The Higher Council for Environment and Natural Resources (HCENR), Sudan

The Second Nationally Determined Contributions (NDCs) Project

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The Forestry Sector Role in the Nationally Determined Contributions (NDCs)

2021-2025

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1. Background & Project Description:

1.1 *The Context of climate change issues in Sudan:*

In addition to its political instability, , Sudan is one of the most vulnerable arid and desertified regions of Sub-Saharan Africa. It is highly vulnerable to global climatic change and extreme events, such as drought and flooding (IPCC, 2013). The United Nations Convention on Combating Desertification (UNCCD) has defined dry lands (arid, semi-arid, and dry sub-humid zones) as areas other than polar and sub-polar regions in which the aridity index (i.e. the ratio of annual precipitation to potential evapotranspiration) falls within the range of 0.05-0.65 (UNCCD, 1994). According to this definition, about 80 % of the area of Sudan would be classified as dry land, which extends from hyper-arid and arid zones in the north, through the semi-deserts in the middle, to low rainfall woodland savanna in the deep south and southeast (Goda, 2007 and Mustafa, 2007).

Perhaps unsurprisingly, the impacts of cilmate change have already been observed in these vulnerable regions. Reports Zakieldeen (2009), Funk et al. (2011) and Badri (2012) reportson the environment in Sudanwarned that desertification is probably under a range of scenarios of climate change. Even in the most optimistic scenario, by 2060, average summer temperatures in Sudan are projected to rise between 1.5° and 3.0°C, and average winter temperatures are projected to rise 1.1° to 2.1°C. Moreover, the rainy season is expected to be much shorter than it has been in the last 50 years, and the timing of precipitation is forecast to become much more temporally variable (estimated coefficient of variation 15 – 190%). Extreme events such as occurrence, severity, and frequency of droughts are likely to increase in the semi-arid regions such as Northern state, Kassala, Kordofan and Darfur, as well as floods in the areas adjacent to the Nile.

Unfortunately, this trend will not only contribute to the degradation of natural resources or the loss of biodiversity in the country but also will eventually influence community's livelihoods.

1.2. Paris 2015 & NDCs concept & importance:

Over the last two decades, international reports have documented a substantial increase in Greenhouse Gases (GHGs) emissions and concentrations in the atmosphere, including CO_2 due to the increase of industrial activates particularly in the developed world (IPCC, 2013). Perhaps this increase in the GHGs has led to a significant warmer and drier climate worldwide. Based on these drastically observed impacts of climate change especially in the developing countries, world governments have gathered in the memorable Paris meeting of the Conference of Parties (COP24) to seriously discuss this problem and finding agreeable path forward. Among the many findings that all parties had to agree on, was setting clear, transparent and understandable national contributions those help to reduce the country's GHGs emissions and ultimately contributing to the collective efforts of combating global warming. In other words, COP24 put the industrialized countries in front of their responsibilities for their significant share of the GHGs pollutions hence global warming. Moreover, the agreement urged all parties to reduce their GHG emissions in order of magnitude that reduces global average temperature 2 C° by 2030.

2. Project Objectives and Scope of Work:

2.1. Objectives of Sudan's NDCs project:

In accordance with the recent guidance from COP24 (2015), in particular decision 4/CMA.1, paragraph 7, Sudan intends to update and resubmit its Nationally Determined Contributions (NDCs), with the overall objective of transforming it from a communication document into

an action plan implementable within the agreed timeframe. NDCs aiming to achievethe following specific objectives under project:

- *Update the current NDCs in line with the relevant COP decisions (since Paris 2015) including a review of its timeframe, contributions and the information required to be reported.*
- *Develop a strategy for NDCs implementation and integration into sectoral and national development planning.*
- *Strengthen national institutional arrangements for progression in NDCs preparation and implementation.*

With generous funding from the United Nations Development Program (UNDP), the Higher Council for Environment and Natural Resources (HCENR) is the implementing agency of the "Sudan's Nationally Determined Contributions (NDCs) Project". The Sudan NDCs project composed of the following components:

- **Component 1**: *Sudan NDCs project is updated in line with the relevant COP decisions and submitted to UNFCCC secretariat.*
- **Component 2**: *NDCs implementation strategy in consultation with concerned stakeholders.*
- **Component 3**: *Institutional arrangements for NDCs preparation and communication have been established and strengthened.*

2.2. Study Objectives & Scope of Work:

The broad objective of the study is helping HCNER's NDCs project by reporting the mitigation contributions in the forestry sector, according to the national sectoral priorities and in line with the *Paris Agreement* (i.e. COP24 decisions). Specific aims of this report include;

1. *Reviewing national circumstances relevant to the development of the forest sectors in Sudan, including status of the forest resources, socio-economic contributions, etc.*
2. *Reviewing legal, policy, and planning framework of the forest sector in Sudan.*
3. *Reviewing GHGs fluxes related to the forest sector in Sudan and provides information, as appropriate, on trends and projections.*
4. *Reviewing and mapping the various climate change mitigation relevant programmes in Forest sector, including the national forest programme, REDD+, Afforestation and reforestation, forest managements, biomass energy, etc.*
5. *Identifying the development, progress, challenges and barriers facing the implementation of these programmes.*
6. *Reviewing available FNC reports and other relevant information to assess available lands and opportunities for Afforestation and reforestation.*
7. *Reviewing available literature on forest related mitigation projects, the progress achieved in their implementation, lesson learned, barriers, challenges.*
8. *Drafting and finalizing report and present outcomes of the study to the NDCs technical committee and stakeholders, as appropriate.*

3. Study approach and methodology:

3.1. *Priority Areas & Timeframe of Setting the Forestry NDCs:*

To achieve the above-mentioned objectives, *five priority areas* were identified by the HCNER's NDCs technical committee as the *focused directions* for setting up the forestry mitigation contributions as well as for measuring the success in the future. These priority areas were:

1) *Forest Restoration and Conservation.*
2) *Afforestation in Rainfed Agricultural Schemes.*
3) *Implementation of National REDD+ strategy.*

4) *Rehabilitation of Mangrove forests & Blue Carbon Conservation.*

5) *Biomass energy & Conservation of Carbon stock.*

The 5 year period 2021 – 2025 was set as a timeframe for assessing progress made towards meeting the forestry NDCs.

3.2. *Methodology of Setting Forestry Contributions:*

The study was primarily relied on the following methods including:

(1) ***Literature search and analysis:***

Several documents related to the NDCs project have been explored & reviewed. A special emphasis was given to the annual reports during the past five years and project documents of the *Forest National Corporation (FNC)* as well as other *relevant stakeholders.*

(2) ***Consultation meetings:***

Many meetings were primarily held with FNC members of the National NDCs technical committee to coordinate efforts through achieving these three goals; 1) agree on priority areas of contributions; 2) discuss & set reasonable quantities proposed for each activity or area of focus and; and 3) agree on common principles, references, and estimation procedure so that estimates produced by this report are consistent with other similar reports.

(3) ***Validation workshop for forestry NDCs draft report:***

After all, the draft report of the proposed forestry NDCs has been shared with FNC & related stakeholders to discuss and approve the proposed contributions.

3.4. *Estimation Procedure & Rational for Setting Forestry Contributions:*

The comprehensive literature search & analysis and these consultation meetings, have successfully resulted in the following common grounds and general principles for estimation procedure & Setting Forestry Contributions:

1. Forestry contributions and subsequent activities are divided in to two modalities. Either activity that contribute to the *removal* of atmospheric GHGs (e.g.

Afforestation) or activity that contribute to the *reduction* of GHGs emissions (e.g. improved stoves).

2. Quantities proposed for each activity (e.g. restoration areas or number of distributed improved stoves) were based on FNC's plans.
3. Estimation of total removal $CO_2$by adopting three proposed rehabilitation activities were based on recent reports by FNC and related projects.
4. Areas proposed for restoration and rehabilitation contributions were set at average (i.e. 273,928.9 ha) of the total areas that planned by FNC for same purpose during 2016 – 2018 (FNC, 2016; 2017; 2018). Thus the annual target areas to be restored under this NDCs project equals to 273,928.9 ha/year for the coming five years.
5. Areas proposed for Afforestation contributions in the rainfed schemes were set at 314,000 ha/year for the next five years.
6. Stocking density (number of trees per hectare) was based on the estimates of recent National Forest Inventory (NFI) report, which is about 81 trees/ha (FNC, 2020).
7. Estimation of total CO_2 removal expected by the proposed contribution activities will be based on the recent Sudan's Forest Reference Level (FRL) report to the UNFCCC, 2020 - table 18 (FNC, 2021). See table (1) below for more details on the estimates of emission factors and box (1) for the equations used as well.
8. The cost of restoration of one hectare of *Acacia sp.* are estimated at 422.4 USD and estimated cost of restoration of one hectare of mangrove forest equals 250 USD.

Box 1: equations used in computing total removal from accumulated afforestation and reforestation activities proposed for the forestry-NDCs adapted from FRL report.

<u>Equation 1:</u> *total removal from accumulated afforestation and reforestation activities proposed for the forestry NDCs*

$$\textbf{Total removal} = \Delta C_G\ (A+B+C)*0.60*44/12$$

Where:

ΔC_G= annual increase in biomass carbon stocks due to biomass growth in land remaining in the same land-use

A, B, & C = A/R area in the proposed activities, accumulated over the reference period (2021-2025) , ha

0.60 = percentage of the survival rate of the A/R

44/12 = The ratio of the molecular weights to C to CO2

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

$$\Delta C_G = \sum_i (G_{TOTAL} * CF)$$

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

<u>Equation 3:</u> *Average 5 annual increment in biomass of the 4 Acacia species:*

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

Where:

G_{TOTAL} = average annual biomass growth above and below-ground, (4 species) tonnes d. m. ha-1 yr-1

GW = Mean annual increment (merchantable volume) 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 belowground biomass to aboveground biomass for a specific vegetation type, in

tonne d. m. belowground biomass (tonne d. m. aboveground biomass)-1.

Table (1)*: Summary of emission factors used in estimating total removal of CO_2 by the proposed forestry NDCs (i.e. Aforestation and reforestation activities) which are primarily based on *Acacia species*.

No.	Item / factors	Estimate
1	Stoking density (trees / hectare)	81
2	Average volume (m3/ha/yr)	2.31
3	Wood Density (total .dry .matter/m^3)	0.7
4	Root shoot ratio (R)	0.56
5	Carbon Fraction of dry matter	0.47
6	Annual removal / growth rate (Ton. C / ha / yr)	1.64
7	Trees seedlings survival rate	0.60
8	Cost of afforestation/ reforestation of 1 hectare (USD)	422.4
9	Cost of afforestation/ reforestation of 1 hectare of mangrove forests (USD)	250
10	Cost of 1 unit of improved stove (USD)	5
11	Cost of 1 unit of LPG cylinder (USD)	44.85

*Sources: NFI (FNC, 2020) & Sudan's Forest Reference Level (FRL) report to UNFCCC, 2020 - table 18 (FNC, 2021).

4. Study results:

4.1. Status of forest resources & socio-economic contributions in Sudan:

Sudan's endowed diverse forests and woodlands spread over several ecological zones according to rainfall, soil and topography. Sudan ecological structure and biodiversity follow a trend as from north to south. The Sudan's forests structure and species composition follow

the ecological classification profile and rainfall trends as from north to south with forests taking the form of bush land and scattered trees and shrubs in the north and in dense forests of large trees in mixture of acacias and broad-leaved trees in the southern end of the savanna and montane region.

Forests are considered among the most important natural features in Sudan, where they form with other varying entities of plant cover, the base for the terrestrial ecosystems of the country (FAO, 2006). They important at local and national levels because of the support they provide for the economy and livelihoods of communities including wood and non-wood forest products and the numerous services provided in enhancement of agricultural production, maintenance of hydrological cycles, recreational and amenity values (Elsiddig *et al.,* 2007, Gadallah, 2018). The forestry sector contributes about 15% to national GDP, provides 15% of job-opportunities available in the rural areas and 30% of the feed of the national herds and contribute by 70 % to the national energy supply (FAO, 2006, HCENR, 2009, Elsiddig et al., 2007).

The status of forest cover in Sudan witnessed substantial changes in the last decades as reported in a plethora of literature. The FAO (2015), reported the total forest cover of Sudan to be 23.57 Mha, 21.826 Mha, 20.954 Mha, 20.082 Mha, and 19.21 Mha in 1990, 2000, 2005, 2010 and 2015 respectively. FAO (2015) observed that there hadbeen a consistent reduction in total forest cover in Sudan yearly and the figure attributed to 2015 constitutes about 10.3% of the country's land area. Recently, the National Forest Corporation has conducted a National Forest Inventory, which stated that the total forest area to be 29.83 Mha accounting for 15.58% of the country's land area (FNC, 2020) – table 2 & figure 2 below has more details on Sudan's forest areas.

Deducing form the above estimates, Sudan is lying in the phase of post transition that addressed in the Forest Transition Model (Hosonuma *et al.,* 2012, Gadallah, 2018).

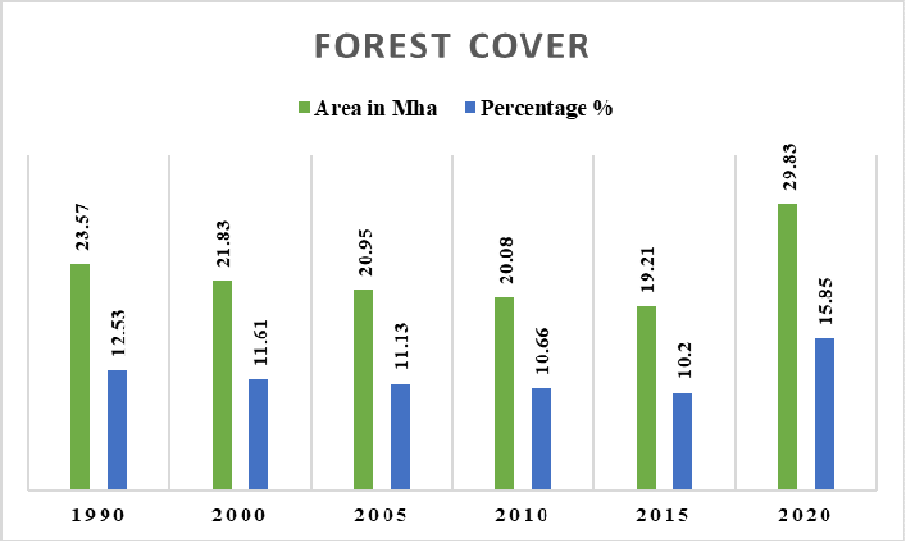

Figure (1): Forest Cover in areas and percent out of total sudan's area. Source FRA 2015.

4.2. Forest policies in Sudan:

Forest policy is critical to achieving sustainable forest management as it defines the procedure for the use and management of a country's forest resources and contributions to global issues such as climate change mitigation. The evolution of the forest-related activities in Sudan in the early 20 century where the Woods and Forests Ordinance was enacted in 1901 and as a result, the Department of Woodlands and Forests was established in 1902. Since then, forest policies in Sudan have progressively been changing in line with global forestry policies beginning with traditional forest use, colonial forest use, forest for national economic growth, through to internationalization and globalization. Thus, the following table is summarizing the main forest policies in Sudan with their prominent features.

Table (2): the development of forest policy in Sudan

Policy	Features	Projected forest cover	Stakeholders
1932	- Protection and establishment of forests together with the development of their	Reservation of 15% of the Country as forested area	

	resources in order to sustain their protective, environmental and productive role. - Meet the population needs in terms of forests products (primarily timber).		
1986	- Emphasis on environmental protection, popular participation and the multiple uses of forests - Recognized need for research in forest development and emphasized the role of forest extension	20% of the Country area as forest reserves	Local Communities, private and institutional sector
Forests and Renewable Natural Resources Act 2002	- It promotes an inter-sectoral approach to natural resources management involving forests, range and pasture and agriculture. - The Act recognizes three categories of forest ownership – private, community and institutional under the technical	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	Native administration Traditional leaders and local communities

	supervision of the FNC.		
2006 (not yet ratified)	- Incorporating poverty reduction strategy, improvement of people standards, amelioration of the physical environment and combating desertification.	25% of the Country area as natural resources mainly forests	Non-governmental, scientific, business, indigenous peoples and other organizations

Developed from (FAO, 2006; Elsiddig et al., 2007; Kobbail and Elfeel, 2012, FNC, 2020)

4.3. GHGs fluxes related to the forest sector in Sudan and trends and projections:

Forests play a central role in environmental conservation and climate stability. Plants take up carbon dioxide (CO_2) from the atmosphere and nitrogen (N) from the soil when they grow, re-distributing it among different pools, including above and below-ground living biomass, dead residues, and soil organic matter. The CO_2 and other non-CO_2 greenhouse gases (GHG), largely methane (CH_4) and nitrous oxide (N_2O), are released to the atmosphere by anthropogenic land-use activities, and changes in land use/cover (e.g. conversion of forestlands to cropland, afforestation).

Furthermore, forest sector activities lead to both sources of CO_2 (e.g. deforestation) and sinks of CO_2 (e.g. afforestation). Therefore, the main mitigation options within the forest sector involve one or more of three strategies: reduction/prevention of emissions to the atmosphere by conserving existing carbon pools in vegetation; sequestration enhancing the uptake of carbon in terrestrial reservoirs, and thereby removing CO_2 from the atmosphere; and reducing CO_2 emissions. The Sudan national GHG inventory of 2020 has considered the 2011-2015 data. In 2015, forestland remaining was estimated to be a source of 31,411 Gg CO2. The emissions increased by 81.9% (14,145 Gg CO2) during the period from 2011 to 2015. The

main driving factor that led to emissions' increment in 2011 has reported as a biomass loss due to areas affected by disturbances.

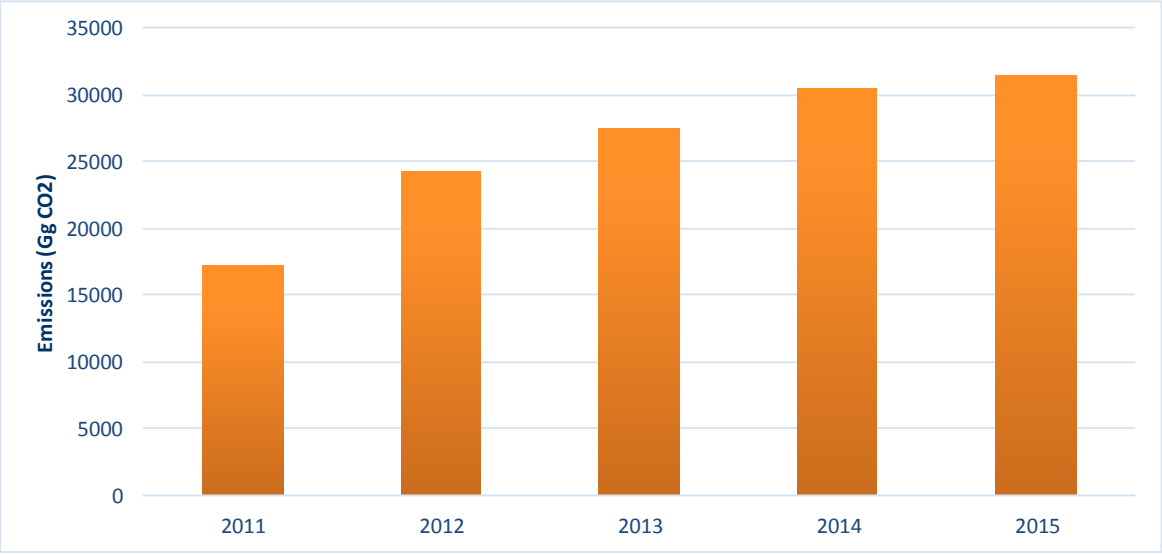

Figure (2): Trend of Sudan's forest land remaining forest land emissions, 2011-2015

On the other hand, the Integrated Carbon Sequestration Project in Sudan (from2013-2019) has intended to contribute to the global incremental benefits of GHG mitigation while at the same time to enhance rural sustainable development in the eastern Sudan. The main achievements of this project were: the carbon stock in the project's area increased to 190,863 tons by afforestation & Reforestation activities, which is higher than the target of 108,000 tons, and the net GHGs emission in the project area was decreased based on the adoption of usage of an alternative source of energy reached 56,149 tons.

4.4. Forestry-NDCs activities during 2021 - 2025:

4.4.1. Afforestation of 10% area within Rain-Fed Schemes:

Reports of the Federal Ministry of Agriculture and Natural Resources indicated that the average rain-fed schemes' cropped area in 2017/2018 was 15,700,000 ha which mostly cultivated by sorghum, wheat, millet, maze, and cotton. According to forest and renewable natural resources act for the year 2002, 10% of the rainfed schemes must be vegetated by

forest trees. Unfortunately, this legislation is largely inactive and not adopted by farmers. Therefore, FNC would like to activate this law and achieve the goal of planting 1,570,000 ha (i.e. 10%) with trees over the next five years (2021 to 2025) with 314,000 ha/year as annual target. Thus, the carbon removal will be about *2,574,800 Ton C / 5-years* (table 3).

4.4.2. Forest Restoration & Rehabilitation Efforts by FNC:

FNC is making great efforts to restore harvested and/or degraded forestland nationwide on an annual basis. Therefore, the annual reforested areas in 2016, 2017 and 2018 were reported as 252,840, 230,006 and 296,940 ha/year with an average of 273,928.9 ha/year (FNC, 2016, 2017, 2018). In pursuing this effort, Sudan intends to restore at least the average of 273,928.9 ha/year as part of its forestry sector NDCs. Successful restoration of this area should contribute in removing *2246216.98* Ton C over the coming five years. Details of annual removal and calculation factors are presented in table (4) below.

4.4.3. Blue Carbon – Rehabilitation of Mangrove:

The area of Sudan mangrove forests is approximately range between 329 - 721 ha and thus the average has been estimated at 525 ha. In fact, mangrove forests are considered excellent sinks for carbon and store three times higher than terrestrial ecosystems. A study conducted by Afefee, et al. (2020) has estimated that the mangrove forests in the Red Sea removes 49.76 ton C / ha/ year. Based on this, and as part of its REDD+ activities Sudan is aiming at restoring about 600 ha of Mangrove forests in the coming five years, which can contribute to the removal of 26124 ton C in 5- years (table 6).

4.4.4. Forest related mitigation projects: A. Senegal – GAMS project

The coming GAMS projects targeting to establish about 15000 hectares of Acacia Senegal stands in the coming five years, which can contribute to removal of 20500 ton C during this five- years period of the NDCs (table 7).

4.4.5. Biomass Energy Conservation:

Plethora of literatures has acknowledged the role that improved stoves and LPG play in the reduction of GHG emissions. Because of this appeal, FNC is planning to reduce biomass-based carbon emissions to the minimal possible levels by distributing 20000 improved stoves and 15000 LPGs cylinders to communities in rural areas. Overall, this plan is expected to contribute to the reduction of ***973497.3*** ton carbon over the next five years. The contributions of LPGs and Improved stoves in Carbon emission reduction have been detailed in tables 7 and 8.

4.4.6. Summary of Sudan's forest-based NDCs:

Overall, the proposed contributions of forestry-based afforestation and restoration activities under the NDCs project is expected to remove about ***4,867,640.98*** ton C/ in the next five years. Similarly, the biomass energy conservation activities through distribution of improved stoves and LPGs are expected to reduce ***973,497.3*** ton C carbon emissions during the period 2021 – 2025. In summary, table (9) provides total proposed estimates of Sudan forest-based NDCs in removals & reduction of GHG (mainly CO2) emissions during 2021 – 2025.

Table 3: Targeted afforestation areas along with their expected carbon removal and costs

Year	Target area (ha)	Total Ton C / ha/yr	Total removal (Ton Co2e / yr)	A/R Cost ha/USD	Cost (USD)	SGDs-Relevance	Contribution to Gander
2021	314000	1.64	514960	422.4	132633600	Goal 1,2,3,6,7,13,15	Youth- based Investment
2022	314000	1.64	514960	422.4	132633600		Social Cohesion
2023	314000	1.64	514960	422.4	132633600		Job Creation (Men & Women)
2024	314000	1.64	514960	422.4	132633600		Gender Equity
2025	314000	1.64	514960	422.4	132633600		
Total of 5-years	1570000		2574800		663168000		

Source: MANR Reports

Table 4: Targeted Restoration's areas with their removal and cost

Year	Target area (ha)	Total Ton C / ha/yr	Total removal (Ton Co2e /yr)	A/R Cost ha/USD	Cost (USD)	SGDs-Relevance	Contribution to Gender
2021	273928.9	1.64	449243.396	422.4	189760410.5	Goal 1,2,3,6,7,13,15	Social Cohesion
2022	273928.9	1.64	449243.396	422.4	189760410.5		Youth-based Investment
2023	273928.9	1.64	449243.396	422.4	189760410.5		Job Creation (Men & Women)
2024	273928.9	1.64	449243.396	422.4	189760410.5		Gender Equity
2025	273928.9	1.64	449243.396	422.4	189760410.5		
Total of 5-years	1369645		2246216.98		948802052.4		

Source: FNC 2017; 2018; 2021

Table 5: Mangrove's targeted area with their removal and cost

Year	Target area (ha)	Total Ton C / ha/yr	Total removal (Ton Co2e /yr)	A/R Cost ha/USD	Cost (USD)	SGDs-Relevance	Contribution to Gender
2021	125	49.76	6220	250	31250	Goal 1,2,3,6,7,13,15	Social Cohesion
2022	100	49.76	4976	250	25000		Youth- based Investment
2023	100	49.76	4976	250	25000		Job Creation (Men & Women)
2024	100	49.76	4976	250	25000		Gender Equity
2025	100	49.76	4976	250	25000		
Total of 5-years	525		26124		131250		

Table 6: Targeted areas for planting *Acacia senegal* plantations under GAMS project with their expected removal and costs

Year	Target area (ha)	Total Ton C / ha/yr	Total removal (Ton Co2e / yr)	A/R Cost ha/USD	Cost (USD)	SGDs-Relevance	Contribution to Gender
2021	1500	1.64	2460	422.4	1039104	Goal 1,2,3,6,7,13,15	Social Cohesion
2022	2000	1.64	3280	422.4	1385472		Youth- based Investment
2023	2500	1.64	4100	422.4	1731840		Job Creation (Men & Women)
2024	3000	1.64	4920	422.4	2078208		Gender Equity
2025	3500	1.64	5740	422.4	2424576		
Total of 5-years	12500		20500		8659200		

Table 7: Total expected emission reduction of LPG and their costs

Year	Targeted No. of LPGs	Reduction %	Total Expected Reduction(Ton C /Year)	Unit Cost (USD)	Cost (USD)	SGDs-Relevance	Contribution to Gander
2021	1000	50%	190939.46	44.85	44850.00	Goal 1, 2, 3, 7,13,14, 15	Creation of Jobs (Men, Women & Youth)
2022	2000		190939.46	44.85	89700.00		Youth- based Investment
2023	3000		190939.46	44.85	134550.00		Gender Equity
2024	4000		190939.46	44.85	179400.00		
2025	5000		190939.46	44.85	224250.00		
	15000		954697.30		672750.00		

Table 8: Total expected emission reduction of improved stoves and their costs

Year	Targeted Improved Stove No.	Equivalent Reduction(Ton C /Year)	Total Expected Reduction(Ton C /Year)	Unit Cost (USD)	Total Cost (USD)	SGDs-Relevance	Contribution to Gander
2021	2000	0.94	1880.00	5	10000.00	Goal 1, 2, 3, 7, 13, 15	Creation of Jobs (Men, Women & Youth)
2022	3000	0.94	2820.00	5	15000.00		Youth- based Investment
2023	4000	0.94	3760.00	5	20000.00		Gender Equity
2024	5000	0.94	4700.00	5	25000.00		
2025	6000	0.94	5640.00	5	30000.00		
Total	20000		18800.00		100000		

Summary of Sudan's forest-based NDCs

Table 9: Total proposed estimates of Sudan forest-based NDCs in removals & reduction of GHG (mainly CO2) during 2021 – 2025.

	Total Expected CO2 Equivalent Removal by the four priority areas in 5 Years					
No.	**Priority Areas (Activities)**	**Total Expected CO2 Equivalent Removal in 5 Years**	**Cost (USD)**	**SGDs-Relevance**	**Contribution to Gender**	**References**
1	**Forest Restoration by FNC**	2246216.98	948802052.4	Goals 1,2,3,6,7,13,15	Social Cohesion, Gender Equity, Youth-based Investment	FRL (FNC 2021)
2	**Afforestation of 10% within Rain-fed Scheme**	2574800	663168000	Goals 1,2,3,6,7,13,15	Gender Equity, Social Stability, Youth-based Investment	FRL (FNC 2021)
3	**Blue Carbon – Mangrove forests**	26124	131250	Goals 1,2,3,6,7,13,15	Social Stability, Gender Equity, Youth-based Investment	(IPCC, 2006; Afefe et al., 2020)
4	**SFM- Projects: A. Senegal stands**	20500	8659200	Goals 1,2,3,6,7,13,15	Social Stability, Gender Equity, Youth-based Investment	FRL (FNC 2021)
	Total	***4,867,640.98***	***1,620,760,502***			
	Total Expected CO2 Equivalent Reduction by biomass energy conservation activities in 5 Years					
5	**Energy Conservation**	973497.3	772750	Goals 1, 2, 3, 7, 13, 15	Creation of Jobs for Women &Men, Gender Equity, Social Stability	FRL (FNC 2021)

4.5. Challenges & obstacles of implementing Forestry Sector NDCs:

Siddig (2014) and Siddig et al (2019) have provided comprehensive analysis to the challenges face the forest sector in Sudan as related to planning, governance, information gaps, and funding which we can reiterate them in the following:

1) Forest's management programs are limited and not fully addressing the related fields (e.g. Carbon trade & biodiversity conservation).
2) Budgets to implement the national strategies of forest sector are limited.
3) Absence of rigorous national plans for integrated land use and natural resources.
4) Awareness raising programs related to the importance of forest conservation and public engagement, need to keeping pace with modern technolog
5) Enforcement of the laws and legislations is not up-to-speed due to Lack of coordination and institutional arrangement
6) Wars and conflicts in some parts of the country are still present, hence forcing thousands of people to flee their home villages to seek shelters inside the forests and protected areas. These refugee camps have dramatically contributed to forest degradation.
7) Despite recent the presence of funding and international partners, however synergies between these projects is very limited,
8) Shortage in equipment and use of technology as well as limited training opportunities.
9) Data management, networks and information gaps.

5. Conclusions & Recommendations:

The three priority areas of contributions were suggested by FNC as its nationally determined contributions (NDCs) to mitigate climate change impacts. Four of the proposed contributions are intended to remove atmospheric carbon while one of the proposals, is centered on reducing carbon emissions from forest-based biomass energy.

According to the current status of the forest-related efforts the study recommends the following:

1. Urgent investigations and research need to be a central task to better inform forest resources contributions as removals to the persistent GHG influxes. Specific areas of study can be focused on identification of wood densities, carbon fraction, shoot-root ratio … etc. for the common Sudanese trees species.
2. Adoption of a robust estimation of tree biomass in a unit area (e.g. Species-biomass/hectare).
3. More attention needs to be given to the Mangrove forests by demarcation and estimation of its carbon equivalent per unit area is needed.
4. Improvement of forest monitoring and evaluation system to determine Sudan's NDCs.
5. Strengthen national institutional arrangements for progression in NDCs preparation and implementation.

6. Rreferences & literature cited:

Adam, H.S. 2002.The agro-climatology, 2nd addition. Administration of Arabinization – University of Gezira. Gezira print press.

Afefe, A. A., Abbas, M. S., Soliman, A. S., Khedr, H. A., & Hatab, B. E. (2020). Tree biomass and soil carbon stocks of a mangrove ecosystem on the Egyptian-African Red Sea coast. *Fundamental and Applied Limnology*, 239-251.

Badri, S. 2012. Sudan environmental threats and opportunities assessment with special focus on biological diversity and tropical forests. A report conducted by the United States Agency for International Development (USAID).

Elsiddig, E.N.A., Mohammed, A.G., Magid, T.D.A., 2007. Sudan forestry sector review. Khartoum, Sudan.

FAO, 2006. Sudan National Forestry Policy Statement. Khartoum, Sudan

FAO. (2015). *Global Forest Resources Assessment 2015 - Desk reference*. Rome: Food and Agriculture Organization of United Nations. Retrieved from http://www.fao.org/3/a-i4808e.pdf

FNC (Forest National Corporation) (2021). Sudan's Forest Reference Level (FRL) report to UNFCCC, 2020

FNC (Forest National Corporation) (2016). Annual Forestry Report. General Directorate of Planning. Khartoum, Sudan

FNC (Forest National Corporation) (2017). Annual Forestry Report. General Directorate of Planning. Khartoum, Sudan

FNC (Forest National Corporation) (2018). Annual Forestry Report. General Directorate of Planning. Khartoum, Sudan

FNC (Forest National Corporation) (2020). Sudan National Forest Inventory. Final Report. Khartoum, Sudan

Funk, C., Eilerts, G., Verdin, J., Rowland, J., and Marshall, M., 2011. A Climate Trend Analysis of Sudan. Famine Early Warning Systems Network—Informing Climate Change Adaptation Series: U.S. Agency for International Development, Washington, D.C. Fact Sheet 2011–3072

Gadallah, N.A.H., 2018. Assessment of Sudan Forest Management Policies and Practices In Relation To Deforestation and Forest Degradation Drivers in Tozi and Wad Al-Bashir Forests. Pan African University, Life and Earth Sciences Institute, Nigeria.

Goda, S.2007.A forestation in Arid lands with particular reference to the Sudan. Desertification and desert cultivation studies institute (DADCSI) and UNESCO chair on desertification studies – University of Khartoum.

Harison and Jackson. (1958). *Ecological Classification of Vegetation*. Khartoum, Sudan: The Sudan Agricultural Publications Committee.

HCENR- Higher Council for Environment and Natural Recourses (2009). *Sudan's Fourth National Report to the Convention on Biological Diversity*. Khartoum, Sudan.

HCENR- Higher Council for Environment and Natural Recourses (2020). Sudan National Greenhouse Gases Inventory Report of Sudan. Khartoum, Sudan

Hosonuma, N., Herold, M., De Sy, V., De Fries, R. S., Brockhaus, M., Verchot, L., … Romijn, E. (2012). An assessment of deforestation and forest degradation drivers in developing countries. *Environmental Research Letters*, *7*(4), 1–12.

IFAD (2019). International Fund for Agricultural Development/ Global Environment Facility (IFAD/GEF) Project on Integrated Carbon Sequestration Project. Khartoum, Sudan

IPCC (2006). IPCC Guidelines for National Greenhouse Gas Inventories: Vol. 4. Agriculture, Forestry and Other Lan Use. Hayama, Japan: IPCC/IGES

IPCC, 2013: Climate Change 2013: The Physical Science Basics Contribution of Working Group I to the Fifth Assessment Report of Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.

Karr, J. R., 1981. Assessment of biotic integrity using fish communities. Fisheries 6: 21-27.

Mustafa. M. A. 2007.Desertification processes. Desertification and desert cultivation studies institute (DADCSI) and UNESCO chair on desertification studies – University of Khartoum –University of Khartoum press.

Siddig, A. A. H., T. D. Abdel Magid, H. M. El-Nasry, A. I. Hano, and A. Awad. 2019. Biodiversity of Sudan. In Pullaiah, T. Global Biodiversity, Volume 3. Selected countries in Africa. Apple Academic Press, distributed by CRC Press.

Siddig, A. A. H. 2014. Biodiversity of Sudan: between the harsh conditions, political instability and civil wars. Biodiversity Journal. 5 (4): 545–555.

Taha, M. E., T. Bekele, and F. Siddig. 2014. Participatory management of natural community forests: the case of El Ain natural forest management project, North Kordofan, Sudan. American Journal of Research Communication. 2(1):212 -233.

UNCCD . 1994. United Nation Convention on Combating Desertification, Rio De Ganero. Article III

UNEP .2013. Africa Environment Outlook 3: Summary for Policy Makers. ISBN: 978-92-807-3315-0. Job No.: DEW/1629/NO.

Zakieldeen, S. A. .2009. Adaptation to Climate Change: A Vulnerability Assessment for Sudan. The gatekeeper series of the Natural Resources Group at the International Institute for Environment and Development (IIED). No. 142, November 2009.