The Republic of Sudan

Forest National Corporation (FNC)

Forest Reference Level (FRL)

Submission to the UNFCCC

January 2020

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ACRONYMS/ABBREVIATIONS

AD	Activity Data
A/R	Afforestation and reforestation
AGB	Above-ground biomass
BGB	Below-ground biomass
BUR	Biennial Update Report
CO2e	Carbon Dioxide equivalent
FAO	Food and Agriculture Organization of United Nation
FNC	Forests National Corporation
FREL	Forest Reference Emission Level
FRL	Forest Reference Level
GDP	Gross domestic product
GHG	Green House Gas
GLCN	Global land cover network
ha	Hectare
HECNER	Higher Council for Environment and Natural Resources
INC	Initial National Communication
IPCC	Intergovernmental Panel on Climate Change
LUCF	Land use change and forestry
LULUCF	Land use land use change and forestry
NDCs	National determined contribution
NFI	National Forest Inventory
NFMA	National Monitoring and Assessment
NWFP	Non woody forest products

OBIA	Object base image analysis
REDD+	Reducing Emissions from Deforestation and forest Degradation; and the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks
RSSA	Remote Sensing and Seismology Authority
SLC	Scan Lune Corrector
SNC	Second National Communication
SU	Sampling Unit
t.C	Tonnes of Carbon
TNC	Third National Communication
UNFCCC	United Nations Framework Convention on Climate Change

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SUMMARY

This document presents the submission of Sudan's first sub-national Forest Reference Emission Level/ Forest Reference Level (FRL) to the UNFCCC. The proposed FRL includes the values of the average annual change in carbon stock due to deforestation (786, 202 t. CO2 /y) over the reference period and accumulated CO_2 removals (-344,458 t. CO2 /y) from the A/R activities implemented during the same reference period (2006-2018). Table 1, below provides summary description of this FRL submission and its consistency with the relevant UNFCCC guidance and summarizes the decisions made by the government of Sudan on the scale and the scope of this FRL. This FRL represents forest conditions in Sub Sahara African drylands

Table 1 Sudan's FREL/FRL compliance with the relevant UNFCCC decisions

:UNFCCC reference	Description	Sudan's FREL/FRL
Decision 12/CP.17 Paragraph 1	Stepwise approach	- Sudan follows stepwise approach through submission of its first sub-national FRL covering three states (blue Nile, Sennar and Gadaref). The main objective is to develop knowledge, resources and expertise within the related national institutions. Sudan intends to submit the national FREL/ FRL through lessons learnt and institutional capacity building from sub-national FRL
Decision 12/CP.17 Annex, paragraph (c)	Pools and gases	- Aboveground and below ground biomass - CO_2
Decision 12/CP.17 Annex, paragraph (c)	Activities	- Deforestation - Enhancement of forest carbon stocks - Forest degradation is also a significant REDD activity in Sudan, however, currently sufficiently reliable data is not available to assess forest degradation
Decision 12/CP.17 Annex, paragraph (d)	Forest definition applied in the GHG inventories	- Forest means an area of land spanning at least a minimum area of 0.4 ha with trees that have attained, or have the potential to attain at least 2 m. in height and a minimum tree canopy cover of 10%. It includes wind-breaks and/or shelter-belts with a minimum of 20 m. in width.
Decision 12/CP.17 Annex	The information contents is guided by the most recent IPCC guidance and guidelines)	- IPCC 2006 Guidelines for national GHGs inventories

Decision 12/CP. 17 II. Paragraph 9	Submission of information and rationale on the development of FRLs, about the details of national circumstances and their consideration	- Description of national circumstances provided - No adjustment has been done, - It assumed that the reference period is representatives in terms of capturing the effects of development in national circumstances on forest land

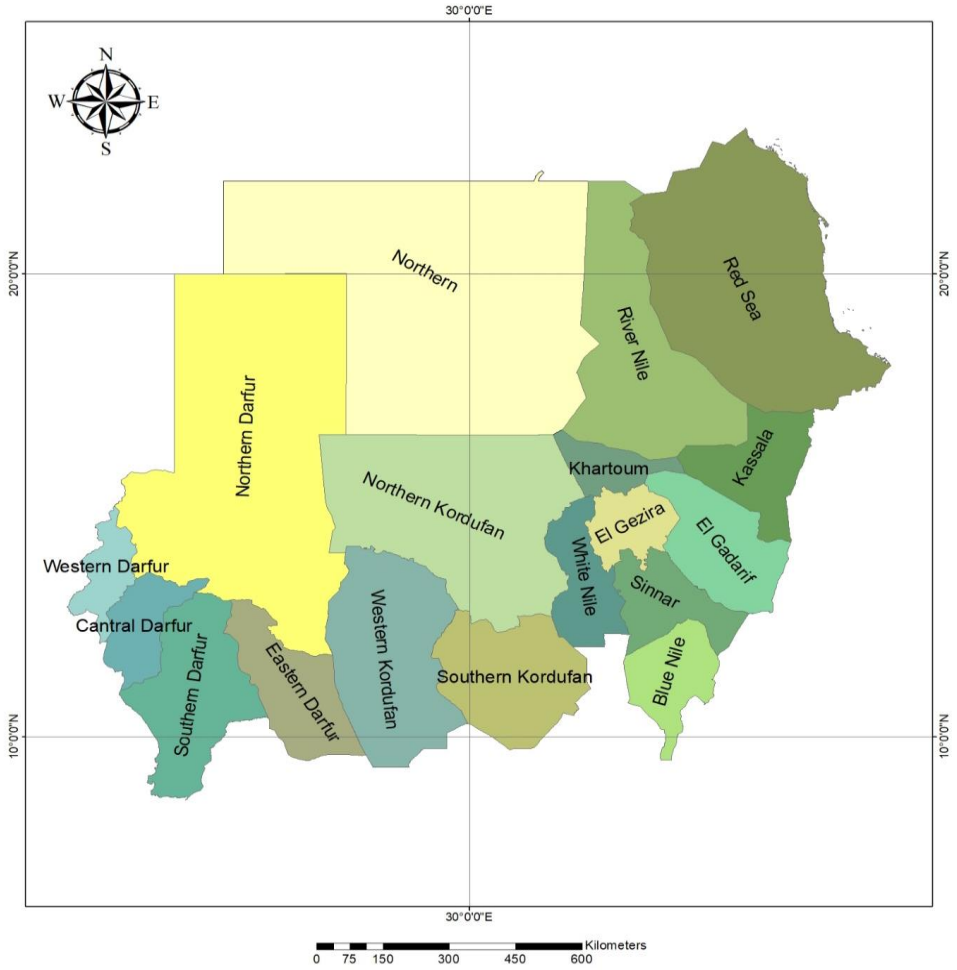
1. INTRODUCTION

Sudan is submitting its Forest Reference Level (FREL/FRL) in response to the invitation of the Conference of Parties to the UNFCCC, issued in paragraph 13 of decision 12.CP/16 and the request in paragraph 71(b) of decision 1.CP/16, for developing countries to develop and submit, on a voluntary basis, FREL/FRL, for consideration by the UNFCCC. This submission is intended for technical assessment in the context of results-based payments for reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries (REDD+) under UNFCCC. Sudan also considers the development of the FREL/FRL as very important for enhancing implementation of national forest programme including REDD+ strategy and for contributing to the global climate change mitigation and adaptation objectives through preparation and implementation of NDCs.

Sudan is a country with a highly diverse vegetation cover and ecological zones where, the rainfall varies from zero in the northern desert to more than 1,200 mm in the High Rainfall Woodland Savannah in the south-western portion of the country. Five distinct ecological zones representing biomes with different ecological conditions and different vegetation cover, desert, semi-desert, woodland Savanah, flood region and montane vegetation.

Located in North Eastern Africa, The Republic of Sudan (RoS) is bound by Egypt, The Red Sea, Eretria, Ethiopia, Republic of South Sudan (RSS), Central African Republic, Chad and Libya (Figure 1). The total area1* is 1, 886,068 km^2. The highest point in the country is Jebel Marra; 3,024 meters above sea level (m a.s.l.). The lowest is the Red Sea; 0.0 m a.s.l. The most salient geographical features are the Nubian and Bayuda Deserts in the north, the Nile Valley, Jebel Marra, Nuba, Ingessena & Red Sea Hills. The Blue Nile originates in the Ethiopian Highlands. The White Nile runs from the Equatorial Lakes. The two rivers unite at Khartoum and with their tributaries form the River Nile which runs north to the Mediterranean Sea (Figure 1). The vegetation can be divided into seven principal types which in general follow the isohyets and form consecutive series from north to south: 1. Desert; 2. Semi-Desert; 3. Acacia Short Grass Scrub; 4. Acacia Tall Grass Scrub; 5. Broad-leaved Woodlands & Forests; 6. Swamps (permanent swamps, seasonally inundated land), 7. Grassland and Mountain Meadow.

[1] *en.wikipedia-org/wiki/Sudan#Government_and_politics*



Sudan's forests cover is about 10.3% of its total land surface, with an estimated annual rate of deforestation of about 174,400 ha, or about 0.8% (FAO 2015). Forests have been facing encroachment by agriculture, urbanization, and unsustainable wood fuel extraction for several decades. The lack of integrated land use plans and coordination across institutions has resulted in the uncontrolled land use changes and conversion of vast forest tracts into agricultural areas over the past 40 years.

Forests play a significant role in integrated land use systems in Sudan in the sense of socio-economic development and environmental protection functions in addition to provision of the needs of the various stakeholders and in livelihood support. However, of the total population (33.4 million) 70% is rural & nomadic and considered as forest-dependent for livelihood, wood energy and on round timber for buildings. Contribution of forests sector to the national economy is under-estimated where the formal national accounts reveals an under-estimation of the forestry sector to the GDP in the range of 3%. The 1994 energy consumption study confirmed that the per capita consumption of fuel wood is 0.7 m^3/annum which, when converted into Ton/Oil Equivalent (TOE), could be valued at nearly 2.0 Billion US dollars. Moreover, Non-Woody Forest Products (NWFPs) are diverse and have substantial contribution in the livelihood at the household level and at the national economy.

The contribution of forests to the national economy is grossly under estimated. The Bank of Sudan and Ministry of Finance tend to only consider the direct revenue realized by FNC and export proceeds from forest products and estimate that to contribute 3.0% of GDP. They do not take into account:

- The value of total consumption of the country of wood at 0.73 m^2 per capita per annum (FAO 1995) derived from the country's forests, directly collected by people for no payment or traded in informal market,
- The total consumption of fodder & animal feed for national herd of 130 million head derived from natural pastures & woodlands,
- The monetary value of the environmental services particularly the protection of watersheds & courses, agricultural land and human habitats.
- The direct revenue from institutional, community or private forests which accrues to the owners of these forests.

1. SCALE

To define the scale and the boundaries of the proposed Forest Reference Level, Sudan recall paragraph 71(b) of Decision 1/CP.16 and paragraph 11 of Decision 12/CP.17 which states that Parties may elaborate a subnational Forest Reference Emission Level and/or Forest Reference Level (FREL/FREL), as an interim measure, while transitioning to a national FREL/FREL and

also recalling paragraph 10 of Decision 12/CP.17 in which the Conference of the Parties (CP) agreed that a step-wise approach to national FREL/FRL development may be useful, enabling Parties to improve their FREL/FRL by incorporating better data, improved methodologies and, where appropriate, additional pools, noting the importance of adequate and predictable support as referenced to by Decision 1/CP.16, paragraph 71.

Therefore, Sudan decided to follow a stepwise approach in the construction of its first national FRL, with the main objective of developing knowledge, resources and expertise within the related national institutions for developing the national FREL/FRL in the next step. Accordingly the areas encompassing the forest lands of Sudan have been defined for potential two subnational FRELs/FRLs to be constructed in sequential manner, building on experiences, capacities, resources and lesson learned, see Figure 2. These two FREL/FRLs would cover all forests in the country as no forests are expected to grow under the ecological conditions in the Northern part of Sudan.

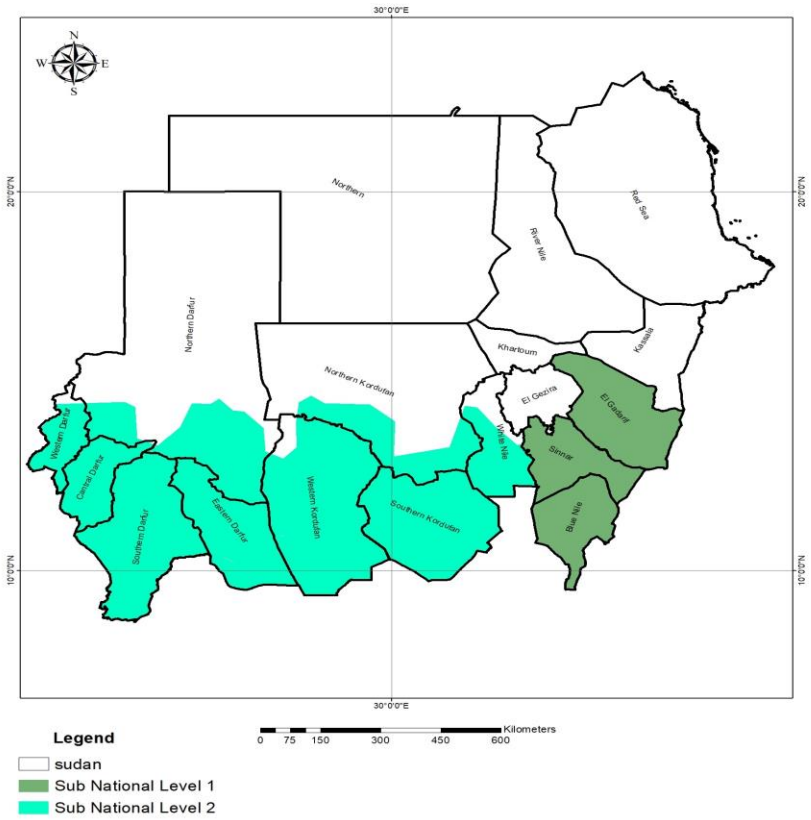


Figure 2. Two suggested Sub-National Forest Reference Levels

Sudan choose to construct its first subnational FRL in a region consisting of three States (subnational administrative units) namely, Blue Nile, Sinnar and Gadaref States which covers an area of 134,918 km² (Blue Nile: 38,149 km², Sennar: 39, 241 km², Gadaref: 57, 527 km²), see Figure 3. The area of this first FRL represents about 7.2% of the country total area. As estimated by Africover (2012) forest area in this region represents 11% of the total forest land in Sudan. The forests in the three states can be stratified into two main strata low rainfall savannah in the northern part, which is the largest one and the high rainfall savannah in the southern part, in addition to a small area of riverain forest ecosystem (*Acacia nilotica*) along the banks on the Blue Nile and Rahad Rivers.

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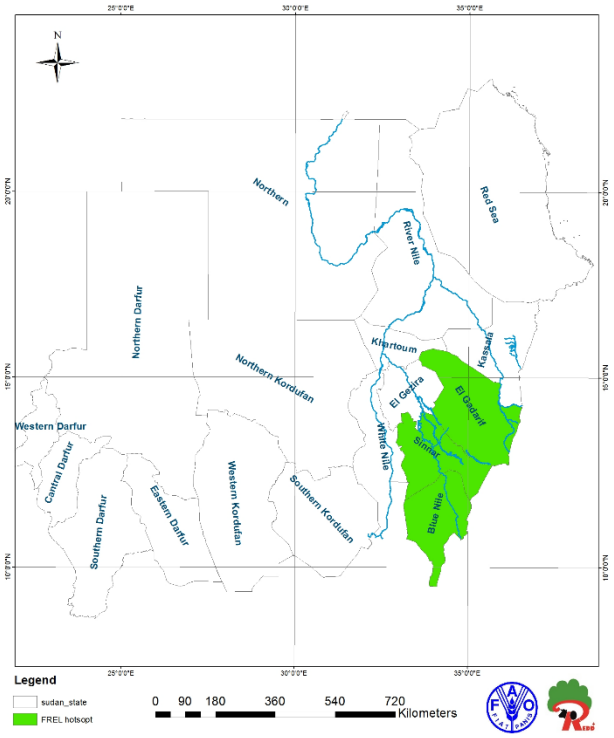

Figure 3. Area of the sub-national FREL/FRL

2. SCOPE: ACTIVITIES, POOLS AND GASES INCLUDED

In line with the stepwise approach, Sudan decided to define a limited scope, however, in line with the UNFCCC requirements. The aim is to test application of methods and tools, improve data, then to scale up by adding activities, pools and gases over time. The UNFCCC have not defined specific activities, pools or gases that are mandatory to be included in the FREL/FRL, however, decision 12CP.17 requires parties to include in their FREL/FRL significant pools and gases, and activities listed in decision 1/CP.16, paragraph 70, and to justify omission of any significant pool, activity.

2.1. REDD+ activities in the FREL/FRL

In 2000 the Land use Change and Forestry sector (LUCF) accounts for about 12% of all GHG emissions in Sudan, mostly from forest and grassland conversion (SNC 2013). The data from the two national Greenhouse Gases inventories of the LUCF completed so far in Sudan confirms the LUCF sector as a net source of emissions, with 15,577 Gg CO_2 emissions in 1995 and 9,392 Gg CO_2 emissions in 2000 (INC 2003, SNC 2013). The forest and grassland conversions are the main source category in both inventory years, with a total 28,714 Gg CO_2 emissions in 1995 and 23,924 Gg CO_2 emissions in 2000, (see table 2) below. The results of the recently conducted GHG inventory by the third national communication project showed similar trend in the GHG emissions from the land use, land use and forestry sector (LULUCF).

Table 2 :GHGs emissions/removal estimates of the LUCF in Sudan for years 1995 and 2000 in Gg

Sources sink category	Emissions CO_2		Removals CO_2		CH_4		N_2O	
	1995	2000	1995	2000	1995	2000	1995	2000
Total	28,714	23,924	-13,138	-15,906	90	59	1	0.4
Change in Forest and Other Woody Biomass Stocks	0	0	-9,700	-12,125	0	0	0	0
Forests and Grassland Conversions	28,714	23,924		0	90	59	1	0.4
Abandonment of Managed Lands	0	0	-3,438	-3,781	0	0	0	0

The SNC 2013 further indicated that the category conversion of forests and grasslands accounts for all CO_2e emissions from the LUCF sector. This is mostly due to the deforestation and degradation of forests associated with unsustainable biomass extraction in rural areas. In Sudan mechanized farming is also known as a main driver of forest and grass lands conversion. Energy consumption rank second in the causes of deforestation and forest degradation, biomass energy represents a main source of energy especially in rural Sudan, contributing about 60% of the national energy demand. In addition, there are other factors contributing to deforestation and forest degradation such as over grazing, needs for construction materials, forest fires etc (DoDD, 2018). The selected sub-national FRL states (Blue Nile, Sennar, Gadaref) are also indicated as a hotspot area for deforestation, in which about 50% of all mechanized framing area is located and has been the main source of biomass energy supply for several decades to the major urban areas in central Sudan including the capital city i.e. Khartoum State (DoDD, 2018). The region also hosts large portion of Sudan's animal resources and suffers from overgrazing (DoDD, 2018). Therefore, the vast areas of the mechanized framing are degraded or being degraded as a result of mal-cultivation practices and large areas of which was left abandoned. These degraded farm lands represent a large potential for afforestation and reforestation programme and the government has a policy in place to convert 10% of mechanized farming lands into forests. In terms of data availability to support the preparation of first subnational FREL and the inclusion of these two REDD+ activities (deforestation and enhancement of forest carbon stocks), this region has better data sources on deforestation, A/R areas, mechanized farming and other forest management related data compared to the other regions delineated for preparation of the other subnational FREL(s) in Sudan. Although forest degradation is a significant REDD+ activity in Sudan, however, currently there is no data suitable for assessing and estimating the effect of forest degradation on the carbon stock, as this requires well established and repeated NFI data.

Based on the above assessment, Sudan decided that the most appropriate two[2] REDD+ activities to be included in the first subnational FREL in the region encompassing the three state of Gedarif, Sinnar and Blue Nile are:

- Reducing emission from deforestation

[2] *Reducing emissions from forest degradation in case there possible to conduct assessment of the change in forest carbon stock over the selected reference period for deforestation.*

- Enhancement of forest carbon stocks

The inclusion of these two activities is also consistent with the national REDD+ strategy, as they support the achievement of a number of REDD+ objectives and activities indicated in the national REDD+ strategy (see table 3 below). The REDD+ programme is currently working on developing emission reduction programmes in the same region to initiate the implementation phase of REDD+ in Sudan.

Table 3 Relevance of the proposed FREL/FRL REDD+ activities to the implementation of the National REDD+ Strategy

Objectives in the national REDD+ strategy	REDD+ activities included in the FREL/FRL
• Enhance agricultural productivity and avail alternative income generating sources for rural communities and promotion of application of research, technologies, targeted financing and institutional reforms. • Adopt environmentally-friendly energy policies that promote renewable energy and energy efficiency in production and use including improved firewood & charcoal stoves and conversion of wood into charcoal. • Support of private sector investment in production and dissemination of solar cook stoves, investment in ethanol, biogas digesters and biogas cookers. • Increase production of firewood and charcoal from sustainably managed forest plantations • Promote sustainable fuelwood (Firewood & Charcoal) production, consumption and usage • Improve Policy towards refugees to address their humanitarian needs and guard against deforestation and land degradation	Reducing emission from deforestation
• Restoration of degraded (forest, grazing and farming) landscapes. • Carbon sequestration through restoration, avoided deforestation and conservation of biodiversity • Gum Arabic restocking and rehabilitation of the gum belt for carbon sequestration, climate resilience • Gums other than gum Arabic– resins production and commercialization • Develop and implement master plan for tree-	Enhancement of forest carbon stocks

planting in major human settlements, agricultural holdings, highways and rail roads • Establishment of shelterbelts, wind-Breaks and woodlots in mechanized rainfed schemes	

2.2. Carbon pools in the FRL

The UNFCCC has defined five pools to be considered in the estimation of carbon stock change and GHGs emissions in the LULUCF. The largest pools in terms of emissions/removal contribution are living biomass, divided into two pools aboveground biomass (AGB) and belowground biomass (BGB). Other pools are dead organic matter (DOM), which includes two pools, deadwood, litter and soil carbon stock (SOC). Estimating emissions and removal associated with carbon fluxes in these other pools requires good quality data and parameters that are not available, particularly for dead organic matter and SOC pools. The recent National Forest Inventory (NFI 2017) of Sudan developed good quality data only for above-ground biomass, however, it does not include measurements of parameters required for estimation of DOM and SOC, which require more resources. The LULUCF GHG inventory in Sudan provides estimates mainly based on above and below ground carbon pools. There is data available, in the Forest National Corporation (FNC), on wood removals, official harvest, however, these data records are not complete, since significant amount of wood removal is happening through direct collection by local people for energy and other domestic uses, and these are not recorded by FNC. Data is not available for estimating below-ground biomass, however, root-shoot ratios from IPCC 2006 Guidelines can be used. Based on these circumstances, Sudan decided to include only above and below ground biomass pools in this first subnational FREL submission (see table 4) for future justifications.

Table 4 Pools included in the FRL submission

Pools	Inclusion in FRL	Justification
Aboveground biomass	included	significant
Belowground biomass	included	significant
litter	Not included	Not significant in drylands, Lack of data
Deadwood	Not included	Not significant in case of the selected REDD+ activities, Lack of data
Soil organic carbon	Not included	Lack of data

2.3. Gases in the FRL

CO_2 is the only gas included in this first sub-national FREL estimation by Sudan. Because currently there is no reliable data to include other activities, pools and to estimate other gases. CO_2 is also the main gas estimated in SNC and the GHGs inventory of the forthcoming Third National Communication (TNC) of Sudan. Following a stepwise approach provides a good opportunity to develop capacities, data collection and resources necessary for improving the FREL/FRL submission overtime.

3. FOREST DEFINITION / DEFINITIONS USED

Sudan's national forest definition defines forest as an area of land spanning at least a minimum area of 0.4 ha with trees that have attained, or have the potential to attain at least 2 m. in height and a minimum tree canopy cover of 10%. It includes wind-breaks and/or shelter-belts with a minimum of 20 m. in width"

This forest definition was used in the recent national forest inventory (NFI 2017). This definition is different from the one used in GHGs inventory published in the Sudan Second National Commination (SNC 2013), however, it will be used in the GHG inventory to be reported in the TNC and Sudan's first Biennial Update Report (BUR), to be submitted in 2020.

The forest definition has been developed recently to take into consideration the new situation in the forest resources after the separation of South Sudan (2011) with one third of the country total area and about 60% of the forest resources. This situation raised the need for a definition that enhances and maximizes the protection and production functions of the remaining forest resources. The new definition also responds to climate change challenges and the role the forest resources in Sudan are envisioned to play in meeting Sudan's obligations under the UNFCCC and Paris Agreement.

4. CONSISTENCY WITH GHG INVENTORY REPORTING

Sudan submitted its Second National Communication (SNC) in 2013 and currently is embarking on the preparation of the third national communication (TNC) and the first biennial update report (BUR) both are expected to be submitted to the UNFCCC secretariat in 2020. This FRL submission is not consistent with the GHGs inventory reported in the SNC, as it is based on the

2006 IPCC Guidelines while the GHGs inventory of the SNC was based on the 1996 IPCC Guidelines. However, this is consistent with the recently completed GHGs inventory prepared under the current project of the TNC, in which the 2006 IPCC Guidelines were applied for the first time in Sudan. The recent GHG inventory and its update will be published in the TNC and first BUR in late 2020.

5. INFORMATION USED FOR FREL CONSTRUCTION

5.1. Activity Data for Deforestation:

Historically, the targeted region of the three states was subjected to large scale mechanised agriculture since early 1980s, where forest areas have been cleared of tree cover at a rapid pace and the land was subject to cultivation for a number of years after which they lost productivity and are now degraded and oftentimes abandoned (DoD, 2018). Commercial mechanized agricultural activities are concentrated in the dry savannah in this region where, the mechanization of rain-fed agriculture was initiated by the British in the region (Gadaref) in 1944 and continues up to now on clay soil by the government and private sector. In the late 1970s, about 2.2 million hectares of land had been allocated for mechanized farming, and about 420,000 hectares more had been occupied without official demarcation. However, today, mechanized agriculture occupies a large area of the clay plains in the high rainfall savannah belt estimated to be 6.5 million hectares, extending from the Butana plains in the east to Southern Kordofan in central Sudan (DoD 2018). The largest proportion (48%) of mechanized farming in Sudan was found to be in this region of the subnational FREL/FRL, which also represents a high potential for implementation of the REDD+ activities of Enhancement of carbon stock through afforestation and reforestation, by the communities, private sector and the government.

5.1.1. Methodology and data used

Land cover maps of EL Gadarif, Sinnar and BlueNile states were developed for the years of 2006, 2010, 2014 and 2018 to estimate forest area based on the national forest definition (as described above) and the areas of forest remaining as forest, other land converted to forest and forest converted to other land for three time periods (i.e., 2006 to 2010, 2010 to 2014 and 2014

to 2018). The maps were developed using the same methods and same classification system. Based on the availability, there were some differences in the selection of satellite imagery used to develop the maps. In the following sections, land cover mapping processes are described, followed by the description of steps to generate the activity data.

5.1.2. Development of land cover maps of 2006, 2010, 2014 and 2018

For the creation of individual landcover map Global Land Cover Network (FAO/GLCN) approach was followed (GLCN/FAO) (http://www.fao.org/geospatial/projects/detail/en/c/1035672). Each single image (e.g. 2006, 2010, 2014 and 2018) was processed, interpreted, validated using available very high resolution images from Bing map in Qgis and Google earth. The reason of using GLCN approach was because country was familiar with this methodology since the development of national landcover map 2011 (Africover, 2012).

5.1.2.1. Image acquisition

For land cover mapping of 2010, 2014 and 2018 Landsat images of 30-meter spatial resolution were used. Due to data gaps caused by the Scan Line Corrector (SLC) failure, Landsat 7 images could not be used for 2006 land cover mapping, instead Aster 15-meter spatial resolution images were used. The images were downloaded from United State Geological Survey (USGS) www.usgs.gov/landsat. In the dry and wet seasons, with maximum cloud cover of 30%. Aster images were already combined on the website, the bands used for Landsat 7 were 4, 3, 2, and for Landsat 8 the bands were 5, 4, 3 The list of satellite imagery used for land cover mapping of different years are provided in ANNEX 1

5.1.2.2. Image segmentation and land cover interpretation

Object-based image analysis (OBIA) approach was used to create image objects defined by spectral, textural and border properties. The resulted vector layer of objects (i.e., image segments) represent regions with similar pixel values with respect to some characteristic or computed property such as colour, intensity or texture and pattern. Segmentation process was run, using eCognition, aiming at a minimum mapping unit (MMU) of 0.4 hectares (ha). Objects

smaller than 0.4 ha were merged to comply with the defined requirements for MMU. Then overlapping areas were corrected and the layer was made ready for interpretation.

The image segments developed were used as the basic unit of classification (labelling and assigning each segment to the target land cover class). All the interpreters were trained to have a clear understanding of the land cover legend based on Land Cover Classification System (LCCS) and of all conditions and criteria to detect each class. The land cover labels were assigned to each polygon (i.e., image object) during the visual interpretation using LCCS 3 Basic Coder plugin in QGIS. The classes of the land cover are seven classes as described in table 5 below.

Table 5: Land cover classes

Code	Classes for mapping	Description
AG	Agriculture	Agriculture in terrestrial and aquatic/regularly flooded land
TCO	Forest	Trees closed-to-sparse in terrestrial and aquatic/regularly flooded land
SCO	Shrubs	Shrubs closed-to-sparse in terrestrial and aquatic/regularly flooded land
HCO	Herbaceous	Herbaceous closed-to-sparse in terrestrial and aquatic/regularly flooded land
URB	Urban areas	Urban areas
BS	Bare Rocks and Soil	Bare Rocks and Soil and/or Other Unconsolidated Material(s)
WAT	Water Bodies	Seasonal/perennial, natural/artificial Water bodies

5.1.2.3. Preparation of forest maps

Sudan Like other dryland countries where remote sensing is defined by unique challenges such as low vegetation signal-to-noise ratios, high soil background reflectance, presence of photosynthetic soils (i.e., biological soil crusts), high spatial heterogeneity from plot to regional scales, and irregular growing seasons due to unpredictable seasonal rainfall and frequent periods of drought. The forests are composed of open vegetation with low canopy cover. These conditions make it challenging to detect changes using medium resolution free public images such as Landsat. As such, it is expected that the areas estimates coming from the change map produced for the current FREL could be over or underestimated as a result of mis-classifications that would be corrected during the accuracy assessment process, with very high resolution

imagery available through public databases (Google Earth, Here Maps, Bing Maps) for visualization.

As a consequence, it is very likely that the area estimation coming from a stratified design, such as the one that will be implemented for the accuracy assessment, gives different numbers from the map areas. The figures provided in the current report will probably be modified when the areas from the accuracy assessment are finalized.

Forest maps for different years were produced, based on Sudan's new forest definition (see section 4 above), where the forest and shrub classes (i.e., TCO and SCO) were merged as a forest class (F) and the other classes were merged to non-forest class (NF).

***TCO and SCO classes were aggregated in to forest, while other classes were aggregated in to non-forest.**

5.1.3. Results forest area change detection

The forest maps of 2006, 2010, 2014 and 2018 were overlaid to obtain a change map in which each polygon contains:

- Forest / non-forest class in 2006
- Forest / non-forest class in 2010
- Forest / non-forest class in 2014
- Forest / non-forest class in 2018
- Area in hectares (ha)
- State name (in which the polygon is located)

These classes were aggregated into stable forest overall, stable non-forest overall, loss (forest converted to non-forest) for 3 periods and gain (non-forest converted to forest, mostly natural regeneration of trees on abandoned agriculture lands or shifting cultivation areas) for 3 periods. Polygon with loss or gain in only one time period was classified as loss or gain in that time period. Polygons with no change were classified as stable. The remaining polygons had both loss and gain. Depending on the land cover status in 2018, these polygons were classified as either stable forest overall (forest in 2018) or stable non-forest overall (non-forest in 2018).

Table (6) below shows the resulting areas estimates and the Figures (4, 5 and 6) show the location of the change classes.

Note: F = Forest, NF = Non-forest.

Table 6. Areas (in hectares) of aggregated change classes

Aggregated change class	Area ha
Gain (2006 – 2010)	150 922.7
Gain (2010 – 2014)	124327.2
Gain (2014 – 2018)	125 324.1
Loss (2006 – 2010)	362 543.5
Loss (2010 – 2014)	96 385.1
Loss (2014 – 2018)	264 138.8
Stable forest overall	4 059 584.6
Stable non-forest overall	8,30 8566.7

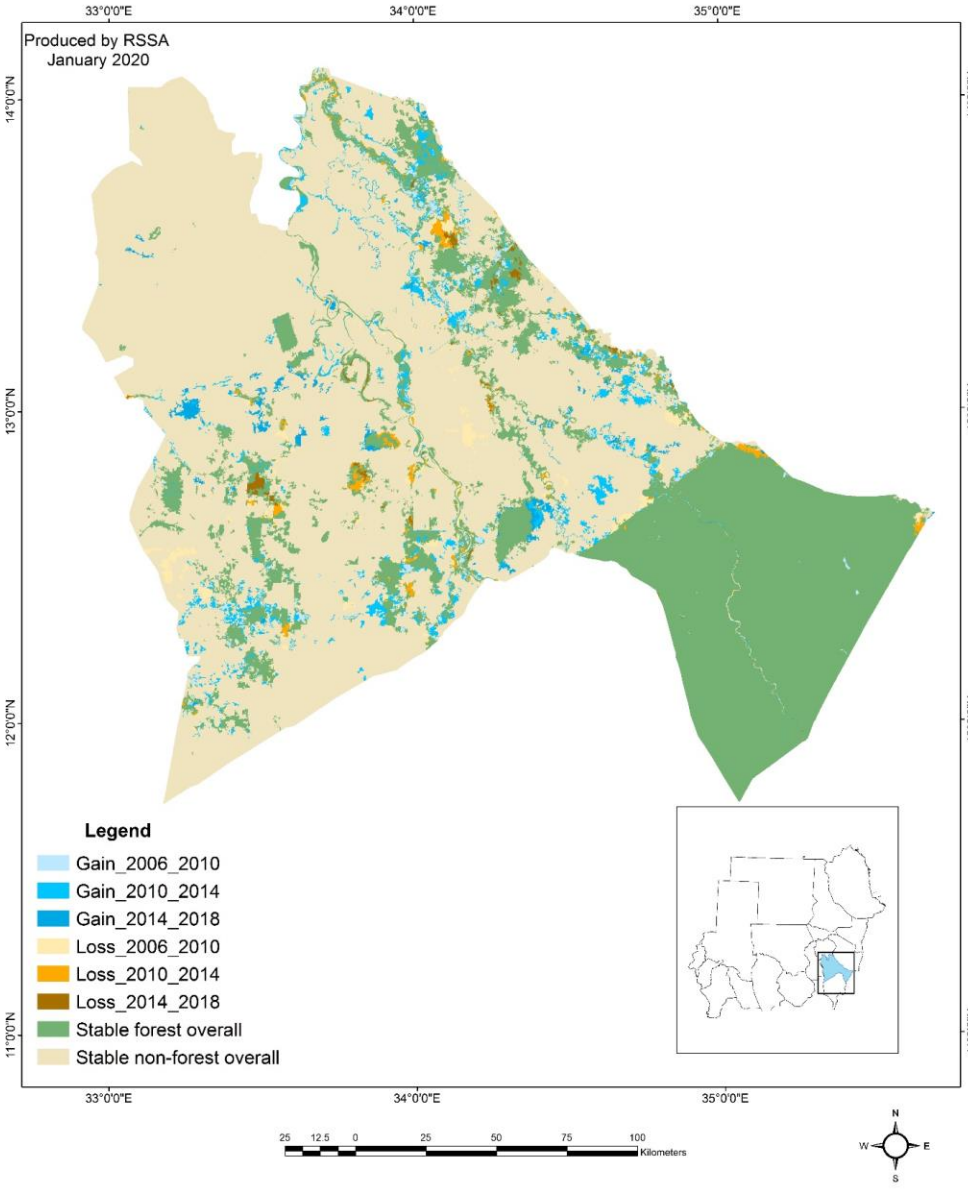

Figure 4 Sinnar change map from 2006 to 2018

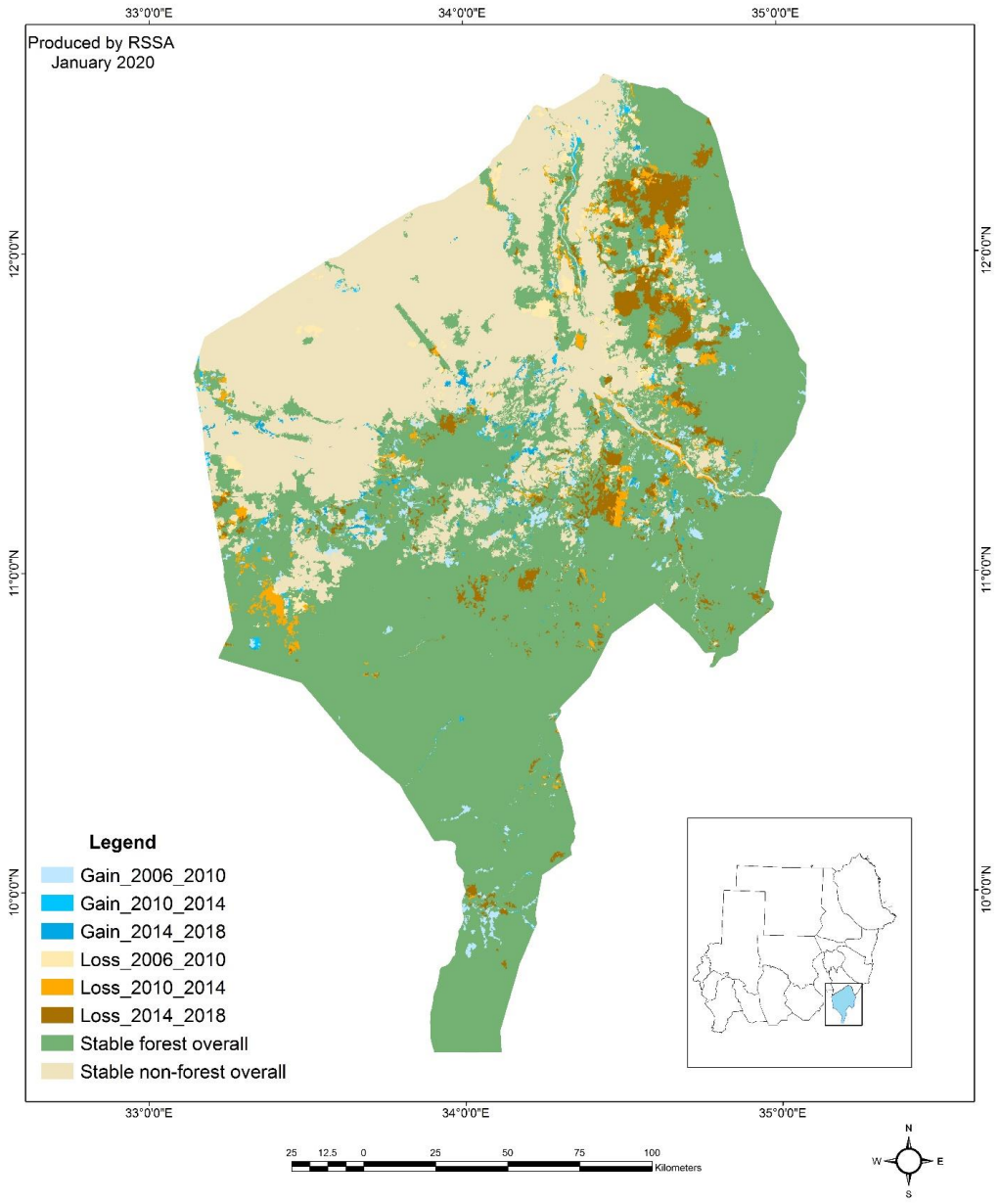

Figure 5 Blue Nile change **m**ap from 2006 to 2018

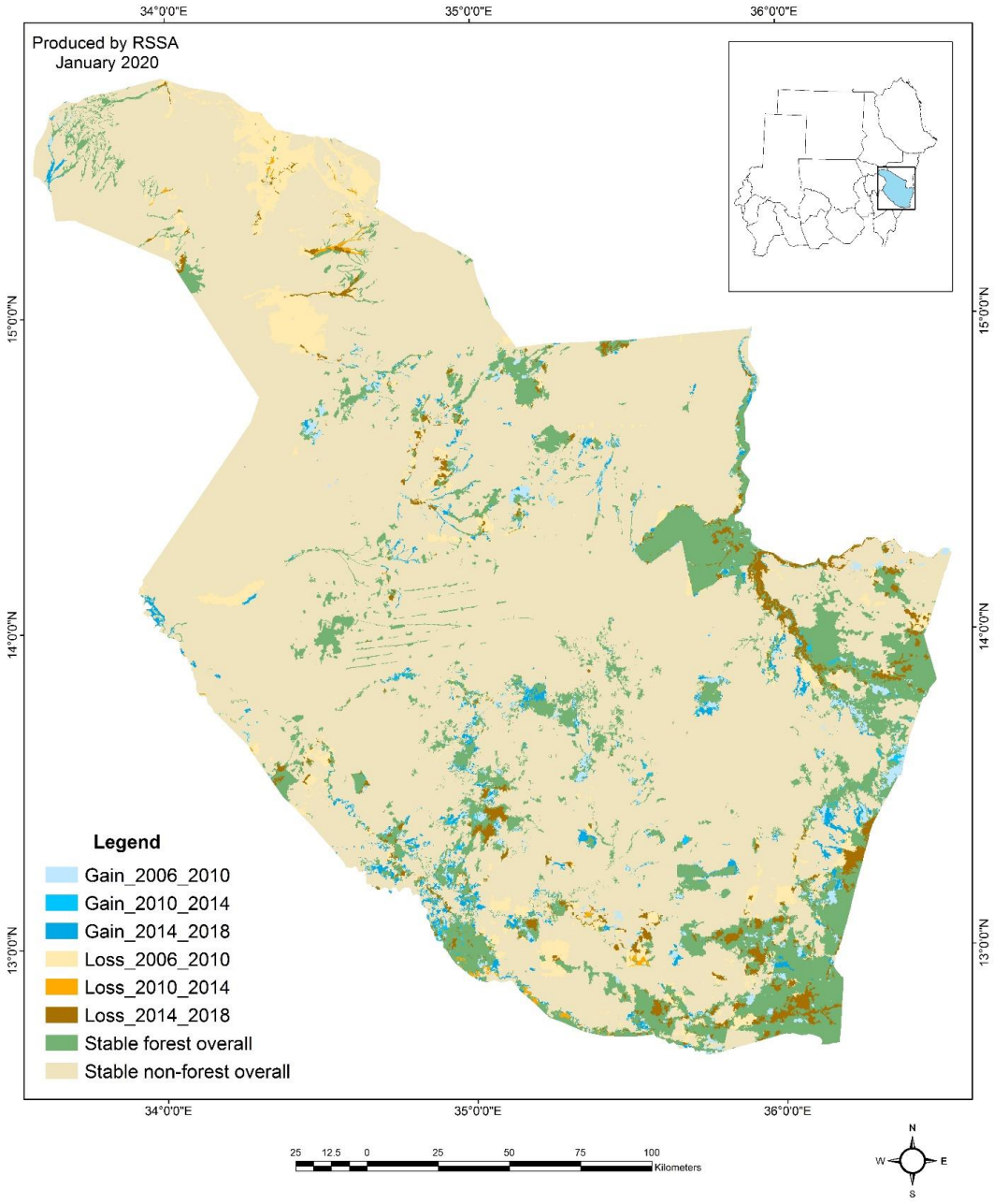

Figure 6 Gedarif change map from 2006 to 2018

5.2. Activity Data for Enhancement of Forest Carbon Stocks:

In Sudan, afforestation occurs on land that was not forest before, such as cropland, abandoned lands, etc, while reforestation occurs inside reserve forests in areas that was cleared of their tree cover through deforestation and forest degradation human related activities and the cleared forest areas cannot regenerate naturally without human intervention, because of various reasons including the continuation of the same activities that causes their clearance. Therefore, implementation of enhancement activities of Afforestation and Reforestation (A/R) are a result of planting of trees through seeds, seedlings and related land preparation. Enhancement or forest gains associated with forestland remining forestland, in Sudan such as natural forests (falls under protection provisions on the Forest Act), are not included in this FRL. Enhancement on forestland remaining forestland in Sudan is mainly a result of natural regeneration on abandonment mechanized agriculture lands and/or recovery of areas subjected to shifting cultivation, which is a common practice in many parts of the country.

Data for Enhancement of forest carbon stocks through A/R activities is obtained from the Forest National Corporation (FNC) offices at the three states where the subnational FRL is established. The A/R data is recorded annually for FNC official annual A/R programme which is implemented inside forest reserves, in addition to afforestation on agriculture schemes (cropland) in collaboration with farmers. Such afforestation is supported by forest Act (2002) which stipulates that 10% and 5% of the rainfed and the irrigated agriculture farms respectively are to be allocated to forest plantations. This is in addition to FNC records on afforestation activities by the local communities in the area, which is also supported by FNC in terms of seeds, seedlings and extension services. The available records (ANNEX 2) cover the period 2000-2018, with few gaps in some years such as 2000, 2002, 2003 in Sinnar state, and year 2000 in Gedarif state. However, for the selected reference period (2006-2018) data is available.

Sudan estimated the A/R part of its FRL as the accumulated removals from the A/R activities during the reference period. All land areas, in the three states, planted in years 2000 to 2018 was taken into account as they represent A/R areas < 20 years old, which according to the IPCC fall under the category of land converted to forestland. Then, the FRL was estimated from the accumulated A/R areas during the reference period (2006-2018), as an example, the A/R removals in year 2006 is calculated as the accumulated in A/R areas in years 2000 to 2006. The average of the annual removals (the FRL) on the accumulated A/R areas in year 2006-2018

was then estimated. Table 7 below shows the accumulated A/R areas in the years of the reference periods used in the estimation of the FRL for the enhancement carbon stocks activities. Wood removal due to harvest and fuel wood collection has not been included in the estimation of the removal from A/R areas. The rotations for managing these four main Acacia species used in A/R are different ranging between 15-20 years for *A. mellifera*, 17-23 years to *A. seyal*, 20-23 for *A. senegal,* and 25-30 for *A. nilotica.* The wood harvest occurs mainly on plantation managed forests, where according to rotations areas with mature trees are cleared and replanted. This is not expected to occur during the reference period, given the rotation of the species used in A/R activities in this region. Also due to the fact that the A/R areas used in the calculation of the accumulated removals are the areas planted during the period 2006-2018. The wood collections mostly takes place in natural forests that are only subjected to protection provided for in the Forest Act, however, without proper management planning. Data on wood collected from natural forests, for commercial purposes, are mostly based on the records of Royalties collection by FNC. However, data is not available on wood collected directly by local people for energy and other domestic uses and this is considered a significant amount, according the forest products demand study (1996).

Table 7[3] : Accumulated[4] A/R areas over the reference period (2006-2018) in ha **Accumulated**

	Years	**Sinnar State**	**Blue Nile State**	**Gedarif State**	**Total A/R areas**
Reference period	**2006**	22 978.0	12930	27691.1	63599.1
	2007	26796.5	14965	30430.6	72192.1
	2008	34387.2	19506.8	38037.6	91931.5
	2009	37585.9	22964.3	42394.1	102944.3
	2010	41123.2	23891.8	45543.6	110558.6
	2011	46927.7	24453.8	49994.6	121376.1
	2012	51384.0	25343.5	54331.1	131058.6

[3] Source of data: Forest National Corporation of Sudan

[4] Accumulated A/R areas, for the FREL/FRL reference period, are calculated from A/R areas planted since year 2000 and till year 2018

	2013	63108.0	27475	58303.6	148886.6
	2014	67578.5	29827.3	61223.4	158629.1
	2015	73421.2	31568.8	63474.9	168464.9
	2016	76210.5	32741.5	66966.9	175918.9
	2017	82041.2	37749.5	70368.8	190159.5
	2018	89334.2	40090.6	74545.2	203970
Average		54836.6	26423.7	52562.0	133822.2

IPCC 2006 methodology was applied in the estimation of the removal on the A/R land areas, in particular equations 2.9 and 2.10, for estimating the changes in biomass carbon stocks associated with A/R activities. According to FNC assessment records, the survival rate of the A/R is between 55 and 65 percent, accordingly the removals from A/R over the reference period have been adjusted by 60%.

Equation 1: Total removal from accumulated afforestation and reforestation areas in the 3 states of the subnational FREL/FRL

$$Total\ Removal = \Delta C_G \left(A_{Sinnar} + A_{Blue\ Nile} + A_{Gedarif}\right) * 0.60 * 44/12$$

Where:
ΔC_G= annual increase in biomass carbon stocks due to biomass growth in land remaining in the same land-use
A = A/R area in Sinnar, Blue Nile and Gedarif states, accumulated over the reference period (2006-2018) , ha
0.60 = percentage of the survival rate of the A/R (FNC evaluation reports)
44/12 = The ratio of the molecular weights to C to CO_2

Equation 2: Annual increase in biomass carbon stocks due to biomass increment in land subjected to A/R activities:

$$\Delta C_G = \Sigma_i (G_{TOTAL_i} * CF)$$

Where:
ΔC_G= weighted average annual increase in biomass carbon stocks due to biomass growth in A/R area category by vegetation type (4 species), tonnes C yr^{-1}
G_{TOTAL}= mean annual biomass growth, tonnes d. m. ha^{-1} yr^{-1}
i = species
CF = carbon fraction of dry matter, tonne C (tonne d. m.)$^{-1}$

Equation 3: Average5 annual increment in biomass of the 4 Acacia spp:

$$G_{TOTAL_i} = G_i * WD_i * (1 + R)$$

Where:
G_{TOTAL} = average annual biomass growth above and below-ground, (4 species) tonnes d. m. ha^{-1} yr^{-1}
G_W = Mean annual increment (merchantable volume)[6] over rotation for species, m3/ha/yr (IPCC 2006 table 4.11B)
WD*i* = Wood density of specific species, t. d. m /ha (country specific data)
R = ratio of below-ground biomass to above-ground biomass for a specific vegetation type, in tonne d. m. below-ground biomass (tonne d. m. above-ground biomass)$^{-1}$.

5.3. Emission factors for deforestation

5.3.1. Description of NFI

The primary source of data used to derive emission factors was the current National Forest Inventory (NFI 2017), initiated by the National REDD+ Program supported by the World Bank and implemented by the Food and Agriculture Organization of the United Nations (FAO). The NFI methodology follows the approach developed by the Support to National Forest Resources Monitoring and Assessment (NFMA) program of the FAO that is based on countrywide sampling and field data collection as well as on remote sensing.

[5] Weighted Average rate is based on the fact that 25% of the area planted with Acacia nilotica (with higher increment) compare to the 3 Acacia spp of similar increment

[6] Merchantable volume in the case of the Acacia species used in the A/R in Sudan is equivalent to whole aboveground volume because these species are mostly used for energy purposes (fuel wood) including A. nilotica, which in the past used also for production of railway sleepers, however, now is mostly used as fuel wood.

5.3.2. Stratification

Different maps and dataset have been used to create not-overlapping strata in the GIS environment. The base map is the Aridity zones from CGIAR-CSI to derive the main zones in the country (according to precipitation and evapotranspiration factors). The aridity zones map elaborated by CGIAR-CSI7 (in the context of land suitability analysis to delineate CDM-AR suitable areas8) was used to capture the main country landscapes, characterized by a climate that ranges from hyper-arid in the north to tropical wet-and dry in the far southwest. Methodology is well documented in Zomer et al., 2006, 2007 and 2008. A further division of the second strata was possible applying Africover 2000 and Harrison and Jackson (1958) maps. To the resulting four strata, a separate fifth strata was assigned to the main rivers and selected streams. To make a sharp division between semi-arid zone and savanna Harrison and Jackson (1958) and Africover (2000) have been overlaid and a manual editing (splitting) of the original strata carried out. Another refinement of the third stratum regards the Xeric Woodland ecoregion (according to WWF) on the west, analysed and drafted using very high resolution images (VHRI). As regard the river layer, a separate shapefile has been used and database with rivers names completed with the knowledge of the colleagues in the field where buffer of 1.5 km has been created. The river (polyline) shapefile has been rasterized and polygonised to be erased from the buffer layer, in order to mask out water. The final result has been integrated in the original layer and dissolve has been applied, after removing sliver polygons in the fifth strata.
The resulting map used for stratification is shown in Figure 7 and description of the Strata and corresponding areas are found in Table 8 and Annex 4.

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[7] http://www.cgiar-csi.org/data/global-aridity-and-pet-database
[8] The CDM allows for a small percentage of emission reduction credits to come from reforestation and afforestation (CDM-AR).

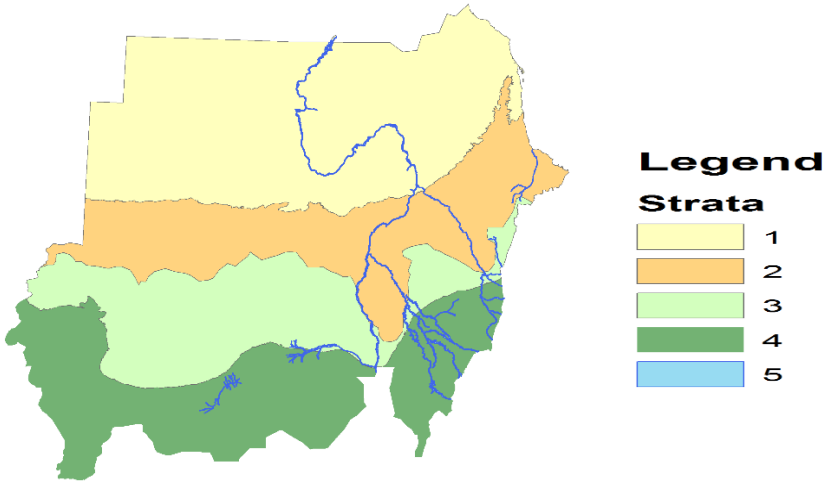

Figure 7 The map with the resulted five strata and their corresponding

Table 8 Description of the Strata

Stratum	Description	Area (ha)	Area (%)
I	The stratum that mostly comprised Deserts	67,327,512	36
II	The stratum characterized by semi-desert ecosystems (e.g. few Acacia trees and thorny bushes and zerophytes)	38,802,725	21
III	The stratum indicated as 'Low rainfall woodland Savannah' by Harrison and Jackson (1958)	35,695,771	19
IV	This stratum includes semi-arid, dry sub-humid, humid aridity zones. Forest and Woodland vegetation is mostly found here.	42,743,777	23
V	This stratum includes rivers and streams. It is probably the most heterogeneous since it is the stratum where human activities are dominated and patch of vegetation (natural and not) found as riverine vegetation. This layer cross all the latitudes of the country.	2,438,969	1

5.3.3. Sampling Design

The sampling design adopted for the NFMA in Sudan was systematic. Sampling units selected at the intersection of every degree of the latitude longitude grid. The number of sampling units (SU) or tracts to be surveyed is determined by the required statistical reliability of the data, the

available financial and human resources for the assessment, and with a view to enabling periodic monitoring. Sample units (SU) were allocated to each stratum according to their vegetation density as shown in table 9 and figure 8 below. Based on FREL/FRL team recommendations, sample intensification has been done in strata 3 and 4 where most of the forest lands is located, 732 new samples were added in the areas between the original sample units. The NFI team made a plan based on available resources and location forest lands, to visit 968 SUs out of 1755 SUs. The plan focuses mostly on strata 4 and 3, it does not include strata 1 (desert) and includes only 23 SUs in strata 2 (mostly grass crop, bare lands). Each SU has an area of 1 km2 and is composed of 4 plots (with cumulative plot area of 2 ha), see ANNEX 3. Out of the 968 planned SU, 784 accessible ones containing a total of 3,132 sample plots were visited. About 42,217 trees and 1800 stumps were recorded and analyzed, and 9 field crews had surveyed a cumulative area of 1,461.51 ha in 22 months.

Table 9 Sample Units, their distribution and actual measurements

Strata	**Area in Km**	**Intervals in m**	**Number of Sample Units (SUs)**	**Planned and actual number of SUs visited**
1	676741.6	Base Line 80,000	107	0
		Survey Line 80,000		
2	389852.79	Base Line 80,000	123	23
		Survey Line 40,000		
3a	359723.1	Base Line 40,000	431	161
3b		Survey Line 20,000		
4a	431459.	Base Line 20,000	1065	755
4b		Survey Line 20,000		
5	28292.3	Random	29	29
Total			1755	968 Planned
				784 Actual
				184 Inaccessible

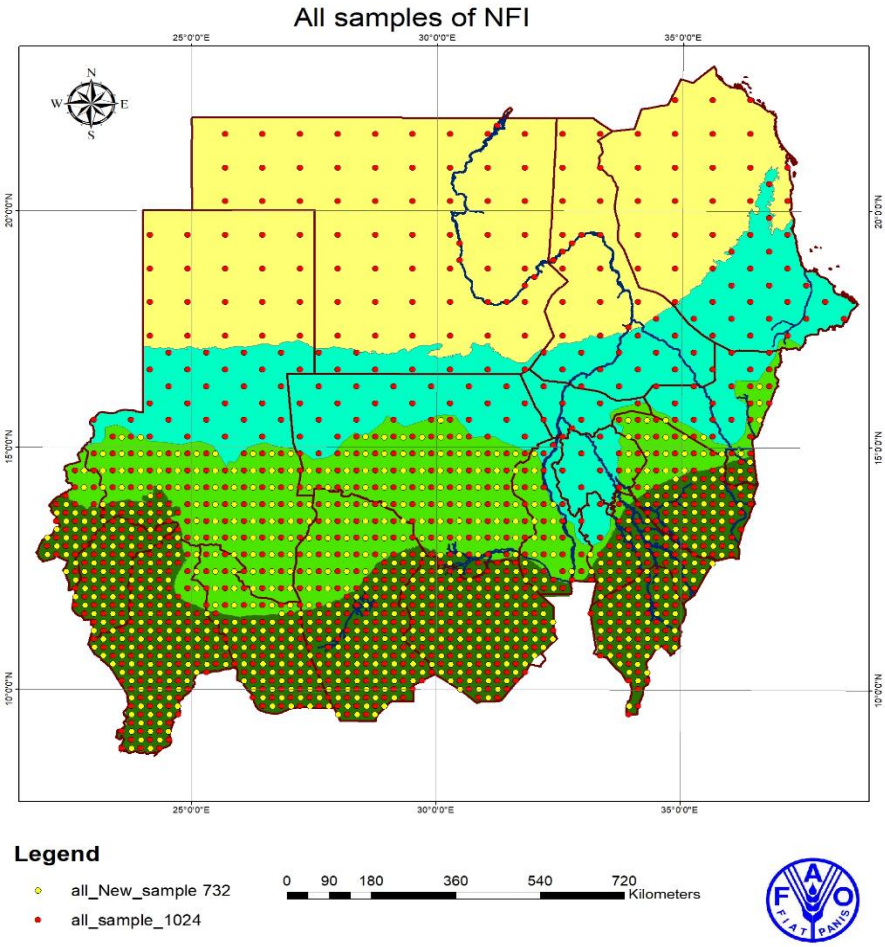

Figure 8 : Map of all sample plots of the NFI 2017

5.3.4. Analysis of collected NFI data

A detailed guideline has been developed for data processing and analyses. Analyses of biophysical and socio-economic data were done using excel and OpenForis. The Open- Foris tools are described in the FAO website (www.fao.org/forestry/fma/openforis/en/) and on the OpenForis wiki-page (www.openforis.org/OFwiki/index.php/Main_Page). After the data was processed it was analyzed jointly by the FNC staff, the national consultants and the NFI international consultants. For the purpose of FRL the average wood volume per hectare for each of the 3 states was calculated from sample plots allocated within the forest stock area to obtained a representatives volume per hectare for the estimation of the emissions associated with deforestation.

Tree density, Basal area and Regeneration count:
The number of stems, basal area per ha and regeneration count were computed using standard procedures.

Volume:
The tree volumes have been divided into commercial volume and gross volume according to measured commercial height and total height of trees (NFI field manual).

The Gross Tree Volume has been calculated as:

$$V=Dbh^2/4*\pi^2*Htot*ff$$

Where

Dbh = Tree Diameter at breast height
Htot = Tree total Height
Π = 3.1416
Ff = Default form factor

The Commercial Tree stem Volume has been calculated as:

$$V=Dbh^2/4*\pi^2*Htot*ff$$

Where

Dbh = Tree Diameter et breast height
Htot = Tree bole Height
Π = 3.1416
ff = Default form factor

Form Factors: Values in table below are based on expert judgment depending on regional and national studies, the NFI team and experts decided on the form factors values to be used as related to LUCS as follow:

TYPE	Form factors		
	Trees	Branches	Stumps
Forest	0.5	0. 5	0.45
Other woodland	0.50	0. 5	0.45
Other land	0.45	0. 5	0.40
Inland water	0.45	0. 5	0.40

5.3.5. Results and proposed emission factors

Sudan applies methods of the IPCC 2006 guideline for estimation of the emission factors for deforestation in the three states of the FRL. In particular equation 2.15 of Chapter two, with country-specific data of stock density (V/ha) in the initial land use obtained from the NFI 2017 and country specific data on wood density, in addition to the IPCC 2006 default data for root shoot ratio (section 4.5, table 4.4). Carbon stocks in biomass immediately after conversion (B_{AFTER}) are assumed to be zero, since the land is cleared of all vegetation before it is turned into other land uses, in the case of this region the change is mostly to annual crops cultivation. Therefore, change in biomass of annual crops, in subsequent years, is also considered zero because carbon gains in biomass from annual growth are offset by losses from harvesting, and there is no good quality data available to estimate soil carbon stock in general in Sudan including this region.

Equation 1: Average change in biomass carbon stock on forestland converted to other land use

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

Where:

ΔC_B= change in carbon stocks in biomass on land converted to other land-use category, in tonnes C /ha

ΔC_G= annual increase in carbon stocks in biomass due to growth on land converted to another land-use category, in tonnes C yr^{-1}

$\Delta C_{CONVERSION}$ = initial change in carbon stocks in biomass on land converted to other land-use category, in tonnes C/ha

ΔC_L = annual decrease in biomass carbon stocks due to losses from harvesting, fuel wood gathering and disturbances on land converted to other land-use category, in tonnes C/ha (assumed equal to zero)

Equation 2: Initial carbon stock on forest land after conversion to another land use

$$\Delta C_{CONVERSION} = \sum (B_{After_j} - B_{Before_j}) * CF$$

$$B_{Before_j} = V_{AG_j} * WD_j * (1 + R)$$

Where:

$\Delta C_{CONVERSION}$ = initial change in biomass carbon stocks on land converted to another land category, tonnes C/ha

B_{AFTER_i} = biomass stocks on land type *i* immediately after the conversion, tonnes d.m/ ha (assumed equal zero)

B_{BEFORE_i} = biomass stocks on land type *i* before the conversion, tonnes d.m/ ha^{-1}

V_{AG} = above ground biomass m3 /ha

WD= wood density t. d. m /ha

CF = carbon fraction of dry matter, tonne C (tonnes d.m.)$^{-1}$

i = species

Table 10 Emission factors for deforestation :

States	Average growing volume	Wood[9] density	Root-shoot Ratio	Carbon Fraction of dry matter	Carbon stock	Emission Factor
	m 3 / ha	t. d.m/m3	R		t C / ha	t CO2 / ha
Bule Nile	11.9	0.7	0.56	0.47	6.1	22.4
Gendarif	2.9	0.7	0.56	0.47	1.5	5.5
Sinnar	9.2	0.7	0.56	0.47	4.7	17.3

5.4. Removal factor for enhancement of forest carbon stocks:

In the estimation of the removals associated with the carbon stocks enhancement activities, Sudan applied country specific wood density values and default IPCC 2006 data for root-shoot ratio (section 4.5, table 4.4) and IPCC data on mean annual increment (section 4.5, table 4.11B) for the four species used in A/R. Table 11 shows the emission factors data used in the estimation of carbon removals in A/R activities.

[9] Average wood density of eleven dominant species see ANNEX 4

Table 11 emission factors data used in the estimation of carbon removals

Tree type	Growth rate	Rotation year	Wood Density	Root shoot ratio	Growth rate	Growth rate (weighted average)[10]
Unit	**m3/ha/yr**	**years[11]**	**t. d. m/m3**	**R**	**t. C /ha/yr**	**t. C /ha/yr**
Source	table 4.11B	RPP	National data[12]	IPCC table 4.4	calculated	calculated
Acacia nilotica	12	25-30	0.8	0.56	7.04	1.17
Acacia seyal	1.8	17-20	0.7	0.56	0.92	
Acacia senegal	1.1	20-23	0.7	0.56	0.56	
Acacia mellifra	1.7	17-20	0.7	0.56	0.87	

6. DETAILS ON NATIONAL CIRCUMSTANCES

Forestry activities started in the Sudan in 1901 and, the Woods & Forests Ordinance was promulgated in 1901 and the Department of Woodlands & Forests established in 1902. The 1901 Ordinance was replaced in 1908 by the First Forest Act. Adoption and implementation of administrative & legislative measures continued ever since. The most salient of these are the endorsement of Sudan's Forest Policy in 1932, the Central & Provincial Forest Ordinances (1932), the Local Government Act of 1972, Regional Government Act 1980, the amendment thereof in 1985, the revision of Forest Policy in 1986 and creation of the Forests National Corporation (FNC) and Revision of Forest Act in 1989.

The first national forest policy in Sudan was declared in 1932. The main objective of that policy was the protection and establishment of forests together with the development of their resources in order to sustain their protective, environmental and productive role so as to meet the population needs in terms of forests products and services. To this end so many

[10] 25% of the A/R area is planted with Acacia nilotica, which has significantly more volume per hectare compared to the other 3 Acacia species which have comparable stocking density

[11] A. nilotica is managed for 25-30 years rotations for woodfuel and timber (railway sleepers) production respectively; A. Senegal and A. Seyal are managed for 20-23 years for Gum production and A. Mellifera is managed for 17-20 year mostly for building and other local materials

[12] Sources of wood density data: Acacia nilotica: M. A. Elfdl, 1985. Biomass estimation and energy content of acacia nilotica in the Blue Nile Master thesis , University of Khartoum. Acacia Seyal, Acacia Senegal and Acacia mellifera: Tarig O. Khider and Osman T. Elsaki, 2012. Heat Value of Four Hardwood Species from Sudan, JOURNAL OF FOREST PRODUCTS & INDUSTRIES, 2012, 1(2), 5-9.

approaches and scientific techniques and administrative procedures have been followed in order to assign responsibilities to central and state level institutions regarding the management of forest resources.

The 1932 Forest Policy was reviewed in (1986) and the new policy encourages forest reservation and conservation and community and private sector participation in forestry development and management. The Forest Policy 1986 also responded to the new concepts and approaches of forest managements, which emphasis environmental protection, popular participation and multiple purposes forest management. The 1986 forest policy recognizes new forms of forest tenure including private, community, and institutional forests. Sets a target of 20% of the area of the country as forest reserves. It stresses the role of forests in environmental protection by creating new obligations in semi-mechanized farming or irrigated area to maintain or establish green belts. It emphasizes the role of public participation and community integration in afforestation and sustainable management of forests. It also recognizes the role of research in forest development and emphasizes the role of forest extension.

The current forest act is the Forests and Renewable Natural Resources Act 2002. It promotes an intersectoral approach to natural resources management involving forests, range and pasture and agriculture. The act supports agroforestry and includes a requirement for 5% of irrigated agricultural land to be planted with trees and 10% of rainfed agricultural land to be planted with trees. The Act recognises three categories of forest ownership – private, community and institutional but places all types of registered forests under the technical supervision of the FNC. It recognises the role of the native administration and traditional leaders and local communities and it recognises the multiple uses of trees and forests and usufruct rights of communities living around forest reserves.

Sudan 2006 National Forest policy Statement, developed through technical support of FAO, is the recent update of Sudan's Forestry Policy1986. The 2006 policy statement, made important changes in forest development and management. As it incorporates objectives of poverty reduction and amelioration of physical environment and combating desertification. Other policies forest related include Water Policy, Forest Outlook, Sudan’s Commitment to Social Development and Population Policy.

The Comprehensive National Strategies (CNS 1992 – 2002 and 2003 - 2027) are both concerned with the importance of forestry in environmental conservation and as a source of goods and services for the country and local communities. The CNS supported an increase in forest cover, range and nature reserves to an area equivalent to 25% of Sudan area. Since 1992, Sudan also put in place several strategies, policies and programmes aimed at sustainable development including the forest sector. These include:

- The National Comprehensive Strategy (1992 – 2002 & 2003-2027)
- The Natural Resources Strategy (2003-2027)
- Sudan's Forest Products Strategy (2003- 2027)
- National Action Plan to combat Desertification (2003),
- Sudan Intended Nationally Determined Contribution (2015)
- National Biodiversity Strategy and Action Plan (2001, 2017),
- National Adaptation Plan (NAP 2016)

It can be concluded that the conservation and enhancement of the forest cover is a priority of the Government of Sudan as stated in the constitution and Forest & Environmental and related policies where, FNC and other related institutions obliged to work and achieve forest land area and tree cover of 20% percent of the total country area by 2027.

7. PROPOSED FRL

Sudan’s first subnational FRL is constructed based on two main significant REDD+ activities, Deforestation and Enhancement of Forest Carbon Stocks. The selected historical reference period of 2006 – 2018, considered representative of the effect of relevant policies and development in national circumstances on forest land including implementation of A/R activities. 2006 IPCC Guidelines for national GHGs inventory, with country specific data on changes in forest stock from NFI 2017 and wood density, in addition to IPCC defaults were applied. Afforestation and reforestation data was obtained from the annual records of the FNC state offices. The activity data for Deforestation was developed using Remote Sensing data on detection of changes in forest area in three (3) change assessment points during the reference

period. The FRL includes the values of the net average annual change in carbon stock over the reference period and accumulated CO_2 removals from the A/R activities implemented during the same reference period (2006-2018).

Table 12. Sudan's Proposed Subnational FRL

States	Deforestation	Enhancement of Forest Carbon Stocks (A/R)
	t CO_2 / yr	**t CO_2/yr**
Sinnar	138, 278	-141,149
Gedarif	170, 129	-68,014
BlueNile	477, 796	-135,294
Total	**786, 202**	**-344,458**

8. HISTORICAL PERIOD CONSIDERED

Sudan selected relatively a longer reference period (2006-2018) to ensure covering important development in its national polices and circumstances that have led to deforestation and forest degradation in the area of the subnational level, but also similarly affected forest areas in other parts of the country. This includes the effect of the green revolution policies implemented in late 1970s, 1980s and till mid 1990s, when fast forest and woodland areas have been cleared for crop production, the so call mechanized rainfed agriculture. The affected land areas continued to be cultivated in the absence of proper extension services and appropriate cultivation practices, a situation led to a large areas lost productivity in central Sudan (highest population intensity area) and is now severely degraded or degrading. Another example is the agriculture investment policies, which led to large foreign investment in agricultural sector both rainfed and irrigated farming. The secession of South Sudan in 2011 with its richest forest resources also happened during this period. A final example, is the forest Act issued 2002, which allocate 10%

of the rainfed agricultural schemes and 5% of the irrigated agricultural farms to forestry. Given the development in national policies and circumstances in the country as indicated above, and also taking into consideration the guidance from UNFCCC, FCPF and REDD+ financing communities (e.g. GCF) Sudan selected a reference period of 13 years starting 2006 and ending 2018 when REDD+ programme has started its implementation phase.

9. ADJUSTMENT FOR NATIONAL CIRCUMSTANCES

Sudan's current forest and related policies development framework is considered conducive for REDD+ implementation. However, future reforms in the current forest and related policies are also underway as a result of the outcomes of the REDD+ readiness programme. The reference period selected for this subnational FREL/FRL, is considered representative in terms of capturing the effect of the development in forest and related policies and regulations. Accordingly Sudan does see the need to future undertake an adjustment to the propose FREL/FRL in this submission. However, further work on the effects of policy development on forest management and implementation of REDD+ activities will be studied in the future submission of the national FREL/FRL.

10. UPDATING FREQUENCY

The sub-national FREL/FRL is planned to be updated as part of the development on the national FREL/FRL, in line with the expected development in the activity data and other parameters based on the completion of the NFI and the work currently undertaken by the REDD+ readiness programme and the national inventory team of Higher Council for Environment and Natural Resources (HCENR). Also updating of the FREL/FRL is expected based on experiences gained and improvements in the methods used and their application. Further updates in future will depend on the development on NFI, remote sensing and related research data, in addition to the development in the international guidance, methods and standards.

11. FUTURE IMPROVEMENTS

Sudan followed a stepwise approach as guided the UNFCCC decisions and started at the subnational level in order to develop required knowledge, experience, resources and capacities within its national institutions. The experience gained in the preparation of the current FREL/FRL, reveal the need to improve application of methods and tools, activity data, emission factors and other parameters to inform and improve the development of the national FREL/FRL.

11.1. Improvement of Activity Data

The activity data (AD) used in the construction of the present sub national FREL/FRL was based on the accessible remote sensing data and technologies, current institutional capacities and expertise. The US sanctions, hindered Sudan ability to access and utilize cost-effective, high-resolution imageries that could have further improved the quality of the activity data. However, this situation is expected to improve after the current political change in Sudan and expected to result in a better access to advanced technology in remote sensing.

Specific activities will be planned for the improvement of AD, including provision of high resolution imageries, establishment of permanent sample plots network (land trothing), strengthening the capacity of the staff, providing technical support on the up-to-date remote sensing and GIS technology and their application in forest monitoring in order to provide high quality data and information for future national FREL submission. Sudan also planning to use advanced remote sensing technologies such as RADAR and LIDAR for biomass estimation.

11.2. Improvement of Emission Factors

The emission factors and other parameters used in this submission were derived from the ongoing National Forest Inventory (NFI 2017) and available published data. NFI (2017), which is still being finalized, provides a good opportunity though establishing permanent sample plots network all over the country, to improve the available field data. The network of permanent plots are distributed in a grid across the country and will be assessed on a regular cycle of measurements, thus enabling a time-series database to be established. Measurements will provide accurate data including on stand volume, biomass, increment, and tree species in

addition to site productivity and biological diversity. Moreover, country specific allometric equations to calculate biomass and volume will be developed to increase accuracy of volume estimates. The ongoing project on NFI is also planning to develop country specific parameters such as wood density and root shoot ratio for number of dominant tree species in the country.

11.3. Inclusion of other REDD+ Activities

This FREL/FRL submission covers only two activities: deforestation and enhancement of carbon stocks (A/R), other REDD+ activities are not yet covered, mainly because of lack of data. Forest degradation is a significant REDD+ activity in Sudan, however, it was not included in this submission. For assessing deforestation used accessible historical Landsat images (TM, ETM, OLI 30 m and SPOT 20 m) to create land-cover maps that are suitable for detection of deforestation with good accuracy. However, these are not suitable to monitoring forest degradation with the same level of accuracy.

Sudan intends to undertake further work to include forest degradation its national FREL/FRL through improving relevant national records, developing ground observations data including through the permanent sample plots established by the recent NFI (2017), and to use very high spectral and spatial resolution remote sensing data. The role of conservation and sustainable management (SFM) of forest also has a potential to be included in future improvements of the national FREL/FRL since these approaches have been introduced in Sudan since 1932

11.4. Inclusion of forest Fires

In the context of Sudan, forest fires are considered important by the REDD+ readiness programme, However, the effects of forest fires on the forest carbon stocks need to be understood and estimated in the future. Most of the Acacia species that are dominant in the forest cover are less affected by forest fires e.g. *A. Seyal*, however, there are some other species in natural forests and plantations (e.g Eucalyptus) sensitive to forest fires. Sudan Still has no comprehensive fire management strategy and the current fire related activities are limited to opening of fire lines within some forest reserves and protected areas.

In February 2019, in the framework of its REDD+ readiness in Sudan, Food and Agriculture Organization of the United Nations (FAO) in collaboration with the Forests National Corporation

(FNC) and the Remote Sensing & Seismology Authority (RSSA) initiated a series of workshops targeting the states that are most affected by forest fires including Darfur, Kordofan, and Blue Nile. The intention of the workshops was to initiate discussions with natural resources specialists, stakeholder, beneficiaries and local leaders about the current situation of fire management, as well as means and ways to establish a well-equipped national fire monitoring system including institutional arrangements. The REDD+ readiness programme initiated work on forest fire monitoring system, using Remote Sensing techniques, aiming to prepare historic forest fire maps for the period 2000-2018 in order to identify and visualize forest fire hotspots. These maps are expected to provide data for inclusion of the effects of forest fires in future National Forest Reference (Emission) Level and national Greenhouse Gas Inventories.

12. REFERENCES

Aamir Osman Ali Elmaleeh, 1996. An approach for study wood supply from Acacia seyal stands on Gadaref State, A case study: Wad Elkheseid natural forest reserve, A Thesis Submitted for the Degree of Master of Science in Forestry , University of Khartoum

Abdalla, G., (2019) Draft of Climate Change Mitigation potential od Sudan's Forestry Sector,

Amado S. Tolentino (1994), Environmental Legislations and Institutions in the Sudan.

Africover, 2012. Sudan Land Cover Atlas

Atta El Moula, M.E., 1985. On the problem of resource management in the Sudan. institute of Environmental Studies, University of Khartoum. Environmental Monograph No. 4.

Brown, S. and A.E. Lugo, Aboveground biomass estimates for tropical moist forests of the Brazilian Ama7.on, Intt:rtit:n<ia, 11, 8-18 (1992).

Donna Lee, Margaret Skutch, Marieke Sandker (2018), Challenges with measurement and accounting of the plus in REDD+

Drivers of Deforestation and Forest Degradation (D O D), 2018. Report for Republic of Sudan REDD+ Programme, In-depth analysis of Drivers of Deforestation & Forest/Range Degradation

Elmahi, A. G. and Abdel Magid, T. D. (2002) The Role of the Private Sector, Civil Society and NGOs in the Formulation and Implementation of National Forest Policies and National Forest Programmes in Sudan, Prepared as a contribution of the Sudan Forests National Corporation to the Regional Workshop held by FAO/RNE in Khartoum 26-27 January 2002.

GFOI 2016, Integration of remote-sensing and ground-based observations for estimation of emissions and removals of greenhouse gases in forests: Methods and Guidance from the Global Forest Observations Initiative, Edition 2.0, Food and Agriculture Organization, Rome

Global Forest Resources Assessment (FRA) 2010. FAO. Rome

Hassan O., EL Nour A. (2012), Readiness Preparation Proposal (R-PP), The United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries, Sudan

Mahgoub Suliman Mohamedain1, Elmar Csaplovics2, Mohammed H. Mohammed, 2009 .Model for Estimation of Acacia senegal Volume from NDVI. Tropentag, October 6-8, 2009 "Biophysical and Socio-economic Frame Conditions for the Sustainable Management of Natural Resources

Republic of Sudan (2015), Intended National Determined Contributions (INDCs)

Sudan's Readiness Preparation Proposal (R-PP), 2010. Sudan National REDD+ programme

Tarig O. Khider and Osman T. Elsak, 2012. Heat Value of Four Hardwood Species from Sudan JOURNAL OF FOREST PRODUCTS & INDUSTRIES, 2012, 1(2), 5-9

Mohammed Hamed Mohammed, 2011. Management of natural stands of Acacia seyal Del. variety seyal (Brenan) for Production of Gum Talha, South Kordofan, Sudan, MSc. Forestry, University of Khartoum, Sudan

The Open- Foris tools are described in the FAO website (www.fao.org/forestry/fma/openforis/en/) and on the OpenForis wiki-page (www.openforis.org/OFwiki/index.php/Main_Page).

FAO 2018, forest and climate change working paper No. 17, form reference level to results reporting: REDD+ under the UNFCCC 2018 update

FNC/FAO 2017, Manual for integrated field data collection. Adapted from the original Edited by Anne Branthomme, in collaboration with Dan Altrell, Kewin Kamelarczyk and Mohamed Saket FAO, Rome, 2012, NFMA Working Paper N° 37/E Rome, 2012

IPCC 2006 Guidelines for National Greenhouse Gases Inventories

http://www.fao.org/fileadmin/user_upload/geospatial/docs/GLCN/GLCN_Internat_partnership_for_harmonized_accessible_LC_data_information.pdf

13. ANNEXES:

ANNEX (1): List of images used for AD

	ASTER	Landsat
1	AST_L1T_00302262006081408_20150513081112.tif	171051_20181220
2	AST_L1T_00304062006081350_20150508151807.tif	172050_20180226
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4	AST_L1T_00304062006081407_20150508151822.tif	172053_20181211
5	AST_L1T_00304062006081416_20150508151822.tif	171052_20181227
6	AST_L1T_00304062006081425_20150508151822.tif	171053_20181220
7	AST_L1T_00304062006081434_20150508151829.tif	172051_20181211
8	AST_L1T_00304062006081443_20150508151839.tif	172052_20181211
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11	AST_L1T_00304062006081951_20150508122625.tif	173049_20181227
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13	AST_L1T_00304062006082000_20150508122628.tif	172049_20141216
14	AST_L1T_00304062006082006_20150508173616.tif	171053_20141225
15	AST_L1T_00304062006082007_20150512033114.tif	171051_20141209
16	AST_L1T_00304062006082016_20150512033125.tif	171050_20141225
17	AST_L1T_00304062006082601_20150508144452.tif	171052_20141209
18	AST_L1T_00304062006082609_20150508144452.tif	172050_20141216
19	AST_L1T_00304062006082615_20150512054143.tif	172051_20141216
20	AST_L1T_00304062006082624_20150512054144.tif	172053_20141216
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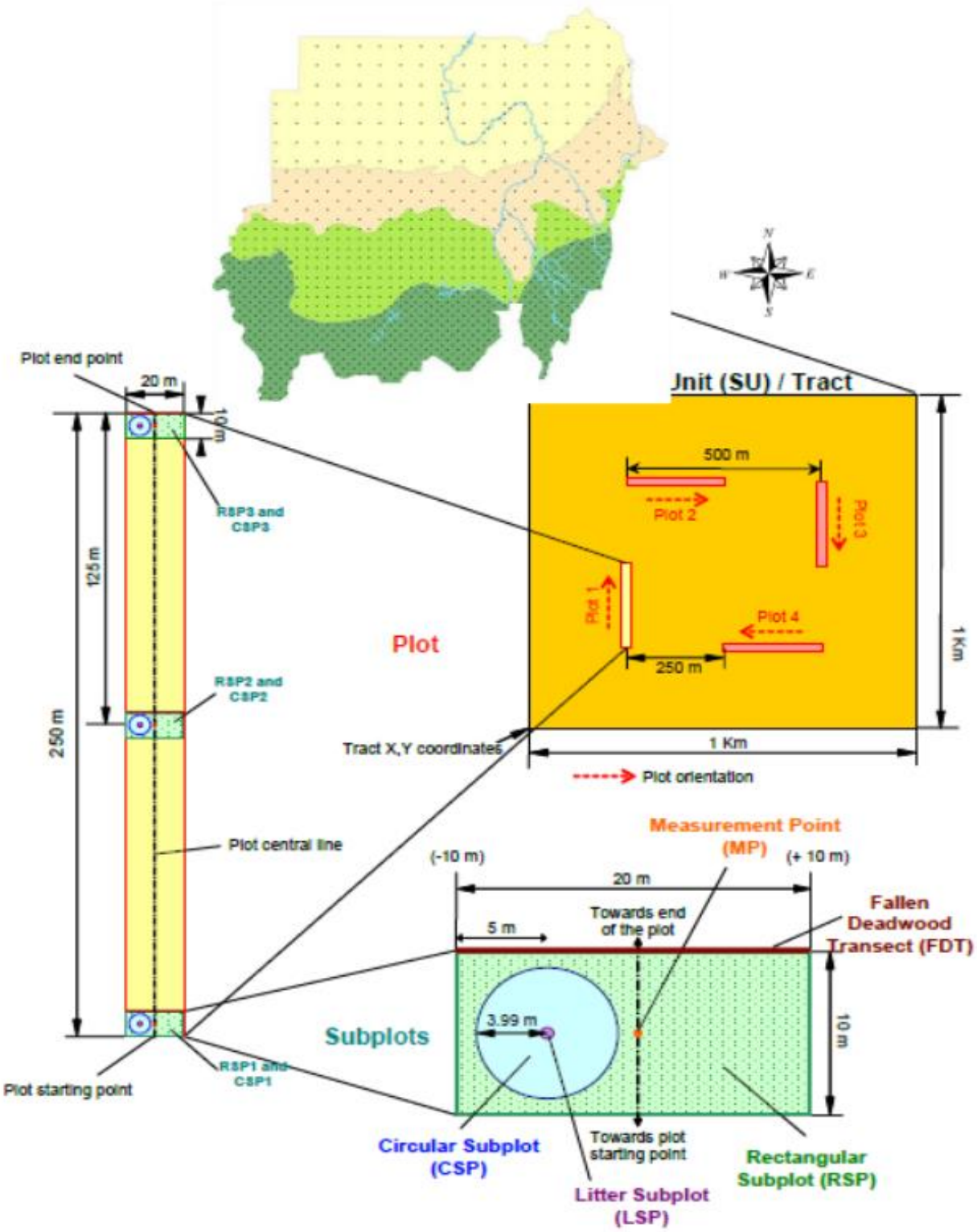
110	AST_L1T_00304062006082049_20150513205500.tif	

ANNEX 2 / Afforestation and Reforestation 2000 - 2018

Sinnar State																				
Year	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Official A/R	3090	3464	3664	3645	398	4280	3638	3369	7337	2982	3514	5771	4402	6697	3980	4630	1576	5655	7134	
Popular A/R	124	161	179	160	30	92	53	450	254	217	23	34	55	5027	491	1213	1213	176	160	
total	3214.5	3624.5	3843.4	3805.1	428.2	4371.4	3690.9	3818.5	7590.6	3198.8	3537.3	5804.5	4456.3	11724.0	4470.5	5842.8	2789.3	5830.8	7293.0	
Blue Nile State																				
Year	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Official A/R	425	400	2915	825	375	425	1315	1285	3541.75	2502.5	302.5	196	307.25	381.5	602.25	360	314.75	343	841.05	
Popular A/R	250	750	1000	750	750	1000	1750	750	1000	955	625	366	582.5	1750	1750	1381.5	858	4665	1500	
Total	675.0	1150.0	3915.0	1575.0	1125.0	1425.0	3065.0	2035.0	4541.8	3457.5	927.5	562.0	889.8	2131.5	2352.3	1741.5	1172.8	5008.0	2341.1	
Gedarif State																				
Year	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Official A/R	3675	3818	4192	3336	3628	4085	2563	2405	7107	3857	2900	3951	3837	3723	2506	1846	3077	2998	3784	
Popular A/R	341	361	119	600	250	250	475	335	500	500	250	500	500	250	414	406	415	404	392	
Total	4016.4	4178.7	4310.5	3935.5	3877.5	4335.0	3037.5	2739.5	7607.0	4356.5	3149.5	4451.0	4336.5	3972.5	2919.8	2251.6	3492.0	3401.9	4176.4	

ANNEX 3a


Plot end point
20 m
10 m
RSP3 and CSP3
125 m
RSP2 and CSP2
250 m
Plot central line
Plot starting point
RSP1 and CSP1
Jnit (SU) / Tract
500 m
Plot 2
Plot 3
Plot 1
Plot 4
Plot
250 m
1 Km
1 Km
Tract X,Y coordinates
Plot orientation
Measurement Point (MP)
(-10 m)
(+ 10 m)
20 m
Towards end of the plot
5 m
Fallen Deadwood Transect (FDT)
Subplots
3.99 m
10 m
Circular Subplot (CSP)
Towards plot starting point
Litter Subplot (LSP)
Rectangular Subplot (RSP)

Annex (3b):

Land Use Classes (LUCs)

Level 1	*Level 2*	*Level 3*	*Brief description*	*Code*
Forest	***National Definition*: Forest means land bearing a vegetative association and spanning more than 0.5 ha (or 0.42 ha =an equivalent of a Sudanese feddan) with trees at least 2m high and a minimum tree canopy cover of 10%; or young forests stands that have not yet reach, but are expected to attain these thresholds in situ. It does not include land that is predominantly under agricultural and/or agro-forestry production systems or urban land use.**			***F***
	Natural regenerated forest	***Forest predominantly composed of trees established through natural regeneration.***		
		Evergreen forest	*Naturally regenerated forest composed of more than 75% of evergreen trees species.* Includes : • Moist forest • Dry forest	***FE***
		Deciduous forest	*Naturally regenerated forest composed of more than 75% of deciduous trees species.* Includes : • Moist forest • Dry forest • Secondary young	***FD***
		Semi-deciduous forest	*Naturally regenerated forest where trees are at least 25% each of evergreen and deciduous species.* Includes : • Moist forest • Dry forest • Secondary young	***FSD***
		Bamboo forest	*Naturally regenerated forest predominantly composed of bamboo vegetation.*	***FB***
		Raffia/Palms	*Naturally regenerated forest predominantly composed of palm or raffia vegetation.*	***FRP***
		Forest predominantly composed of trees established through planting and/or deliberate seeding. Includes coppice from trees that were originally planted or seeded.		
		Broadleaved planted forest	*Planted forest composed of more than 75% of broadleaved species.* Includes: • *Eucalyptus sp.* • *Acacia sp.* • *Gravillia*	***FPB***

	Plantation	***Coniferous planted forest***	*Planted forest composed of more than 75% of coniferous species.* Includes : • *Cupressus lusita.* • *Juniperus* • *Pinus patula*	***FPC***
		Mixed planted Forest	*Planted forest of at least 25% each of coniferous and broadleaved species.*	***FPM***
Other wooded lands	**Area ≥ 0.5 ha, tree crown cover 5- 10% or shrubs/bushes canopy cover ≥10%**			***W***
	Woodland	Includes : • *Acacia comiphora* • *Combretum terminalia* • *Others (bushes,..)*		***W***
	Wooded grassland	*Land covered by natural growth of graminea and herbaceous vegetation, with some scattered trees (tree canopy cover between 5-10%); Land not covered seasonally or permanently by water.* Includes: • *Acacia sp*. • Others (*Combretum* sp...)		***WG***
	Wooded wetland	*Land seasonally or permanently covered by water with natural growth of graminea and herbaceous vegetation and some scattered trees (canopy cover between 5-10%).*		***WW***
	Land not classified as forest or other wooded land, as described above (Includes land with tree canopy cover <5% or with shrubs/bushes <10% or with predominant agricultural/urban land use or with shrubs/ trees<0.5ha).			***O***
	Natural	***Barren Land***	*Land where vegetation cover is less than 2%. Includes land covered of sand, soil and rocks.*	**OX**
		Natural Grassland	*Land covered with natural growth of graminea and herbaceous vegetation.*	***OG***
		Marsh	*Land seasonally or permanently covered by water and dominated by natural growth of graminea, reed and other herbaceous.*	***OM***
	Cultivated	***Improved pastures***	*Land sown with introduced grass and leguminous for the grazing of livestock.*	***OP***
		Annual Crop	*Area covered by crops that are sown and harvested during the same production season/ agricultural year.*	**OCA**
		Perennial crop	*Crops that are sown or planted once and need not to be replanted after each annual harvest. Includes trees (e.g.*	***OCP***

			apples or other fruit trees), bushes and shrubs (e.g. berries, coffee...), palms (e.g. dates), vines (e.g., grapes), herbaceous stems (e.g. bananas) and stemless plants (e.g.	
Oth Land		***Mixed annual and perennial crop***	*Association of annual and perennial crops.*	***OCM***
		Fallow	*Previously cultivated land kept free from crops or weeds during at least one growing season, where woody vegetation is and will not reach 5m height.*	***OF***
		Wood lot of Bamboo	*Bamboo areas spanning between 0.2 and 0.5 ha , with trees >5m at maturity mainly used is for wood stock*	***OWB***
		Wood lot	*Other areas spanning between 0.2 and 0.5 ha , with trees >5m at maturity mainly used is for wood stock*	***OW***
	Built up area	*Populated areas with significant constructions. Includes homes scattered in the field.* *<u>Notes</u>: a road is considered as a distinct Land Use/Cover Section (built-up area) if wider than 15 meters (from bottom of ditch on one side to the bottom of ditch on the other side when ditches exists, otherwise the width of the road bank) and if not a forest road.*		***OB***
	Quarry/Mining site	*Areas used for extraction of minerals, rocks, sands, clay... Includes: quarry, mining, extraction areas, oil/gas wells.*		***OQ***
Inland water	***Area occupied by major rivers (width ≥ 15m), lakes, ponds and reservoirs.***			***IW***
	Perennial River	*Rivers (width ≥ 15m) that maintains water in its channel throughout the year.*		***IRP***
	Intermittent River (seasonal)	*Rivers (width≥ 15m) that flows only at certain times of the year.*		***IRS***
	Lake	*Large body of salt or fresh water surrounded by land.*		***IL***
	Dam	*Reservoir created by a barrier constructed to hold back the water and raise its level.*		***ID***
	Pond	*Small body of still water formed naturally or by hollowing or embankment.*		***IP***

Level 1	***Level 2***	***Level 3***	***Brief description***	***Code***

Forest	***National Definition*: Forest means land bearing a vegetative association and spanning more than 0.5 ha (or 0.42 ha =an equivalent of a Sudanese feddan) with trees at least 2m high and a minimum tree canopy cover of 10%; or young forests stands that have not yet reach, but are expected to attain these thresholds in situ. It does not include land that is predominantly under agricultural and/or agro-forestry production systems or urban land use.**			***F***
	Natural regenerated forest	***Forest predominantly composed of trees established through natural regeneration.***		
		Evergreen forest	*Naturally regenerated forest composed of more than 75% of evergreen trees species.* Includes : • Moist forest • Dry forest	***FE***
		Deciduous forest	*Naturally regenerated forest composed of more than 75% of deciduous trees species.* Includes : • Moist forest • Dry forest • Secondary young	***FD***
		Semi-deciduous forest	*Naturally regenerated forest where trees are at least 25% each of evergreen and deciduous species.* Includes : • Moist forest • Dry forest • Secondary young	***FSD***
		Bamboo forest	*Naturally regenerated forest predominantly composed of bamboo vegetation.*	***FB***
		Raffia/Palms	*Naturally regenerated forest predominantly composed of palm or raffia vegetation.*	***FRP***
	Plantation	***Forest predominantly composed of trees established through planting and/or deliberate seeding. Includes coppice from trees that were originally planted or seeded.***		
		Broadleaved planted forest	*Planted forest composed of more than 75% of broadleaved species.* Includes: • *Eucalyptus sp.* • *Acacia sp.* • *Gravillia*	***FPB***
		Coniferous planted forest	*Planted forest composed of more than 75% of coniferous species.* Includes : • *Cupressus lusita.* • *Juniperus* • *Pinus patula*	***FPC***

		Mixed planted Forest	*Planted forest of at least 25% each of coniferous and broadleaved species.*	***FPM***
Other wooded lands	**Area ≥ 0.5 ha, tree crown cover 5- 10% or shrubs/bushes canopy cover ≥10%**			***W***
	Woodland	Includes : • *Acacia comiphora* • *Combretum terminalia* • *Others (bushes,..)*		***W***
	Wooded grassland	*Land covered by natural growth of graminea and herbaceous vegetation, with some scattered trees (tree canopy cover between 5-10%); Land not covered seasonally or permanently by water.* Includes: • *Acacia sp*. • Others (*Combretum* sp...)		***WG***
	Wooded wetland	*Land seasonally or permanently covered by water with natural growth of graminea and herbaceous vegetation and some scattered trees (canopy cover between 5-10%).*		***WW***
Other Land	***Land not classified as forest or other wooded land, as described above (Includes land with tree canopy cover <5% or with shrubs/bushes <10% or with predominant agricultural/urban land use or with shrubs/ trees<0.5ha).***			***O***
	Natural	***Barren Land***	*Land where vegetation cover is less than 2%. Includes land covered of sand, soil and rocks.*	**OX**
		Natural Grassland	*Land covered with natural growth of graminea and herbaceous vegetation.*	***OG***
		Marsh	*Land seasonally or permanently covered by water and dominated by natural growth of graminea, reed and other herbaceous.*	***OM***
	Cultivated	***Improved pastures***	*Land sown with introduced grass and leguminous for the grazing of livestock.*	***OP***
		Annual Crop	*Area covered by crops that are sown and harvested during the same production season/ agricultural year.*	**OCA**
		Perennial crop	*Crops that are sown or planted once and need not to be replanted after each annual harvest. Includes trees (e.g. apples or other fruit trees), bushes and shrubs (e.g. berries, coffee...), palms (e.g. dates), vines (e.g., grapes), herbaceous stems (e.g. bananas) and stemless plants (e.g. pineapples).*	***OCP***
		Mixed annual and	*Association of annual and perennial crops.*	***OCM***

		perennial crop		
		Fallow	*Previously cultivated land kept free from crops or weeds during at least one growing season, where woody vegetation is and will not reach 5m height.*	***OF***
		Wood lot of Bamboo	*Bamboo areas spanning between 0.2 and 0.5 ha , with trees >5m at maturity mainly used is for wood stock*	***OWB***
		Wood lot	*Other areas spanning between 0.2 and 0.5 ha , with trees >5m at maturity mainly used is for wood stock*	***OW***
	Built up area	*Populated areas with significant constructions. Includes homes scattered in the field.* *<u>Notes</u>: a road is considered as a distinct Land Use/Cover Section (built-up area) if wider than 15 meters (from bottom of ditch on one side to the bottom of ditch on the other side when ditches exists, otherwise the width of the road bank) and if not a forest road.*		***OB***
	Quarry/Mining site	*Areas used for extraction of minerals, rocks, sands, clay... Includes: quarry, mining, extraction areas, oil/gas wells.*		***OQ***
Inland water	***Area occupied by major rivers (width ≥ 15m), lakes, ponds and reservoirs.***			***IW***
	Perennial River	*Rivers (width ≥ 15m) that maintains water in its channel throughout the year.*		***IRP***
	Intermittent River (seasonal)	*Rivers (width≥ 15m) that flows only at certain times of the year.*		***IRS***
	Lake	*Large body of salt or fresh water surrounded by land.*		***IL***
	Dam	*Reservoir created by a barrier constructed to hold back the water and raise its level.*		***ID***
	Pond	*Small body of still water formed naturally or by hollowing or embankment.*		***IP***

ANNEX (4): Wood Density of Species dominant in deforested area

Species	WD	Source
Acacia tortilis f. raddiana	0.44	FNC 2019, Integrated Carbon Sequestration Project Establishment of Biomass Carbon Baseline
Boswellia papyrifera	0.720	Robert Nygård*and Björn Elfving (1999), Stem basic density and bark proportion of 45 woody species in young savanna coppice forests in Burkina Faso. https://hal.archives-ouvertes.fr/hal-00883170/document
Dalbergia melanoxylon	0.817	Robert Nygård*and Björn Elfving (1999), Stem basic density and bark proportion of 45 woody species in young savanna coppice forests in Burkina Faso. https://hal.archives-ouvertes.fr/hal-00883170/document
Acacia gerrardii var. gerrardii	-	-
Combretum ghasalense	-	-
Albizia Amara	0.7	FAO: Appendix 1 - List of wood densities for tree species from tropical America, Africa, and Asia. http://www.fao.org/3/w4095e/w4095e0c.htm Also in the IPCC 2006, chapter 4 table 4.13
Anogeissus leiocarpus	0.73	Ogunwusi, A.A. and Onwualu,A.P and 2Ogunsanwo, O.Y (2013) Comparative Analysis of Wood Properties of Afzelia africana and Anogeissus leiocarpus Growing in Nigeria. Chemistry and Materials Research www.iiste.org ISSN 2224- 3224 (Print) ISSN 2225- 0956 (Online) Vol.3 No.3, 2013
Balanites aegyptiaca	0.63	IPCC 2006, Chapter 4, table 4.13
Albizia amara	0.70	IPCC 2006, Chapter 4, table 4.13
Acacia Seyal	0.7	Tarig O. Khider and Osman T. Elsaki, 2012. Heat Value of Four Hardwood Species from Sudan, JOURNAL OF FOREST PRODUCTS & INDUSTRIES, 2012, 1(2), 5-9
Acacia Senegal	0.7	Tarig O. Khider and Osman T. Elsaki, 2012. Heat Value of Four Hardwood Species from Sudan, JOURNAL OF FOREST PRODUCTS & INDUSTRIES, 2012, 1(2), 5-9
Acacia Mellifera	0.7	Tarig O. Khider and Osman T. Elsaki, 2012. Heat Value of Four Hardwood Species from Sudan, JOURNAL OF FOREST PRODUCTS & INDUSTRIES, 2012, 1(2), 5-9
Acacia Nilotica	0.8	M. A. Elfdl, 1985. Biomass estimation and energy content of acacia nilotica in the Blue Nile Master thesis , University of Khratoum

ANNEX 5: List of contributors

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