & Other land		-94.44	-94.44	-43.23	-41.36	-41.36	-41.36	-21.18	-21.18	-21.18	-87.55				

4. EMISSIONS FROM LAND USE CHANGE

4.1. Emission Estimates

Activity data for land use change conversions (Table 4) and the Emission Factors calculated for the specific land use conversions (Table 19) were used to calculate CO_2 emissions associated with each land use change for each epoch. This is shown in Tables 20-23.

The largest emissions occurred when dense montane forests were converted into either Croplands, Wetlands or Settlement and Otherlands resulting to a net emission of 577.95 Tonnes of CO_2 per ha. The reverse however, does not sequester the equivalent of emitted GHG because the forest is still in a recovery mode at age 4.

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Table 20: Emissions (CO_2 Tonnes) calculated for land use changes (2002 to 2006)

Forest strata			2006													
			Montane &Western Rain Forest			Coastal & Mangroves Forest			Dryland Forest			Plantation	Cropland	Grassland	Wetland	Settlement & Other land
			Dense	Moderate	Open	Dense	Moderate	Open	Dense	Moderate	Open	Dense				
2002	Montane &Western Rain Forest	Dense	0	33,402,790	14,952,439	0	0	0	0	0	0	0	63,970,436	71,655,345	144,916	256,958
		Moderate	-1,079,014	0	1,396,195	0	0	0	0	0	0	0	2,355,007	8,840,448	21,194	34,144
		Open	-734,972	-308,355	0	0	0	0	0	0	0	0	360,219	2,339,276	759	11,540
	Coastal & Mangroves Forest	Dense	0	0	0	0	957,251	465,807	0	0	0	0	480,910	6,577,554	95,791	121,980
		Moderate	0	0	0	-1,083,064	0	1,333,070	0	0	0	0	1,002,960	12,324,488	47,025	113,301
		Open	0	0	0	-129,630	-47,079	0	0	0	0	0	74,933	632,966	1,072	6,353
	Dryland Forest	Dense	0	0	0	0	0	0	0	560,352	1,329,447	0	3,606,220	23,672,823	180,967	230,717
		Moderate	0	0	0	0	0	0	-1,705,968	0	948,998	0	1,313,196	13,483,713	175,828	142,251
		Open	0	0	0	0	0	0	-683,703	-356,075	0	0	272,758	4,091,434	45,693	335,808
	Plantation			0	0	0	0	0	0	0	0	0	3,019,518	8,782,822	6,589	6,398
	Cropland		-3,500,587	-351,190	-114,753	-12,418	-24,117	-4,203	-343,535	-35,565	-115,221	-483,208		0	0	0
	Grassland		-8,255,667	-5,803,365	-936,099	-1,384,632	-1,090,906	-1,077,714	-2,121,493	-816,374	-1,414,338	-400,154		0	0	0
	Wetland		-19,387	-5,729	-1,004	-21,221	-23,838	-15,210	-47,195	-37,433	-38,861	-890		0	0	0
	Settlement & Other land		-43,653	-6,077	-2,081	-10,996	-6,455	-4,761	-36,156	-28,809	-84,815	-347		0	0	0

Table 21: Emissions (CO_2 Tonnes) calculated for land use changes (2006 to 2010)

			2010													
			Montane &Western Rain Forest			Coastal & Mangroves Forest			Dryland Forest			Plantation	Cropland	Grassland	Wetland	Settlement & Other land
			Dense	Moderate	Open	Dense	Moderate	Open	Dense	Moderate	Open	Dense				
2006	Montane &Western Rain Forest	Dense	0	17,070,483	9,631,385	0	0	0	0	0	0	0	33,234,376	62,588,594	147,829	1,296,129
		Moderate	-2,186,221	0	916,880	0	0	0	0	0	0	0	641,058	8,623,860	6,009	17,258
		Open	-869,436	-395,724	0	0	0	0	0	0	0	0	194,514	1,058,624	704	4,357
	Coastal & Mangroves Forest	Dense	0	0	0	0	2,514,938	48,646	0	0	0	0	139,539	6,282,487	113,702	34,396
		Moderate	0	0	0	-213,728	0	69,327	0	0	0	0	56,881	3,348,489	79,186	16,287
		Open	0	0	0	-36,046	-297,093	0	0	0	0	0	10,178	1,237,805	23,475	11,411
	Dryland Forest	Dense	0	0	0	0	0	0	0	687,757	1,668,294	0	2,675,256	22,938,859	269,626	229,252
		Moderate	0	0	0	0	0	0	-988,102	0	794,694	0	278,196	6,898,571	142,429	67,092
		Open	0	0	0	0	0	0	-459,594	-455,333	0	0	312,609	3,304,391	64,602	224,316
	Plantation			0	0	0	0	0	0	0	0	0	2,969,681	5,544,797	7,997	192
	Cropland		-6,340,425	-806,099	-363,176	-102,764	-106,401	-12,314	-592,272	-95,234	-269,644	-334,294		0	0	0
	Grassland		-10,543,466	-6,219,016	-1,153,433	-1,574,598	-3,228,446	-245,011	-3,004,578	-1,424,344	-1,709,779	-868,478		0	0	0
	Wetland		-21,011	-3,680	-1,194	-16,609	-22,848	-759	-60,353	-27,178	-28,782	-1,521		0	0	0
	Settlement & Other land		-83,329	-90,817	-5,957	-20,950	-39,100	-7,668	-89,580	-451,569	-231,643	-1,127		0	0	0

Table 22: Emissions (CO_2 Tonnes) calculated for land use changes (2010 to 2014)

			2014													
			Montane &Western Rain Forest			Coastal & Mangroves Forest			Dryland Forest			Plantation	Cropland	Grassland	Wetland	Settlement & Other land
			Dense	Moderate	Open	Dense	Moderate	Open	Dense	Moderate	Open	Dense				
2010	Montane &Western Rain Forest	Dense	0	15,610,247	16,036,988	0	0	0	0	0	0	0	39,197,047	61,436,643	124,214	305,593
		Moderate	-2,054,576	0	1,038,642	0	0	0	0	0	0	0	1,239,653	6,533,103	14,763	33,623
		Open	-614,621	-372,719	0	0	0	0	0	0	0	0	362,152	1,182,669	1,879	5,334
	Coastal & Mangroves Forest	Dense	0	0	0	0	1,809,649	112,104	0	0	0	0	232,125	10,059,001	89,979	176,559
		Moderate	0	0	0	-634,485	0	109,077	0	0	0	0	482,940	12,713,774	99,468	35,646
		Open	0	0	0	-6,702	-9,963	0	0	0	0	0	48,549	324,386	742	3,570
	Dryland Forest	Dense	0	0	0	0	0	0	0	843,032	1,648,963	0	2,931,093	37,377,617	257,218	260,428
		Moderate	0	0	0	0	0	0	-1,091,665	0	1,046,613	0	316,036	13,485,959	110,723	398,281
		Open	0	0	0	0	0	0	-496,680	-276,412	0	0	368,015	4,420,666	59,385	255,702
	Plantation			0	0	0	0	0	0	0	0	0	4,186,177	4,667,342	8,765	6,653
	Cropland		-5,915,120	-627,891	-149,208	-107,782	-19,014	-614	-608,119	-99,679	-73,974	-447,272		0	0	0
	Grassland		-9,388,981	-5,600,946	-1,310,483	-3,614,253	-977,878	-58,429	-2,385,584	-832,356	-1,039,548	-869,672		0	0	0
	Wetland		-31,185	-1,054	-432	-46,590	-14,223	-63	-87,077	-26,814	-8,727	-1,276		0	0	0
	Settlement & Other land		-183,019	-12,069	-10,341	-15,202	-8,029	-127	-57,351	-25,447	-138,787	-977		0	0	0

Table 23: Emissions (CO_2 Tonnes) calculated for land use changes (2014 to 2018)

2014		2018: Montane &Western Rain Forest – Dense	Montane &Western Rain Forest – Moderate	Montane &Western Rain Forest – Open	Coastal & Mangroves Forest – Dense	Coastal & Mangroves Forest – Moderate	Coastal & Mangroves Forest – Open	Dryland Forest – Dense	Dryland Forest – Moderate	Dryland Forest – Open	Plantation – Dense	Cropland	Grassland	Wetland	Settlement & Other land
Montane &Western Rain Forest	Dense	0	21,651,842	10,552,404	0	0	0	0	0	0	0	51,342,310	51,702,465	240,417	474,592
	Moderate	-1,178,313	0	1,221,932	0	0	0	0	0	0	0	1,573,535	6,618,484	10,728	4,507
	Open	-288,162	-302,242	0	0	0	0	0	0	0	0	278,178	1,456,014	436	1,093
Coastal & Mangroves Forest	Dense	0	0	0	0	7,614,288	199,091	0	0	0	0	1,256,626	28,942,580	319,374	161,431
	Moderate	0	0	0	-236,831	0	121,268	0	0	0	0	388,871	4,743,776	50,009	25,466
	Open	0	0	0	-11,996	-10,637	0	0	0	0	0	5,469	96,905	469	572
Dryland Forest	Dense	0	0	0	0	0	0	0	1,708,213	2,620,098	0	2,298,665	35,836,894	362,633	215,951
	Moderate	0	0	0	0	0	0	-919,222	0	1,482,003	0	362,697	7,824,389	93,596	77,496
	Open	0	0	0	0	0	0	-337,031	-324,191	0	0	126,249	3,060,342	45,466	134,488
Plantation			0	0	0	0	0	0	0	0	0	12,709,896	5,053,745	18,233	16,058
Cropland		-7,426,718	-770,231	-283,940	-69,858	-106,163	-18,121	-449,021	-194,042	-215,215	-340,227		0	0	0
Grassland		-6,782,015	-3,883,689	-1,099,942	-2,026,449	-2,176,942	-353,769	-2,336,368	-1,283,405	-979,692	-350,685		0	0	0
Wetland		-25,201	-16,642	-537	-14,167	-13,066	-1,582	-34,902	-22,924	-39,737	-1,245		0	0	0
Settlement & Other land		-81,816	-10,063	-73,567	-16,442	-19,446	-614	-35,299	-51,327	-69,442	-567		0	0	0

4.2. Emissions Estimates per REDD+ Activities

The Emissions were calculated for each of the selected REDD+ activities and also the net emissions for the Country. Calculation of emissions per REDD+ activity allows the identification of REDD+ policies and measures that can address the drivers of emissions in the selected activities

4.2.1. Emissions from Deforestation

Table 24 illustrates that deforestation has an average annual emission of 48,166,940 Tonnes of CO_2 in the reference period implying that a total of 770,671,037 Tonnes of CO_2 were emitted in the period 2002-2018. The greatest emissions came from the Montane and western Rain forests with an annual average of 30,121,437 Tonnes of CO_2. Though larger in area, the dryland strata did not present as high emissions due to the smaller forest area here and also their associated lower Emission Factors. Historically, the period 2002-2006 had the greatest emissions at 54,755,246 Tonnes of CO_2. However, Figure 7 shows that after a dip in emissions in the year 2010, there has been a gradual increase in emissions post year 2010. Though very minimal, there is an overall decrease in the emissions due to deforestation in the Reference period.

Table 24: Historical Annual CO_2 Emissions from Deforestation

Forest strata	Emissions (Tonnes of CO_2)				
	2002-2006	2006-2010	2010-2014	2014-2018	Average
Montane &Western Rain Forest	37,497,560	26,953,329	27,609,168	28,425,689	30,121,437
Costal & Mangrove Forest	5,369,833	2,838,459	6,066,685	8,997,887	5,818,216
Dryland Forest	11,887,852	9,351,299	15,060,281	12,609,716	12,227,287
Total	54,755,246	39,143,087	48,736,134	50,033,292	48,166,940

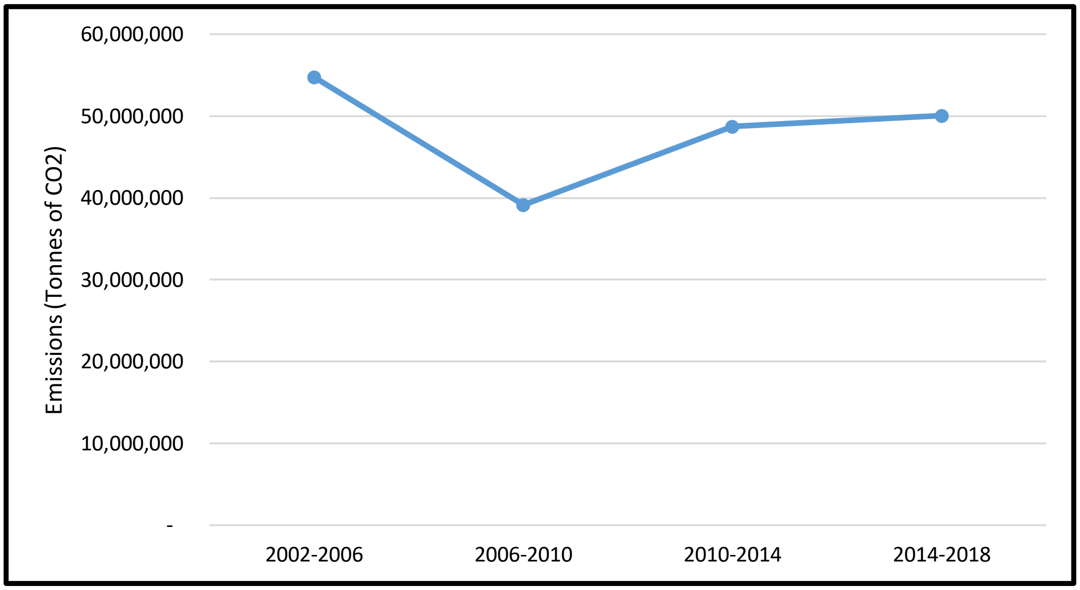

Figure 7: The Trend of Emissions due to Deforestation in the period 2002-2018

4.2.2. Emissions from Forest Degradation

Table 25 illustrates that forest degradation has an average annual emission of 10,885,950 Tonnes of CO_2 in the reference period implying a total of 174,175,207 Tonnes of CO_2 were emitted in the period 2002-2018. About 82% of emissions due to forest degradation came from the Montane and Western Rain forests with an annual average of 8,967,639 Tonnes of CO_2. Historically, the period 2002-2006 had the greatest emissions at 13,836,587 Tonnes of CO_2 and the trend of emissions from this REDD+ activity decreases with time (Figure 8).

Table 25: Historical Annual CO_2 Emissions from Forest Degradation

Forest strata	Emissions (Tonnes of CO_2)				
	2002-2006	2006-2010	2010-2014	2014-2018	Average
Montane &Western Rain Forest	12,437,856	6,904,687	8,171,469	8,356,545	8,967,639
Costal & Mangrove Forest	689,032	658,228	507,708	1,983,662	959,657
Dryland Forest	709,699	787,686	884,652	1,452,579	958,654
Total	13,836,587	8,350,601	9,563,829	11,792,785	10,885,950

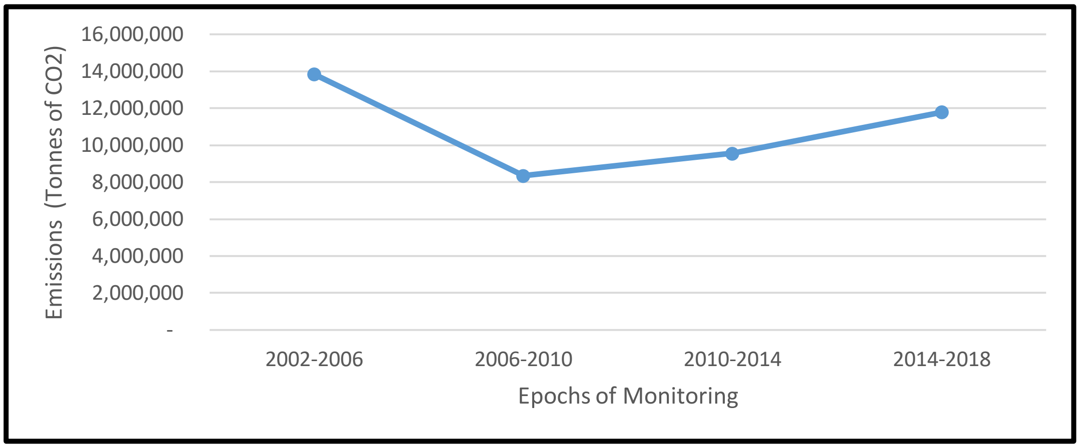

Figure 8: The Trend of Emissions due to Forest Degradation in the period 2002-2018

4.2.3. CO_2 Sinks due to Afforestation (Enhancement of Carbon)

Table 26 shows the CO_2 sinks due to afforestation activities. There was an annual removal of 8,205,540 Tonnes of CO_2 from the atmosphere in the reference period implying a total of 131,288,638 Tonnes of CO_2 were sequestered from the atmosphere due to afforestation activities in the period 2002-2018. About 67% of the sequestered CO2 was achieved in the Montane and Western Rain forests with an annual average of 5,522,268 Tonnes of CO_2. Historically, Sequestration of CO_2 due to afforestation programmes has been increasing in the reference period because a negative gradient illustrates the trend of increasing sequestration volumes (Figure 9).

Table 26: Historical Annual CO_2 sinks from Afforestation

Forest strata	Emissions (Tonnes of CO_2)				
	2002-2006	2006-2010	2010-2014	2014-2018	average
Montane &Western Rain Forest	-4,759,898	-6,407,901	-5,807,682	-5,113,591	-5,522,268
Costal & Mangrove Forest	-919,118	-1,344,367	-1,215,551	-1,204,155	-1,170,798
Dryland Forest	-1,279,949	-1,996,239	-1,345,866	-1,427,843	-1,512,474
Total	**-6,958,965**	**-9,748,507**	**-8,369,099**	**-7,745,589**	**-8,205,540**

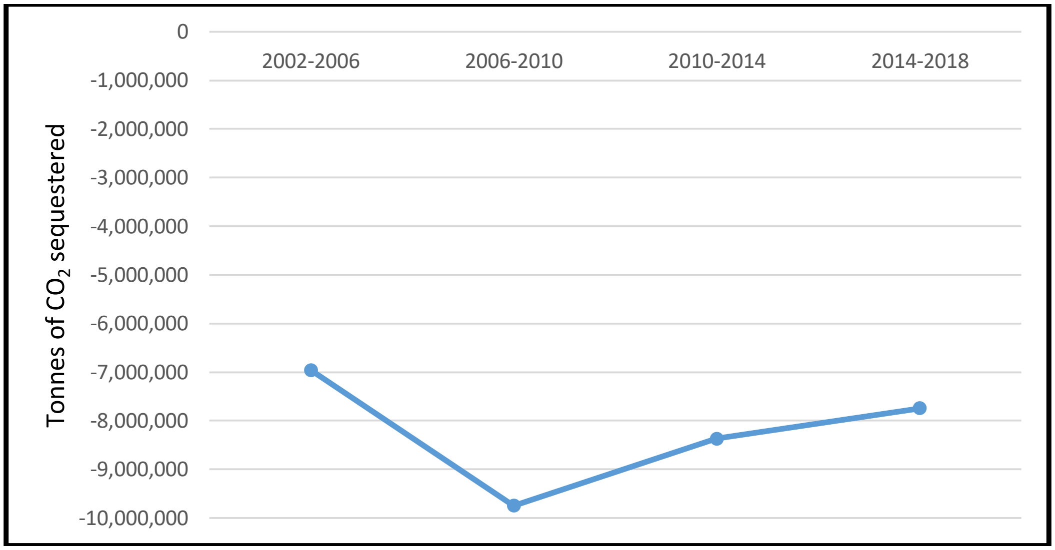

Figure 9: The Trend of CO_2 sequestration due to afforestation

4.2.4. CO_2 Sinks due to Canopy improvement (Enhancement of Carbon)

Table 27 shows the CO_2 sinks due to canopy improvement. There was an annual removal of 1,324,724 Tonnes of CO_2 from the atmosphere in the reference period implying a total of -21,195,588 Tonnes of CO_2 were sequestered from the atmosphere due to forest conservation and canopy improvement activities in the period 2002-2018. All the strata have a significant contribution to the sequestered CO_2 implying that this is an activity that should be prioritized in all the strata. Historically, Sequestration of CO_2 due to forest conservation and canopy improvement have been on a decrease in the reference period with 1,531,965 Tonnes of CO_2 sequestered in the period 2002-2006 as compared to 902,157 Tonnes of CO_2 sequestered in the period 2014-2018 (Figure 10).

Table 27: Historical Annual CO_2 sinks from Canopy improvement

Forest strata	Emissions (Tonnes of CO_2)				
	2002-2006	2006-2010	2010-2014	2014-2018	average
Montane &Western Rain Forest	-530,585	-862,845	-760,479	-442,179	-649,022
Costal & Mangrove Forest	-314,943	-136,717	-162,788	-64,866	-169,828
Dryland Forest	-686,437	-475,757	-466,189	-395,111	-505,874
Total	**-1,531,965**	**-1,475,319**	**-1,389,456**	**-902,157**	**-1,324,724**

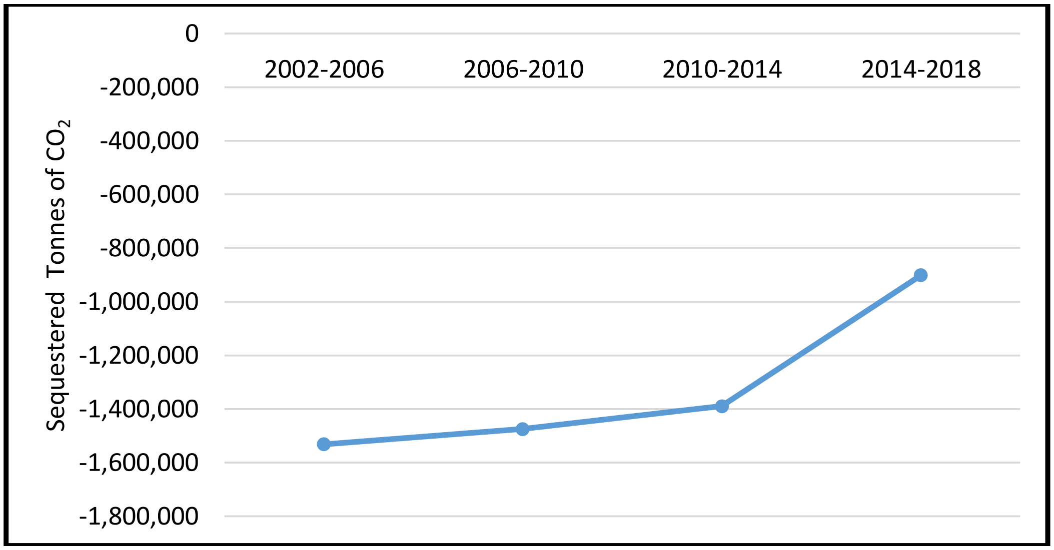

Figure 10: The Trend of CO_2 sequestration due to Canopy improvement

4.2.5. Emissions of CO_2 due to sustainable management of forests

Table 28 shows the CO_2 sinks due to sustainable management of forests. A backlog in the replanting programme of the public plantation forests of Kenya, has resulted in a net emission of CO_2 from the public plantation forests with an average emission of 2,681,433 Tonnes of CO_2 implying a total of 42,902,925 Tonnes of CO_2 were emitted in the period 2002-2018. Historically, Emissions from this stratum have an increasing trend (Figure 11).

Table 28: Historical Annual CO_2 Emissions from public forest plantations

Forest strata	Emissions (Tonnes of CO_2)				
	2002-2006	2006-2010	2010-2014	2014-2018	Average
Harvesting	2,953,832	2,130,667	2,217,234	4,449,483	2,937,804
Replanting	-221,150	-301,355	-329,799	-173,181	-256,371
Net	**2,732,682**	**1,829,312**	**1,887,435**	**4,276,302**	**2,681,433**

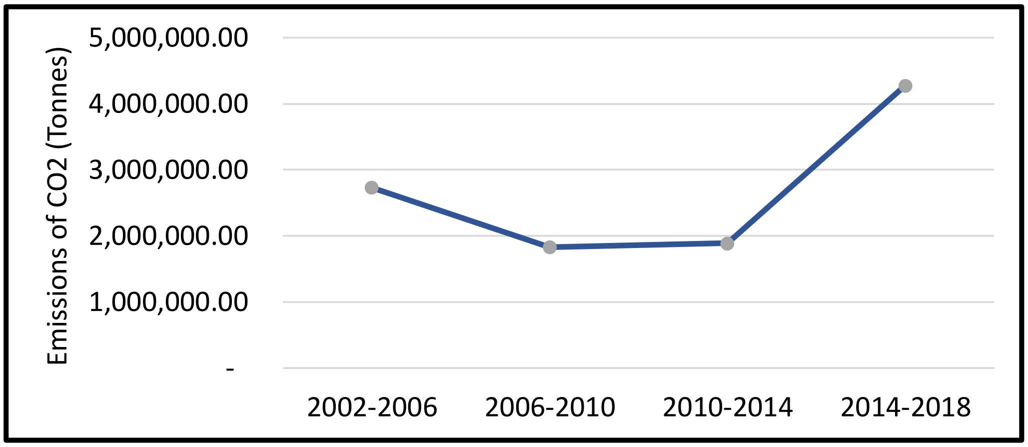

Figure 11: The Trend of CO_2 Emissions in the public plantation forests

4.2.6. Net National Emissions

The Reference period provides a net Emissions of CO_2 at the national Level. Table 29 illustrates that Kenya has an average annual emission of 52,204,059 Tonnes of CO_2 in the reference period implying a total Net emission of 835,264,942.23 Tonnes of CO_2 in the period 2002-2018. The dip in emissions in the period 2006-2010 (Figure 12) does not comprise an outlier based on 2 standard deviations from the mean (at 95% CI, the emissions range from 30,829,478 to 84,208,165 Tonnes of CO_2). Figure 10 shows that in the reference period, Kenya has attained a minimal decline in Emissions from the forest sector. This minimal decline of Emissions is associated with activities like a decline in deforestation, a decline in forest degradation, an improvement in the conservation activities which enhance forest canopy and an enhanced afforestation programme.

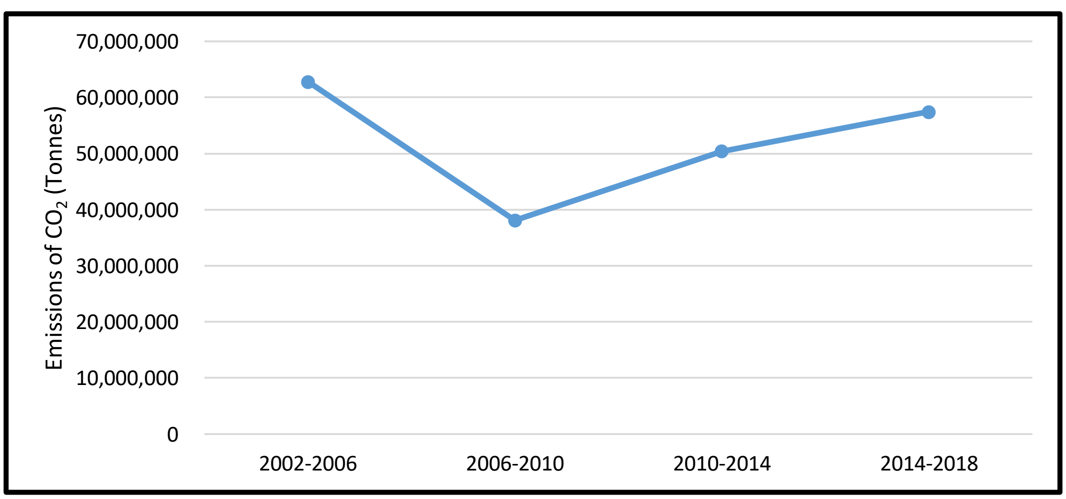

Figure 12: The Trend of Net Emissions in the period 2002-2018

Table 29: Historical Annual CO_2 Net Emissions classified by forest strata

Forest Strata	Emissions (Tonnes of CO_2)				
	2002-2006	2006-2010	2010-2014	2014-2018	Average
Montane &Western Rain Forest	44,644,932	26,587,270	29,212,476	31,226,464	32,917,786
Costal & Mangrove Forest	4,824,805	2,015,603	5,196,054	9,712,528	5,437,247
Dryland Forest	10,631,166	7,666,989	14,132,878	12,239,340	11,167,593
Public Plantations	2,732,682	1,829,312	1,887,435	4,276,302	2,681,433
Total	**62,833,585**	**38,099,174**	**50,428,843**	**57,454,634**	**52,204,059**

The greatest emissions came from the Montane and Western Rain forests with an annual average of 32,917,786 Tonnes of CO_2 (Table 29 and Figure 13). The annual emissions for the Dryland forest strata, the Coastal and Mangrove strata and the Public Plantation forest strata were 11,167,593 Tonnes of CO_2, 5,437,247 Tonnes of CO_2 and 2,681,433 Tonnes of CO_2 respectively. Historically, the period 2002-2006 had the greatest emissions at 62,833,585 Tonnes of CO_2.

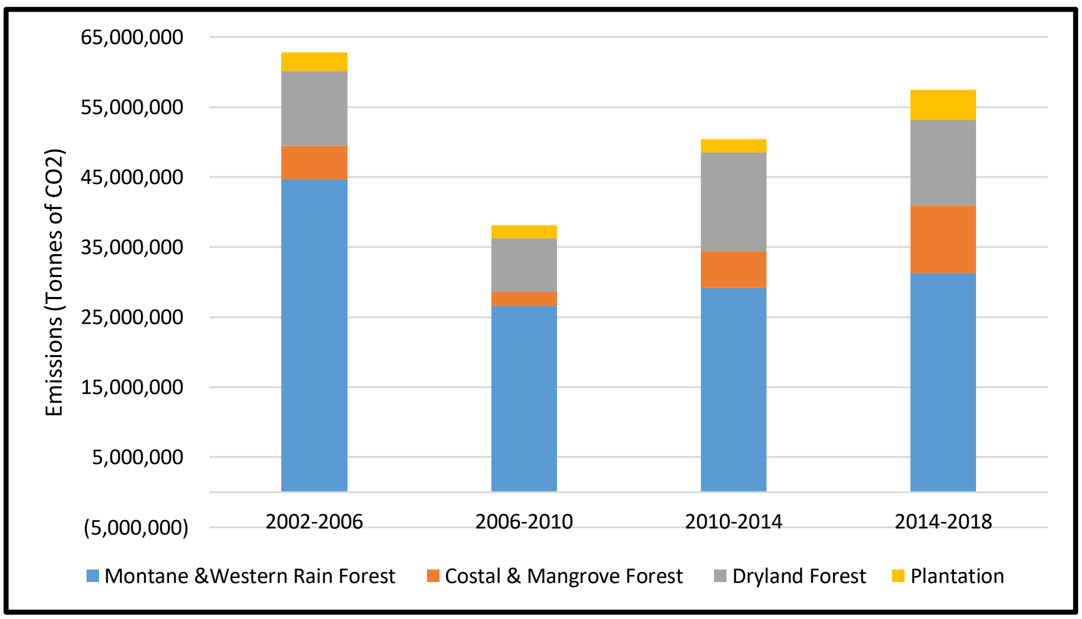

Figure 13: A cumulative bar graph to compare emissions among the forest strata of Kenya

The summary of the statistics associated with emissions from the specific REDD+ activities is shown in table 30 and Figure 14. Deforestation has the biggest contribution to national emissions with an average of 48,166,940 Tonnes of CO2. A key Category Analysis shows that Deforestation contributes over 68% of the national CO_2 sources and sinks and is therefore a main activity to be addressed in Reducing Emissions for REDD+. Similarly, Emissions from Forest degradation and Enhancement of carbon stocks are significant activities for Kenya's REDD+ programme. Though a key Category Analysis identifies that public plantation forests of Kenya are not a Key source of Emissions for the REDD+ programme (3.76%), these forests supply material for wood based industries and therefore support livelihoods and economic development and qualify as an important REDD+ activity.

Table 30: Historical Annual CO_2 Net Emissions classified by REDD+ Activity

REDD+ Activity	Emissions (Tonnes of CO_2)					KCA
	2002-2006	2006-2010	2010-2014	2014-2018	Average	
Deforestation	54,755,246	39,143,087	48,736,134	50,033,292	48,166,940	67.59
Degradation	13,836,587	8,350,601	9,563,829	11,792,785	10,885,950	15.28
Sustainable management of forest	2,732,682	1,829,312	1,887,435	4,276,302	2,681,433	3.76
Enhancement	-8,490,930	-11,223,826	-9,758,555	-8,647,746	-9,530,264	13.37
Total (Emission estimates (Net)	**62,833,585**	**38,099,174**	**50,428,843**	**57,454,634**	**52,204,059**	

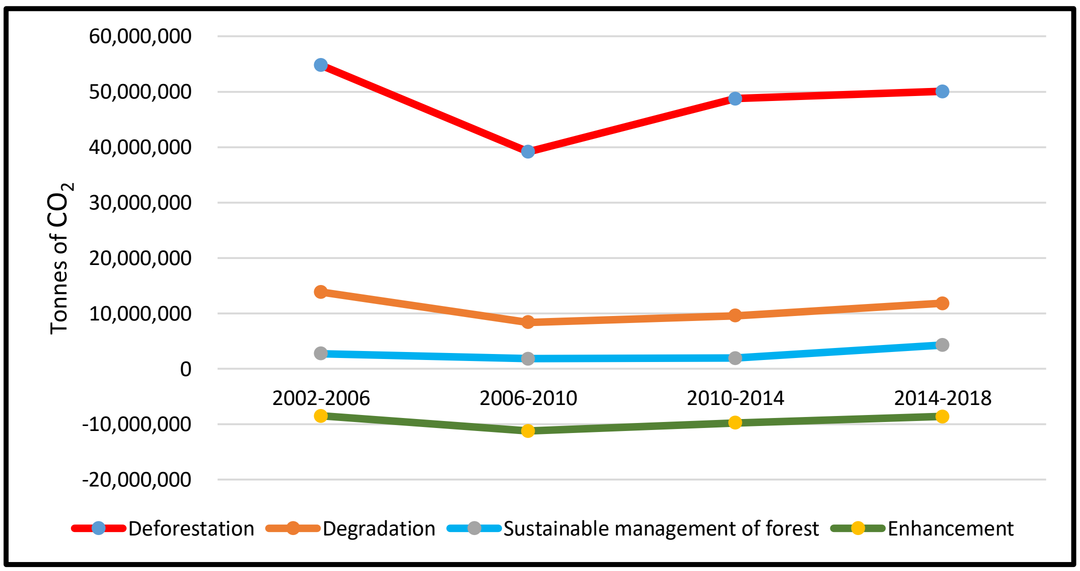

Figure 14: Comparison of Annual Emissions from REDD+ Activities in the reference period

5. NATIONAL CIRCUMSTANCES

5.1. Qualitative analysis

This section describes how the national circumstances are likely to influence future forest sector emissions and removals. The national circumstances considered include current and evolving institutional arrangements for forest management and administration, implementation of policies and legislation, national and international forest commitments, and national development strategies likely to impact on future forest resources management and conservation.

The forest sector is today a critical asset for economic growth, environmental sustainability, and provision of social and cultural values. For instance, about 50,000 people are directly employed in the forest sector while about 300,000–600,000 are indirectly employed depending on the sector, (FAO, 2015). Further, over 2 million households within 5 kilometers from forest edges have significant dependency on the forest services and products which include, cultivation, grazing, fishing, fuel, food, honey, herbal medicines, water and other benefits.

The results of emissions classified by strata show that Montane forests have historically (In the reference period) accounted for the largest source of emissions and this may be attributed to encroachment of forests and their conversion to agriculture specifically before enactment of the Forest Act 2005 and its subsequent revisions. Another major source of emissions is identified as the dryland forests where agriculture is actively converting former dryland forests into arable land (Drigo et al., 2015). Poor management of plantation forests has resulted to backlogs as illustrated by reduced forest cover in the plantation zones and this stratum has become a source of emissions.

5.2. Socio-Economic profile

Kenya has experienced significant growth in population in the recent past. As Kenya seeks to transit from a Least Developed country to a middle-income economy [21] a number of developmental activities have been proposed for implementation. Such activities target industrial development and development of service industries but also note the need to enhance conservation of environment and natural resources including forests.

The current population of about 50 million (Figure 15) has a very high positive relationship with forest cover and the rates of deforestation and forest degradation The government has proposed drastic measures to boost food production, including increased acreages under irrigation and provision of subsidies for agricultural inputs. There is rapid urbanization in the country as a result of growth in population and an enabling economic environment in the country. The expansion of cities and towns will continue to cause deforestation and forest degradation by encroaching into the forest areas and causing increased demand of forest products for construction and energy. Both rural and urban population is highly dependent on biomass energy especially the use of charcoal accounting for 60% energy demand (Drigo et al., 2015).

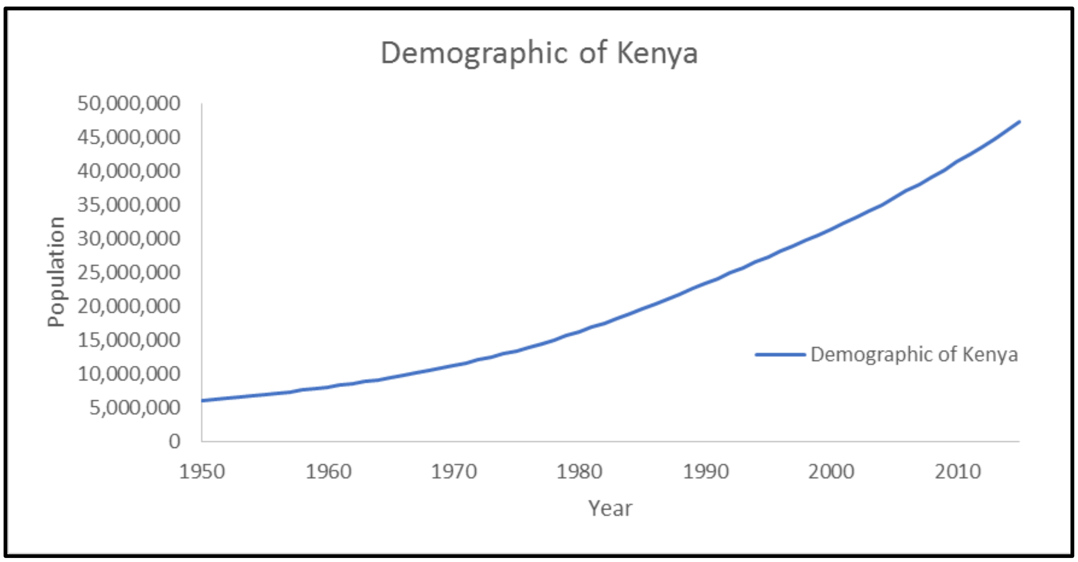

Figure 15: Kenya's Demographic trend (UN 2019)

5.3. Infrastructural, and industrial developments

Kenya has an aggressive infrastructural, commercial and industrial development programme based on the vision 2030. This development is likely to result in clearing of large areas of previously forested landscapes. The surrounding forest areas are also more likely to be converted

[21] Vision 2030 targets

to settlements leading to deforestation and forest degradation. It has been pointed out that the current and planned developments are concentrated in the fragile ecosystems including the dryland forest and woodland areas which will adversely affect the forest cover in the country. The current and planned developments that are expected to lead to planned deforestation and forest degradation include Konza technology city, Isiolo Port, Lamu port, LAPSSET Project, comprising of a road, rail and pipeline connecting Kenya to South Sudan and Ethiopia, The Northern Corridor Transport Project, Construction of a standard gauge railway line from Mombasa to Kisumu, Creation of a one-million-ha irrigation scheme in the Tana Delta.

5.4. Development Priorities and commitments

There are different development priorities recognized in the country due to the set national development agenda, agreements within regional economic blocks, international treaties and multilateral agreements. Most of these agreements have identified forests and woodlands as important resources for economic growth and poverty reduction, especially with regard to energy, food, and timber. There are also other non-timber forest products and environmental services that underpin ecosystem functions in support of agricultural productivity and sustainability". Important development priorities affecting the forest sector include; SDG Targets, UNFCCC, Convention on Biological Diversity (CBD), Forest Law Enforcement and Governance (FLEG), International Tropical Timber Agreement 2006 (ITTA), Reducing Emissions from Deforestation and Forest Degradation (REDD+ mechanisms) and the United Nations Convention to Combat Desertification (UNCCD)

The Sustainable Development Goals (SDG) which recognize multiple functions of forests including ensuring conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems, the need to mobilize resources for forest management, protecting forest catchments area in line with obligations under international agreements (SDG15.1, SDG15.2, SDG15b, SDG6.6) by year 2020. Under the United Nations Framework Convention on Climate Change (UNFCCC), through the Nationally Determined Contribution (NDC) the government has committed to contribute to the mitigation and adaptation to climate change by using the forest sector as the main sink for GHG Emissions.

While significant changes in policy and Legislation have been undertaken over the last decade that seeks to strengthen sustainable forest management and conservation, the country's forest resources continue to experience severe pressure from the expanding agricultural frontier, settlements and other developments. There are genuine concerns that commitments to national and international forest goals may not be realized if the current challenges are not addressed. There is expectation, however, that improved governance of the sector arising from the devolution and public participation in management may reverse the current negative practices. This is, however, expected to take some time as capacities within county governments are strengthened to assume expanded responsibilities. Figure 16 illustrates the historical trend of areas under agriculture and cropland in the reference period based on the mapping programme that was used to develop this FRL. It can be noted that the area of grasslands has been decreasing while that of cropland has been increasing.

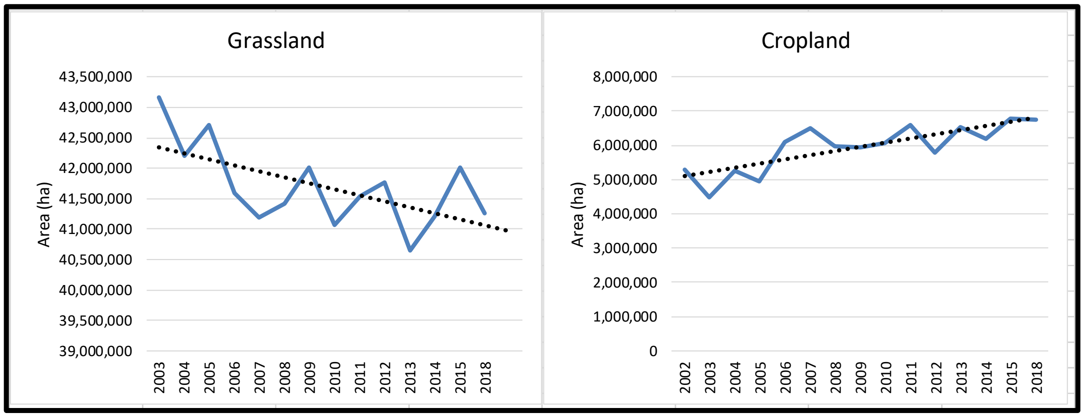

Figure 16: Historical Trends of Grassland and Cropland (SLEEK maps)

5.5. Forest Sector Governance

As described in the introductory part, Kenya has policies and legislation for sustaining its resources and ecosystems. According to the Constitution and Vision 2030[22], Kenya desires to achieve and maintain at least 10% forest cover of the total national land area by the year 2030. Further, the Forest Conservation and Management Act, 2016 identifies all the forest tenure systems of Kenya (Public, community and private forests) as potential for reforestation towards meeting the constitutional requirements of the 10% forest cover. The Forest Landscape Restoration Project for Kenya[23] identified a potential of afforesting up to 5.1 million ha in the different strata of Kenya which would double the current forest area and therefore exceed the 10% forest cover target.

The other key policies and legislation that have a bearing on the forest management include; National Wildlife Conservation and Management Act, 2013, supporting management of forest areas in significant wildlife habitats; The Land Act, 2012 and the County Government Act, 2013

[22] The Constitution states that "land in Kenya shall be held, used and managed in a manner that is equitable, efficient, productive and sustainable," and entrenches "sound conservation and protection of ecologically sensitive areas."
[23] http://www.kenyaforestservice.org/index.php/2016-04-25-20-08-29/news/437-forests-and-landscape-restoration-a-key-component-of-climate-change-mitigation-and-adaptation

which requires engagements of the local communities in the planning and management of forest resources to ensure sustainable and strategic environmental, ecological, social, cultural and economic benefit sharing. Other important policy and legislation include Environmental Management and Coordination (Amendment) Act, 2015; The Energy Policy 2014; Agriculture, Fisheries and Food Authority Act, 2013; The Water Act, 2012; National Museums and Heritage Act, 2006; and the Climate change Act, 2016.

The country recognizes the forest sector as a key sector in her national development strategies and plans which include the national Climate Change Response Strategy (2010), and the Kenya Green Economy Strategy and Implementation Plan (2017) which recognizes the critical role of the forest sector in meeting the climate change mitigation and adaptation obligations.

Kenya has already developed a National Determined Contribution (NDC) in line with her commitment to the global climate change goals under the Paris climate agreement in which it identifies forests as a significant sector in reducing emissions and meeting the NDC targets.

Figure 17 is a projection of the forest cover increase that would allow Kenya to meet the Vision 2030 requirement of 10% forest cover. This graph is developed based on the forest cover recorded in year 2018.

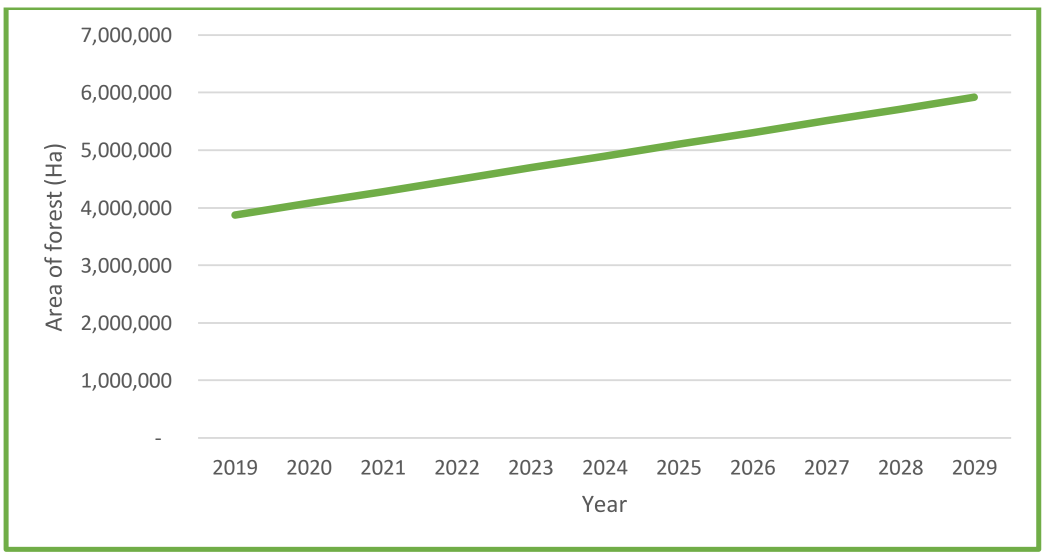

Figure 17: Projected forest cover towards 10% by year 2030[24]

[24] Estimated at afforesting/increasing forest cover by 204,727ha per year

5.6. Governance challenges

A few challenges manifest and have continued to cause significant deforestation and forest degradation in Kenya. The main challenge in the management of the forest resources is the increasing population and associated increased demand for forest products and services. Though the government has clear policies to support conservation of forests, a spiralling population poses pressure on the forest resource and calls for enhanced awareness in supporting conservation measures. It is noted that the ongoing development of the Forest strategy has noted these challenges and seeks to create an all-inclusive strategy that will support forest conservation.

Historically poor enforcement of forest regulations has been a challenge to forest conservation. This is exacerbated by the dwindling funding for conservation activities in Kenya and the small human resource capacity within the Kenya Forest Service (MENR 2016). A continuous improvement in the functions of the Kenya Forest Service and the involvement of communities through Community forest Associations is expected to enhance enforcement though successful community management of forests in Kenya has only been actualised in communities with harmonised cultural characteristics (KWTA, 2014). It is hoped that an all-encompassing REDD+ strategy will enhance awareness of conservation, involvement of more stakeholders and a campaign towards environmental protection.

Overlapping policies and institutional mandates, Policy conflicts, inadequate land tenure policies, and inadequate collaboration among forest conservation agencies are identified as other governance challenge affecting forest conservation (FAO, 2017). It is noted that the Environmental Management and Coordination Act (EMCA) (NEMA, 2018) is the supreme environmental law and seeks to enhance forest conservation and biodiversity conservation. However implementation of the EMCA is still a challenge. Other challenges including Inadequate regulation of grazing in the semi- arid and arid lands woodland and Dryland forests that has resulted to overstocking and overgrazing leading to wide spread deforestation and degradation of forests which needs to be addressed through programmes that support development of marginal areas.

5.7. Factors influencing future Emissions

No modelling studies have so far been carried out to understand how various land use and land resources policies implementation will manifest in future against the challenges of competing land claims by key economic sectors, increasing population and increased demand for forest resources and food insecurity. As discussed in chapter 2, it is proposed that the FRL will be projected based on the historical average of emissions using the 2002-2018 data. The foregoing discussion has illustrated two major factors that will influence emissions in Kenya. Population growth and increased demands for developmental needs, has historically put pressure on the forests. With the projected population growth of 2.5% in 2018[25] an equivalent increase in emissions would increase CO_2 Emissions in the four REDD+ activities from the current annual average of 52,204,059 Tonnes of CO_2. Noting that population increase is not the only factor influencing forests of Kenya, a Business as Usual scenario under the current forest product consumption rates would increase CO_2 emissions from the forest sector unless efforts are put in place to integrate emission reductions in developmental activities.

On the conservation front, Kenya's vision 2030 targets an increase in forests from the current 5.85% in 2018 to 10% in 2030. This translates to an increase of the current forest cover by 0.3458% per year which is equivalent to 207,213 ha per year for the period 2019 to 2030. Such a planting and conservation rate if implemented would reverse Kenya's emission status from the current state of net emission to a net sink.

The ongoing discussion therefore proposes that a projection of the future emissions for Kenya would preferably use a historical average to represent a business as usual scenario. A decrease in emissions in the future would therefore illustrate an extra effort by the country to deviate from the Business As Usual scenario towards reducing emissions

[25] Obtained from Kenya Population (LIVE). Yearly Population Grentity_medium growth Rate (%).https://www.worldometers.info/world-population/kenya-population/

6. PROJECTIONS OF THE FRL

6.1. Historical average projected into the future

The values of Emission estimates of each REDD+ activity are shown in the Tables 29 and 30. The value of Net emission is calculated as the sum of emissions arising from the four REDD+ activities (Deforestation, Forest degradation, Sustainable Management of Forests and Enhancement) and also classified by forest strata (Montane and western Rain forests, Coastal and Mangrove forests, Dryland forests and Public plantation forests). It is also hoped that emissions in the future will be monitored at 4 year intervals because Kenya is continuously improving its land cover mapping programme. There are also plans to implement a National Forest Inventory based on the designs that have already been developed.

The process of projection adopted an average of the historical emissions. It was noted that the linear relationship developed from the 4 point data (2002-2006, 2006-2010, 2010-2014 and 2014-2018) had a weak Coefficient of Determination (R^2) which explains that the trend of emissions is not accurately defined by the time series monitoring. A historical average therefore explains that a Business as Usual scenario is assumed in projecting emissions into the future and the assumptions for this are clearly explained in the Chapter on National Circumstances. The Chapter on National Circumstances did not identify any need to create an adjustment of the average emissions because there are no specific development and human livelihood activities prioritized by the government that may result to a reversal of the ongoing conservation activities.

6.2. Projected Net National Emissions

A projection of Emissions using the Business as Usual Scenario is an extension of the average emissions into the future (Figure 18 and table 31). The table presents the averages calculated for the historical period and their projection into the future which implies that the same historical numbers have been projected into the future.

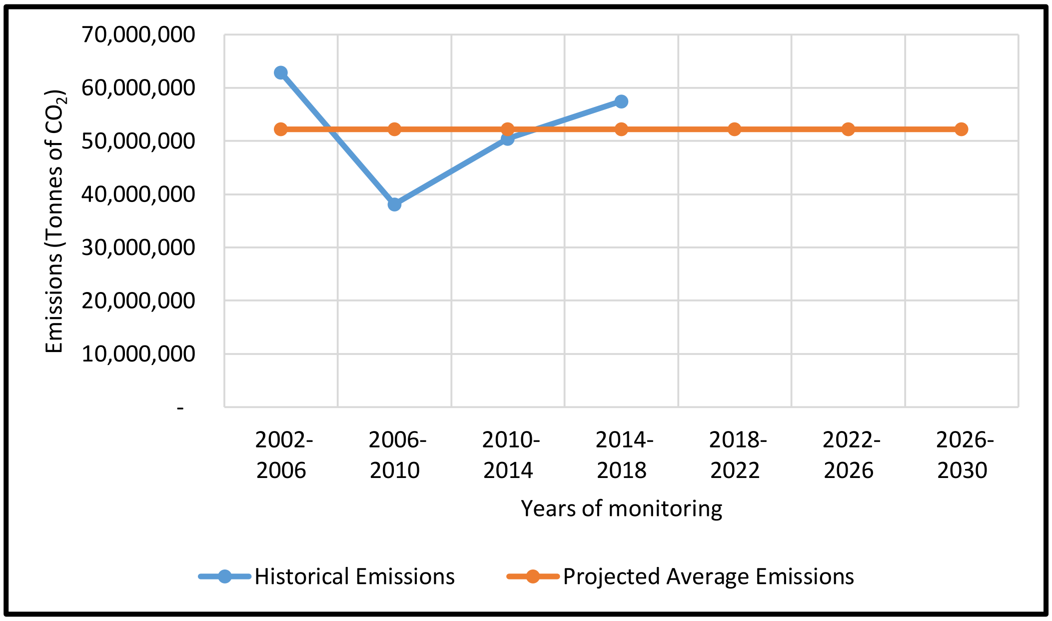

Figure 18: Projections of Net Emissions

6.3. Projected emissions from REDD+ activities

Projected emissions for the various REDD+ activities and based on the historical average emissions for each REDD+ activity are shown in Figure 19 and table 31. The table presents the averages calculated for the historical period and their projection into the future which implies that the same historical numbers have been projected into the future.

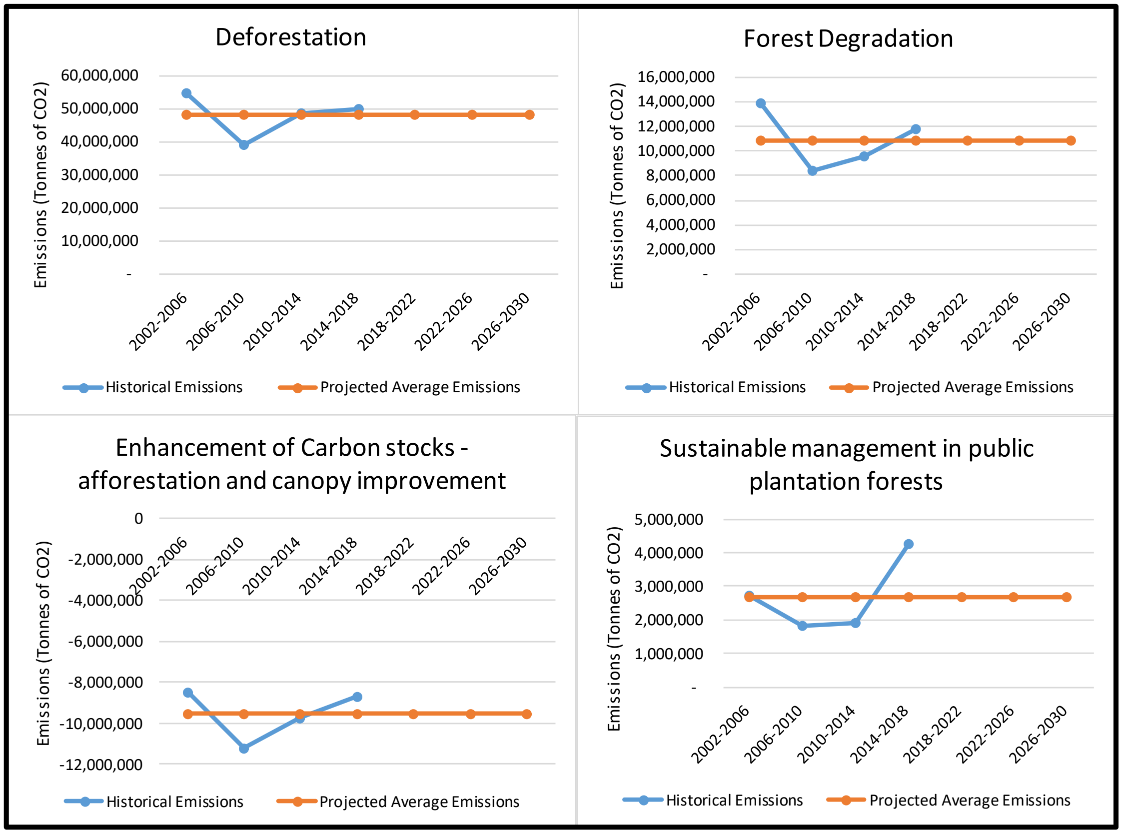

Figure 19: Projections of Annual Emissions from the selected REDD+ Activities

Table 31: Projected Annual CO_2 Emissions based on historical averages

REDD+ Activity	2002-2006	2006-2010	2010-2014	2014-2018	2018-2022	2022-2026	2026-2030
Deforestation	48,166,940	48,166,940	48,166,940	48,166,940	48,166,940	48,166,940	48,166,940
Degradation	10,885,950	10,885,950	10,885,950	10,885,950	10,885,950	10,885,950	10,885,950
Sustainable management of forest	2,681,433	2,681,433	2,681,433	2,681,433	2,681,433	2,681,433	2,681,433
Enhancement	-9,530,264	-9,530,264	-9,530,264	-9,530,264	-9,530,264	-9,530,264	-9,530,264
Total (Emission estimates)	**52,204,059**	**52,204,059**	**52,204,059**	**52,204,059**	**52,204,059**	**52,204,059**	**52,204,059**

7. UNCERTAINTY OF THE FRL

7.1 Uncertainty of AD

The accuracy assessment of the AD aids in checking the correctness of the land cover and forest cover change maps. The accuracy information is crucial in estimating area and uncertainty. The aim is to reduce uncertainties as far as practicable to have neither over nor underestimates. Statistically robust and transparent approaches are critical to ensure the integrity of land use change information. The steps followed were as recommended by Global Forest Observation Initiative Methods and Guidance Document [26]. The most common approach for accuracy assessment is to conduct ground referencing where each pixel in the land cover map is verified. However, field work is normally expensive and time consuming and therefore sampling methods were used to generate representative classes for field verification.

7.1.1. Uncertainty of individual land cover maps

The 2018 map was developed during the same year and allowed ground truthing. A total of 1894 field sample points were visited for ground truthing done based on accessibility, and security situation in Kenya. Another 1905 sample were independently interpreted using Google Earth as high resolution imagery. Since no ground truthing would be done for historical maps, ground truthing was done using Google Earth imagery.

The classification accuracy was calculated by comparing the classification result with presumably correct information (ground truth) as indicated by either field verification and/or Google Earth imagery. The accuracy assessment results illustrated in Table 32 show values for all the years and highlight the years that were used for the FRL. Table 33 shows the correctness of each of the landcover classes. In all the years used for developing the FRL, the accuracy of the maps is within acceptable limits and have over 70% agreement.

[26] Methods and Guidance from the Global Forest Observations Initiative Version 2: Integration of remote-sensing and ground-based observations for estimation of emissions and removals of greenhouse gases in forests

Table 32: Kappa Coefficients of the time series Land cover maps

S/No	Year	Overall Accuracy %	Kappa Coefficient		S/No	Year	Overall Accuracy %	Kappa Coefficient
1	2000	83.018	0.743		9	2009	89.485	0.851
2	2002	87.030	0.815		10	2010	82.392	0.748
3	2003	83.931	0.738		11	2011	81.818	0.727
4	2004	81.611	0.705		12	2012	77.526	0.705
5	2005	82.258	0.749		13	2013	83.139	0.764
6	2006	88.713	0.828		14	2014	75.635	0.7025
7	2007	78.227	0.697		15	2015	78.870	0.727
8	2008	78.001	0.688		16	2018	76.021	0.705

Table 33: Correctness of the 2018 land cover map by land cover classes

Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy
Dense Forest	270	232	171	63.33%	73.71%
Moderate Forest	213	174	87	40.85%	50.00%
Open Forest	152	118	51	33.55%	43.22%
Wooded Grassland	1084	1157	945	87.18%	81.68%
Open Grassland	499	599	413	82.77%	68.95%
Perennial Cropland	216	230	169	78.24%	73.48%
Annual Cropland	875	846	696	79.54%	82.27%
Vegetated Wetland	86	61	50	58.14%	81.97%
Open Water	41	36	30	73.17%	83.33%
Otherland	212	195	162	76.42%	83.08%
Totals	3648	3648	2774		
Overall Classification Accuracy =		76.04%			

7.1.2. Uncertainty of change Maps (Activity Data)

To allow for calculation of error propagation due to AD and EF, the "Error-adjusted" estimator of area formula (Olofsson, et al, 2013) shown below was used to calculate the uncertainty of the change maps. The results of uncertainty are presented in Table 34.

$$S(\hat{p}_{\cdot j}) = \sqrt{\sum_{i=1}^{q} W_i^2 \frac{\frac{n_{ij}}{n_{i\cdot}}\left(1-\frac{n_{ij}}{n_{i\cdot}}\right)}{n_{i\cdot}-1}}.$$

Table 34: Uncertainty of Activity Data

Uncertainty (%) of Change map 2002-2006	
Overall Accuracy	41.05
Overall Uncertainty	4.94
Limits	41.05%±4.94%
Uncertainty (%) of Change map 2006-2010	
Overall Accuracy	51.9
Overall Uncertainty	4.03
Limits	51.9%±4.03%
Uncertainty (%) of Change map 2010-2014	
Overall Accuracy	35.75
Overall Uncertainty	2.17
Limits	35.75%±2.17%
Uncertainty (%) of Change map 2014-2018	
Overall Accuracy	30.01
Overall Uncertainty	2.15
Limits	30.01%±2.15%

Noting that 4 intervals were used for the AD, an average of the uncertainties for the 4 epochs was used to calculate the overall uncertainty of AD as illustrated below,

$$\frac{4.94}{4} + \frac{4.03}{4} + \frac{2.17}{4} + \frac{2.15}{4} = 3.32$$

Therefore the average uncertainty of the maps is 3.32%.

The mean accuracy of the Activity data was calculated using the same method from data for the four epochs and gives a mean of 39.68%

$$\frac{41.05}{4} + \frac{51.9}{4} + \frac{35.75}{4} + \frac{30.01}{4} = 39.68$$

7.2. Uncertainty of EF

In Kenya, a full national forest inventory has never been implemented. The number of plots in the pilot forest Inventory which was done for EF setting was limited to only 121 plots distributed among the 10 strata described in Table 2. An analysis of the data shows high uncertainty of the mean (Table 35) which is attributed to the small sample size. The standard deviations are extremely high illustrating a need for creating substrata within all the selected strata. A comparison of the data with other independently carried out research in the specific forests of Kenya (e.g. Kinyanjui *et al* 2014, Glenday, 2006 and Kairo, 2009) also showed a great variation in carbon and biomass values within strata of Kenya and thus, an NFI using the nationally approved methodology will be expected to be implemented in the future to provide more accurate values of EF for the variety of forests. This may necessitate creating further substrata within the current ones.

Table 35: Uncertainty of the Field data

Strata	Canopy Class	Mean (Tonnes of AGB)	Std Dev	No Samples	Uncertainty	Uncertainty of mean
Montane & Western Rain Forest	Dense	244.80	157.94	8	126.46	44.71
	Moderate	58.43	34.64	7	116.20	43.92
	Open	23.26	13.64	6	114.94	46.92
Coastal & Mangrove forest	Dense	94.63	45.03	18	93.27	21.98
	Moderate	60.45	31.90	12	103.43	29.86
	Open	35.47	34.03	16	188.04	47.01
Dryland Forest	Dense	42.43	32.11	8	148.33	52.44
	Moderate	34.52	15.01	8	85.22	30.13
	Open	14.26	6.89	7	94.70	35.79
Plantation	Plantation	324.79	249.38	36	150.49	25.08

Due to the limitations in the EF data, a Bootstrap simulation according to the 2006 IPCC Guidelines[27] (Volume 1 Chapter 3) was used to calculate the Uncertainty of the EF. The Bootstrap simulation helps to obtain the confidence interval of the mean in cases where of the uncertainty of the mean is not a symmetric distribution. The results of the bootstrap analysis describes the ranges of 95 % Probability of the confidence interval. Then, the 2.5 Percentile and the 97.5

[27] Volume 1 chapter 3of the 2006 IPCC guidelines. Uncertainty

Percentile are 142.34 and 228.95, respectively. The mean EF is 183.51 and the uncertainty of the EF was calculated as 24.8%

7.2. Uncertainty of FRL

Olofsson, et al, (2013) have explained that the error of the estimated Green House Gas emission is a product of the AD and EF and provide the following formula for estimating the error propagation

$$SD\ CO_2 = \sqrt{\overline{Total_{carbon}}_{1\to 2}^{2}\left[\left(\frac{SD^2_{Emissions_{factor}}}{\overline{Emissions_{factor}}_{1\to 2}^{2}}\right)+\left(\frac{SD^2_{Activity_{data}}}{\overline{Activity_{data}}_{1\to 2}^{2}}\right)\right]}$$

The uncertainty of AD and uncertainty of EF were 2.9 % and 24.8 % respectively. The total CO_2 calculated for the FRL was 52,204,059. Therefore the uncertainty of the FRL was calculated as

$$Uncertainty\ of\ the\ FRL = \sqrt{52{,}204{,}059^2 * [(24.8^2/183.51^2) + (3.32^2/39.68^2)]}$$

The Uncertainty of this Submission is ± 8,299,540. This implies that the FRL is 52,204,059 ± 8,299,540 t CO2/year which is equivalent to 16%:

8. FUTURE IMPROVEMENTS

Kenya will develop its FRL according to a stepwise approach informed by available data, expertise and technologies. There are proposed improvements in the future FRL setting. Listed as follows

8.1. National Forest Inventory

The Emission factors presented in this FRL are based on a very small sample size representing the different forest strata of Kenya. As noted in the accuracy assessment section, better accuracy of this EF would be achieved when a wider data set is considered. Similarly, the wide variations in the collected data within strata calls for creation of sub strata to enhance accuracy. It is noted that within the current strata there exists some sub strata which may require sub sampling. For example, within the Montane and Western rain forest strata, Montane forests can be separated from Bamboo forests and Western rain forests to create three strata. Similarly, separation of Mangrove forests from Coastal forests would enhance accuracy noting the great variation in the tree characteristics and biomass components (Kairo et al., 2009).

An NFI should develop permanent sample plots which will provide better information on stock changes and growth rates. This FRL has adopted IPCC default values for growth rates and these might not be very accurate at the strata specific level. For example growth rates for the Montane and western rain forests have been adopted from the Tropical rain forests of the world. However Kenya's Montane forest have slightly less stocking (Kinyanjui et al., 2014) and growth rates compared to the tropical rain forests, but they can also not be classified as mountain ecosystems under the IPCC classification system because the mountain ecosystems of Kenya have dwarf vegetation that is slow growing.

8.2. Land cover mapping

The SLEEK land cover mapping programme has generated 18 maps using Approach 3 of the IPCC guidelines[28]. From this time series set of land cover maps, five maps were selected to develop this FRL. An improvement in the accuracy of the maps would have made it possible to select more maps and shorter time intervals would have been adopted to create a more realistic scenario for the FRL. Though the use of 4 year intervals to describe land cover changes and historical emissions was used, the future reporting of Biennial Update Reports may require doing monitoring at 2 or 1 year intervals. This implies a need for capacity building to enhance the accuracy of the maps so that they may provide accurate estimates of Emission trends

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[28] 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Chapter 3: Consistent Representation of Lands

The land cover maps used in the FRL have 7 land cover classes. It is noted that settlements and other lands have been mapped as a single category and this can be a source of errors. An improvement in the mapping programme would enhance accuracy moving from a Tier 1 reporting towards a Tier 3 reporting.

8.3. Carbon pools

Currently, only AGB and BGB have been considered. In future, dead wood, litter, soil organic matter and harvested wood products should be measured and included in subsequent FRL estimation. It is noted that immediate oxidation for all deforestation as presented in this FRL may not be the case on the ground.

8.4. Non CO_2 emissions

In this FRL, CO_2 is the only gas considered. Noting that emissions from the forest sector include other non CO_2 emissions, it is proposed that further research should be done to allow inclusion of CH_4 and N_2O gases.

8.5. Stock change vs Gain loss method

The FRL has been developed using a gain loss method that uses land cover changes to inform changes in the forest stocks. However, all deforestation has assumed instantaneous oxidation but this is not the case for harvested wood products. Similarly the method provided here assumes that forest degradation is fully captured when a forest canopy degrades from a superior to an inferior canopy. A more realistic method would have analyzed data for harvested wood products. However, such data which changes over time is not available and there is not accurate method of estimating it. A mechanism for collecting such data should be put in place to allow better estimation of Emissions from the forest sector

8.6. Calculation of emissions into the future

The future monitoring of emissions based on the FRL projections will be done in short time epochs. Therefore, lands converted to forestlands will be assigned the growth factors based on their forest strata and sub strata. However, such lands should be isolated so that they do not exaggerate emissions from deforestation in the subsequent change map. This activity is not included in the current land cover change analysis. A model that has been tested in Kenya under the SLEEK programme requires further testing because its efficient use would greatly enhance emission estimation into the future. This model has been used to do an external validation of this FRL.

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ANNEXES

Annex 1 Methodology for Land Cover / Land Use Mapping

1. Classes for Land Cover / Land Use Map

The categorized classes for Land Cover / Land Use Map was considered based on international guidelines, local definitions of land uses, ability to capture variations of carbon stocks among land uses and simplicity of land cover mapping system. The Six broad classes were adopted from IPCC where these classes were further subcategorized. The IPCC classes are:

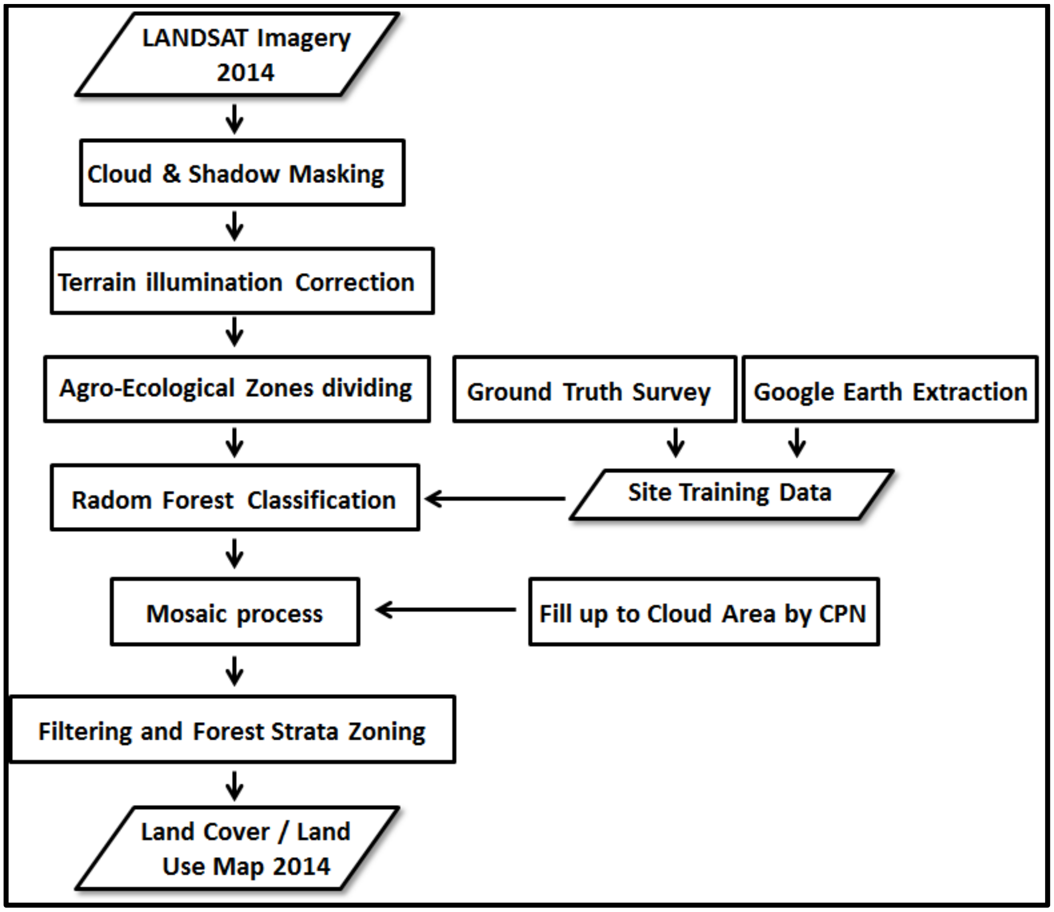
- Forestland,
- Cropland,
- Grassland,
- Settlement,
- Wetlands and
- Other lands.

The subcategorized classes were based on local definitions of land cover and land use. Forest and forest conversion were of high importance in terms of carbon stocks and emissions. The forestland was subcategorized based on national forest definition which is canopy density not less than 15%, and was divided into three categories: Open, moderate and dense. The cropland was divided into two categories: annual crops, and perennial crops. The grassland had also been classified into wooded grass (shrubs and grasses) and open glass. The wetland had been mapped as two categories: water body and vegetated wetland. And the other land was included barren land, rocks, soils and beaches. However, the settlement was not classified due to required alternative methodology other than Satellite Imagery Remote Sensing.

For the subcategorized forestland by forest definition, it was mixed type of forest e.g. plantation and dryland forest. The subcategorized forestland i.e. open, moderate and dense had been zoned by ancillary data which was classified by forest strata definitions in Kenya. The forest strata definitions are described in Annex 2. The table 2 in the report show sub categorization of forestland.

2. Methodology for preparation of Land Cover / Land Use Map

The Land Cover / Land Use Maps were created based on the following process steps using Landsat Imagery as show in the Figure below. The best available Landsat images for each year were selected from the USGS archive which provided a complete cloud-free (threshold 20% cloud cover) coverage of Kenya. Cloud cover was a major consideration. Dry season images are preferred for classification purposes as these allow for better discrimination between trees and grasses or crops.



Flow chart for preparation of Land Cover / Land Use Map 2014

1) Cloud and shadow cover masking

Minimal cloud cover is a major consideration in scene selection, but the best selected scenes may still contain areas of cloud and cloud shadow. This must be removed prior to the classification. The cloud masking process involves masking all cloud, shadow and have affected areas and set them to a null value (0)

2) Terrain illumination correction

Terrain illumination variations exist in imagery because of variations in slope and aspect of the land that affects the amount of incident and reflected energy (light) from the surface. For digital classification of land cover, it is desirable to correct terrain illumination effects so that the same land cover will have a consistent digital signal. The correction requires a knowledge of the slope and aspect of each pixel (from a DEM), and knowledge of the solar position at the time of overpass (from Landsat acquisition data).

3) Agro-Ecological zoning

Land use and land cover varies tremendously across Kenya. Land cover ranges from the dense forests to vast dry wooded grassland areas. Climate, soil variations, and altitude are the main drivers for differences in natural cover. They also affect agricultural land cover and land use. Stratification is a technique used to divide a set of data into groups (strata) which are similar in some way. For the classification process of Land Cover / Land Use, Kenya was divided into 'spectral stratification zones' (SSZ). These zones divide the country into geographic areas within which the spectral signatures of land cover types are similar. The classification process is trained and applied separately within zones. The spectral stratification zones were initially based on Kenya's Agro-Ecological Zones.

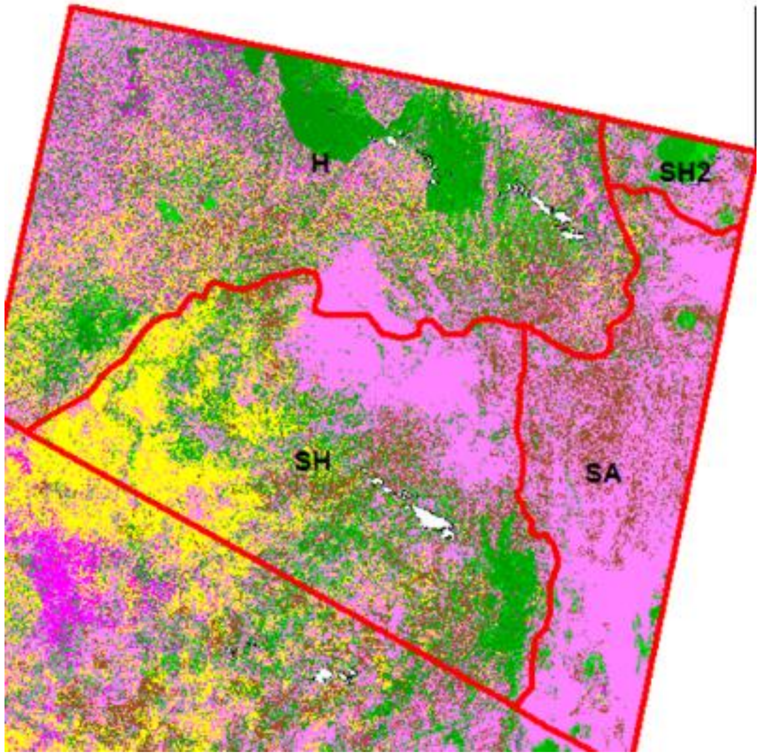
4) Random Forest classification with training data (ground truth survey and Google Earth)

For image classification method, supervised (Maximum Likelihood Classifier) and Random Forest classification had been tested. As a result of the test, The Random Forest classification has better accuracies than supervised classification. The Random Forest classification had been selected as method for preparation of Land Cover / Land Use Map.

Training sites were extracted from ground truth survey and Google Earth in cases of inaccessible areas, and they are simply groups of pixels which are identified by the operator as having a particular land cover class. These training sites are defined as polygons which are digitized as training data on the image and labelled using the land cover codes. The set of training data for each class represented the full range spectral variation of that class in the zone for that scene, and 'balanced' with respect to the different spectral colors for that class. The set of training data contained enough pixels. The prepared site training data was applied to individual terrain-corrected and masked images which had been processed as Random Forest classification process. And this process was applied separately to each stratification zone within the image.

5) Mosaic process and fill up to cloud area by CPN

The mosaic process was required due to the application of Random Forest classification to individual images. Individual images were mosaicked as one classified image map. The Figure below shows mosaicked individual classification result for a single scene from 2014.



Mosaicked individual classification result for a single scene from 2014

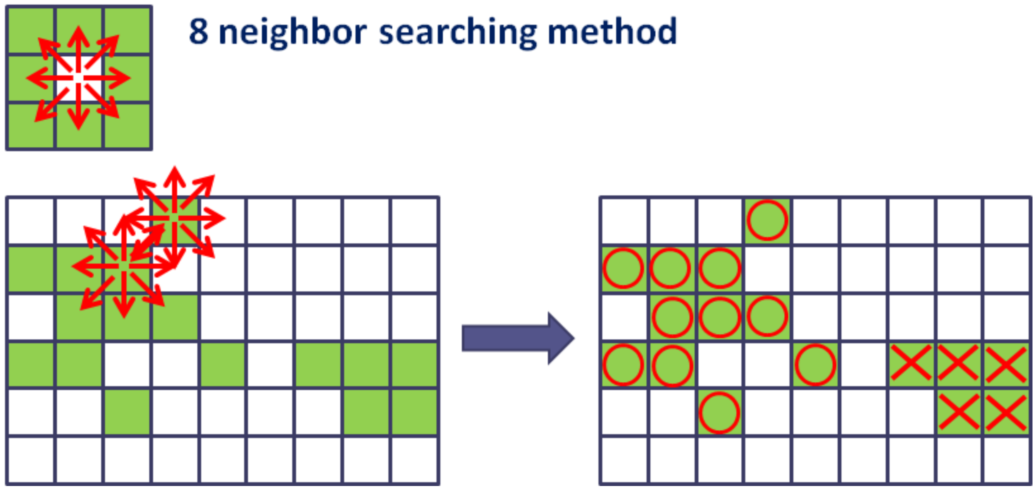
The mosaicked classification result has gap area as cloud masked image. To fill up to the gap area, replacement image was generated by the multi-temporal processing. Therefore, the mosaicked maps for all years were modified in the multi-temporal processing.

The multi-temporal processing was carried out in a mathematical model known as a conditional probability network (CPN). The multi-temporal processing resolves the uncertain spectral region and more accurately detects genuine land cover change by using the temporal trends in the probabilities of land covers. CPN are used to combine probabilities from a number of years to give an overall assessment of the likelihood of land cover and its change. The result of multi-temporal processing was utilized to fill up the gap area.

6) Filtering and Forest Strata Zoning

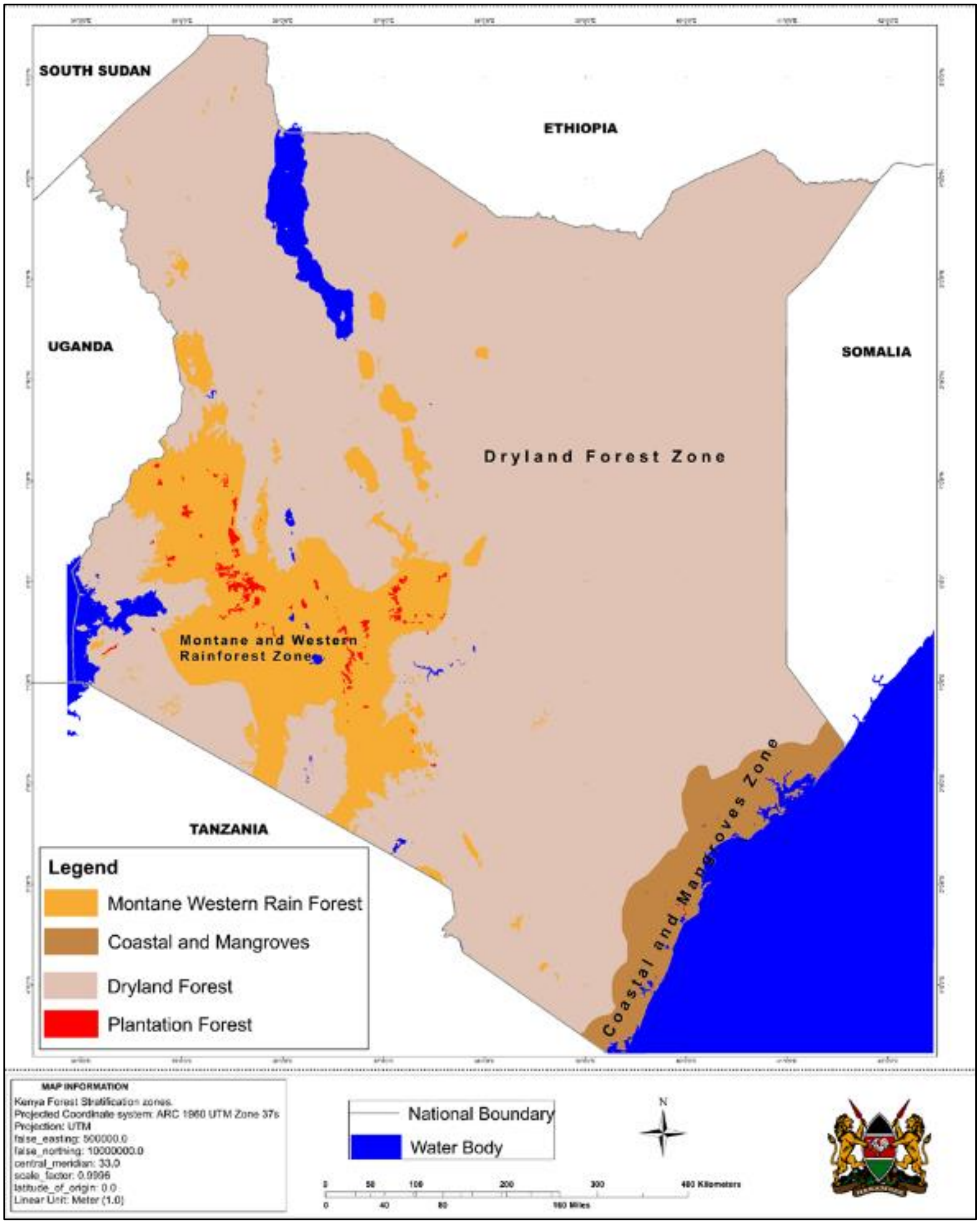
The mosaicked and filled up image map was subjected to a filtering process to obtain the minimum mappable area and to meet the agreed forest definition for Kenya. To meet the forest definition, eight (8) neighbors filtering method was preferred and used for mapping. The eight (8) neighbors filtering method used eight (8) direction searching and clumping as one connected forest as shown in the Figure below. Kenya defines a forest as having a minimum area of 0.5Ha which is defined by approximately 6 pixels of 30m by 30m dimensions

Therefore a clumped forest of less than 6 pixels is eliminated.



Eight (8) neighbors filtering

The filtered classification result map was zoned by forest strata zoning. This forest strata zoning information was generated by the forest strata definition as shown in the Figure below.



Forest Strata Zone Image

As explained above, the process steps for the Land Cover / Land Use Map were applied to all years: 1990, 1995, 2000, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015 and 2018.

Annex 2: Forest Strata Definitions and Supporting Descriptions

1. **Plantation forest land:** Refers to areas with even aged monocultures and would therefore have a unique spectral characteristics that can allow separation from other vegetation types by remote sensing. Their boundaries in public forests (Government owned forests) are also clearly defined and it is possible to delineate them from the other natural forests. The trees are mainly planted for commercial purposes and undergo a series of silvicultural activities like pruning and thinning which affect their carbon stocks. Plantations may be divided based on commonly species grown and the areas where these species are grown. In public forests, exotic plantation species include *Cupressus lusitanica, Eucalyptus sp.* and several pine species (*P. patula* in montane areas and, *P. carribeae* in coastal forests). In the private forests, Eucalypts are the main plantation species in the montane areas, with *Melia volkensii* in many dryland areas, and *Casuarina equisetifolia* dominating at the coast. Since these varied plantation species may not be easily separated by remote sensing, ancillary data will be used for sub categorization by species. Similarly these plantations exist in different age classes which imply different carbon stocks. Information on the age class of the plantations is available with the managers of specific forests (e.g. the inventory section of KFS).

2. **Mangroves and coastal forests**
    a. Mangroves have been defined as trees and shrubs that have adapted to life in saline environments. They are characterized by a strong assemblage of species according to geomorphological and salinity gradients, and tidal water currents. There are nine species of mangroves in Kenya which occur on a typical zonation pattern with the seaward side occupied by *Sonneratia alba,* followed by *Rhizophora mucranata*, then *Bruguiera gymnorrhiza*, *Ceriops tagal*, *Avicennia marina, Lumnitzera racemosa* and *Heritiera litoralis* respectively (Kokwaro, 1985; Kairo et al., 2001). Other mangrove species include *Xylocarpus granatum* and *Xylocarpus mollucensis*. Shapefiles of the mangrove zones which will be used for sub categorization are available at KFS.
    b. **The coastal forests:** These are the forests found in the coastal region of Kenya within a 30km strip from shoreline. They are part of the larger coastal belt including, Arabuko-sokoke forest, Shimba hills forest and the forests of Tana River region and Boni-Dodori forest complex. They are dominated by species of *Combretum, Afzelia, Albizia, Ekerbergia, Hyphaene, Adansonia and Brachestegia* woodlands and are biodiversity hotspots. This class was defined as unique by the KIFCON in Wass (1994) and the shapefiles of the forests are available at KFS.
3. **The montane and western rain forests and bamboo:**

a. **Montane forests:** These are forests in high altitude regions of Kenya (above 1,500m). They are the most extensive and have been described as water towers due to their support to water catchments (DRSRS and KFWG, 2006). They include the Mau, Mt. Kenya, Aberdares, Cherangany and Mt Elgon blocks, as well as Leroghi, Marsabit, Ndotos, the Matthews Range, Mt Kulal, the Loita Hills, The Chyulu Hills, the Taita Hills, and Mt. Kasigau among others. These forests differ in species composition due to climate and altitude. The moist broad-leafed forests occur on the windward sides while the drier coniferous mixed forests are found on the leeward sides (Beentje, 1994). At higher altitudes the highland bamboo (*Yushania alpina*) predominates.

b. **The western rain forests**: These are forests with characteristics of the Guineo-Congolean forests and include Kakamega forest, the North and South Nandi forest and Nyakweri forest in Transmara Sub-County. The trees are significantly taller and larger as compared to the other forests of Kenya. The shapefile describing these forests developed by KIFCON is available at KFS.

4. **The Dryland forests**: These are the forests found in the arid and semi-arid regions of Kenya. Their tree composition is dominated by Acacia-Commiphora species but also include *Combretum, Platycephelium voense, Manilkara, Lannea, Balanites aegyptiaca, Melia volkensii, Euphorbia candelabrum* and *Adansonia digitata*. The category also includes riverine forests in dry areas. Their carbon stocks may differ from that of other forests due to leaf shedding, elongated rooting systems and high specific wood density.

Categorization of these forests will be done using the shapefiles developed by KIFCON (1994) which are based on climate and altitude. These shapefiles are available at Kenya Forest Service

.

Annex 3 The Plot data form the Pilot NFI

Montane and Western rain forest Dense Canopy

Project	Cluster	Plot	Forest type	Canopy cover (%)	D/M/O	AGB Volume (m3/ha)				AGB Biomass (ton/ha)					AGB Carbon stock (ton/ha)				County	District	Division
						Tree	Bamboo	Climber	Total	Tree	Bamboo	Climber	Total	Total	Tree	Bamboo	Climber	Total			
ICFRA	5999	2	Montane Forest	100.0	Dense	263.89	1.61		265.49	208.38	0.98	7.88	217.24	217.24	97.94	0.46	3.70	102.10	Nyeri	Nyeri	Tetu
ICFRA	6001	1	Montane Forest	79.2	Dense	105.90	0.00	0.00	105.90	87.87	0.00	0.00	87.87	87.87	41.30	0.00	0.00	41.30	Nyeri	Nyeri	Tetu
ICFRA	6002	4	Montane Forest	95.0	Dense	195.91	0.00		195.91	160.50	0.00	3.16	163.67	163.67	75.44	0.00	1.49	76.92	Nyeri	Nyeri	Aberdare Forest
JICA	915	2	Montane Forest	95.0	Dense	246.38	0.00	0.00	246.38	200.15	0.00	0.00	200.15	200.15	94.07	0.00	0.00	94.07	Nyeri	Nyeri	Gathiuru
JICA	9141	1	Montane Forest	98.3	Dense	361.74	0.00	0.00	361.74	288.13	0.00	0.00	288.13	288.13	135.42	0.00	0.00	135.42	Nyeri	Nyeri	Narumoru
JICA	9150	1	Montane Forest	99.2	Dense	646.28	0.00	0.00	646.28	511.25	0.00	0.00	511.25	511.25	240.29	0.00	0.00	240.29	Nyeri	Nyeri	Narumoru
JICA	9150	2	Montane Forest	99.2	Dense	532.79	0.00		532.79	427.02	0.00	2.11	429.13	429.13	200.70	0.00	0.99	201.69	Nyeri	Nyeri	Gathiuru
JICA	912	1	Montane Forest	65.0	Dense	72.25	0.00	0.00	72.25	60.93	0.00	0.00	60.93	60.93	28.63	0.00	0.00	28.63	Nyeri	Nyeri	Kabaru
	Average								303.34				244.80	244.80				115.05			
	SD												157.94					74.23			
	CV (%)												64.52					64.52			
												First Quar	144.7172								
												Third Qua	323.3808								
												IQR	178.6636								
												Q3+1.5*I(	591.3762	511.25							
												Q1-1.5*IQ	-123.2782	60.93							

Montane and Western rain forest Moderate canopy coverage

Project	Cluster	Plot	Forest type	Canopy cover	D/M/O	AGB Volume (m3/ha)				AGB Biomass (ton/ha)				AGB Carbon stock (ton/ha)				County	District	Division
						Tree	Bamboo	Climber	Total	Tree	Bamboo	Climber	Total	Tree	Bamboo	Climber	Total			
ICFRA	6002	1	Montane Forest	61.7	Moderate	39.26	0.00		39.26	33.33	0.00	1.58	34.91	15.66	0.00	0.74	16.41	Moderate	Nyeri	Nyeri
ICFRA	6002	2	Montane Forest	47.5	Moderate	40.15	0.00	0.00	40.15	34.24	0.00	0.00	34.24	16.09	0.00	0.00	16.09	Moderate	Nyeri	Nyeri
ICFRA	6002	3	Montane Forest	63.3	Moderate	52.47	0.00	0.00	52.47	44.93	0.00	0.00	44.93	21.12	0.00	0.00	21.12	Moderate	Nyeri	Nyeri
ICFRA	6162	2	Montane Forest	40.0	Moderate	135.33	0.00		135.33	108.50	0.00	3.48	111.97	50.99	0.00	1.63	52.63	Moderate	Nyeri	Nyeri
JICA	911	1	Montane Forest	44.2	Moderate	22.90	0.00	0.00	22.90	19.71	0.00	0.00	19.71	9.26	0.00	0.00	9.26	Moderate	Nyeri	Nyeri
JICA	912	2	Montane Forest	51.7	Moderate	79.36	0.00	0.00	79.36	66.89	0.00	0.00	66.89	31.44	0.00	0.00	31.44	Moderate	Nyeri	Nyeri
JICA	928	2	Montane Forest	49.2	Moderate	117.65	0.00		117.65	95.87	0.00	0.52	96.39	45.06	0.00	0.24	45.30	Moderate	Nyeri	Nyeri
	Average								69.59				58.43				27.46			
	SD												34.64				16.28			
	CV (%)												59.28				59.28			
												First Quar	34.57354							
												Third Qua	81.63634							
												IQR	47.0628							
												Q3+1.5*I(	152.2305	111.97						
												Q1-1.5*IC	-36.0207	19.71						

Montane and Western rain forest Open canopy coverage

Project	Cluster	Plot	Forest type	Canopy cover	Canopy coverage	AGB Volume (m3/ha)				AGB Biomass (ton/ha)					AGB Carbon stock (ton/ha)				County	District	Division
						Tree	Bamboo	Climber	Total	Tree	Bamboo	Climber	Total	Total	Tree	Bamboo	Climber	Total			
JICA	911	2	Montane Forest	21.7	Open	23.49	0.00	0.00	23.49	20.48	0.00	0.00	20.48	20.48	9.63	0.00	0.00	9.63	Nyeri	Nyeri	Kabaru
JICA	913	1	Montane Forest	25.0	Open	12.23	0.00	0.00	12.23	10.57	0.00	0.00	10.57	10.57	4.97	0.00	0.00	4.97	Nyeri	Nyeri	Kabaru
JICA	913	3	Montane Forest	30.8	Open	13.88	0.00	0.00	13.88	12.25	0.00	0.00	12.25	12.25	5.76	0.00	0.00	5.76	Nyeri	Nyeri	Kabaru
JICA	913	4	Montane Forest	16.7	Open	32.10	0.00	0.00	32.10	27.69	0.00	0.00	27.69	27.69	13.01	0.00	0.00	13.01	Nyeri	Nyeri	Kabaru
JICA	9120	3	Montane Forest	30.0	Open	21.45	0.00		21.45	19.05	0.00	1.51	20.56	20.56	8.95	0.00	0.71	9.66	Nyeri	Nyeri	Kabaru
	Average								20.63				18.31	18.31				8.61			
	SD												6.97					3.28			
	CV (%)												38.07					38.07			
												First Quar	12.24935								
												Third Qua	20.55853								
												IQR	8.309178								
												Q3+1.5*I(	33.02229	27.69							
												Q1-1.5*I(	-0.21442	10.57							

Coastal forest and Mangrove Dense canopy coverage

Project	Cluster	Plot	Forest type	Canopy cover (%)	Canopy coverage	AGB Volume (m3/ha)				AGB Biomass (ton/ha)				AGB Carbon stock (ton/ha)				County	District	Division
						Tree	Bamboo	Climber	Total	Tree	Bamboo	Climber	Total	Tree	Bamboo	Climber	Total			
JICA	922	2	Coastal Forest	94.2	Dense	168.62	0.00		168.62	140.95	0.00	0.39	141.34	66.25	0.00	0.18	66.43	Kilifi	Malindi	Gede
JICA	922	3	Coastal Forest	92.5	Dense	170.55	0.00	0.00	170.55	138.68	0.00	0.00	138.68	65.18	0.00	0.00	65.18	Kilifi	Malindi	Gede
JICA	930	1	Coastal Forest	99.2	Dense	73.05	0.00		73.05	63.40	0.00	1.70	65.10	29.80	0.00	0.80	30.60	Kilifi	Malindi	Jilore
JICA	930	2	Coastal Forest	77.5	Dense	92.18	0.00		92.18	78.77	0.00	0.47	79.24	37.02	0.00	0.22	37.24	Kilifi	Malindi	Jilore
JICA	9210	2	Coastal Forest	99.2	Dense	102.77	0.00		102.77	86.45	0.00	22.52	108.98	40.63	0.00	10.59	51.22	Kilifi	Malindi	Gede
JICA	9210	4	Coastal Forest	100.0	Dense	204.43	0.00		204.43	168.15	0.00	5.79	173.94	79.03	0.00	2.72	81.75	Kilifi	Malindi	Gede
JICA	9230	2	Coastal Forest	94.2	Dense	102.87	0.00		102.87	86.60	0.00	2.80	89.40	40.70	0.00	1.32	42.02	Kilifi	Malindi	Jilore
JICA	9230	3	Coastal Forest	100.0	Dense	88.11	0.00	0.00	88.11	76.95	0.00	0.00	76.95	36.17	0.00	0.00	36.17	Kilifi	Malindi	Jilore
ICFRA	3019	1	Mangrove Forest	96.7	Dense	180.97	0.00	0.00	180.97	160.92	0.00	0.00	160.92	75.63	0.00	0.00	75.63	Kwale	Other	Other
ICFRA	3046	4	Mangrove Forest	80.8	Dense	39.40	0.00	0.00	39.40	39.64	0.00	0.00	39.64	18.63	0.00	0.00	18.63	Kwale	Other	Other
ICFRA	3047	3	Mangrove Forest	72.5	Dense	65.95	0.00	0.00	65.95	59.79	0.00	0.00	59.79	28.10	0.00	0.00	28.10	Kwale	Other	Other
ICFRA	3062	2	Mangrove Forest	95.8	Dense	67.24	0.00	0.00	67.24	87.45	0.00	0.00	87.45	41.10	0.00	0.00	41.10	Kwale	Other	Other
ICFRA	3063	1	Mangrove Forest	78.3	Dense	54.38	0.00	0.00	54.38	52.51	0.00	0.00	52.51	24.68	0.00	0.00	24.68	Kwale	Other	Other
ICFRA	3070	1	Mangrove Forest	91.7	Dense	50.63	0.00	0.00	50.63	45.91	0.00	0.00	45.91	21.58	0.00	0.00	21.58	Kwale	Other	Other
ICFRA	3070	2	Mangrove Forest	100.0	Dense	80.42	0.00	0.00	80.42	98.48	0.00	0.00	98.48	46.28	0.00	0.00	46.28	Kwale	Other	Other
ICFRA	3070	3	Mangrove Forest	89.2	Dense	51.41	0.00	0.00	51.41	78.42	0.00	0.00	78.42	36.86	0.00	0.00	36.86	Kwale	Other	Other
ICFRA	3070	4	Mangrove Forest	78.3	Dense	38.43	0.00	0.00	38.43	35.64	0.00	0.00	35.64	16.75	0.00	0.00	16.75	Kwale	Other	Other
ICFRA	3085	4	Mangrove Forest	93.3	Dense	120.94	0.00	0.00	120.94	170.89	0.00	0.00	170.89	80.32	0.00	0.00	80.32	Kwale	Other	Other
	Average								97.35				94.63				44.47			
	SD												45.03				21.16			
	CV (%)												47.59				47.59			
												First Quar	61.1206							
												Third Qua	131.2507							
												IQR	70.13013							
												Q3+1.5*I(	236.4459	173.94						
												Q1-1.5*I(	-44.0746	35.64						

Coastal forest and Mangrove Moderate canopy coverage

Project	Cluster	Plot	Forest type	Canopy cover	Canopy coverage	AGB Volume (m3/ha)				AGB Biomass (ton/ha)					AGB Carbon stock (ton/ha)				County	District	Division
						Tree	Bamboo	Climber	Total	Tree	Bamboo	Climber	Total	Total	Tree	Bamboo	Climber	Total			
JICA	921	1	Coastal Forest	60.0	Moderate	85.44	0.00	0.00	85.44	70.85	0.00	0.00	70.85	70.85	33.30	0.00	0.00	33.30	Kilifi	Malindi	Gede
JICA	923	3	Coastal Forest	49.2	Moderate	79.82	0.00	0.00	79.82	66.27	0.00	0.00	66.27	66.27	31.15	0.00	0.00	31.15	Kilifi	Malindi	Jilore
JICA	925	1	Coastal Forest	44.2	Moderate	70.79	0.00	0.00	70.79	58.25	0.00	0.00	58.25	58.25	27.38	0.00	0.00	27.38	Kwale	Kwale	Msambweni
JICA	950	1	Coastal Forest	50.8	Moderate	28.75	0.00	0.00	28.75	25.39	0.00	0.00	25.39	25.39	11.93	0.00	0.00	11.93	Kwale	Kwale	Kwale
JICA	9210	1	Coastal Forest	60.8	Moderate	63.74	0.00	0.00	63.74	53.94	0.00	0.00	53.94	53.94	25.35	0.00	0.00	25.35	Kilifi	Malindi	Gede
JICA	9230	1	Coastal Forest	63.3	Moderate	63.47	0.00	0.00	63.47	53.71	0.00	0.00	53.71	53.71	25.24	0.00	0.00	25.24	Kilifi	Malindi	Jilore
JICA	9241	3	Coastal Forest	60.0	Moderate	83.10	0.00	0.00	83.10	67.80	0.00	0.00	67.80	67.80	31.87	0.00	0.00	31.87	Kwale	Kwale	Kwale
ICFRA	3011	2	Mangrove Forest	41.7	Moderate	13.31	0.00	0.00	13.31	11.39	0.00	0.00	11.39	11.39	5.35	0.00	0.00	5.35	Kwale	Other	Other
ICFRA	3063	2	Mangrove Forest	47.5	Moderate	41.38	0.00	0.00	41.38	63.92	0.00	0.00	63.92	63.92	30.04	0.00	0.00	30.04	Kwale	Other	Other
JICA	960	1	Mangrove Forest	60.8	Moderate	62.07	0.00	0.00	62.07	53.58	0.00	0.00	53.58	53.58	25.18	0.00	0.00	25.18	Kwale	Kwale	Msambweni
JICA	961	3	Mangrove Forest	50.0	Moderate	63.67	0.00	0.00	63.67	55.12	0.00	0.00	55.12	55.12	25.91	0.00	0.00	25.91	Kwale	Kwale	Msambweni
	Average								59.59				52.75	52.75				24.79			
	SD												18.33					8.62			
	CV (%)												34.75					34.75			
												First Quar	53.64467								
												Third Qua	65.09486								
												IQR	11.45019								
												Q3+1.5*I(	82.27015	70.85							
												Q1-1.5*I(	36.46938	11.39							

Coastal forest and Mangrove Open canopy coverage

Project	Cluster	Plot	Forest type	Canopy cover	Canopy coverage	AGB Volume (m3/ha)				AGB Biomass (ton/ha)					AGB Carbon stock (ton/ha)				County	District	Division
						Tree	Bamboo	Climber	Total	Tree	Bamboo	Climber	Total	Total	Tree	Bamboo	Climber	Total			
JICA	950	2	Coastal Forest	30.8	Open	25.95	0.00	0.00	25.95	22.97	0.00	0.00	22.97	22.97	10.80	0.00	0.00	10.80	Kwale	Kwale	Kwale
JICA	9241	1	Coastal Forest	36.7	Open	28.30	0.00	0.00	28.30	24.57	0.00	0.00	24.57	24.57	11.55	0.00	0.00	11.55	Kwale	Kwale	Kwale
JICA	9241	2	Coastal Forest	35.0	Open	48.47	0.00	0.00	48.47	40.43	0.00	0.00	40.43	40.43	19.00	0.00	0.00	19.00	Kwale	Kwale	Kwale
JICA	9290	3	Coastal Forest	36.7	Open	38.61	0.00	0.00	38.61	33.62	0.00	0.00	33.62	33.62	15.80	0.00	0.00	15.80	Kwale	Kwale	Kwale
JICA	9291	1	Coastal Forest	36.7	Open	25.05	0.00	0.00	25.05	21.68	0.00	0.00	21.68	21.68	10.19	0.00	0.00	10.19	Kwale	Kwale	Kwale
JICA	9291	2	Coastal Forest	29.2	Open	68.63	0.00	0.00	68.63	57.54	0.00	0.00	57.54	57.54	27.04	0.00	0.00	27.04	Kwale	Kwale	Kwale
JICA	9291	3	Coastal Forest	35.8	Open	31.82	0.00	0.00	31.82	27.15	0.00	0.00	27.15	27.15	12.76	0.00	0.00	12.76	Kwale	Kwale	Kwale
ICFRA	3026	3	Mangrove Forest	16.7	Open	30.30	0.00	0.00	30.30	30.08	0.00	0.00	30.08	30.08	14.14	0.00	0.00	14.14	Kwale	Other	Other
ICFRA	3046	1	Mangrove Forest	15.8	Open	2.67	0.00	0.00	2.67	2.45	0.00	0.00	2.45	2.45	1.15	0.00	0.00	1.15	Kwale	Other	Other
ICFRA	3047	1	Mangrove Forest	20.0	Open	8.45	0.00	0.00	8.45	8.01	0.00	0.00	8.01	8.01	3.76	0.00	0.00	3.76	Kwale	Other	Other
JICA	960	3	Mangrove Forest	20.0	Open	23.20	0.00	0.00	23.20	20.35	0.00	0.00	20.35	20.35	9.57	0.00	0.00	9.57	Kwale	Kwale	Kwale
JICA	960	4	Mangrove Forest	31.7	Open	7.00	0.00	0.00	7.00	6.34	0.00	0.00	6.34	6.34	2.98	0.00	0.00	2.98	Kwale	Kwale	Msambweni
JICA	961	1	Mangrove Forest	30.0	Open	23.90	0.00	0.00	23.90	20.80	0.00	0.00	20.80	20.80	9.78	0.00	0.00	9.78	Kwale	Kwale	Msambweni
JICA	961	2	Mangrove Forest	25.0	Open	22.58	0.00	0.00	22.58	20.08	0.00	0.00	20.08	20.08	9.44	0.00	0.00	9.44	Kwale	Kwale	Msambweni
	Average								27.50				24.01	24.01				11.28			
	SD												14.18					6.66			
	CV (%)												59.05					59.05			
												First Quar	20.14589								
												Third Qua	29.3473								
												IQR	9.201413								
												Q3+1.5*I(	43.14942	57.54							
												Q1-1.5*I(	6.343772	2.45							

Dryland forest Dense canopy coverage

Project	Cluster	Plot	Forest type	Canopy cover	D/M/O	AGB Volume (m3/ha)				AGB Biomass (ton/ha)					AGB Carbon stock (ton/ha)				County	District	Division
						Tree	Bamboo	Climber	Total	Tree	Bamboo	Climber	Total	Total	Tree	Bamboo	Climber	Total			
ICFRA	1887	2	Dryland Forest	66.7	Dense	16.02	0.00	0.00	16.02	13.97	0.00	0.00	13.97	13.97	6.56	0.00	0.00	6.56	Baringo	Baringo	Marigat
ICFRA	2048	3	Dryland Forest	75.0	Dense	13.93	0.00	0.00	13.93	11.94	0.00	0.00	11.94	11.94	5.61	0.00	0.00	5.61	Baringo	Baringo	Marigat
JICA	918	1	Dryland Forest	77.5	Dense	68.66	0.00	0.00	68.66	58.04	0.00	0.00	58.04	58.04	27.28	0.00	0.00	27.28	Makueni	Makueni	Kibwezi
JICA	918	2	Dryland Forest	88.3	Dense	119.50	0.00		119.50	97.01	0.00	8.67	105.68	105.68	45.59	0.00	4.08	49.67	Makueni	Makueni	Kibwezi
JICA	920	1	Dryland Forest	67.5	Dense	33.46	0.00	0.00	33.46	29.65	0.00	0.00	29.65	29.65	13.94	0.00	0.00	13.94	Makueni	Makueni	Kibwezi
JICA	9170	2	Dryland Forest	95.0	Dense	42.00	0.00	0.00	42.00	36.18	0.00	0.00	36.18	36.18	17.00	0.00	0.00	17.00	Makueni	Makueni	Kibwezi
JICA	9170	3	Dryland Forest	93.3	Dense	49.01	0.00	0.00	49.01	41.56	0.00	0.00	41.56	41.56	19.53	0.00	0.00	19.53	Makueni	Makueni	Kibwezi
	Average								48.94				42.43	42.43				19.94			
	SD												32.11					15.09			
	CV (%)												75.68					75.68			
												First Quar	21.8098								
												Third Qua	49.80036								
												IQR	27.99056								
												Q3+1.5*I(	91.7862	105.68							
												Q1-1.5*I(	-20.1761	11.94							

Dryland forest Moderate canopy coverage

Project	Cluster	Plot	Forest type	Canopy cover	D/M/O	AGB Volume (m3/ha)				AGB Biomass (ton/ha)				AGB Carbon stock (ton/ha)				County	District	Division
						Tree	Bamboo	Climber	Total	Tree	Bamboo	Climber	Total	Tree	Bamboo	Climber	Total			
ICFRA	1887	4	Dryland Forest	60.8	Moderate	30.92	0.00	0.00	30.92	27.57	0.00	0.00	27.57	12.96	0.00	0.00	12.96	Baringo	Baringo	Marigat
ICFRA	1888	2	Dryland Forest	56.7	Moderate	25.98	0.00	0.00	25.98	22.47	0.00	0.00	22.47	10.56	0.00	0.00	10.56	Baringo	Baringo	Marigat
JICA	918	3	Dryland Forest	42.5	Moderate	58.26	0.00	0.00	58.26	49.71	0.00	0.00	49.71	23.36	0.00	0.00	23.36	Makueni	Makueni	Kibwezi
JICA	918	4	Dryland Forest	42.5	Moderate	13.65	0.00	0.00	13.65	11.68	0.00	0.00	11.68	5.49	0.00	0.00	5.49	Makueni	Makueni	Kibwezi
JICA	9170	1	Dryland Forest	47.5	Moderate	32.74	0.00		32.74	29.17	0.00	5.06	34.23	13.71	0.00	2.38	16.09	Makueni	Makueni	Kibwezi
JICA	9190	1	Dryland Forest	58.3	Moderate	54.65	0.00	0.00	54.65	46.82	0.00	0.00	46.82	22.01	0.00	0.00	22.01	Makueni	Makueni	Kibwezi
JICA	9190	2	Dryland Forest	60.8	Moderate	62.05	0.00	0.00	62.05	55.48	0.00	0.00	55.48	26.08	0.00	0.00	26.08	Makueni	Makueni	Kibwezi
JICA	9190	3	Dryland Forest	60.8	Moderate	31.66	0.00		31.66	27.57	0.00	0.64	28.21	12.96	0.00	0.30	13.26	Makueni	Makueni	Kibwezi
	Average								38.74				34.52				16.23			
	SD												15.01				7.05			
	CV (%)												43.47				43.47			
												First Quar	26.29685							
												Third Qua	47.5431							
												IQR	21.24625							
												Q3+1.5*I(	79.41248	55.48						
												Q1-1.5*I(	-5.57252	11.68						

Dryland forest Open canopy coverage

Project	Cluster	Plot	Forest type	Canopy cover	D/M/O	AGB Volume (m3/ha)				AGB Biomass (ton/ha)				AGB Carbon stock (ton/ha)				County	District	Division
						Tree	Bamboo	Climber	Total	Tree	Bamboo	Climber	Total	Tree	Bamboo	Climber	Total			
ICFRA	1888	1	Dryland Forest	20.0	Open	22.40	0.00	0.00	22.40	19.80	0.00	0.00	19.80	9.31	0.00	0.00	9.31	Baringo	Baringo	Marigat
ICFRA	1888	3	Dryland Forest	32.5	Open	8.74	0.00	0.00	8.74	7.72	0.00	0.00	7.72	3.63	0.00	0.00	3.63	Baringo	Baringo	Marigat
ICFRA	1888	4	Dryland Forest	26.7	Open	6.63	0.00	0.00	6.63	5.78	0.00	0.00	5.78	2.72	0.00	0.00	2.72	Baringo	Baringo	Marigat
ICFRA	2211	4	Dryland Forest	36.7	Open	11.30	0.00	0.00	11.30	10.30	0.00	0.00	10.30	4.84	0.00	0.00	4.84	Baringo	Baringo	Marigat
ICFRA	2212	1	Dryland Forest	35.0	Open	26.09	0.00	0.00	26.09	23.95	0.00	0.00	23.95	11.25	0.00	0.00	11.25	Baringo	Baringo	Marigat
ICFRA	2212	2	Dryland Forest	29.2	Open	21.59	0.00	0.00	21.59	19.51	0.00	0.00	19.51	9.17	0.00	0.00	9.17	Baringo	Baringo	Marigat
ICFRA	2370	4	Dryland Forest	37.5	Open	15.27	0.00	0.00	15.27	12.79	0.00	0.00	12.79	6.01	0.00	0.00	6.01	Baringo	Baringo	Marigat
	Average								16.00				14.26				6.70			
	SD												6.89				3.24			
	CV (%)												48.28				48.28			
												First Quar	9.009695							
												Third Qua	19.65707							
												IQR	10.64737							
												Q3+1.5*I(	35.62813	23.95						
												Q1-1.5*I(	-6.96136	5.78						

Plantation forest

Project	Cluster	Plot	Forest type	Canopy cover	D/M/O	AGB Volume (m3/ha)				AGB Biomass (ton/ha)				AGB Carbon stock (ton/ha)				County	District	Division
						Tree	Bamboo	Climber	Total	Tree	Bamboo	Climber	Total	Tree	Bamboo	Climber	Total			
ICFRA	287	1	Plantation	100.0	Dense	578.35	0.00	0.00	578.35	473.36	0.00	0.00	473.36	222.48	0.00	0.00	222.48	Kericho	Kericho	Londian
ICFRA	287	2	Plantation	100.0	Dense	646.20	0.00	0.00	646.20	527.43	0.00	0.00	527.43	247.89	0.00	0.00	247.89	Kericho	Kericho	Londian
ICFRA	288	1	Plantation	90.0	Dense	270.18	0.00	0.00	270.18	221.46	0.00	0.00	221.46	104.09	0.00	0.00	104.09	Kericho	Kericho	Londian
ICFRA	288	2	Plantation	88.3	Dense	111.99	0.00		111.99	92.84	0.00	1.65	94.49	43.63	0.00	0.78	44.41	Kericho	Kericho	Londian
ICFRA	447	1	Plantation	100.0	Dense	690.31	0.00	0.00	690.31	558.65	0.00	0.00	558.65	262.56	0.00	0.00	262.56	Kericho	Kericho	Londian
ICFRA	447	3	Plantation	89.2	Dense	311.50	0.00	0.00	311.50	252.08	0.00	0.00	252.08	118.48	0.00	0.00	118.48	Kericho	Kericho	Londian
ICFRA	447	4	Plantation	98.3	Dense	409.91	0.00	0.00	409.91	335.08	0.00	0.00	335.08	157.49	0.00	0.00	157.49	Kericho	Kericho	Londian
ICFRA	607	2	Plantation	91.7	Dense	1,078.64	0.00	0.00	1,078.64	864.66	0.00	0.00	864.66	406.39	0.00	0.00	406.39	Baringo	Koibatek	Mumberes
ICFRA	607	3	Plantation	82.5	Dense	987.63	0.00	0.00	987.63	784.27	0.00	0.00	784.27	368.61	0.00	0.00	368.61	Baringo	Koibatek	Mumberes
ICFRA	1082	1	Plantation	96.7	Dense	1,205.69	0.00	0.00	1,205.69	968.77	0.00	0.00	968.77	455.32	0.00	0.00	455.32	Baringo	Baringo	Other
ICFRA	1083	1	Plantation	79.2	Dense	836.62	0.00	0.00	836.62	675.93	0.00	0.00	675.93	317.69	0.00	0.00	317.69	Baringo	Koibatek	Eldama ravine
ICFRA	1083	2	Plantation	86.7	Dense	662.83	0.00	0.00	662.83	519.80	0.00	0.00	519.80	244.31	0.00	0.00	244.31	Baringo	Koibatek	Eldama ravine
ICFRA	1241	1	Plantation	90.0	Dense	647.91	0.00	0.00	647.91	524.72	0.00	0.00	524.72	246.62	0.00	0.00	246.62	Baringo	Koibatek	Esageri
ICFRA	1241	2	Plantation	96.7	Dense	715.18	0.00	0.00	715.18	582.32	0.00	0.00	582.32	273.69	0.00	0.00	273.69	Baringo	Koibatek	Esageri
ICFRA	1241	3	Plantation	92.5	Dense	652.09	0.00	0.00	652.09	534.50	0.00	0.00	534.50	251.22	0.00	0.00	251.22	Baringo	Koibatek	Esageri
ICFRA	1241	4	Plantation	80.0	Dense	500.59	0.00	0.00	500.59	410.79	0.00	0.00	410.79	193.07	0.00	0.00	193.07	Baringo	Koibatek	Esageri
ICFRA	1242	1	Plantation	80.0	Dense	205.15	0.00		205.15	168.42	0.00	3.21	171.63	79.16	0.00	1.51	80.67	Baringo	Koibatek	Eldama ravine
ICFRA	1242	2	Plantation	89.2	Dense	143.35	0.00		143.35	117.53	0.00	5.32	122.85	55.24	0.00	2.50	57.74	Baringo	Koibatek	Eldama ravine
ICFRA	1242	3	Plantation	100.0	Dense	473.19	0.00		473.19	386.66	0.00	1.27	387.93	181.73	0.00	0.60	182.33	Baringo	Koibatek	Eldama ravine
ICFRA	6000	4	Plantation	86.7	Dense	548.94	0.00	0.00	548.94	444.25	0.00	0.00	444.25	208.80	0.00	0.00	208.80	Nyeri	Nyeri	Tetu
ICFRA	6001	3	Plantation	75.0	Dense	299.83	0.00	0.00	299.83	242.10	0.00	0.00	242.10	113.79	0.00	0.00	113.79	Nyeri	Nyeri	Aberdare Forest
ICFRA	6161	3	Plantation	80.8	Dense	298.85	0.00		298.85	240.62	0.00	0.77	241.39	113.09	0.00	0.36	113.45	Nyeri	Nyeri	Aberdare Forest
ICFRA	6161	4	Plantation	83.3	Dense	127.41	0.00		127.41	103.69	0.00	1.37	105.06	48.74	0.00	0.64	49.38	Nyeri	Nyeri	Aberdare Forest
ICFRA	286	1	Plantation	50.0	Moderate	28.98	0.00	0.00	28.98	24.47	0.00	0.00	24.47	11.50	0.00	0.00	11.50	Kericho	Kericho	Other
ICFRA	287	4	Plantation	55.0	Moderate	60.81	0.00	0.00	60.81	52.85	0.00	0.00	52.85	24.84	0.00	0.00	24.84	Kericho	Kericho	Londian
ICFRA	6000	2	Plantation	54.2	Moderate	152.90	0.00		152.90	122.41	0.00	1.88	124.29	57.53	0.00	0.88	58.42	Nyeri	Nyeri	Tetu
ICFRA	6000	3	Plantation	51.7	Moderate	327.41	0.00	0.00	327.41	265.47	0.00	0.00	265.47	124.77	0.00	0.00	124.77	Nyeri	Nyeri	Tetu
ICFRA	6001	2	Plantation	53.3	Moderate	106.77	0.00	0.00	106.77	90.52	0.00	0.00	90.52	42.54	0.00	0.00	42.54	Nyeri	Nyeri	Aberdare Forest
ICFRA	6001	4	Plantation	59.2	Moderate	149.86	0.00	0.00	149.86	123.64	0.00	0.00	123.64	58.11	0.00	0.00	58.11	Nyeri	Nyeri	Aberdare Forest
JICA	914	3	Plantation	24.2	Open	429.01	0.00	0.00	429.01	332.00	0.00	0.00	332.00	156.04	0.00	0.00	156.04	Nyeri	Nyeri	Kabaru
JICA	928	1	Plantation	29.2	Open	91.69	0.00	0.00	91.69	74.61	0.00	0.00	74.61	35.07	0.00	0.00	35.07	Nyeri	Nyeri	Narumoru
JICA	929	1	Plantation	27.5	Open	121.34	0.00	0.00	121.34	99.14	0.00	0.00	99.14	46.60	0.00	0.00	46.60	Nyeri	Nyeri	Gathiuru
JICA	9140	4	Plantation	29.2	Open	51.24	0.00	0.00	51.24	41.46	0.00	0.00	41.46	19.49	0.00	0.00	19.49	Nyeri	Nyeri	Kabaru
JICA	9141	2	Plantation	36.7	Open	138.06	0.00	0.00	138.06	110.33	0.00	0.00	110.33	51.86	0.00	0.00	51.86	Nyeri	Nyeri	Kabaru
JICA	9141	3	Plantation	38.3	Open	276.81	0.00	0.00	276.81	218.79	0.00	0.00	218.79	102.83	0.00	0.00	102.83	Nyeri	Nyeri	Gathiuru
JICA	9141	4	Plantation	25.0	Open	113.62	0.00	0.00	113.62	91.21	0.00	0.00	91.21	42.87	0.00	0.00	42.87	Nyeri	Nyeri	Kabaru
	Average								401.41				324.79				152.65			
	SD												249.38				117.21			
	CV (%)												76.78				76.78			
												First Quar	109.01							
												Third Qua	521.03							
												IQR	412.02							
												Q3+1.5*I(	1,139.06	968.77						
												Q1-1.5*IC	(509.01)	24.47						