Kondowa Forest
The forest was exist in 2008

Kondowa Forest
The forest completely converted to crops by displaced people in 2010

The Republic of Sudan
Ministry of Agriculture and Forests
National Forest Corporation

Reducing Emissions from Deforestation and Forest Degradation (REDD+) Readiness Program

In-depth analysis
of Drivers of Deforestation & Forest/Range Degradation

Hassan & Tag Consultants
Khartoum
January 2018

Consultancy report prepared by **Hassan and Tag Consultants**, under the Sudan's National UN-REDD+ Programme

Contacts

Hassan & Tag Consultant, P.O. Box 8116, Amarat-Khartoum, The Republic of Sudan. Telephone: +249 900908187

Email: salil34calotropis76@gmail.com ; hassanour@hassantagconsultants.com

Contributors to the Report

#	Consultant	e-mail
	Professional Staff Consultants	
1	Prof. Hassan Osman Abdelnour	salil34calotropis76@gmail.com
2	Prof. Tag El Sir Ahmed Mohamed	tagahamid@hotmail.com
3	Dr. Abdel Latif A. Mohamed Egeimi	Ijaimi2000@yahoo.com
4	Prof. Babo Fadla Alla Dafa Alla	babo_f@yahoo.com
5	Dr. Ismail Abdel Rahim El Gizouli	ismailelgizouli@gmail.com
6	Dr. Mutasim Bashir Nimir	mutasimnimir2002@yahoo.com
7	Adil Mohamed Ali Sid Ahmed	Sanjak1955@yahoo.com
8	Prof. Ms. Salwa Mansour Abdel Hameed	s.abdelhameed2016@gmail.com
9	Ahmed Hanafi Abdel Magid	ahamagid@gmail.com
10	Dr. Waleed Mohomed El Amin Mutwali	melwaleed@yaoo.com
11	Dr. Taib Saeed Mohamed Ganawa	ganawagis@gmail.com
12	Dr. Mohamed El Gamri Atta El Mannan	melgamri@gmail.com
13	Dr. Hanan El Hadi	hananelhadi@yahoo.com
14	Fath Al Aleem Mohi El Deen	Mohiedeen2000@yahoo.co.uk
	Collaborator consultants	
1	Dr. El Siddig Mohamed Ali Faris	
2	Hassan El Amin Hassan	hassanibrahim098@gmail.com
3	Mustafa Yousif Mudawi	
4	Ms. Muna Mohamed Rakhi	

Foreword

During the UNFCCC COP-13 in Bali, the international community has called upon countries to explore the concept of reducing emissions from deforestation and forest degradation (REDD). Recently, the concept has been expanded to include conservation of forest carbon stocks, sustainable management of forests and enhancement of forest carbon stocks (REDD+). In this context, the Republic of Sudan considered the REDD+ mechanism to be a priority area for development in the conservation and management of forest resources and rangeland in the country and the government in collaboration with a wide range of key stakeholders has established the Sudan National REDD-Plus Program (SNRP).

To support the implementation of the SNRP particularly the REDD-plus readiness phase, the Republic of Sudan has received a grant through the Forest Carbon Partnership Facility of the World Bank to support Sudan in preparing for the implementation of its National REDD+ Programme.

In line with the country's efforts towards forest conservation and the development of appropriate policy and instruments for pursuing REDD-plus as foreseen under the SNRP, the Project supported the conduct among others of a study of the analysis of drivers of deforestation and forest degradation. Such study could provide appropriate information to policy makers and other stakeholders at local and national levels to look deep into the drivers of deforestation and forest degradation to reduce its negative impacts of Climate Change through mitigation and adaptation.

We would like to extend our deep appreciation to Hassan and Tag Consultants® and the study team from different related institutions who have been involved in the study for their tireless efforts in gathering data, interviewing relevant stakeholders, analysing data and information and preparing the excellent and comprehensive report that is envisaged to contribute to a better understanding of key drivers of deforestation and forest degradation in the Republic of the Sudan.

Dr. Mohamed Ali Elhadi   Dr. Sayeda Ali Khalil

FNC General Manager   SNRP Coordinator

Acknowledgements

Contents

List of Tables

List of Figures

Executive Summery

The area of the Republic of Sudan (RoS) decreased from 2.5 million km² to 1.88 million km² after the cessation of South Sudan (SS). Out of this remaining area 50.7% is bare rocks and soil and/or other unconsolidated materials (BS). The remaining area consists of agriculture (AG, 12.6%; trees closed-to-sparse in terrestrial and aquatic/ regularly flooded land (TCO, 10.0 %); shrubs closed-to-sparse in terrestrial and aquatic/ regularly flooded land (SCO, 11.8 %); herbaceous closed-to-sparse in terrestrial and aquatic/ regularly flooded land (HCO, 13.8%); urban areas (URB, 0.4%); and seasonal/perennial, natural/ artificial water bodies (WAT, 0.7 %). Forest/Rangeland area which is represented by TCO, SCO and HCO amounts to (35.6%) of the present area of Sudan or 669,472 km²,

RoS's forest cover has declined from 76.4 million hectares (ha) in 1990 to 70.49 million ha in 2000 and 69.95 million ha in 2010 (30.5% to 28.1% and 27.9% of the country total area, respectively (FRA, 2010). For the period 2000-2008 the estimated area of actual forest loss was 907,599 ha/year. The great loss in both categories paved the way to land degradation and diminution of water resources at country level.

Assessing drivers of Deforestation and Forest/Range Degradation is essential to design and implement policies to slow down deforestation and forest degradation in the country.

The RoS formulated its National REDD-plus program (SNRP) in 2012 which indicates that drivers of deforestation and forest degradation need to be identified at national, State and local level to inform policy reform, conservation interventions and financial feasibility of reducing emissions from deforestation and forest degradation (REDD+) in the country.

RoS's national REDD+ program provided financial support of the REDD-plus readiness activities including the conduct of four strategic studies. One such study was on "Analysis of Key Drivers of Deforestation and Forest Degradation in the Sudan'' as basis for conservation interventions and feasibility of REDD-plus in the country.

This study aimed at in-depth analysis of Drivers of Deforestation & Forest Degradation with focus on:

- Analysis and assessment of underlying causes of deforestation and forest degradation and develop a strategic agenda and differentiated recommendations to address the various drivers of deforestation and forest degradation in RoS,
- The review of legal, policy and political economy considerations, as well as review of agriculture, forestry and other land uses,
- Review of forest governance and related issues, including traditional customary land ownership and usage,
- Describe, quantify and analyze the production, processing and utilization of wood-based fuel and the potential for alternative fuels and a more efficient fuel use, in a spatially disaggregated context.

In conducting the study, the Consultant adopted a Consultative, Participatory, Interactive Methodology & Approach, endorsed by the Sudan's National REDD+ Program Authority. The Methodology encompassed a mix of quantitative and qualitative data collection from secondary as well as primary sources. The primary data was to complement, and bridge identified gaps in secondary data.

The primary data sources included direct field observations through field visits to deforestation & forest degradation hotspots, focus group discussions and consultation meetings with key stakeholders, key informants including community, tribal and local leaders and key project staff and relevant counterparts at the federal and State levels who are involved in the program implementation. During discharging the study, the Consultant planned and organized fifty-two (52) Consultative, Interactive, Awareness-raising & Whistle-blowing sessions together with some three direct, targeted, tailor-made training sessions.

The secondary sources encompassed historic and contemporary relevant reports & studies by national, regional & international organizations and bodies as portrayed in Bibliography of data & information sources consulted.

Analysis of secondary data and key informant interview revealed that the Proximate /Direct drivers of Deforestation encompass a set of broad categories including:
- Commercial Agriculture Principally Large-Scale, Mechanized Rainfed Farming, together with Irrigated forms of Agriculture,
- Urban Sprawl,
- Infrastructure Development,
- Petroleum Exploration,
- Mining,
- Refugees & Internally Displaced People (IDPs)

It is also revealed that the direct causes of Forest/Range Degradation encompass unsustainable extraction of wood including legal, illegal and selective logging for energy & other uses, Overgrazing; Insecurity and Biotic (man, animal and insect) or A-Biotic (Drought spells, Fire, Wind and Floods) destructive agents

Such findings indicated that the main underlying causes of deforestation & range depletion include rapid human & animal population increase and the associated growing demand for land and energy, subsistence agriculture, legal and institutional gaps including lack of stable and equitable forest tenure, lack of stakeholder participation in forest management and benefit-sharing schemes and weak law enforcement,

Cross-cutting underlying causes identified and summarized by the study into two main Groups
- Natural Environmental Factors (natural disturbance) such as Climate Change, flood, wind & Desertification,
- Socio-economic Factors such as Poverty and landlessness

The local communities were able to identify the major drivers of deforestation and forest/Range degradation as follows

- Agricultural expansion is the major cause of deforestation and forest degradation.

- Extraction of wood for energy

- Drought

- Overgrazing

- Fire

♦ Lack of awareness 0.8%.

A ranking of relative importance of drivers of deforestation and forest/range degradation done by key informants revealed that expansion of agriculture is the most important driver followed by Urban Sprawl and Infrastructure Development with gross impact of 40%, 15% and 15% respectively. The gross impact of mining is estimated to be 10% Oil exploration 10% and Refugees & IDPs 10%. Ranking done by local community indicated that, expansion of agriculture is the most important driver followed by energy consumption, overgrazing, drought, fire, lack of awareness and infrastructure respectively

The study recommends policy agenda that include: revision and harmonization of existing policies & legislations of relevant land-using sectors, formulation a fresh, passing and promulgation of polices in sectors that lack policies such as Range, Wildlife, Water Resources, Migrants, Refugees and Internally Displaced People, sustainable management of forests and range resources and conduct of studies to ascertain interaction/dependency of forest/range dependent communities on specimen neighbouring resources. The recommendations also encompass adoption of sustainable animal production, environmentally-friendly energy policies and comprehensive population, town and infrastructure planning policies.

Operational recommendations posed by the present study include recommended remedial action & agencies envisaged to address such actions. These actions include the following:

- ➤ Transformation of the agricultural sector particularly the rain-fed thereof through improvement of land tenure,
- ➤ Technology promotion, applied research, targeted financing and institutional reforms,
- ➤ Enhancement of agricultural productivity and availing alternative income generating sources for rural communities
- ➤ Extraction of lessons learnt and replication of best practices,
- ➤ Decentralization and division of authority of management of and sharing of revenue & other benefits from the entire Natural Resources Sectors,
- ➤ Continuous updating of the country's database of forest cover and land use,
- ➤ Mainstreaming of anti-corruption efforts at all levels.
- ➤ Collate efforts to consolidate social peace and resolve territorial and other conflicts in RoS,
- ➤ Revision of Sudan national forest programme (nfp) to pigeonhole all aspects of natural and other resources including National Forest Programme, National Forest Inventory and Forest Policy Statement.
- ➤ Address Legal & Institutional Gaps and shortcomings in the context of legal Reform within the sought nfp Revision

In conclusion, Deforestation and Forest/Range Degradation is a complex process with many drivers operating at all levels and different sectors in RoS and most of these drivers are outside the forest sector. Therefore, cross-sectoral commitments will be essential to address these drivers through the implementation of suggested interventions to reduce pressures on forest and range resources and slow the rate of deforestation and forest/range degradation in the future

Abbreviations & Acronyms

Abbreviation	Term
AOAD	Arab Organization for Agricultural Development
bnm³	Billion Cubic meters
BADEA	Arab Bank for Development in Africa
COMESA	Common Market for East & Southern Africa
CPA	Comprehensive Peace Agreement
CSOs	Civil Society Organizations
FAO	Food & Agriculture Organization of the United Nations
FNC	Forests National Corporation
FRA	Forests Resources Assessment
GDP	Gross Domestic Product
GoS	Government of the Sudan
ha	Hectare
HRWS	High Rainfall Woodland Savannah
IFAD	International Fund for Agricultural Development
IGAD	Intergovernmental Agency for Development
ILO	International Labor Organization
IMF	International Monetary Fund
Km²	Square kilometer
NGOs	Non-governmental Organization
NWFPs	Non-wood Forest Products
masl	Meters above sea level
Mha	Million hectares
OWL	Other Wood Land
REDD+	Reducing Emission from Deforestation & Forest Degradation Plus
RoS	Republic of Sudan
RoSS	Republic of South Sudan
SECS	Sudanese Environment Conservation Society
SNRP	Sudan National REDD+ Program
TOE	Tons of Oil Equivalent

Background

The Republic of Sudan

Geographic Characteristics:

Located in North Eastern Africa, The Republic of Sudan (RoS) is bound by Egypt, The Red Sea, Eretria, Ethiopia, Republic of South Sudan (RoSS), Central African Republic, Chad and Libya. (Maps 1, 2,3). The total area is   1, 886,068 km².

Map 1. Geography & Natural Features the Republic of Sudan.

The highest point in the country is Jebel Marra; 3,024 meters above sea level (masl.). The lowest is the Red Sea; 0.0 masl. 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.

Administration:

As of 2017, Sudan is administratively arranged into 18 States (Wilayat; singular Wilayah). Wilayat are further divided into localities (provinces). Each Wilayah is governed by an

elected Legislature and an elected Wali (Governor), assisted with a cabinet of 5-8 appointed ministers. Each locality is governed by an appointed Commissioner and an elected legislature. RoS Wilayat are as in Map (2).

Map (2) RoS Wilayat (States) 2017. Source: World Atlas, courtesy Dr. T.M.S. Ganawa

Population

In population terms, Sudan in 2016 ranked 35th, 3rd and 9th globally, in Arab and African terms respectively. At an annual growth of 2.8%, total population is projected by Central Bureau of Statistics to be 35.1 million, 38.4 million and 40.8 million in 2012, 2015 and 2017 respectively. This is an increase of more than 16 folds in 11 decades as it was around 2,000,000 in 1900. Some 30% of the population live in urban areas and 63% in rural areas. The remaining 7% live a nomadic lifestyle. About 71% of all males are literate which is the case for only 51% of women. Overall life expectancy is 59 years, being 58 years for men and 61 years for women. 43%, 53% and 3% of the population are in the age groups of 14-0, 65-15 and 65+ respectively.

Sudanese women obtained the right to vote, equal pay & pension for equal job and right of election in 1953, 1964 and 1964 respectively. They were the first to hold judiciary, ministerial & governor posts in Africa.

Economic situation:

Sudan is overwhelmingly an agricultural country. Much of farming is of subsistence kind. Agriculture occupies some 70% of the workforce but contributes 35% of the GDP. The government plays an important role in planning the economy. The leading export crops are sesame, groundnuts, cotton and sugar. Sheep, cattle, goats and camels are raised. Sudan has the largest livestock inventories in Africa next to Ethiopia. Good natural pastures cover almost 75 million feddans[1] and the nomadic pastoral sector accounts for more than 90% of the huge animal population.

Cattle, sheep and goats provide an important capital asset and a risk management tool for

pastoralists and farmers at times of drought. A variety of forest products are produced, by far the most being gum Arabic with Sudan accounting for much of the world production.

Sudan began exporting crude oil in 1999.Until the second half of 2008, Sudan's economy boomed on the back of increases in oil production, high oil prices and large inflows of
……………………………
[1]. Feddan= 60X70 meters=4200m²
Foreign Direct Investment. GDP growth registered more than 10% per year in 2006 and 2007. From 1997 to date Sudan has been working with the International Monetary Fund (IMF) to implement macroeconomic reforms including managed floating of the exchange rate. The Darfur conflict, the aftermath of two decades of civil war in the South and the lack of basic infrastructure in large areas are the most pronounced impediments to economic stability. On November 3rd, 1997, the US Government imposed trade embargo against Sudan and a total asset freeze[1]. On October 12th, 2017, the US Government issued an Administrative Order, partially lifting economic sanctions,

Sudan is a LDC that has had to deal with social conflict, civil war, and the July 2011 secession of South Sudan - the region of the country that had been responsible for about two-thirds of the former Sudan's total oil production. Following South Sudan's secession, Sudan has struggled to maintain economic stability, because oil earnings now provide a far lower share of the country's needs for hard currency and for budget revenues. Sudan is attempting to generate new sources of revenues, such as from gold mining, while carrying out an austerity program to reduce expenditures. Services and utilities have played an increasingly important role in the economy.

Table 1: Summary of the value of Republic of Sudan's oil & non-oil exports (2012-2015)

Commodities	2012		2013		2014		2015	
	M$	%	M$	%	M$	%	M$	%
Oil Product	**955**	**23.5**	**1,717**	**35.8**	**1,254**	**28.8**	**627**	**19.8**
Non-oil products			**3,073**	**64.2**	**3.096**	**69.5**	**2,542**	**80.2**
Metal Goods			1,067	22.3	1.307	29.4	753	23.8
Gold	**2,158**	**53.1**	1.084	21.9	1.271	28.5	726	22.9
Other metals			19	0.4	36	0.8	27	0.9
Livestock	447	11.0	682	14.2	857	19.7	910	28.9
sheep	286	7.0	478	10.2	550	12.6	493	15.6
camels	62	1.5	98	2.1	208	4.9	260	8.2
goats			11	0.2	22	0.5	30	0.9
Other livestock products			96	2.0	77	2.3		
Agricultural products	33.8	8.5	863	18.0	664	15.3	834	26.3
Gum Hashab	44	1.1	93	1.9	62	1.4	66	2.0

Commodities	2012		2013		2014		2015	
	M$	%	M$	%	M$	%	M$	%
Gum Talh	23	0.6	42	0.9	35	0.8	40	1.3
cotton			103	2.1	34	0.8		
sesame			472	9.9	446	10.7	453	14.2
Manufactured goods			155	3.2	41	0.9	22	0.7
Others			306	6.4	30	0.7	**23**	0.7
Total	4,067	100	4.790	100	4.350	100	3,169	100

Source: Central Bank of Sudan, Sudan Customs Authority, Ministry of Petroleum

Forests play a significant role in integrated land use systems in RoS 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) 77% is rural & nomadic and considered as forest-dependents for livelihoods, wood energy and on round timber for buildings. Contribution of forests sector to the national economy is under-estimated where the formal national accounts indicate an under-estimation of the forestry sector contribution 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 m3/annum which, when converted into Ton/Oil Equivalent (TOE), could be valued at nearly 2.0 Billion US dollars. Moreover, NWFPs are diverse and have substantial contribution in the livelihoods at the household level and at the national economy. Table (1) only portrays the proceeds from the sale of wood from forest reserves and royalty levied on products from outside forest reserves. The table does not refer to revenues from the annual export of 50-60 thousand tons of Gum Arabic, which averaged US$ 74.4 million per year over the period 2008-2013 making up 2.4% of total non-oil exports and 0.7% of total exports.

Income generation from forests in Sudan include income at the government level (federal, state and local), household and investment organization at the private sector. Various sources of income generation presently under government control can be listed including direct sales of wood products such as fuel wood, construction timber and sawn timber. Sudan forests produce diversity of NWFPs that constitute potential sources for industrial development for local use and for export. At local level, cottage industry is recognized at many households. Cottage industries could make up to 20-50% of rural household income, amounting to some US$ 1 billion a year. Traditional cottage industry supplies the market with many products that are attractive to tourists.

The contribution of forests and rangelands 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 consider:
- The value of total consumption of the country of wood at 0.73 m² 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 106 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.

Water Resources:

Total water resources are estimated at 30.8 billion cubic meters (bnm³)- (Table 2)
Average River Nile Discharge Central Sudan: 93 bnm³,
Sudan's Share of Nile Waters as per 1959 Nile Water Treaty: 18.5 bnm³,
Average annual precipitation: 400.00 bnm³
Renewable ground water: 4.02 bnm³
Average other water sources (Khors & wadis): 6.00 bnm³

Land-use:

Arable land: 200 million feddans' (84 million ha): Stable, cash and export crops: Sorghum, wheat, millet, cotton, cane sugar, ground nuts, sesame, dates, sunflower, citruses, tropical fruits and vegetables.
Irrigated cropped land: 11 million feddans (4.6 million ha),
Rain fed cropped land: 29 million feddans (12 million ha),
Forests, wood and rangelands: 67 million ha (669 471 km²)
Green area per capita: 1.68m²/person.

Table 2: Water sources and usage

River	Water Consumption	
	Source	Annual Yield bnm³
Blue Nile	River Nile	15.0
White Nile	Renewable Ground water	1.2
Atbara River	-Used in Agriculture	0.7
Rahad River	-Used for drinking	0.5
Dinder River	Khors & wadis	2.5
Total	Total	18.7

Source: Sudan, Land of Opportunities (2011)

Agriculture:

Although most of the country is arid, the economy has predominately depended on the agricultural sector, including livestock production, forestry and fishing. Together, they used to contribute about half of the GDP before the discovery & exploitation of oil in 1999. Despite the emergence of Sudan as an oil exporter and the diminishing share of agricultural sector in overall export earnings, agriculture continues to be the backbone of the country's economy in terms of its contribution to GDP. The sector contributed on average about 34

percent of the country's GDP from 2009 to 2013. While ranging from 32.2 to 34.4 percent over that period, the largest share of agricultural GDP was derived from livestock production (47 percent), followed by large-scale irrigation (28 percent), traditional rain-fed farming (15 percent), forest products (7 percent) and semi- mechanized farming (3 percent).

It contributed around 35% during the years 2007-2010; in comparison to about 60% contributed by the petroleum sector. Agriculture also remains the main source of employment as about 70% of the work force is employed in agriculture and related activities such as agro-industries, transport and trade and the main source of household income in rural areas where 70.2% of the population live,

Farming systems have evolved mainly as a function of agro-ecological conditions, acquired technology, market and socio-economic conditions. Crop production is practiced in three main farming systems, namely: irrigated, mechanized rain-fed and traditional rain-fed.

Forestry in the Sudan:
Following the Battle of Omdurman at Karare between the Mahdist and the Anglo-Egyptian army, and the start of Condominium Rule in 1898, forestry activities started in the Sudan in 1901. The Government commissioned an Indian forester, Mr. C.E. Moriell to tour the country and produce a report about the state of forests in the country. Based on his report, 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.

Civil war erupted in South Sudan in August 1955, barely four months before independence in January 1956. The Addis Ababa Accord of 1973 which was reached to stop the civil strife in the South created three ministries for agriculture; one in each of the three provinces of South Sudan, for which the forest sector was added. Since then forestry matters formally went out of the jurisdiction of the Central Government and Director of Forests in Khartoum.

Benefits of Forests & Rangelands in RoS:
Forestry institutions namely Forests Service, Forestry Research & Forestry Education came into being and subsequently developed on the understanding that forests, woodlands, rangelands, tree formations and individual trees in the country render tangible and non-tangible benefits, towards the welfare and enhancement of peoples' livelihoods. These benefits were later expressed as productive and protective functions. Box 1.

Box 1	Benefits of Forests & Rangelands in RoS
Forests and rangelands in RoS have significant protective and productive functions and as such offer many opportunities to contribute to the economic, environmental and social development of the country. As such, they can contribute to poverty alleviation and the enhancement of the well-being of people living near forest and of the country at large. Protective functions of forests, trees and rangelands in Sudan encompass their safeguard of	

watersheds; protection & amelioration of soil; shielding of agricultural systems; habitat for livestock & wildlife and shelter to human settlements.

Productive functions of forests, trees, shrubs and rangelands in the country include provision of wood and NWFPs.

Wood products include lumber, sawn timber, industrial wood, building poles, firewood and charcoal.

NWFPs on the other hand include a wide range of products such as browse & range material; ivory; bush meat; bee-honey & wax; gums & resins; bark derivatives such as tanning material; fruits, nuts & seeds such as Gonglais (fruit of Tabeldi=Boabab-*Adansonia digitata*), Goddeim (fruits of *Grewia tanix*), Aradaib (fruit of *Tamarindus indica*), Lalob= Desert dates (Fruit of *Balanites aegyptiaca*), Dom (fruit of *Hyphane thebaica*), Dolaib (Fruit of *Borassus aethiopum*) and Nabag (fruit of *Ziziphus spina-christi*) together with medicinal plant parts such as Senna pods & leaves (*Cassia sennna*), Garad pods (of *Acacia nilotica*).

Products from forest tree leaves include robes, baskets, mats, food covers and hats made from Dom and Doleib fronds together with bark of Tabeldi.
Range products include browse and grazing material from thorny trees & shrubs together with thatching material and food covers from Banu (*Eragrostis* spp).

Productive Functions:
Productive functions of forests, woodlands, rangelands, tree formations and individual trees in RoS include provision of Wood and Non-wood Forest Products (NWFPs),

Wood products:
Include lumber, sawn timber, industrial wood, building poles, firewood and charcoal. Sudan is well endowed with valuable timber trees. Examples include Sunut (*Acacia nilotica*), which grows on the banks of rivers and is suitable for railway sleepers, building material & firewood. Many indigenous species such as Mahogany (*Khaya senegalensis*), Gimbeel (*Cordia africana*), Humeid (*Sclerocarya birrea*) and exotic species such as Teak (*Tectona grandis*), Sarru (*Cupressus lusitanica*) provide high-quality wood for joinery and construction. Tree species with wood most suitable for firewood and charcoal making include: Heglig (*B. aegyptiaca*, Kittir (*A. mellifera*), Talh (*A. seyal*) while Sunt (*A. nilotica*) wood is excellent as firewood but poor for charcoal-making.

Non-wood Forest Products:
NWFPs on the other hand include a wide range of products such as browse & range material, bush meat, bee-honey & wax, gums & resins, bark derivatives such as tanning material, fruits, nuts & seeds such as Gonglais (fruit of Tabeldi syn.Boabab-*Adansonia digitata*), Goddeim (fruits of *Grewia tanix*), Aradaib (fruit of *Tamarindus indica*), Lalob syn.Desert dates (Fruit of *Balanites aegyptiaca*), Dom (fruit of *Hyphane thebaica*), Dolaib (Fruit of *Borassus aethiopum*) and Nabag (fruit of *Ziziphus spina-christi*) together with medicinal plant parts such as Senna pods & leaves (*Cassia sennna*), Garad pods (of *Acacia nilotica*),

Protective Functions:

Protective functions of forests, trees and rangelands in RoS encompass their safeguard of watersheds & courses, protection & amelioration of soil, shielding of agricultural systems, habitat for livestock & wildlife and shelter & recreation to human settlements.

Ecological classification of the vegetation of Sudan:
The soil in about 60% of the country, particularly in the northeast, north and northwest is predominantly sandy. Heavy cracking clay soils form a triangular in the central eastern plain which makes some 25% of the country. Red soils of different types are characteristic of the remaining south-western portion. The rainfall varies from zero in the northern desert to more than 1,200 mm in the High Rainfall Woodland Savannah (HRWS) in the south-western portion of the country,

The vegetation of the Sudan has been ably described by Harrison and Jackson (1958) and the following account is largely based on this work with some modifications based on several works such as Agriculture in the Sudan, Arabic version (Anon 1999), a study on sustainable modern technologies for Forest Resources Development in the Arab Region, Arab Organization for Agricultural Development (AOAD 1998), and Wickens (1991),

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. This classification encompassed the old Sudan, which in 2011 separated into two brother countries: The Republic of Sudan (RoS) (Map 1) and the Republic of South Sudan (RoSS), (Map 2). The vegetation classification, forest extent and estate in the two brother countries can be extrapolated by super imposing the map of Harrison & Jackson's 1958 on the maps of the two countries (AbdelNour 2011). Table (3),

The effect of the topography on vegetation is limited and confined to mountain massifs, hills, upland country and Nile Valley and its tributaries (Map 3).

Legend

Ecology_vegetation_types_

- BUSHLAND AND THICKET
- DESERT
- EDAPHIC GRASSLAND MOSAICS
- FOREST TRANSITIONS AND MOSAICS
- GRASSLAND
- SEMI-DESERT VEGETATION
- WOODLAND
- WOODLAND MOSAICS AND TRANSITIONS

Kilometers
0   90   180   360   540   720
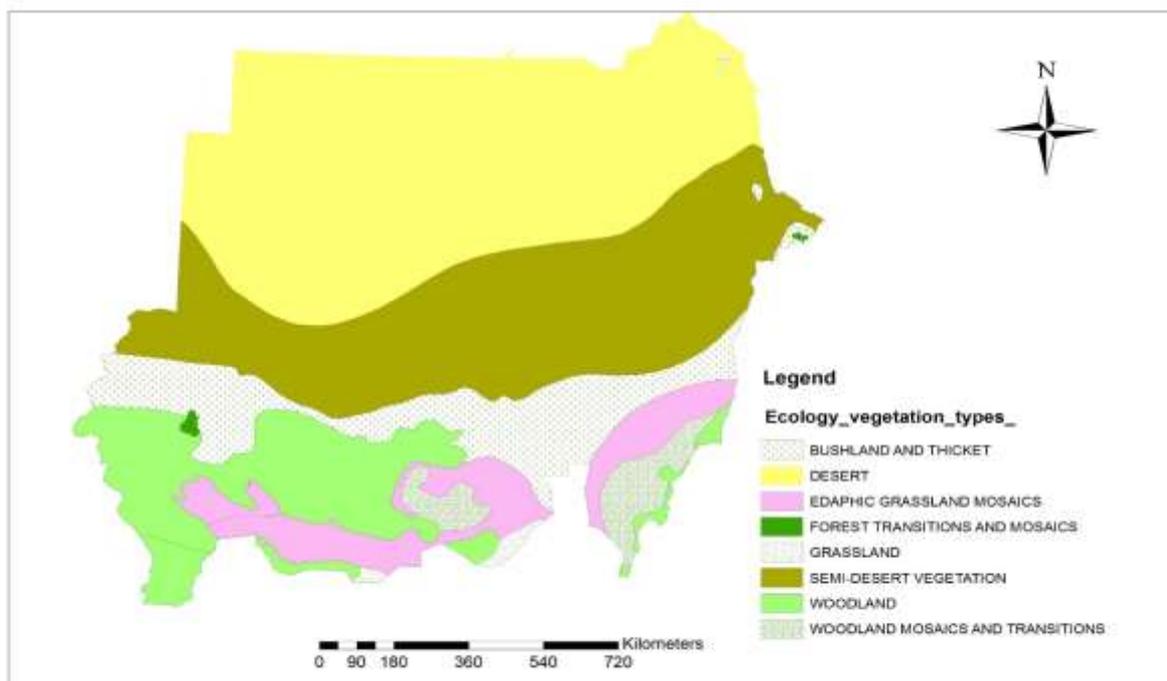
Map 3. Ecological Classification of Vegetation of Republic of Sudan

Biodiversity of Sudan:

Sudan is endowed with a wide range of ecosystems and species diversity. The ecological zones extend over a wide range from the desert in the extreme north to the forests in the south, in addition to the freshwater and marine and coastal environments.

There are some 184 species of trees and shrubs including 33 exotics together with a few endemic and near endemics. Special areas with a wealth of rare species are found in the Red Sea Coast and the tropical rain forests in the south west. About 704 range species were identified. Most of the wildlife resources of the country are to be found within the HRWS. Recent surveys indicated that there despite losses and disturbance to wildlife in the region due to wars and civil strife there remain substantial numbers of migratory wildlife between RoS and neighbouring countries particularly Ethiopia, RSS and Central African Republic.

Fire is a serious problem in all forest, range and wildlife areas except the semi-desert area where the grass is sparse and the small areas of the moist closed forests in the South West.

Table 3: Ecological Classification of vegetation in the Republic of Sudan (RoS)

	Major Division	**Subdivisions**	
I.	Desert		**716.8**
II.	Semi-Desert	1.*Acacia tortilis - M. crassifolia* Scrub	184.3
		2.Semi-Desert Grassland on Clay	102.4
		3. Semi-Desert Grassland on Sand	84.5
		4.*Acacia mellifera – Commiphora* Scrub	84.5
		5.*Acacia glaucophylla – Acaica etbaica* Scrub	30.7
		Total	**486.4**
II.	Woodland Savannah	A. Low Rainfall	
		1. On Clay	
		(a) *Acacia mellifera* – thorn land	
		(i) Dark cracking clays alternating with grass	94.7
		(ii) On soils formed *in situ*, with *Commiphora* and *Boscia*	51.2
		(b) *A. seyal* – Balanites savannah alternating with grass areas	100.1
		(c) *Anogeissus-Combretum hartmannianum S.* Woodland	48.6
		Total on Clay	**294.6**
		2. On Sand	
		(a) Acacia seyal savannah	64.5
		(b) Combretum hartmannianum- Albizzia sericocephala-Dalbergia savannah woodland	84.5
		(c) Terminalia - Sclerocarya - Anogeissus -	63.2

	Major Division	Subdivisions	
		Prosopis savannah woodland	
		Total on Sand	**212.2**
		3.Special Areas	
		(a)Toposa Hills	-
		(b)Hill Catenas	69.1
		(c)Baggara Catena	17.9
		(d)Raqaba Catena	31.6
		Total Special Areas	**118.6**
		Total Low Rainfall Woodland Savannah	**625.4**
		B. High Rainfall	
		(a) *Anogeissus – Khaya – Isoberlinia* Savannah woodland	30.7
		(b) Woodland savannah recently derived from rain forest	-
		Total High Rainfall Woodland Savannah	**30.7**
IV.	Flood Region		**7.3**
V.	Montane Vegetation		**3.8**
	Total Area		**1850.2**

Table 4:Percent-wise coverage of Forests & Woodlands in The Republic of Sudan (2011)

Desert	Semi Desert	LRWS		HRWS	Special Areas	Montane	Flood Region	Total
		Clay	Sand					
38.6	26.2	15.9	11.4	0.9	6.4	0.2	0.4	100
Arid				Sub-humid			Humid	
92.1				7.5			0.4	100

Objectives of the study

The study had the following objectives:
   a) Analytical studies to deepen the analysis of the drivers of deforestation and degradation in The Republic of Sudan, including review of legal, policy and political economy considerations, as well as review of agriculture, forestry and other land uses;
   b) Review of forest governance and related issues, including traditional customary land ownership and usage. It is to provide an overview of the factors influencing decision-making regarding forest and land use. It is also to establish a baseline against which forest governance can be assessed and monitored during REDD+ implementation.
   c) Describe, quantify and analyze the production, processing and utilization of wood-based fuel and the potential for alternative fuels and a more efficient fuel use, in a spatially disaggregated context (State, irrigation scheme, ecological domain, etc.),

Accordingly, the problem areas to be addressed were identified as follows:

1. In-depth analysis of drivers of deforestation and forest degradation:

1.1. Agricultural Expansion,

1.2. Energy Consumption,

1.3. Increasing Demand for Grazing & Browse Material,

1.4. Refugees and Internally Displaced People,

1.5. Factors Affecting Forest Health,

1.6. Fire, Fungal and Insect Attacks and Overgrazing the way they all Hinder Natural Regeneration and impact Forest &Tree Vigor and Growth,

1.7. The Impact of Natural & Man-made Forest Disturbances on Forest Ecosystems in Republic of Sudan

2. Study of Wood-based Energy:

2.1. Options for Sustainable Production of Wood Fuel,

2.2. Options for Sustainable Production of Fuel from Other Renewable Resources,

2.3. Technologies Appropriate for Rural Communities for More Efficient Use of Wood-Fuel,

2.4. Identification and (Technical and Economic) Potential of Alternative Sources of Household Energy that are Climate-Neutral, for Use in Rural Areas.

Methodology

Based on the identified problem areas, the Consultant allocated a team of renowned Professional Staff Consultants (PSCs) for the following assignments:

1. Agricultural Expansion

1.1. Increasing Demand for Grazing & Browse Material

1.2 Refugees & Internally Displaced People

1.3 Factors Affecting Forest Health

1.4 The Impact of Natural & Man-made Forest Disturbances on Forest Ecosystems in Republic of Sudan

1.5 Wildlife, Fauna & Flora

1.6. Water Harvesting

2. Energy Consumption (Study of Wood-based Energy)

2.1. Options for Sustainable Production of Wood Fuel,

2.2. Options for Sustainable Production of Fuel from Other Renewable Resources,

2.3. Technologies Appropriate for Rural Communities for More Efficient Use of Wood-Fuel,

2.4. Identification and (Technical and Economic) Potential of Alternative Sources of Household Energy that are Climate-Neutral, for Use in Rural Areas.

3. Maps, GIS & Geo-informatics

Selection of Study Sites

For data collection, consultation and training, ten States were selected as study sites. These States are Khartoum, Gezira, Sennar, Blue Nile, White Nile, Gadaref, Kassala, South Kordofan, North Kordofan, North Darfur States (for participants from the Greater Darfur). The selected States represent deforestation & forest/range degradation hotspots in different geographical regions with different forest cover and different land use conditions.

Secondary Data:
An interdisciplinary approach was used to collect data for this study integrating literature search & review, stakeholder interviews and field visits.

The secondary sources encompassed review of historic and contemporary relevant reports & studies by national, regional & international organizations and bodies as portrayed in Bibliography of data & information sources consulted. Prior to the field visits hundreds of related literature, relevant reports, statistics, and maps had been read and reviewed to determine the selected sites with conditions with particular focus on the key activities on deforestation and forest degradation. Such documents included documents originated from the Government of RoS, donors; UN agencies and a number of academic studies and various NGO reports. The bulk of the documents consisted of government policies, strategies & planning, studies, background papers, latest documents referred to by the selected states,

specific reports & documents on relevant projects, international and national publications relating to deforestation and forest degradation.

Primary data

In conducting the agreed study, the Consultant and PSCs adopted a Consultative, Participatory, Interactive Methodology & Approach, endorsed by the SNRP. The methodology encompassed a mix of quantitative and qualitative data collection from secondary as well as primary sources. The primary data was to complement, and bridge identified gaps in secondary data. The primary data sources included the following:

- Direct field observations through field visits to deforestation & forest degradation hotspots and focus group discussions with local stakeholders,
- Household questionnaire/surveys intended to solicit perceptions of household representatives on the awareness of the existing drivers of deforestation and degradation in selected sites, the extent and seriousness of the challenges, and possible remedial actions,
- Focus group discussions with key stakeholders to identify the main challenges facing forest & range sectors together with natural resources at large,
- Group discussions and consultation meetings with key informants including community, tribal and local leaders,
- In-depth discussion with key informants and field observations in the targeted places and in the countryside to evaluate certain parameters related to the factors affecting forest status,
- Check lists including the main issues to be answered by the officials and other respondents and natural resource users in government institutions and projects,
- Interviews and discussions with key project staff and relevant counterparts at the federal and state levels who are involved in the program implementation,
- Remote sensing data from the Moderate Resolution Imaging Spectroradiometer, (MODIS)- (MCD45) with multiple observations on monthly basis for monitoring of wild fire and burning activities in RoS. The monthly-burned data summed up to produce the burned area of the entire fire season then clipped by the shape file of the external boundary of Sudan as well as by shape file of each state separately and then maps produced and the area burned calculated in each state for each season. Fire frequency map were generated by summing up all fire seasons maps and density slices obtained for each fire frequency category
- In-Depth study to understand specific issues that came up, various supplementary information was collected through the consultation of success Case Studies and discussions.

During discharging the Study & Assignment, the Consultant planned and organized 52 consultative, Interactive, Awareness-raising & Whistle-blowing sessions together with some three direct, targeted, tailor-made training sessions.

The Consultative, Interactive, Awareness-raising & Whistle-blowing sessions were organized in the Capital City Khartoum (two sessions), Gezira, Sennar, Blue Nile, White Nile, Gadaref, Kassala, South Kordofan, North Kordofan, North Darfur States for participants from the Greater Darfur.

Respondents:
The audience encompassed Politicians, Legislatures, State Ministers of Agriculture, Livestock & Natural Resources, Private Sector Entrepreneurs, Farmer & Livestock Unions representatives, Tribal, Local and Community Leaders, Civil Society Organizations (CSO), Non-Governmental Organizations (NGOs), Gum Arabic Producer Associations (GAPAs), Farmer & Pastoral Unions and Foresters,

Topics presented and deliberated covered such aspects as: Power Point Presentations (PPP) on Concepts of Climate Change (CC), REDD+, New Forest Functions, Land-use Planning, Forest & Range Conservation, Protection & Management, Fuel-wood & Alternative Energy Prices & Policies,

In the process, some 700 persons attended and were involved in deliberations & discussions. Moreover, direct, targeted, tailor-made training sessions were conducted in Khartoum, Gadaref, Sennar Damazine, El Obeid and El Fasher for REDD+ Project Focal Points & Personnel, Forest National Corporation (FNC) HQs & State senior & middle-tier staff, particularly Chiefs and staff of Technical Sectors (Management Plan Officers), selected staff of State & HQs Natural Resources Management (NRM) institutions,

Hands-on training covered such aspects as: Filling-in seven sets of Questionnaires prepared by PSCs on data & information on causative factors of Deforestation & Forest Degradation, Remedial Measures thereof; Socio-economic base-line data on forest-neighbouring communities; Technical data for Forest Management Plan Formulation, Information Technology (IT) & devices for measurement thereof.

Finally, the Draft Report and findings were subjected to a Validation Workshop which, imparted remarks, comments and some alterations to various aspects of the study including the Recommended Actions and Agencies entrusted with their implementation.

International and National Context of Deforestation and forest Degradation:

Global Context:
Forests are important to the global climate system due to their ability to absorb and store carbon and release of Oxygen. Globally, deforestation contributes by 17 to 20 % to the global greenhouse gas (GHG) emissions (IPCC, 2007). The loss of forest biomass and oxidation of soil organic carbon through slash-and-burn and subsequent land use releases approximately 5.8 Gt CO_2 annually into the atmosphere (Nabuurs et al.,2007),

Climate Change (CC) mitigation through avoidance of deforestation was discussed and the concept of reducing emissions from deforestation was brought up to the international climate policy discussion under many Conferences of Parties (COPs) of the United Nations Framework,

In 2007 at COP-13 it was agreed to consider mechanisms on Reducing Emissions from Deforestation and Forest Degradation (REDD) as part of the post-Kyoto climate regime. This was reflected in an UNFCCC decision as part of the Bali Action Plan which called for "policy approaches and positive incentives'' on issues relating to reducing emissions from deforestation and forest degradation in developing countries; and the role of conservation, sustainable management of forests and enhancement of forest carbon,

Then with the objective of mitigating climate change through reducing net emissions of greenhouse gases through 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+), most of the key REDD+ decisions were completed by 2013, with the final pieces of the rulebook finished in 2015. A suite of decisions were made to provide guidance for REDD+ including the development of reference levels and their technical assessment, national forest monitoring systems, safeguard information systems, addressing the drivers of deforestation, and modalities for measuring, reporting and verifying forest-related emissions and removals[1].

As agreed by UNFCCC in the context of the Kyoto Protocol, forest refers to country-specific choice of a threshold canopy cover (any value between 10 and 30%) and tree height (any value between 2 and 5m), with a minimum area of 0.5 ha. In addition, FAO has excluded woody vegetation on land where 'agriculture' is a dominant use, creating ranges of interpretations where 'tree crops' are involved that provide domesticated 'non-timber forest products', as opposed to 'timber' in fast wood plantations." (GIZ, 2012),

Considerable debate continues how to define and measure forest degradation in the context of the UNFCCC on policy on REDD+. An important part of the discussion on the definition of forest degradation at the international level has assumed that it is necessary to establish thresholds and/or indicators that allow forests in non-Annex I countries to be classified as degraded or non-degraded; on the grounds that such a system is required for generating carbon credits under REDD+ (Lucia *et al.*, 2014)

---

[1] https://theredddesk.org/markets-standards/redd-under-unfccc

National Context

Concepts of Deforestation, Forest Degradation, Range Depletion, Range Degradation, Afforestation, Reforestation and Range Rehabilitation in a Sudanese Context.

Box (2)	Deforestation, Forest Degradation, Range Depletion, Range Degradation, Afforestation, Reforestation and Range Rehabilitation in a Sudanese Context

Deforestation: When agriculture, mining, urban development or other land uses replaced forests, as has happened for example with the establishment of national agricultural schemes such as Gezira, Rahad, Suki, New Halfa, Sugar Schemes and Semi-Mechanized Agricultural Schemes, Gravel Quarrying in Hattab, and numerous newly founded and extended Sudanese cities & towns.

Forest Degradation: Is a gradual process through which a forest's biomass declined, its species composition changed, or its soil quality declined as has happened in almost all reserved and non-reserved forest tracts in RoS.

Reforestation: Is the re-growth of forests after a temporary (< 10 years) condition with less than 10% canopy cover due to human-induced or natural perturbations as has happened in refugee affected areas such as Migrih Forest in Gadaref State and Irrigated Plantations in Major Agricultural & Sugar Schemes in N. Halfa, Rahad, Kenana..

Afforestation: Conversion through forest tree planting from other land uses into forest, or the increase of canopy cover to the 10% defined threshold for forest as has happened in rehabilitation of mining sites such as in Hattab in East Khartoum and woodlots in agricultural holdings in Semi-Desert areas east of Khartoum and north of Omdurman.

Range Depletion:
Range depletion here refers to a situation where the range is almost completely wiped out as in the case of expansion of urban settlement, construction of dams and associated agricultural projects as well as other infrastructure such as roads. Satellite images from the towns of El Obeid, en Nuhud and Abu Zabad clearly illustrate the loss of rangelands to urbanization. Plates (L), (M).

Range Degradation:
Range degradation is a condition in which present vegetation and soil conditions represent a significant departure from natural potential. *Syn*. Range Degeneration.
In addition to a decreased amount of feed produced from the rangelands the quality of feed witnessed degradation. In the rainy season grazing areas, herbaceous range plants are intensively and selectively grazed before maturity and are not given a chance to set seeds. Plates (N), (O).

Invasive species: Native and Non- native plant species whose arrival and spread into Sudanese ecosystems caused measurable harm such as Misquite (*Prosopis spp*), Rantuk (*Xanthium brasilicum*), Addar (*Sorghum lanceolatum*) and Sorieb (*Phyllanthus spp*). Plates (Q) (R), (S) and (T).

Climate Change and REDD-plus Initiatives in the RoS

National REDD+ Programme:
RoS, a LDC with substantial biodiversity and natural resources, signed, ratified & partied to UNFCCC since 1993. The country has since participated in many initiatives about CC mitigation and adaptation, including preparation of national inventories of GHGs. Although Sudan is not an emitter of a significant amount of GHGs, continuing deforestation and forest degradation are of concern. As such, a National REDD+ Programme, which estimates in-country emission sources and sinks for GHGs and helps to address underlying drivers, assumes significant importance. Prerequisites for this are reliable estimates of the changes in biomass density, carbon stocks, forests, woodlands and range areas that may occur due to deforestation and forest degradation. Likewise, envisaged multiple benefits under REDD+, financial, social & environmental, are of interest to RoS. However, to make REDD+ operational, the ability to catalyse and influence REDD+ investments to have a positive influence on forest & woodland conservation and management is essential. This requires considerable inter-institutional linkages and cross-sectoral coordination to attain the necessary in-country support and commitment. These aspects are key elements for the assessment of existing capacities to operationalize the REDD+ programme and the design of the national REDD+ Readiness Management Arrangements.

The REDD+ Initiative has the potential to immensely benefit RoS. The latter can reciprocate by sharing its wealth of accumulated acquired and traditional knowledge in Agro-forestry, Agro-silvo-pasture and mobilization of peoples' efforts in management of natural calamities and coping with events.

The <u>ultimate objective</u> of the National REDD+ Programme (NRP) of RoS is:

"Range resources and wildlife habitats, assessment of their present condition with inventories and subsequently subject them to sustainable management and maximizing conserving the country's renewable natural resources particularly forests, woodlands, their direct and indirect benefits in a participative, transparent and equitable manner."

The specific objectives of RoS's NRP include but are not confined to:

1. Detailed quantitative and qualitative inventory of the country's forests, woodlands, tree formations, trees outside forests, range & pasture resources and wildlife habitats inclusive of national parks, sanctuaries and private holdings,
1.1. Ascertain their status in terms of ownership, registration and disputes,
1.2. Judicious assessment of their present condition in terms of stocking diversity, health and vigour,
1.3. Careful evaluation of their designated functions, actual and expected goods provided, and services rendered, particularly in terms of augmenting livelihoods of surrounding communities, the country at large and beyond,
1.4. Appraisal of modalities of their management.

2. Review of relevant policies, institutional arrangements and legislations in force,

2.1. Revise, amend and/or promulgate relevant legislation and undertake institutional reforms conducive to the fulfilment of the ultimate objective.

Means & Steps Towards Realization of RoS National REDD+ Programme:

It is envisaged that the NRP of RoS shall be realized through the following means and steps:

1. Analysis of the current situation with regard to institutional arrangements and cross-sectoral coordination which are relevant for REDD+,
2. Setting up the necessary institutional structures and supporting arrangements to manage and co-ordinate the REDD+ Readiness process to result in the development and implementation of a coherent and successful REDD+ Strategy and a RoS Forest Monitoring System with support for Measurement, Reporting & Verification (MRV) functions, together with other attendant components of the RoS REDD+ Programme,
3. Ensure that the National REDD+ Programme has the necessary enabling decision-making authority, expertise, and wide-ranging stakeholder participation at various societal levels to achieve overall goals for long-term sustainability of desired outcomes,
4. Ensure that the REDD+ programme is supported by technical capacity, effective communication (including awareness raising and consultation with stakeholders), capacity building and human resource development (preceded by a comprehensive need assessment),
5. Mainstreaming REDD+ into broader cross-sectoral plans and programmes, including national development goals, CC goals and REDD+ goals.

REDD+ partners

Line Ministries:
As per Presidential Decree on 11th May 2017, the Cabinet is made up of 31 Federal Cabinet Ministers and 45 State Ministers. Line & State Ministries, subsidiaries thereof, private sector companies, NGOs, CSOs and others with activities that have an impact on renewable natural resources and hence on REDD+ are portrayed in Table (5).

Private sector:
The private sector as individuals, national or multinational companies are involved in agricultural, industrial, mining and services sectors. Some are already exhibiting positive aspects of their corporate social responsibility. Examples of the latter include Kenana Sugar Company, DAL Group, the Greater Nile Petroleum and many steel works in Khartoum suburbs. The notion is exemplified in landscaping & greening of their very premises, investing in social amenities in their vicinities, assisting in environmental sensitization and awareness raising and adhering to directives of allocating set percentage of the area of their holdings to forest & tree formations. All private sector entities will benefit from awareness raising and training in REDD + aspects.

NGOs:
Many indigenous and international NGOs have been functional in Sudan implementing donor funded projects in the domain of agriculture, animal production, socio-cultural & humanitarian assistance and the environment at large through partnerships with CSOs. Of the Indigenous NGOs, it is perhaps judicious to list SECS, the Environmentalists Society (ES), Babiker Badri Society and Social & Human Development and Consultative Group. As for the international NGOs, it's worth mentioning SOS Sahel (Sudan), Help Age (Sudan) and Practical Action. All NGOs active in Sudan can benefit from training in aspects of REDD+ implementation.

Table 5: Line Ministries, Private Sector Companies, NGOs, CSOs involved in or concerned with REDD+ in RoS:

#	Entity
Federal Ministries	
1	Ministry of Finance & Economic Planning
2	Ministry of Agriculture & Forests
3	Ministry of Industry
4	Ministry of Petroleum & Gas
5	Ministry of Water Resources, Irrigation & Electricity
6	Ministry of Animal Resources
7	Ministry of Investment
8	Ministry of Haulage, Roads & Bridges
9	Ministry of Mining
10	Ministry of International Cooperation
11	Ministry of Environment, Natural Resources & Physical Planning
12	Ministry of Tourism, Antiquities & Wildlife
13	Ministry of Interior
14	Ministry of Higher Education & Scientific Research
15	Ministry of Social Security & Planning
States	
Private Sector Companies	
1	DAL Group
2	Greater Nile Petroleum
3	LPG Distributions Companies
4	Kenana Sugar Company
5	Firewood & Charcoal Producer & Trader enterprises
6	Gum Arabic Processing & Exporting Companies
NGOs	
1	Sudanese Environment Conservation Society (SECS)
2	Environmentalists Society (ES)
3	Babiker Badri Society
4	Social & Human Development and Consultative Group
CSOs	
1	Farmers & Pastoralists Unions, Societies and Associations
2	Sudanese Horticultural Society

Civil Society Organizations:

A diverse and wide range of CSOs have been in existence and functional in the country; some throughout contemporary history. Those involved in land-use, natural resources management and environmental fields include tribal indigenous administration leaders, trade unions such as Farmers & Pastoralists Unions, Societies and Associations. Their activities spanned good resources stewardship (forest & range), Agricultural Development, Awareness Raising and implementation of customary law. Of the ones involved in Agricultural Development, Awareness Raising and Sensitization, it's perhaps judicious to name the Sudanese

Horticultural Society. All CSOs active in Sudan can benefit from training in aspects of REDD+ implementation.

The Forest Carbon Partnership Facility (FCPF) is a global partnership, housed within the World Bank's Carbon Finance Unit, which became operational in June 2008. The FCPF provides technical assistance and supports countries in their efforts to develop national strategies and systems for REDD+ in developing forest countries. The FCPF further assists countries to test approaches that can demonstrate that REDD+ can work, and provides them with performance-based payments for emission reductions programs. The support to countries for engaging in REDD+ activities is provided through two mechanisms within the FCPF, the Readiness Fund and the Carbon Fund.

Forests National Corporation (FNC) under the Ministry of Agriculture and Forestry; is the main governmental institution responsible for the conservation of forest cover in RoS, FNC started to initiate the REDD+ in Sudan in collaboration with the UNEP, UNDP, FAO and other partners since 2009. In 2012 FNC started to develop the readiness preparation proposal (RPP) with local funds, and designed the RPP with guidelines of FCPF (RPP template version 12). in 2014 the RPP was accepted by the FCPF, and the program launched in September 2015.

The National REDD+ program consist of four components and related sub-components to be financed by the FCPF for the period from 2015-2018.

Programme components:
The National REDD+ Programme includes the following components and sub components:
1. Support for REDD+ readiness management and institutional arrangements:
1.1. Set up and operation of the National REDD+ Management Unit,
1.2. Set up and operation of the National REDD+ Steering Committee, Technical Advisory Committee and REDD+ Technical Working Groups,
1.3. Strengthen sub-national REDD+ institutional structures
1.4. Capacity building for REDD+ institutional arrangements
1.5. Feedback and Grievance Redress Mechanism for REDD+
1.6. Program monitoring and evaluation
1.7. Support for national REDD+ Strategy (including Strategic Environmental and Social Assessment).
1.7.a. In-depth analysis of drivers of deforestation and forest degradation, including studies on policies, wood-based energy, land tenure and forest governance
1.7.b. In-depth analysis of strategic options to address deforestation and forest degradation
1.7.c. Strategic Environmental and Social Assessment (SESA) and development of Environmental and Social Management Framework (ESMF),
1.7.d. Study on options for benefit-sharing related to REDD+
1.7.e. Support for stakeholder engagement
1.7.f. Consultation and participation for activities to be implemented under the FCPF grant
1.7.g. Setting up and strengthening of civil society platforms
1.7.h. Support for Monitoring, Reporting and Verification
1.7.i. Development a National Forest Inventory (NFI)
1.7.j. Support for remote sensing
1.7.k. Capacity building for forest monitoring activities.

Successful mid-term and additional financing:

The Government of RoS was gratefully granted an additional USD$5m in March 2017at the 23rd FCPF PC meeting having successfully met the eligibility requirements for additional financing. On track to completing the program of activities under the USD 3.8m, RoS REDD+ readiness program has successfully established robust national and state level institutional arrangements, has conducted nationwide sensitization across all 18 states; trained key staff and stakeholders, completed studies –comprehensive assessment of drivers of deforestation and degradation, benefits sharing, land use and change, and communication and awareness strategy. Other major studies are also ongoing to inform the national REDD+ strategy and a national forest monitoring system.

Government support:
A clear demonstration of support and to enable a robust integration and sustainability of the national REDD+ program, the GoS has provided seconded staff and office facilities for the national REDD+ Secretariat and 18 state level focal point offices including 5 regional Technical Advisors. The REDD+ Secretariat runs the day to day operations with oversight and guidance from the high-level REDD+ Steering Committee (SC) led by the H.E. Minister of Agriculture and Forests. An Advisory Committee to the SC has representatives from all line ministries. The Secretariat has created working groups for safeguards, land-use & land tenure; and MRV to provide targeted technical guidance.

Inclusive and participatory:
Consultations and awareness target key groups such as Gum Arabic Producers, Women, Pastoralists & Farmers, Youth, CSOs and NGOs and Private Sector. Formal and informal platforms at the national and state level stimulate and facilitate dialogue. For example, the Gum Arabic Platform represents all organized Gum Arabic Producers within the Gum Arabic Belt; some 2172 Associations and more than 5 million people whose primary livelihoods depend on the Gum Arabic tree husbandry. The CSO platform involves 15 such organizations across RoS.

Management of Forest Resources in RoS:

Policies & Legislation Relevant to Forest Management:
Land Ownership and Usufruct Rights:
Traditional land tenure in rural areas of Sudan is mainly based on the concept of customary tribal homelands. Even in the northern riverine regions land has become a commodity only during the 18th century.

Land and Forest Policies:
Contemporary Policy Changes in Sudan that have a bearing on natural resources conservation started with the passing of a new Forest Policy for 1986 by H.E. the Minister of Agriculture, which formed the basis for the strategy for forestry sector in the country. It was an update for an earlier statement, the Forest Policy 1932,

The Prime objective of both statements was the reservation, establishment and development of forest resources for environmental protection and meeting the needs of population for forest products. Over and above, the Forest Policy 1986:
a. Stressed the role of forests in environmental protection,
b. Recognized and encouraged the establishment of community, private and institutional forests,

c. Subjected tree cutting outside forest reserves to the discretion of the Director, Central Forest Administration provided that these areas are reserved immediately following their utilization for their protection and regeneration,

d. Made obligatory the utilization of tree stocks on land allocated for agricultural investment (not to be burnt into ashes) and to leave specified percentage of tree cover inside and around agricultural investment schemes in the form of shelterbelts and windbreaks,

e. Stressed the mobilization of popular and international efforts for participation in afforestation, tree planting and forest protection,

f. Raised the national goal of forest reserves from 15 to 20% of the total area of the country for environmental protection and meeting the population's needs for forest products,

g. Stressed the role of forest extension,

h. Conceptualized the multiple use of forest,

i. Divided forest administration responsibility between the Central Government and the Regions (States and Provinces),

j. Made the Director, Central Forests Administration, the official counsellor to the regional authorities and institutions on forestry matters,

Forest Legislation:
The Woods & Forests Directorate was established in 1902 with the start of the colonial rule in the Sudan. The Department, under the principles of sustained yield in perpetuity and rational exploitation of the resources, commenced to manage wood- stations along the Nile and its tributaries to supply steam paddle boats with firewood and establishing forest reserves where future felling and regeneration can be concentrated, protect the forests against fires and introduce fast growing tree species. A substantial number of legislations have since been promulgated addressing such issues as forest reservation, levying of a royalty on wood collection from outside forest reserves, sharing of authority over, benefits from and responsibility towards forest resources and promulgation of a series of forest policy statements.

The most prominent of these legislations were perhaps:

1901: Enactment of the first forest act,

1932: Announcement of the first policy statement together with enactments of provincial & central forests ordinances,

1939: Endorsement of the Royalty Ordinance,

1948: Reform of the Provincial Forest Act to delegate power to the local level,

1971: Endorsement of the Local People Government Act,

1972: Endorsement of the Southern Sudan self-autonomous government,

1980: Endorsement of the Regional Government Act,

1981: Endorsement of the Local People Government Act,

1985: Re-centralization of Central Forests Authority,

1986: Amendment of the 1932 Forest Policy & adoption of 1986 Forest Policy,

1989: Enactment of Forests National Corporation (FNC) and new Forest Act,

1994: The adoption of the Federal System of Government,

2002: Endorsement of the Forests & Renewable Natural Resources Act replacing the FNC and the Forests & Acts of 1989,

2006: Development of a new Forest Policy under the process of approval,

2007: Agricultural Revival & Revitalization,

2011: Cessation of Southern Sudan.

The Forest Act 1989 prescribed the allotment and upkeep of 10% and 5% of rain fed and irrigated agricultural land respectively to forests in the form of wood lots and shelter belts.

The Comprehensive National Strategy 1992-2002 stipulates the allotment of 25% of the country's land area to forest, rangelands and wildlife.

Forest & Woodland Tenure and Functions:
Sudan's Forest Policy (1986) defines and recognizes several levels of forest ownership:

- **Federal Forests** which fulfil national protective, productive & social functions (such as the *Acacia nilotica* forests along the banks of the Blue and White Niles & tributaries thereof, mountain forests on watersheds and forests on the fringes of the desert curbing further spread of the latter), owned by the Federal Government and managed on its behalf by the national forest service, currently the FNC,
- **State Forests** which fulfil productive and social roles at the State (Provincial) level, contribute to national protective functions, owned by the State Government and managed on its behalf by State Forest Service or by FNC,
- **Institutional Forests** such as the ones in large agricultural schemes e.g. Gezira, New Halfa and Rahad Schemes and sugar estates as in Kenana, Assalya, W. Sennar, N.Halfa, Guneid and White Nile Sugar Companies. These fulfil productive, protective or social functions in the vicinity but contribute to the national environmental matrix and carbon dynamics. They are owned by the respective institutions and are managed on their behalf or by own forest units,
- **Community Forests** which fulfil a multitude of functions to their respective communities, are owned and managed by them,
- **Private Forests** which fulfil various functions and are owned and managed by their initiators.

The status of forest reservation is reflected by the data given in Table (6). The total reserved area consists of public, institutional, community, private and wildlife forest reserves and by the end of 2016 it reached 12.3 million ha. All reserved forests (public, community, private) represent 4.54% while, that occupied by other protected areas (including wildlife reserves) represent about 7.12% of the total area of the country. Thanks to a Presidential Decree in 1993, public (FNC) reserved forest area was remarkably increased (by nine-fold) from 1.25 million ha, which were reserved before 1993, to approximately 12.3 million ha by the end of 2012. Community and private forest reservation started in mid-1980s and is showing an increase of over six and twelve-fold, respectively, between the periods 1986–2000 and 2001–2012. The area of institutional forests is very small. It increased by nearly 8,687 ha (2.7 fold) from 1986 to 2012. (FNC 2011).

Currently, only 11.66% of the total area of the country is reserved to forests and other natural resources uses, while the Quarter Century Strategy (2003–2027) stipulates 25% of the total area should be assigned for natural resources. This gives a great opportunity to more than double up the area of reserved forests for various purposes allowing for better protection and development of the forest resources and environment. Future reservation of productive forests would likely be either state or community forests because since the establishment of federal system all unregistered land became under the jurisdiction of State Governments.

Forest Governance:
The Decree No. 40 (1997) issued by the Council of Ministers specifically stated that forests protecting inter-state water, watersheds and federal structures and forests arresting the process of desertification are Federal Forests to be managed by FNC. Other forest reserves

are to be managed by the States, and private, community and institutional forests are to be managed by their owners.

Forest Reserves Management:

To date, only 340 forests with a gross area of 447000 feddans have been put under management plans as depicted in table (6).

Table 6:Total Reserved Forests in RoS 2017

State	Total N. Forest	Total Area Feddans	Ecosystem-Dominant Tree Association	Main Produce
Gezira	33	12423	Riverine-Nile. *A. nilotica*	Fuelwood Building poles
Sennar	142	75121	Riverine-Nile. *A. nilotica*	Sawn timber Fuelwood
Blue Nile	16	8340	Riverine-Nile. *A. nilotica*	Sawn timber Fuelwood
Gadaref	75	83855	Riverine-Nile. *A. nilotica*	Sawn timber Fuelwood
W. Nile	27	89202	Riverine-Nile. *A. nilotica*	Fuelwood-Building Poles
N.Kordofan	2	44460	Watershed (El Ain Water Reservoir)-*A. nilotica, A. mellifera, A. seyal*	Protection
Gadaref	2	124290	*Acacia-Balanites* Association	Fuelwood-Range
Gezira	42	4025	Irrigated Plantation-*Eucalyptus*	Building Poles-Fuelwood
Kassala (N. Halfa)	----	3443	Irrigated Plantation-*Eucalyptus*	Building Poles-Fuelwood
S. Darfur (J. Marra)	2	1410	Watershed-Exotics: *Eucalyptus- Cupressus sp.*	Protection-Building Poles
Total Riverine & Watershed Forests	**446 569**			
Total Other Public F. Reserves	**10 915 635**			
Total Public Forest Estate	**11 362 204**			
Total Institutional Forests	**13 723**			
Total Community Forests	**26 056**			
Total Private Forests	**59 770**			
Total Wildlife Parks	**17 740 800**			
Total Forest Estate & W. Parks	**29 202 555**			
Total Surface Area RoS	**448 868 000**			
% Forest Estate & Wildlife	**6.51**			
% Wildlife National Parks	**3.95**			
% Forest Public Forest Estate	**2.53**			
% Riverine & Watershed Estate	**0.10**			
% Community Forests	**0.006**			
% Private Forests	**0.01**			

Source FNC- courtesy Abdel Hai Mohamed Sherif & Hassan & Tag Consultants

Management Status of Forest Reserves FNC Capacity:
The annual plantation areas include afforestation, reforestation, and natural regeneration of existing forest lands and natural expansion of forests into land not previously forested. The data on regeneration include areas which are cleared and then regenerated on both forests and other wooded land, but they exclude natural regeneration under existing tree cover. The data indicates the fluctuating nature of the annual planting, which depends on the availability of resources, perhaps mainly foreign aids. It also shows that community plantations are significantly increasing during recent years (Table 7), Fig. (1).

The current forest monitoring system is based on a bottom up system of reporting from the forest circles (the smallest management unit) up to the state forest and then to FNC at the national level. The data reported includes both qualitative and quantitative information on forest resources with more focus on reserve forests, afforestation and reforestation areas, harvest and production, fires, personnel, etc. This reporting system is done on monthly and annual basis. The current national reporting does not include estimation of GHGs emission/removal. However, FNC reports GHGs estimate to FAO and has at least six of its technical staff trained on GHGs inventory estimation and they participated in the two national communications on GHGs conducted so far in Sudan for UNFCCC. This is in addition to many FNC experts and experts from other related institutions who received training on technical issues related to GHGs inventory, A/R CDM and REDD+.

Table 7:Area (ha) of reserved forests by type of ownership.

Type of land ownership	1901–1985	1986–2000	2001–2015
Public forests	1,253,280	10,032,322.9	11,362,204.6
Institutional forests	5,040	13,723.5	13,723.5
Community forests	0	4,150.44	26,056.38
Private forests	0	4,752.72	59,770.2
Wild life protected reserves	17,740,800	17,740,800	17,740,800
Total	**18,999,120**	**27,795,749.5**	**29,202,554.6**

Source: FNC (2011b).

Table 8:Afforestation/reforestation areas (in ha) from 1990 to 2012.

Period	Public (in and outside reserved forest)		Community		Total
	Total	Average/year	Total	Average/year	
1990-1994	122,940	24,590	56,390	11,280	179,330
1995-1999	117,230	11,160	60,170	12,030	177,400

Period	Public (in and outside reserved forest)		Community		Total
	Total	Average/year	Total	Average/year	
2000-2004	69,870	13,970	52,440	10,490	122,310
2005-2009	133,630	26,730	107,980	21,600	241,610

Source: FNC (2011)
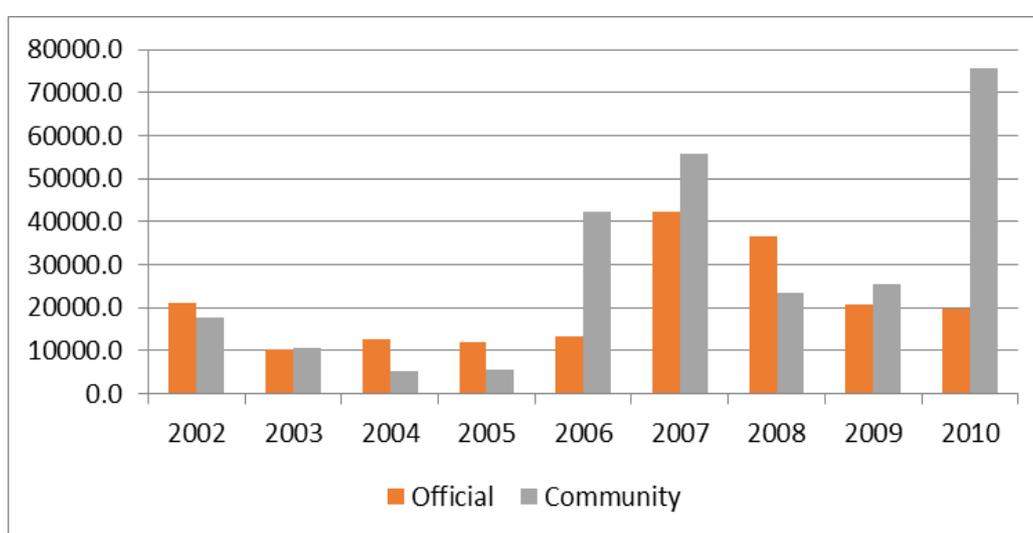
Figure 1:Annual planting areas during 2002-2010.

Community Forests:

Community and private forest reservation started in mid-1980s and is showing an increase of over six and twelve times, respectively, between the periods 1986–2000 and 2001–2012, as indicated in Table (9).

Table 9:Forest ownership and management/use systems.

Category of ownership & Management system	Area (ha)	% of total
Public Forests	15 000 000	70.3
Privately Managed: 1. Gum Arabic Producers (Societies/Families) 2. Individuel Farmers 3. Private Companies	6 006 000 49 000 126 000	28.1 0.2 0.6.
Community Managed	166 000	0.8
Total	**21 347 000**	**100**

Drivers of Deforestation, Range Depletion, Forest & Range Degradation in RoS:

Evidence of Deforestation and Forest/Range Degradation:

Analysis of secondary data:
Forestry:
In Global Forest Resource Assessments ''FRA'' (2010) ''Forest'' is defined as land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds *in situ*. It does not include land that is predominantly under agricultural or urban land use.

Other wood land (OWL) is land and not classified as "Forest", spanning more than 0.5 hectares; with trees higher than 5 meters and a canopy cover of 5-10 percent, or trees able to reach these thresholds *in situ*; or with a combined cover of shrubs, bushes and trees above 10 percent. It does not include land that is predominantly under agricultural or urban.

Other land (OL) is land that is not classified as "Forest" or "Other wooded Land".

Of late, Sudanese Forestry Community and in the context of RoS REDD+ have adopted revised Forest Functions and Definitions of Forest & Rangelands. These are depicted in Boxes (3), (4) and (5).

Box (3). Redefinition of Forest Functions

Box 3	Redefined Forest Functions
A. Immediate national environmental socio-economic variables:	

A. Immediate national environmental socio-economic variables:

1**.** Heightening of Roseires Dam, Construction of Meroe Dam and Twin Dams on Atbara & Setiet are completed, while construction commenced of The Renaissance Dam in neighbouring Ethiopia with all the imminent controversial consequences in terms of regulation of high floods, alteration of ambient relative humidity and water table together reduction of silt reaching most Riverian areas of R o S.

2**.** The Sunt (*Acacia niltotica*) forests on the banks of Blue Nile and tributaries with an area of some 42 000 ha., are perhaps some of the most valuable ecosystems and forests tracts in the country. They were reserved since 1930s and put under sustained yield in perpetuity "nowadays sustainable" management plans to produce railway sleepers, post & telegraph poles, cross arms, sawn timber for construction & ginning mills together with firewood, fodder, fruits & seeds for most of Central Sudan. Their protective functions remain with even more pressing demands. The productive functions and management objectives however, have undergone substantial changes:
2.1. Sudan Railways have shifted from wooden to pre-stressed concrete railway sleepers,
2.2. The Gezira narrow-gauge railway system has been abolished,
2.2. Demand for sawn wood for ginning in the country is no longer there,
2.3. Modern tele-communications system in the country no longer use wooden poles or cross arms,
2.4. Mud bricks baked with firewood have given way to cement concrete blocks,
2.5. The bulk of bakeries in Khartoum and major towns have shifted from firewood to other forms of energy.

3. The Jebel Marra Massive in Darfur is a unique ecosystem. It was managed since independence in 1956 for watershed services, horticulture, agriculture, forestry and of late tourism. Like other similar situations, once war breaks out in an area, the first to leave and the last to return are foresters. They do not and should not return until the dust settles and mines are cleared. We do not know what became of the wonderful *Cupressus lucitanica* plantations managed on selection felling system, nor do we know anything of the immense *Boswellia papyrifera* stands governing the watershed and tapped for Frankincense gum!

4. Wildlife personnel are forced to behave like forests when war engulfs National Parks like Radom in South Darfur,

5. Livestock grazing corridors have been blocked or encroached upon. The strife in Darfur is just one outcome of that.

B. It is envisaged that meagre forest productivity, potential paradox between revenue generation from royalties or other forest products & services together with sharing management and returns with communities and private sector, ALL be addressed within the context of the recommended Sector Review, Revision of National Forests Programme (nfp), redefinition of designated functions and reformulation of management plans of the entire forest estate of RoS.

B.1.Some of the activities that come to mind that could be incorporated in the sought nfp, redefinition of designated functions, reformulation of management plans, R&D, etc.:

B.2. Water harvesting & management for supplementary irrigation of forest tracts-cum-reserves on clay plains for sustainable production of wood and non-wood forest products.

B.3.Incorporation of fodder production in such management plans and devising means of collection of its value,

Research results and experience indicate that irrigated plantations produce biomass three-fold that of natural rain-fed plantations or stands,

B.4. Reclassification of forest sites particularly of riverine and wadi-khor forest tracts and maximization of tree planting of indigenous or exotic high value timber trees.

There is voluminous literature and research results on gerf land plantations of such trees as narrow-leaf Mahogany (Khaya senegalensis), Gimbeel (Cordia spp), Teak (Tectona grandis), Sisso (Dalbergia sisso) and African Bamboo (Oxytenanthera abyssinica) and hollow Asian Bamboo (Bambosa vulgaris),

B.5. Development of means of accounting for Forests services in such aspects as Watersheds, Tourism & Recreation,

B.6. Accommodation and institutionalization of pressures and demands from State Governments and Federal Investment Authorities for utilization of Gerf lands for horticultural production particularly Bananas and Mangoes. *There are precedents of long-term leases at market rental prices,*

B.7. R&D of Production of Non-Wood Forests Products and Value-adding thereof and devising of partnerships with communities and private sector.

Box (4). Recent Definitions of Forests in RoS.

Box 4	Recent Definition of Forests
Sudanese Forests Authorities have the following definition for forest in interim[1], [2] "Forest means an area of land spanning at least a minimum area of 0.4 hectares with trees that have attained, or have the potential to attain at least 2 meters in height and a minimum tree canopy cover of 10%. It includes wind-breaks and/or shelter-belts with a minimum of 20 meters in width"……………………………………………………… [1]. *Definition recently agreed (July 2017) by forest stakeholders (FNC, Academia, Research) through technical support from FAO and REDD+ Programme. The definition is yet to be endorsed by Forests Governing Bodies and subsequently by Federal Legislatures.* [2]. *The Validation Workshop (September 20th ,2017) recommended that Forest Definition be broadened to encompass such parameters as soil and biodiversity.*	

Box (5). Recent Definition of Rangelands

Box 5	Recent Definition of Rangelands
The following definition of Rangelands in RoS is posed by some Sudanese academics and practitioners extracted from various sources®. It is yet to be agreed upon through a process analogous to the definition of Forests: '' Rangelands, Forestlands and Agricultural lands make up some 55% of Planet Earth's Terrestrial surface in arid, semi-arid and savannah environs. Since these environs represent some 85% of RoS's land area, it can be claimed that the bulk of RoS's lands are Rangelands and Steppes, according to the Aridity and Drought classification of UNESCO (1979). Accordingly, rangelands in general, in addition to their immediate benefits from vegetation cover with its rich biodiversity and environmental importance are also a reserve of agricultural and forest lands for future generations, considering that all future agricultural expansion is apt to be on rangelands as has happened in all contemporary national agricultural schemes such as Gezira, New Halfa, Rahad, Semi-mechanized Farming and Sugar Schemes. As such rangelands need to be managed as a unified ecosystem with agricultural and forestlands and cannot be separated except theoretically''. ………………………………… [1]. *The Validation Workshop (September 20th, 2017) recommended that such definition of rangelands in Sudanese context be perused by all relevant authorities & agencies.*	

Table (10) portrays Sudan land cover classes in 2012, while table (11) depicts the Country's forest cover and areas 1990-2010.

Table 10: Sudan land cover classes in 2012

Land Cover Class	Area (ha)	%
Agriculture in terrestrial and aquatic/regularly flooded land	23,710,025	12.6
Trees closed-to-sparse in terrestrial and aquatic/ regularly flooded land	18,733,182	10.0
Shrubs closed-to-sparse in terrestrial and aquatic/ regularly flooded land	22,231,327	11.8
Herbaceous closed-to-sparse in terrestrial and aquatic/ regularly flooded land	25,982,720	13.8
Urban areas	730,331	0.4
Bare Rocks and Soil and/or Other Unconsolidated Material(s)	95,277,727	50.7
Seasonal/perennial, natural/ artificial water bodies	1,290,000	0.7
Total Sudan area[2]	187,955,312	100.0

Source: FAO 2012: Land Cover Atlas of Sudan

Analysis of available literature and statistics was used for detection of deforestation and Forest/Range degradation in RoS.

Harrison and Jackson (1958) estimated the tree cover in Sudan at 36-43%. FRA 2010 indicated a *decreasing trend in the forest cover* from 76.4 million ha in 1990 to 70.49 million ha in 2000 and 69.95 million ha in 2010 (30.5% to 28.1% and 27.9% of the country total area, respectively. For the period 2000-2008 the estimated area of actual forest loss was 907,599 ha/year and that of regeneration was 853,350 ha/year.

Removal rate for OWL during the period 1990-2010 assumed that total removal of forest and OWL is proportional to the area of each of the two classes (57 % for forest and 43% for OWL). Although some OWL may have been converted into forest during this period, some of this loss was outweighed by the substantial increase in the area invaded by Mesquite (*Prosopis chilensis*), which is classified as OWL and was estimated to be 149,420 ha/yr (FRA 2010). Accordingly, figures in Table (5) suggest that the OWL area as percentage of the country area decreased from 23.2% in 1990 to 21.6% in 2000 and 20.0% in 2010.

The data in the table indicate that about 6,432,000 ha of the Sudan's forest land was deforested between 1990 and 2010, and this is equal to 2.57% of the total country area and to over 8.4% of the forest area. During the same period, about 7,858,000 ha of OWL were removed (3.14% of the total country area and over 13.53% of the OWL area). The great loss in both categories paved the way to land degradation and diminution of water resources. The loss of forestland in the marginal areas of the north, accelerated by mechanized farming, a process widely known as desertification animal ranging and drought, resulted in a steady encroachment of the Sahara southward,

---

[2] *Official Sources cite total area of Sudan as 1 886 068 km° (188 606 800 ha.)*

Table 11: Sudan forest cover and areas in 1990, 2000 and 2010

FRA categories	Area (000) ha		
	1990	**2000**	**2010**
Forests	76,381	70.491	69.949
Other wooded land	58,082	54,153	50,224
Other land	103,137	112,956	117,427
Inland water bodies	12,981	12,981	12,981
Total area	250,581	250,581	250,581
Percent of forests area %	32.1	29.7	29.4
Percent of OWL area %	23.2	21.6	20.0

Source: FRA (2010)

The main causes of deforestation in all regions of Sudan are land clearance for agriculture and the unsustainable extraction of wood through legal and illegal cutting of trees mainly for fuel wood (FNC 2011b). In conflict regions such as Darfur the rate of loss is significantly greater partly due to the destructive nature of the conflict and partly due to the concentrated needs of displaced people, especially near camps. Moreover, the absence of a clear framework of land tenure constrains the development of incentives for communities/households to take responsibility for protecting trees.

Rangeland& Animal Resources:

The area of Sudan decreased from 2.5 million km^2 to 1.88 million km^2 after the cessation of South Sudan. Out of this remaining area 50.7% is bare rocks and soil and/or other unconsolidated materials (BS). The remaining area consists of agriculture (AG, 12.6%; trees closed-to-sparse in terrestrial and aquatic/ regularly flooded land (TCO, 10.0 %); shrubs closed-to-sparse in terrestrial and aquatic/ regularly flooded land (SCO, 11.8 %); herbaceous closed-to-sparse in terrestrial and aquatic/ regularly flooded land (HCO, 13.8%); urban areas (URB, 0.4%); and seasonal/perennial, natural/ artificial water bodies (WAT, 0.7 %). Forest/Rangeland area which is represented by TCO, SCO and HCO amounts to (35.6%) of the present area of Sudan or 669,472 km^2,

Livestock numbers increased from 32.6 million head in 1975 to 106.6 million in 2015, equivalent to 40.3 million tropical livestock units (TLU). Adding equine population, the total TLUs will be 44.4 million. The annual requirements of these animals (livestock and equine) are estimated at 133,3 million metric tons of dry matter forage. These requirements do not include those for wildlife,

Available feed resources from all sources (rangelands, cultivated forages, crop residues and industrial by-products) amount to 128.31million tons. Compared with requirements of 133.3 million ton there is a deficit of 5.1 million tons. The requirements identified here, do not include those for wildlife which are not available now. The feed production data shows wide temporal variations especially those from rangelands (e.g. 192 million tons for 2010 but only 35.0 million ton for 2011) showing that only 18% of the production in 2010 was obtained in 2011. This explains why in certain years there are huge mortalities,

The feed gap may be partly bridged in the short term by increasing the production of cultivated forages under irrigation and utilization of crop residues. In the longer term, however, range improvement will be necessary as most feed comes from rangelands/forest (> 80%). Interventions such as reseeding, water harvesting, reduction of animal numbers through opening new markets and providing disincentives to make pastoralists refrain from keeping large herds of unproductive animals, reducing fire incidence and improving availability and distribution of water points may mitigate the problem and reverse the balance towards adequacy,

In addition to a decreased amount of feed produced from the rangelands the quality of feed witnessed degradation. In the rainy season grazing areas herbaceous range plants are intensively and selectively grazed before maturity and are not given a chance to set seeds. Also forest degradation is manifested in browsing of seedlings of shrubs and trees before reaching an age that they can tolerate browsing led to the disappearance of these shrubs/trees or at the best many of them are endangered. This led to a decline in productivity and quality of the range as desirable plants are the first to be grazed explaining the observed retrogression/degradation of the range in these areas and the disappearance of many of the plant species known to be desirable/ preferred,

The drivers of deforestation and forest/range degradation can be summarized in the expansion of agriculture, both traditional and semi-mechanized, decrease in annual rainfall resulting from climate change, increased animal numbers, removal of trees for fuel wood, wildfire which destroys edible fodder and leads to changes in plant species composition, water availability and distribution of water points, and more recently oil explorations and mining in some the states. Settlement also took a toll of land that was previously rangeland. Settlement is associated with removal of plant cover for agriculture, fuel wood, livestock grazing /browsing and building. The expansion of settlements can be illustrated by satellite images from three cities namely El Obeid, Ennuoud and Abou Zabad. The suburbs of these cities used to be favourable rainy season grazing areas for pastoralists from South Kordofan where they used to spend 2-3 months during the rainy season. The available grazing nowadays is not sufficient for 3 weeks. Agriculture blocked the livestock routes, reduced resting areas along the routes and made rainy season grazing areas unhospitable,

The migratory transhumant system prevailing in Sudan (e.g. Kordofan) led to changes in plant species composition and range/forest degradation in the rainy season grazing areas as pointed out above. Moreover, in the dry season grazing areas, the system has a negative impact also but for different reasons. Because of migration to the northern parts of the states during the rainy season the grazing in the southern parts is deferred to be grazed in the dry season. This means that this grazing is not managed to any degree such as by animal interference during the growing period. Over the years this allowed tall plants to dominate after smothering shorter plants resulting in a degradation expressed in reduction of plant biodiversity and in the quality of the dominant species as the tall grasses have low leaf to stem ratio. Furthermore, the practice of burning of the range in early dry season to allow for green regrowth resulted in the domination of annual plants at the expense of perennials. Burning initiates, the green growth of perennial plants out of season for a short time depleting stored food reserves. However, these reserves are quickly exhausted in the absence of moisture and the plants die before storing adequate food reserves for the next growing season. Thus, perennials start to diminish /disappear leaving the space for the growth of annuals which are now the dominant plants in these areas again these are clear indications of range/forest degradation,

An annual National fodder budget deficit of over five million metric tonnes of dry matter exists in the RoS. This fodder budget gap presumably widens when wildlife fodder dry matter requirements are considered. The breadth of fodder deficit / gap determines the degree of reliance of livestock on browse and tree fodder and hence impact on deforestation and forest degradation.

The estimated fodder budget deficit occurs in most of the prevalent livestock husbandry systems but is more conspicuous in the agro-silvo-pastoral village based sedentary traditional husbandry systems where goats and sheep constitute the bulk of the sedentary herds.

The observed fodder budget deficit is customarily bridged using a diversified fodder resource base that include, but not limited to, crop residues tree fodder/browse, cultivated fodders and agro-industrial by-products in that order of importance.

Camels and Goats are classified as true that prefer and relish tree fodder/ browse. Goats browsing activities adversely affect forests restocking as they damage seedlings growth as well as the sustained development of low bushes and shrubs. Camels, on the other hand browse the top lush branches of high fully -grown well established trees.

To supplement the deteriorating quality and quantity communally grazed rangeland herbage, with dry season progress, camel, cattle, sheep and goat's herders may resort to tree felling/lopping and branches cutting of some particularly well known browse trees.

In an endeavour to stimulate regeneration/regrowth of drying rangeland herbage at the beginning of the relatively long dry season, and in attempts to combat disease vectors and insects, deliberately set fires that could destroy vast tracks of forests and rangeland herbage.

Primary Data:

Local community Perceptions on the extend Deforestation and Forest/Range Degradation

As shown in Figure (2) below, most of the respondents (62.7 %) believed that forest and Range are highly degraded while 23.8% classified the degradations as moderate and 11.1% as slight and only 2.4% believe that there is no degradation, which means that almost all the respondents understand that the forest and grazing lands have witnessed some level of negative change compared to their status before.
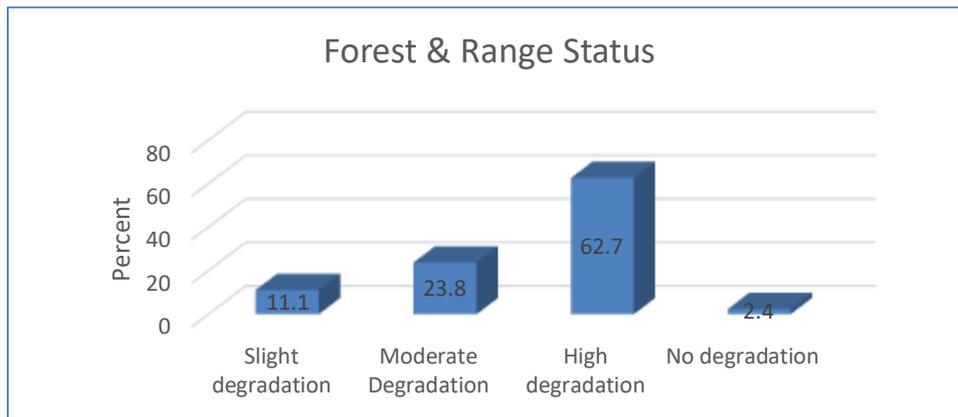
Figure 2:Local Community Perceptions on the Extent of Deforestation & Forest & Range Degradation

Characterization of Drivers of Deforestation

The Deforestation and Forest/Range Degradation drivers identified during the study fall under two categories, the direct/proximate and indirect drivers. The direct drivers of deforestation and forest/range degradation are human activities and actions that directly impact forest cover and result in loss of carbon stocks (Kessy, et.al 2016).

Key Drivers of Deforestation and Forest/Range Degradation in REDD+ database:

In the REDD+ debate, Drivers of Deforestation & Forest Degradation are separated into:
A. Deforestation:
I. Proximate /Direct drivers: These encompass a set of broad categories:
1.1. Agriculture:

I.1.1 Commercial Agriculture: A form of forest clearance for cropland, pasture and tree plantations; for both international and domestic markets and usually large to medium scale,

I.1.2. Subsistence Agriculture: A form of forest clearance for subsistence livelihoods; includes both permanent subsistence cropping and shifting cultivation and usually by (local) smallholders,

I.2. Mining: All types of surface mining,

I.3. Petroleum:

I.4. Infrastructure: Roads, railroads, pipelines, hydroelectric dams,

I.5. Urban sprawl: Mostly for settlement and re-settlement,

I.6. Other (Activities) Drivers.

B. Underlying (indirect) Causes:
These encompass rapid human & animal population increases and the associated growing demand for land and energy, legal and institutional gaps including lack of stable and

equitable forest tenure, lack of stakeholder participation in forest management and benefit-sharing schemes and weak law enforcement,

2. Forest degradation:
These too encompass a set of broad categories:
2.1. Unsustainable extraction of wood,
2.1.1. Legal and Illegal,
2.1.2. Selective logging,
2.1.3. For use in energy production of Fuelwood (Firewood & charcoal),
2.2. Overgrazing,

2.3. Destructive Agents.

Key Drivers identified by key informants

Based on the analysis of secondary data, key informant's interviews and field observations, the present study revealed that the Proximate /Direct drivers of Deforestation encompasses set of broad categories including:
- Commercial Agriculture Principally Large-Scale, Mechanized Rainfed Farming, together with Irrigated forms of Agriculture,
- Urban Sprawl,
- Infrastructure Development,
- Petroleum Exploration,
- Mining,
- Refugees & Internally Displaced People (IDPs)

The study revealed that the direct causes of Forest/Range Degradation encompass unsustainable extraction of wood including legal, illegal and selective logging for energy & other uses, Overgrazing; Insecurity and Biotic (man, animal and insect) or A-Biotic (Drought spells, Fire, Wind and Floods) destructive agents

The study findings indicated that the main underlying causes of deforestation & range depletion include rapid human & animal population increase and the associated growing demand for land and energy, subsistence agriculture, legal and institutional gaps including lack of stable and equitable forest tenure, lack of stakeholder participation in forest management and benefit-sharing schemes and weak law enforcement,

Cross-cutting underlying causes identified and summarized by the study into two main Groups
- Natural Environmental Factors (natural disturbance) such as Climate Change, Floods, wind & Desertification,
- Socio-economic Factors such as Poverty and Landlessness

A ranking of relative importance of drivers of deforestation and forest/range degradation revealed that expansion of agriculture is the most important driver followed by Urban Sprawl and Infrastructure Development with gross impacts of 40%, 15% and 15% respectively. The gross impact of mining is estimated to be 10%, Oil exploration 10% and Refugees & IDPs 10%.

Drivers of Deforestation and Forest Degradation identified by Local communities:

The causes of deforestation & forest degradation and range depletion and range degradation were investigated by interviewing farmers, pastoralists and locals using a questionnaire. The results are presented in Figure (3) and Tables (12), (13).
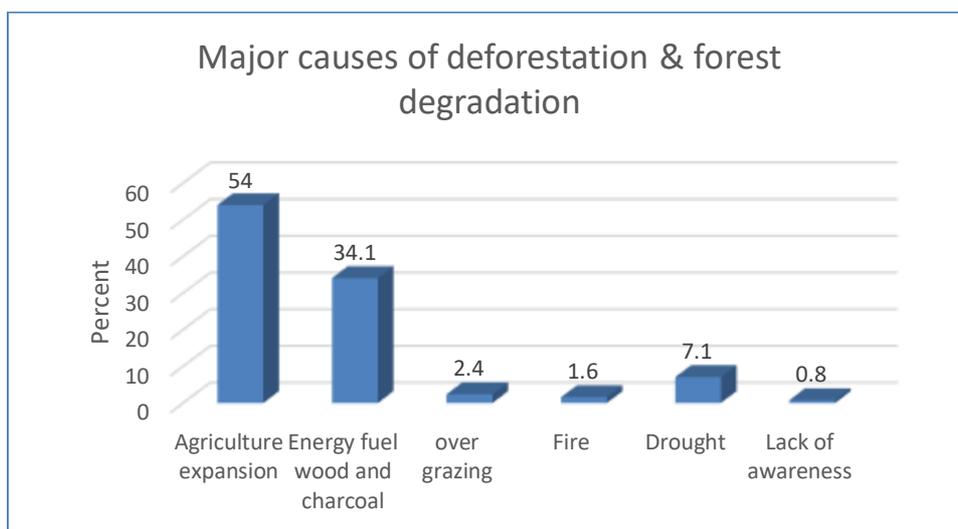
Figure 3:Drivers Deforestation and Forest Degradation identified by Local community

The respondents were able to identify the reasons that caused deforestation and forest degradation Figure (3) shows the major causes of deforestation and forest degradation as perceived by the respondents. 54% believe that agricultural expansion is the major cause of deforestation and forest degradation. Extraction of wood for energy is identified by 34% of the respondents, drought 7.1%, overgrazing 2.4%, fire 1.6% and lack of awareness 0.8%.

Drivers of Range Depletion and Degradation Identified by Locals:

Results are presented in Tables (12) and (13). In Table 12 answers to questions whether the rangeland area has increased/decreased or degraded, 86% of respondents stated that the range area has decreased and degraded, 47 % reported the presence of community forests and rangeland while 67 % mentioned that there is no role for community based organizations (CBOs) in the management of natural resources and 33% admitted that there is CBOs role in management of natural resources.

Table 12:Range area trend, degree of coordination among NRM stakeholders and role of communities

Concept	Percent yes
Rangeland Decreased/Degraded	86
Presence Community Range/forest	47
No role of CBOs in NRM	67

Livestock behaviour/browsing habits and browse preferences:
Answers to the question on preferred browse trees are shown in Table (13). The trees ranked as preferred were *A. seyal* and *A. mellifera* (47% each), followed by *A. nilotica* (40%), *Zizyphus spina christi* and A. tortilis (27% each), and *A. senegal*, *Faiedherbia albida*, *Mesquite* and *Balanitis aegyptiaca* (20% each). This ranking of desirable browse trees appears to be more a reflection of trees available on the range as it ignores many tree species known to be more desirable but are no longer available on the range. This indicates the importance of looking for those rare/endangered tree species that disappeared for propagation in nurseries for further preservation in situ.

Table 13LPreferred Trees for Browse (1preferred, 0 not preferred)

Plant species	Percent yes %
A. senegal	20
A. seyal	47
Ziziphus spina christi	27
A. tortilis	27
A. nilotica	40
L. pyrotechnica	7
Faidherbia albida	20
A. tortilis radiana	7
Ficus sycamorous	7
A. melliferra	47
Mesquite	20
Balanitis aegyptiaca	20
A. nubica	7
Marua cracifolia	7

Most respondents reported that preferred browse trees are decreasing (87%).The decrease was attributed to grazing only (69%) and to grazing plus tree-felling (85%). The result shows that grazing plus felling of trees is more accountable for deforestation, range depletion and forest/range degradation than browsing alone. Browsing affects seedlings establishment more than large trees again directing the attention to the importance of resting certain range/forest areas for a reasonable period to allow the growth of (Table 14).

Table 14:Causes of decrease in trees preferred by animals

Concept		%
Preferred trees and Range species decreasing		87
Causes of decrease	Browsing only	69
	Browsing plus felling	85

Both quantity and quality of grazing was reported as regressing according to replies of 80% of the respondents. The main causes of deterioration were agricultural expansion (77%), decrease in rainfall (66%), increased animal numbers (56%), removal of trees for fuel wood

(54%), fires (46%) and scarce unevenly distributed water points (36%). Intervention is needed to curb the expansion of agriculture noting that in the current practices larger areas of farms result in reduced productivity (tons/unit area). If more emphasis is given to productivity, yields can be stabilized or even increased from the same area without resorting to deforestation. The effect of reduced rainfall may be mitigated by adopting suitable water harvesting techniques and by developing early maturing varieties as well as varieties tolerant to water stress. Livestock numbers are not known with any certainty which emphasizes the need for a livestock census. Increasing livestock productivity may encourage producers to restrict livestock numbers. However, there may be no incentive to reduce numbers under common grazing conditions so legislations to discourage producers from keeping large herds are required. Awareness to discourage pastoralists from keeping unproductive animals is also needed.

Table 15:Decline in quantity and /or quality of grazing

Concept	Cause	Percent
Decrease in quantity and quality of grazing		80
Causes of decrease (5 highest, 1 least)	Decreased rainfall	66
	Expansion of agric.	77
	Increased animal numbers	56
	Security	18
	Mining	20
	Oil explorations	20
	Fires	46
	Scarce/uneven distribution of water points	36
	Fuel wood	54

Table 16:Type of feed animals depend on most? (1 most, 6 least)

Feed	Rank					
	1	2	3	4	5	6
Natural rangelands	91	0	0	0	9.1	0
Planted forages	9.1	63.6	0	0	0	27.3
Crop residues	18.2	9.1	27.3	0	0	45.5
Processed feeds	0	0	0	10	30	60
Browse	20	20	20	30	0	10
Bought feeds	0	0	30	30	20	10

Fire is a main factor causing loss of forage from natural rangelands. In the dry season grazing grounds, it may destroy more than 50% of dry season grazing. It also leads to changes in plant species composition and consequently its nutritional and feeding value. In case of perennials fire stimulate plants to sprout out of season, use store nutrients to grow for a short period and then die after consuming all stored nutrients essential for growth in the next rainy season. Also, fire leads to the dominance of plant species that are fire tolerant thus affecting biodiversity.

Relative importance of Drivers of Deforestation and Forest/Range Degradation as identified by secondary data:

Based on the analysis of secondary data, key informant interview and field observation, the ranking of relative importance of drivers of deforestation and forest/range degradation considered to be as follows

1. Expansion of agriculture with gross impact of 40%

2. Urban Sprawl with gross impact of 15%

3. Infrastructure Development with gross impact of 15%

4. Mining estimated with gross impact of 10%

5. Oil exploration with gross impact of 10% and

6. Refugees & IDPs with gross impact of 10%.

Relative importance of drivers as ranked by Local communities:

Based on the analysis of the primary data collected using the questionnaire, the respondents ranked the driver of deforestation and forest degradation as follows
Expansion of agriculture: 42.1%
Fuelwood and charcoal for energy: 19.8%
Overgrazing: 15.1%
Drought 15.1%
Fire: 3.2%
Lack of awareness: 3.2%

Agriculture expansion ranked by respondents, results of secondary analysis and key informants interviewed the most important drivers. Respondent seem to think about the current and ongoing deforestation and forest degradation.

Table 17:Ranking of deforestation & forest degradation drivers by Locals

Causes	Frequency	Percent	Valid Percent	Cumulative Percent
Agriculture expansion	53	42.1	42.1	42.1
Energy fuel and charcoal	25	19.8	19.8	61.9
Over grazing	19	15.1	15.1	77
Drought	19	15.1	15.1	95.2
Fire	4	3.2	3.2	80.2

Causes	Frequency	Percent	Valid Percent	Cumulative Percent
Lack of awareness	4	3.2	3.2	100
Infrastructure	2	1.6	1.6	96.8
Total	126	100	100	

Respondents identified mechanized agriculture as the most important cause of deforestation and forest/range degradation compared to semi mechanized and traditional agriculture Figure (4) below
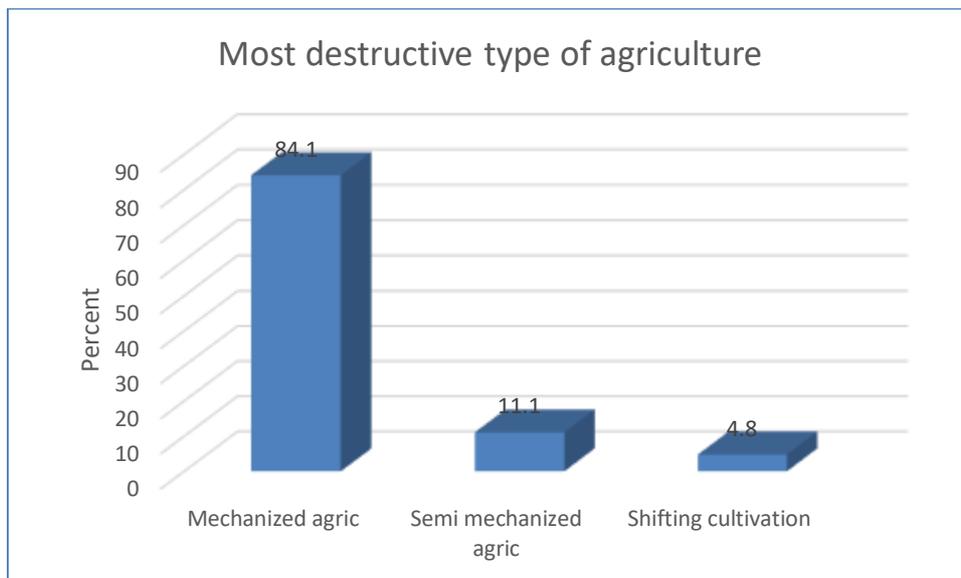
Figure 4:Most important agriculture practice identified by respondents

Respondents identified fuel wood and charcoal together as the most destructive form of energy that cause deforestation and forest/range degradation Table (18) below.

Outcomes from Key Informant Stakeholder Consultation on Drivers of Deforestation and Forest/Range Degradation:
The study team conducted consultation meetings and focused group discussions with key informant stakeholders in the most important forest sector states. The checklists used by the consultant included the main issues related to Driver of Deforestation and Forest/Range Degradation These issues included challenges facing forest sector, the policies for protection and development of forest sector, challenges facing the rangelands sector and policies for improvement, strategy and programme funding, resilience to CC and the success stories for forest development and community participation supporting services. Below is a summary of the conclusions, outcomes and recommendations of the meetings:

Table 18: Type of energy form considered being the most destructive driver

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Fuel wood	7	5.6	5.6	5.6
	Charcoal	13	10.3	10.3	15.9
	Both	105	83.3	83.3	99.2
	Other	1	.8	.8	100.0
	Total	126	100.0	100.0	

.

1.1. The officials of the State Ministry of Agriculture in Sennar State, confirmed that semi-mechanized schemes were introduced in the 1950s with virtually no planning, and that pastoral routes were adversely affected as a result. The Ministry's reports reveal that 60 percent of Sennar's two million hectares under rain-fed agriculture are occupied by non-authorized semi-mechanized schemes, while 30 percent are under planned mechanization and 10 percent under traditional agriculture. These changes in land use continue to lead to violent clashes between farmers and nomads, such as in Dali and Mazmum.

1.2. Forest officials in Southern Kordofan State reported that they had at times been obliged to issue permits for forest clearance even where trees covered more than 50 percent of the land. Soil depletion, yield collapse, desertification and abandonment Mechanized agriculture schemes have traditionally used neither fertilizer, nor organized crop rotation or fallow systems. The inevitable and well documented result has been a collapse in per hectare yields.

1.3. Discussion with stakeholders in Gadaref Sate revealed that in the past the forest area in Gedarif was 78% of the total Gedarif State area. Because of irrational agricultural expansion particularly the semi-mechanized farming this percentage is now only 22%. Sorghum and sesame yields in 2002 had reportedly dropped by about 70 and 64 percent respectively from 1980 levels in established areas. As a direct result of this decline, proprietors of semi-mechanized schemes have been forced to expand the total area under cultivation just to maintain output. The final stage of mechanized agriculture as it is practised in RoS is the abandonment of land due to yields dropping below economic limits,

1.4. In White Nile, the main challenges of the forest sector are the returnees and refugees from RoSS who rely on cutting trees and cultivating land without regulations,

1.5. Discussion with officials in Kassala state pointed out the establishment of Atbara & Seteit Twin Dam shall result in the cutting of 1.6 million feddan from pasture land. Therefore, establishment of pastoral farms is of vital importance to avoid conflicts over natural resources; otherwise it would spell disaster. People in Kassala State are poor depending on firewood and charcoal as the main source for their livelihood. Other serious problem is the practice of the large-scale farmers and investors who started to establish large

terraces to hold the water from moving to fill the Excavations (hafirs). This practice dries the pastures and hence stops pastorals from coming to the area.

The consultative meetings come out with the following reasons for forest encroachment:
Failure of agriculture and declining productivity lead to more dependence on forest for agriculture expansion and as source of income from sale of wood and charcoal

- The declining productivity of food crops particularly sorghum encourage horizontal expansion to maintain the level of production needed to meet demand for sorghum (the basic food crop).
- The most serious impact is the adoption of short-sighted agricultural policies which called for irrational horizontal expansion of cropped areas without giving attention to productivity per unit area. Unfortunately, these policies were backed for long times by funding institutions like Agricultural Bank of Sudan (ABS) which continue giving credits and finance to investors without being conditionality of productivity enhancing technology. The country continues to meet the increase in food production from horizontal area expansion.
- The wrong agricultural policies which encourage irrational horizontal expansion of rain-fed agriculture particularly the semi-mechanized sector. The strategies and agricultural policies normally developed without proper consultations with other stakeholders including those concerned with natural resource management.
- The horizontal expansion of livestock (increasing number) with no reference to the currying capacity of range land impacted negatively the forest sector
- Lack of coordination between the institutions (and users) related to natural resources. For example, the decisions related to agricultural expansion are taken without consultation and coordination between the different users of the natural resources.
- The overlap of responsibility between Federal and State authorities
- Urbanization of agriculture (changing the purpose of land from agriculture to residential areas).
- Oil exploration where large areas were reserved for oil mining impacting particularly rangelands and forests
- The law and legislatives related to natural resources management are not sufficient and suffer from being not respected and/or implemented.
- The returnees and refugees from RoSS, found no source for their livelihoods except to cut forests and sell fire-wood and charcoal. Their number is increasing, and the roles of the international society are not yet clear toward this group particularly the refugees. This problem needs to be addressed very soon.
- The political interference in technical issues, the decision is taken on political ground. Politicians in many cases do not respect the advice technical people.
- CC and frequent drought spells need to be addressed, and their impact mitigated
- Dependence of most people particularly the rural on fire-wood as a source of energy. About 70 to 80 percent of the bakeries across the country depend on wood. The price of gas is now 10 times its price two years back. This wrong policy will enforce poor people particularly in the rural areas who cannot afford this cost to rely completely on firewood as a source of energy
- The establishment of Setate Dam Project shall cut about 1.6 million feddan from pasture land of Kassala State. Therefore, establishment of pastoral farms is of vital importance to avoid conflicts, otherwise it would be a disaster

- In most of the violations that happen, the laws are not applied and participants of the meeting all agreed that laws should be enacted,

- There are some laws that need to be revised or updated such as the forest law that calls for establishment of shelter belts in 10 % of the rain fed schemes and 5 % under irrigated schemes. The participants call for increase of these areas to more than the figures quoted;

- The Minister of Interior on 2 August 1992 issued a decree to reallocate the un-demarcated rain-fed land East of Rahad River in Gedaref State and assign 50 %, 40 % and 10 % of that area for agriculture, forestry and rangelands respectively. Based on his decree the Minister of Agriculture, Natural and Animal Resources and by his letter of 27 August 1992, called for formulation of a technical committee to study the issue and prepare a proposal to be approved by the officials concerned. The committee finished the work and a proposal was submitted to the Minister of Agriculture, Natural and Animal Resources who distributed the proposal on 22 April 1995 to all the concerned parties for their review and approval. The Council of Ministers approved the proposal on 27 August 1995 and copies of the approved report were distributed by the Ministry of Agriculture, Natural and Animal Resources on 21 September 1995. Despite this lengthy process, there is currently expansion of agriculture on the areas allocated to forestry and rangelands. This is one example of many similar cases where forest and rangelands are moved on by agricultural expansion and the law is not enforced;

- Involvement of the communities around the forests, rangelands and wildlife reserve in the management of these natural resources. They should also be provided with alternative livelihoods options to reduce their dependence on the meager natural resources;

- The participants made a comment that instead of blaming other countries that they are not respecting and applying the international laws, we should apply the laws that we put ourselves;

- Poverty has been mentioned as one of the factors that push poor people to destroy the forests in addition to the absence of a proper land use plan;

- The Gum Arabic Association representative mentioned that FNC is lacking strong infrastructure (means of mobility) to enable the staff to do a better job;

- Encouragement of Bee Hive Shelves distribution as an alternative non-wood forestry product;

- Encouraging income generating activities (vegetables production as alley cropping) was proposed;

- The Director of FNC Eastern Sector recommended use of clean energy as much as possible;

The following actions are recommended by respondents as suitable measures to control deforestation and range/forest degradation (Table 19).

1. Proper management conducted jointly with community

2. Effective Protection & law enforcement

3. Proper management conducted by government

4. Formulation and implementation of relevant sectors polices

Proposed Measure	Frequency	%	Valid %	Cumulative %
Effective Protection & law enforcement	39	31.0	31.0	31.0
proper management conducted jointly with community	68	54.0	54.0	84.9
proper management conducted by government	10	7.9	7.9	92.9
controlling agric expansion	2	1.6	1.6	94.4
formulation and implementation of relevant sectors polices	7	5.6	5.6	100.0

5. Controlling agriculture expansion

Table 19:Measures to control deforestation and forest/Range degradation

Proper farming, proper farming system and proper agriculture policy are identified by respondents as appropriate measures to be taken to avoid deforestation by agriculture. Table (20). On the energy drivers, respondents listed measures to be taken as follows

1. Use of LPG

2. Use of energy saving devices

3. Use of alternatives (solar, wind etc)

Table 20:Measures to be taken to avoid deforestation by agriculture

Proposed measure	Frequency	%	Valid Percent	Cumulative Percent
Proper farming	42	33.3	33.3	33.3
Proper land use planning	37	29.4	29.4	62.7
Proper agriculture policy	5	4.0	4.0	99.2
Proper farming system	41	32.5	32.5	95.2

Proposed measure	Frequency	%	Valid Percent	Cumulative Percent
(Agroforestry)				
Proper agriculture policy	5	4.0	4.0	99.2
Other	1	.8	.8	100.0
Total	126	100	100	

Table 21:Measures to be taken to control deforestation and forest/range degradation caused by energy

Concept		Frequency	Percent	Valid %	Cumulative %
Valid	Using of energy saving devices	39	31.0	31.0	31.0
	LPG	48	38.1	38.1	69.0
	Other alternative (Solar, wind, biogas)	39	31.0	31.0	100.0
	Total	126	100.0	100.0	

As shown in Table 21 above, Measures to control deforestation and forest/Range degradation identified by locals includes using of LPG, using of saving devices and using of alternative energy

In Depth analyses of Drivers of Deforestation, Range Depletion, Forest & Range Degradation and their Individual & Collective Bearings on Forest & Range Tracts in RoS

It can be deduced from the analyses of the results, data & information of the study conducted on Drivers of Deforestation & Forest Degradation in the Republic of Sudan that:

Proximate (Direct) Causes of Deforestation & Range Depletion:
The Main Direct Cause of Deforestation & Range Depletion in RoS is Commercial Agriculture Principally Large-Scale, Mechanized Rainfed Farming, together with Irrigated forms of Agriculture.

Agricultural Expansion in RoS:
Five main types of agricultural systems are practiced in Sudan, and each has a specific set of environmental impacts particularly on forest sector. Three are crop sectors: semi-mechanized rain-fed farming; traditional rain-fed farming and irrigation agriculture and number four is a livestock husbandry/pastoralism sector.

Large scale mechanized rain-fed agriculture was developed in the Gadarif Region in 1945, when the Colonial British Government decided to cultivate the cracking clays of Central Sudan to meet the food needs of army units in East Africa. During the 1960s, investment from the private sectors resulted in massive clearing of land for cultivation. By the end of 1970s and in the early 1980s, most of the lands were used for mechanized farming. This situation, coupled with several other factors such as mono-cropping of sorghum, lack of crop rotation, inappropriate methods of soil preparation and management, had resulted in severe land degradation problems. Rapid physical, chemical and biological deterioration of soil and subsequent decline of agricultural productivity and deterioration of environment have taken place within this region. To sum up the total forest area is reduced due to over cultivation by semi mechanized farming because of increase in food demand due to human population increase as well.

Having been aware of the above, the performance of the crop sector is assessed through analysis of area, production and productivity of domestic food supply (cereals and oil seed crops) The three main cereal crops (sorghum, wheat and millet) represent about 97% of the total cereal consumption in Sudan, which would correspond to some 57% of the total food energy consumption in the country (Alemu and Ijaimi 2011). The four major oil seed crops are sesame, groundnuts, sunflower and cotton. The viability of production, particularly under the traditional rain-fed sector, remains a major issue of concern in the context of food security and the resilience of rural livelihoods.

To illustrate the agricultural expansion in the Sudan, a time series data extended for sixty-three years (1953/54-2015/2016) on the area cultivated, production and productivity of the major cultivated food commodities (cereals and oilseeds), was obtained from Ministry of agriculture and forest (Department of Planning and Agricultural Economics). These data were analysed, and the results were presented in the following tables.

Data in Table (22) illustrates the expansion of the agricultural area by comparing a three-year average of the area cultivated and area harvested and production at the start and the end of the 63 years' time series data. As indicated by the figures in the table 22, the area planted increased from an average of 5.6 million feddans during the period 1953/54-1955/56 to 41.3 million feddans during the period 2013/2014-2015/2016. This indicated that the area cultivated increased by more than seven folds during this period. The percentage of the area harvested decreased from an average of 90% during the period 1953/54-1955/56 to only 69% during the period 2013/2014-2015/2016. This implies a loss of almost 31% of the area planted. The production increased during this period by about four folds from 1.5 million metric tons 6.7 million metric tons. This result has far reaching policy implications as it indicated clearly that the country is relying on horizontal area expansion for food security.

Table 22:Area Planted, Area Harvested and Percentage of Area Harvested over Planted

Item	1953/54-1955/56 average	2013/2014-2015/2016 average	area expansion between the two periods (times)
Area planted (000 Ha)	5564	41274	7.42
Area harvested (000 Ha)	4987	28325	5.68
% Area harvested/area planted	90	69	-

Production (000 MT)	1546	6720	4.35

The data in Table **(22)** shows the cropping patterns of the main seven cereals and oilseed crops during the period 1953/54-2013/2015/2016. The data in the Table performed a comparison using three years average for the first and last three years of the time series data. Although the figures in the table are self-explanatory, the following remarks deserved serious attention:

- Sorghum area increased by more than nine folds from an average of 2.29 million feddans during the period 1953/54-1955/56 to 21.55 million feddans during the period 2013/2014-2015/2016 period. Millet area increased by about 4 folds, sesame by 92 folds.

- Sorghum contribution to total area planted has increased from 41% during the first period to 52% during the last period while millet contribution decreased from 33% to only 19%.

- The contribution of sorghum, millet, sesame and groundnuts to total area planted increased from 89.2% in the first period to 97.8% during the second period.

- From the above results sorghum is the main crop responsible for horizontal expansion of agriculture (52.2%) followed by millet (19%), groundnuts (13.4%) and sesame (13.2%). From the average area increase during the mentioned period sorghum contributed 53%.

Table 23: Cropping Patterns (main crops) in 1953/54-2013/2015/2016

Item	First period (1953/54-55/56)				Second period (2013/14-2015/16)			
	Area planted	%	Area harvested	%	Area planted	%	Area harvested	%
Sorghum	2285	41.1	2048	41.1	21545	52.2	14563	51.4
Millet	1820	32.7	1616	32.4	7848	19.0	5170	18.3
Wheat	31	0.6	30	0.6	474	1.1	450	1.6
Sesame	539	9.7	479	9.6	5456	13.2	3898	13.8
Groundnuts	205	3.7	190	3.8	5523	13.4	3890	13.7
Sunflower	0.0	0.0	0.0	0.0	231	0.6	174	0.6
Cotton	684	12.3	624	12.5	197	0.5	180	0.6
Total	5564	100	4987	100	41274	100	28325	100

Sorghum, the main crop responsible for the bulk of area expansion in the Sudan utilized 40.6% of the irrigated area, 83.5% of the semi-mechanized rain-fed area and 32% of the traditional rain-fed sector (annex1). Millet crop is very minor in irrigated and semi-mechanized sectors and in traditional rain-fed sector (28.9% of the cropped area). Sesame

contributed 11.7% of the semi-mechanized area and 14.5% of traditional area. The area of groundnuts represents 21.7% of traditional rain-fed area and 12.3% of the irrigated area.

This expansion happened exclusively in rain-fed sector (semi-mechanized and traditional rain-fed agriculture). About 96.5% of sorghum area, 99.8% of millet area, 96% of groundnuts area and all areas devoted to sesame are under rain-fed sector (table 24).

Table 24:Percentage Share of Crop Area by Sector

Crop /area	Percentage share of Crop Area by Sector				all
	Irrigated	Semi-mechanized	Traditional	Total Rain-fed	
Sorghum	3.5	59.3	37.2	96.5	100.0
Millet	0.1	8.8	91.0	99.8	100.0
Wheat	97.9	0.0	2.1	2.1	100.0
Groundnuts	4.0	0.0	96.0	96.0	100.0
Sesame	0.0	32.7	67.3	100	100.0
Sunflower	60.3	0.0	39.7	39.7	100.0
Ctton	83.1	16.9	0.0	16.9	100.0
Lubia (cow pea)	18.8	0.0	81.2	81.2	100.0
Maize	14.0	0.0	86.0	86.0	100.0
Total	4.3	36.0	59.6	95.6	100.0

From the total area in Sudan (almost 52 million feddans), only 4.3% are irrigated, out of the remaining 95.7%, traditional sector contributed 59.6% and the traditional rain-fed sector contributed 36% (figures 5,6,7 &8) and Figure 2 illustrate the relative importance of sectors in Sorghum area
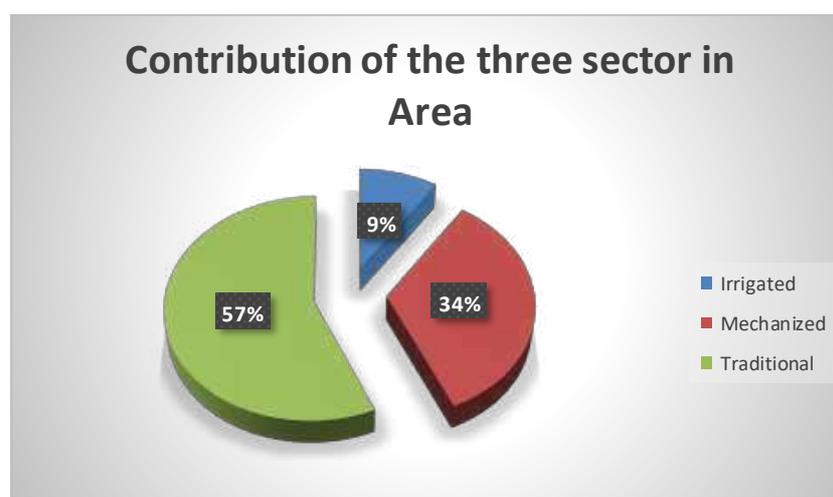
Figure 5:Contribution of Three Sectors in Area Cultivated
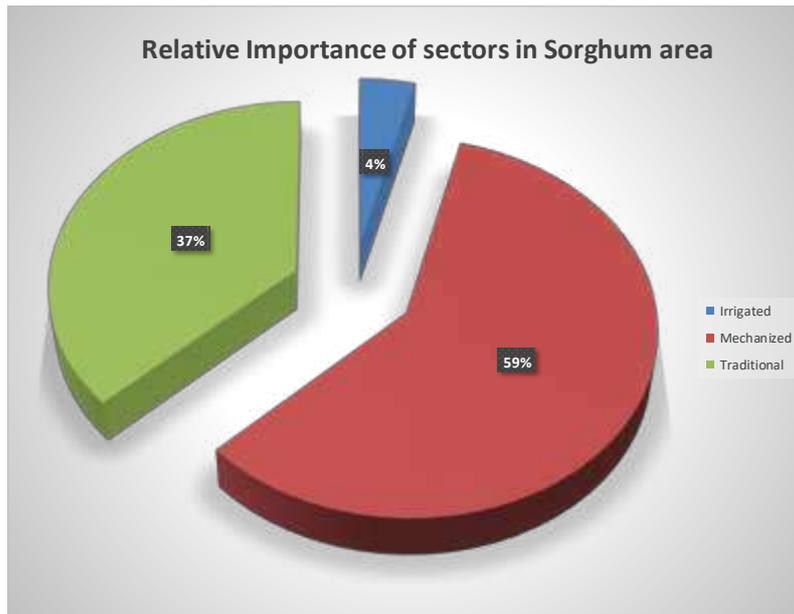
Figure 6:Relative Importance of Sectors in Sorghum Area

For all four main cultivated crops Gadaref State is the main contributor to agriculture expansion with 17.7%, followed by North Kordofan (12.9%), South Darfur (11.5%), Sennar (9.9%), South Kordofan (8.3%) and West Kordofan (5%) while the remaining 11 states collectively contributed 28.5% as in figure 9.
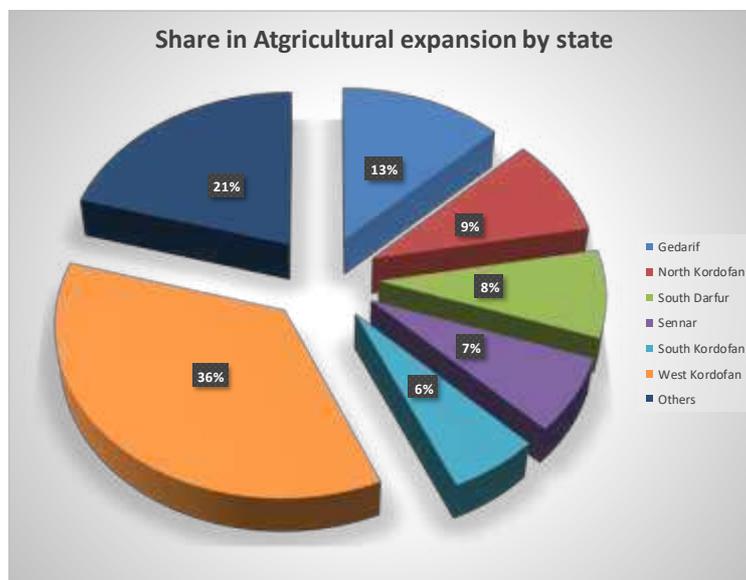
Figure 7:Share in Agricultural Expansion by State

In case of sorghum, the main contributor to agricultural expansion (52%), again Gadarif State is the leader with 28% of Sorghum area expansion. Sennar State ranks second with 14.7%, North Kordofan ranks third with 9.2% and White Nile Ranks fourth with 8.2%. The four states together contributed 60.1% of the country area expansion as indicated by the information in figure 8.
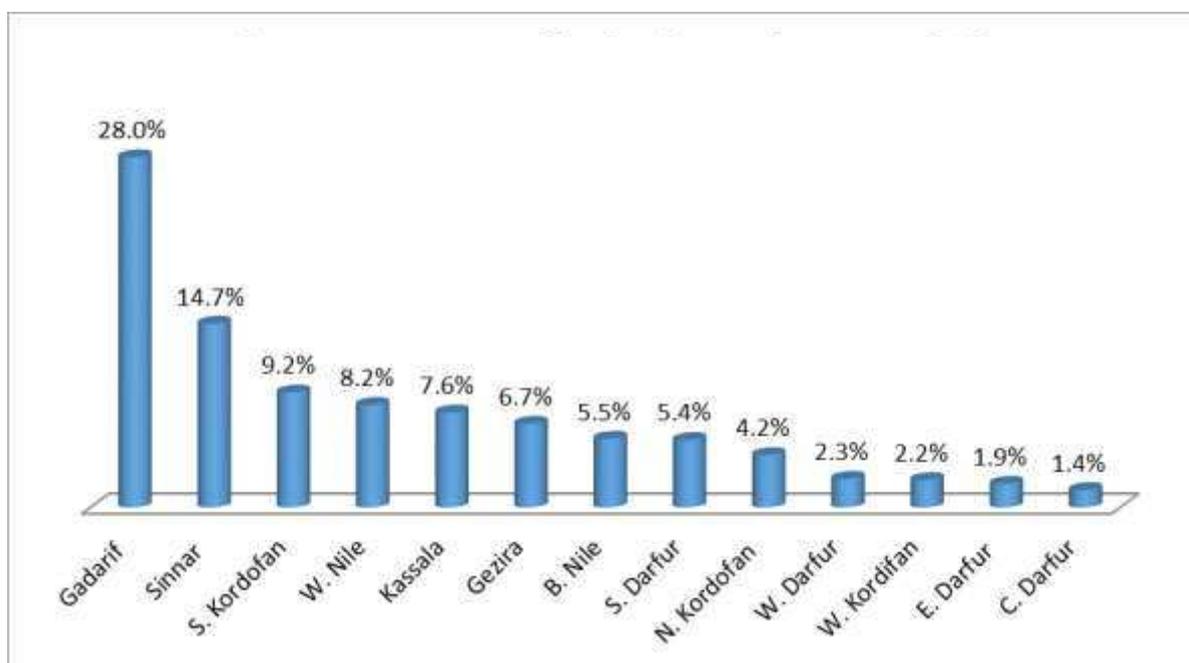
Figure 8:State Contribution in Sorghum Area (Sources of Growth in the Main Four Crops)

Sudan's agriculture is characterized by low productivity of all factors of production as producers are trapped in traditional systems of production. Crop productivity is even decreasing over time. The yield of food crops (cereals and oil seeds) continue to decline at 1.3% per annum (Ijaimi 2016). For instance, sesame productivity decreased from an average of 165 kg per feddan in seventies to 47-60 kg per feddan during the last years. To trace the sources of production growth of the four main crops (sorghum, millet, sesame and groundnuts), the time series data (1970/71-2015/2016) of the area, production and yield was analysed using semi-log regression equation (Table 25).

Table 25:Growth rates for Areas, Production and Yields of the four Main Crops

State	sorghum	sesame	millet	groundnuts
Area planted	3.86 (26.29) ***	3.37 (16.27)***	3.43 (10.55)***	2.19 (5.24)***
Area harvested	3.34 (19.81)***	2.96 (12.02)***	3.03 (13.80)***	1.87 (4.08)***
Production	2.47 (10.63)***	1.31 (5.31)***	1.3 (4.43)***	1.63 (2.95)**
Yield /FD planted	-1.39 (-8.12)***	-2.06 (-10.07)***	-2.13 (-5.08)***	-0.56 (-2.12)*

***= the coefficient is significant at 0.001%.

The following results were obtained:

Sorghum: The whole growth in sorghum production (2.47%) during the mentioned period came from horizontal land expansion (3.86%) as the yield has declined by 1.39% per annum. All these growth rates were found to be statistically significant (figure 9).
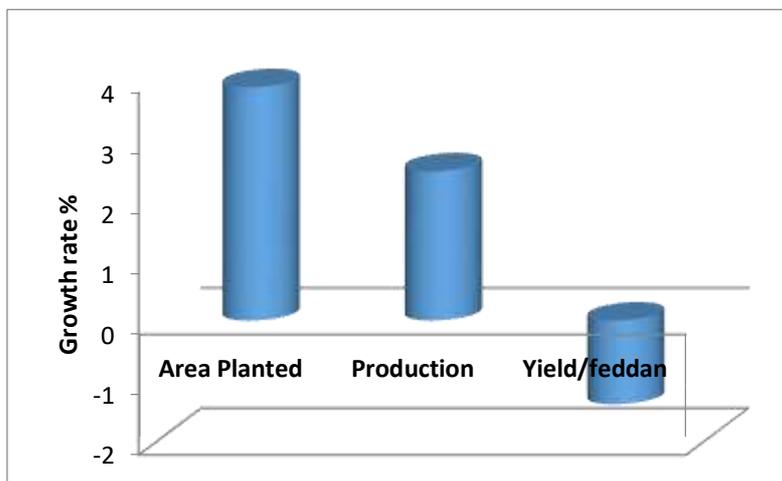
Figure 9:Sorghum Sources of Growth

The productivity per feddan planted decreased from an average of 309 kgs per feddan during the period 1953/54-1955/56 to only 165 kg per feddan during the period 2013/2014-2015/2016. This implies that productivity in early fifties of the last century was two times the average productivity during the last seasons.

Sesame: even though sesame area has increased by 3.37%, production grew by only 1.31% as the yield per feddan declined by 2.06% per annum (figure 10).
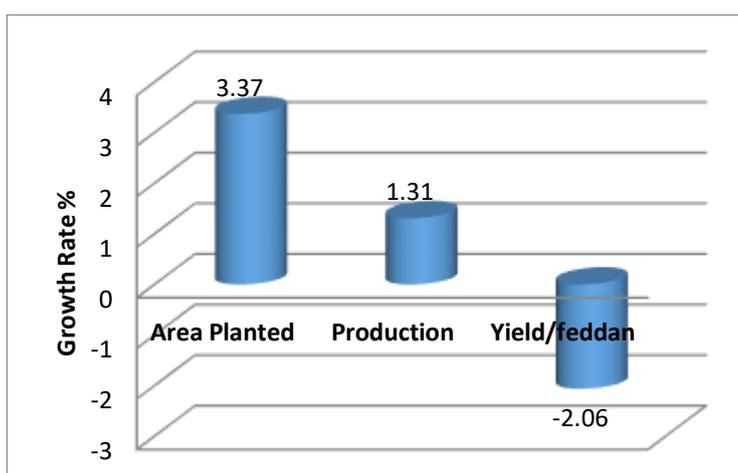
Figure 10:Sesame Source of Growth

The productivity per feddan planted decreased from an average of 219 kgs per feddan during the period 1953/54-1955/56 to only 74 kg per feddan during the period 2013/2014-2015/2016. This implies that productivity during the last three years represented only one third of the productivity in early fifties of the last century.

Millet: rapid area expansion is the source of the entire growth of millet output with yields continued to decline at 2.13% per annum (Figure 11).
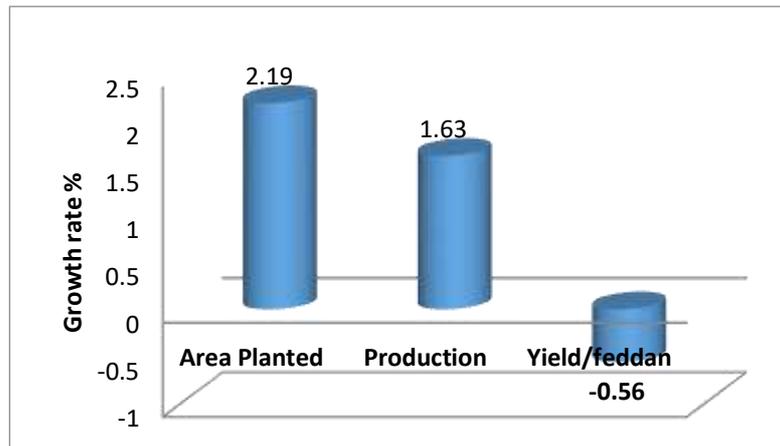
Figure 11:Millet Sources of Growth

All these growth rates were found to be statistically significant at 0.01% probability level. The productivity per feddan planted decreased from an average of 210 kgs per feddan during the period 1953/54-1955/56 to only 83 kg per feddan during the period 2013/2014-2015/2016. This implies that productivity during the last three years represented only 40% of the productivities in early fifties of the last century.

Groundnuts: although still area expansion is source of growth in groundnuts, the decline in yield is less than the other three crops (-0.56%), figure 12.
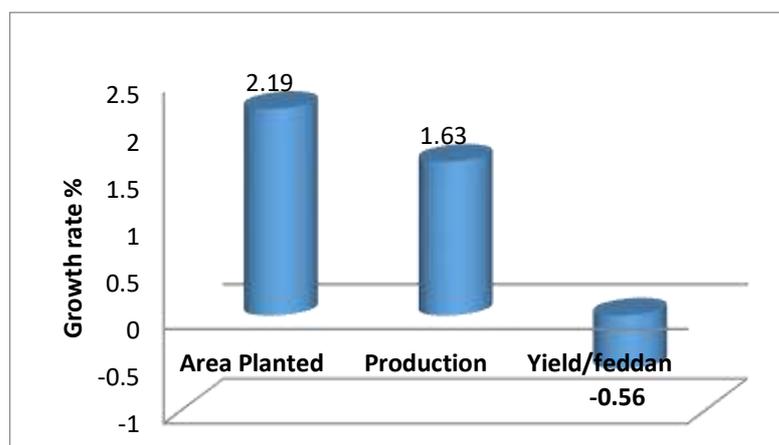
Figure 12:Groundnuts Sources of Growth

The productivity per feddan planted decreased from an average of 275 kgs per feddan during the period 1970/71-1972/73 to 229 kg per feddan during the period 2013/2014-2015/2016. This implies that productivity during the last three years represented 83% of the productivity in early fifties of the last century. this performance may be influenced by productivity in irrigated sector which was more stable without significant improvement.

To conclude, for the whole period which extended for 62 years (1953/54- 2014/2015, rapid area expansion is the source of the entire growth of food output with yields continued to decline at 1.3% per annum. All these growth rates were found to be statistically significant at 0.01% probability level. Ecological degradation and increasing competition over land between pastoralists and small farmers, and semi-mechanized investors are key drivers of deforestation, conflict over natural resources and entail risks of a crash in livestock numbers if drought conditions arise.

The result obtained Indicated dependence on forest for energy in three Kordofan States. According to the report, on average 75% of the sample respondents in Kordofan states reported using fire/straw as a source of energy and another 23% are using charcoal and only 1.8% using gas. These results again indicated the heavy dependence on forest and hence the degree of depletion.

Gross impact of Commercial Agriculture Principally Large-Scale, Mechanized Rainfed Farming, together with Irrigated forms of Agriculture is Estimated @ 40%[3].

Urban Sprawl:
The Second Direct Cause of Deforestation & Range Depletion in RoS in order of magnitude and chronology is Urban Sprawl
Development in Sudan is claimed to have started with the onset of the Anglo-Egyptian Condominium Rule of Sudan following the Karare Battle in 1898. By 1900, contemporary historians tell of one town in the country; Suakin on the Red Sea coast built by the Turks of sandstone. Present day RoS boasts some 90 cities & towns and hundreds of sub-urban villages. Some Cities like the Capital Khartoum is claimed to encompass some 50 townships. What about Wad Medani, Port Sudan, Gadaref, Kassal, El Obeid, Nyala? All these cities, towns and villages were built on what used to be forests or woodlands and were mostly built of mud bricks fired with wood derived from Sudan forests. The life styles of town and large village occupants entailed substantial consumption of wood for building material, furniture, firewood & charcoal. The summation of cleared forestlands for placing the towns & villages and the cumulative forest areas from which the wood requirements & consumed are derived are estimated at some 1.8 Million hectares equivalent to 2% of present day forest cover of the country.
The number of settlements that were classified as urban in the first census was 68. That number increased to 115 in 1983, and to 122 in 1993. This also illustrates the high urbanization tendency in Sudan.
Urbanization that grows at the expense of forests which is the case in most Sudanese urban areas- leads to deforestation and other environmental problems. The rural-urban balance is shifting and the absolute number of rural people will fall. UN projections show that the rural

---

[3] Gross impact calculated by relating total coped areas to forest & woodland cover

population will decrease by 11% between 2000-2020 while the urban population will increase by 110%.

The population of Sudan reached 30.9 million people in the last population census (2008), and is projected to 39.7 people by 2016, growing at a 2.8% growth rate per annum. With this rate of increase, the population could double up in in about 16 years.

The urban population constituted about 29.8% of the total 2008 population. This high rate of population increases, and the tendency towards population concentration in large urban centers, constitutes one of the biggest challenges facing Sudan because it requires heavy investments in infrastructure, energy and housing in urban areas

Urban Sprawl replacing Forest. Port Sudan (Courtesy M. Gamri).

Although the population of Sudan has been growing at high rates (about 2.8% per annum on average during the past 20 years), its urban population has been a growing at much higher rates (about double the natural population growth rate). Therefore, the proportion of urban population of the total population has always been on the rise as can be seen in Table 26. While that proportion amounted to 8.8% at the dawn of independence in 1955-1956 (i.e., the time of the first population census), it reached 29.8% in 2008 (the last population census), i.e. more than three times increase UN-Habitat, 2014)

Table 26:Total vs Urban population in Sudan as recorded in the five population censuses

Population / Year	55 /56	1973	1983	1993	2008
Total Population (000s)	10,300	14,800	21,590	24,900	30,894
Urban Population (000s)	854	2,606	4,154	6275	9,2016
% Urban	8.8	18.5	20.5	25.2	29.8

The national capital, Greater Khartoum that includes the three cities of Omdurman, Khartoum and Khartoum North, is by far the primate city in Sudan. Its 2008 population was about 4.27 million, i.e., more than nine times that of the second largest city, Nyala, whose population amounted to about 443,000 in 2008. Figure 2 illustrates the growth of Greater Khartoum during the five decades between the first and the last censuses. It indicates clearly that its population has been doubling-up almost every ten years.

Because of its relatively better services, large markets more employment opportunities and relatively higher standards of living, Greater Khartoum has always been the first choice for life-time migrants. The 2008 census has shown that 49% of all life-time migrants have migrated to it. It also showed that only 52% of those enumerated in Greater Khartoum were born in it (Central Bureau of Statistics). In addition to life-time migrants, Greater Khartoum and other large cities in Sudan host seasonal migrants who seek employment in urban (UN-Habitat, 2014)

Table (27) presents the population of the nine largest cities in Sudan and their population growth rates. It indicates clearly the urban primacy of Greater Khartoum whose 2008 population amounted to 43% of the total urban population in Sudan (Table 1), and to about three times the population of the four cities that followed it on the urban hierarchy (i.e., Nyala, Port Sudan, Al-Obied and Kassala).

The table also shows a strong tendency towards urban agglomeration. Whereas the percentage of Sudanese people that lived in the nine largest urban centers in Sudan in 1955/56 amounted to 5%, it reached 22% in 2008. Moreover, about 78% of the total 2008 urban population was living in those nine urban centers

Table 27:Population growth in the largest cities in Sudan

City	% Growth Rates		Population (000s)				
	83-93	83-73	2008	1993	1983	1973	55/56
Khartoum	6.6	4.7	4,271	2,918	1,343	784	245
Nayala	7.4	6.1	493	230	144	60	12
Portsudan	3,8	4.6	399	308	213	135	48
Obied	5.0	4.2	345	299	140	92	52
Kassala	5.1	3.6	298	235	143	101	41
Wad Medani	1.9	5.8	289	211	207	118	48
Gedaref	4.8	6.0	269	191	119	66	18
El Fasir	5.4	4.9	218	142	84	52	28
Kosti	6.6	4.3	213	174	92	66	23

Source: population census reports

Research conducted in Western Sudan indicate that, forests are still undergoing significant change, as the urban new extensions plan to be continued. The loss of forests was detected to result in widespread change in land use. In some towns of the North Kordofan, including El Obeid, Bara and Um Rwaba, the new urban extensions are still regularly pointed to as a primary cause of deforestation, and forest land declining is predicted for the immediate future.

In view of increasing forest, and future demand of housing, the loss of forest will be stretched further beyond the exist limit of the town and will become even more critical in larger areas (Ibrahim *et al* 2013).

Gross impact of Urban Sprawl is Estimated @ 15%[4]

Infrastructure Development

The Third Direct Cause of Deforestation & Range Depletion in RoS in order of magnitude and chronology is Infrastructure Development:

Infrastructural developments are foreseen to have positive and negative effects with regard to deforestation. As countries modernize and improve the efficiency and effectiveness of their infrastructure, less areas may need to be deforested as the demand for infrastructure could potentially be satisfied without new roads, railroads etc. Developing countries, however, as surfaced above, may rather have to extend their current infrastructure instead of modernizing

---

[4] **Gross impact calculated by computing all areas cleared of trees for placing the buildings and relating them to the total forest & woodland cover**

it. Such an extension is likely to have negative effects on deforestation. On the one hand, forests will be cut and replaced by roads and railroads. In addition, previously more remote patches of forest may become more vulnerable to logging due to expanded road infrastructure (ECORYS, 2010).

Improvements in infrastructure in all parts of Sudan in recent years have had a strong impact on per capita growth, contributing 1.7 percentage points. Consistent with trends in other countries, the information and communication (ICT) revolution that swept Africa contributed the most to Sudan. Sudan has invested heavily in infrastructure in recent years, with some notable achievements. Power generation capacity five times in just a few years. In the transport sector, even though the road network almost tripled in length (AICD, 2011)

3.1. This is synonymous to the Urban Sprawl. Mega-structures established in Sudan between 1900-2017 can be summarised as follows:

3.1.1. **Hydroelectric Dams:** Jebel Awlia, Sennar, Khashm El Girba, Roseries, Meroe and the recent Twin Atbara & Setiet Dams. Except for Meroe, each of all other Dams swamped thousands of hectares of forests & woodlands or had their basins (projected water storage areas) cleared of trees beforehand,

3.1.1.1. Each of the dams created agricultural schemes which entailed further deforestation and range depletion

3.1.2. **Highways & Roads:** Port Sudan- Haiya-Atbara-Khartoum; Haiya-Kassala-Gadaref-Sennar; Khartoum-Dongola-Ashkeit-Egyptian border; Karima, Meroe, Atbara; Khartoum - Wad Medani-Sennar-Damazine; Khartoum- Kosti- El Obeid, En Nuhud- El Fashir, Nyla-El Fashir; Nylala -Kas- Zalingei- Geneina; Gaderaf, Mettema-Ethiopian border. Some 56000 km in length and an alignment width of 100 meters, almost all on what was forests, woodlands or scattered trees,

3.1.3. **Railways:** Wadi Halfa- Abu Hamad- Atbara; Port Sudan – Haiya- Atbara; Haiya-Kassala, Gadaref- Sennar- Damazine; Khartoum- Wad Medani- Sennar -Kosti- El Obeid-Daei'n, Nyala. Some 16000 km in length and an alignment of 50 meters width mostly on what used to be forests or woodlands or scattered tree.

3.1.3.1. The entire rail length is on wooden sleepers derived from Sudan forests.

3.1.3.1.2. At the beginning of the railway system, locomotives and river paddle boats were running on firewood.

Sudan's infrastructure development has so far had a national focus, and there is much that remains to be done to achieve greater regional integration. While internal road corridors are developed, connectivity with neighbors is largely absent. Sudan has a natural gateway to the sea through Port Sudan but the port's performance (AICD, 2011)

Gross impact of Infrastructure Development is Estimated @ 15%[5]

Petroleum Exploration

The Fourth Direct Cause of Deforestation & Range Depletion in RoS is Petroleum Exploration:

---

[5] **Gross impact calculated by relating the gross area of the alignment of roads & rail to the total area of woodlands and forests**

This is the penultimate new comer in land use which entailed forest clearance and overall environmental disturbance causing measurable forest/range and environmental degradation. Ministry of Energy and Mining has divided the oil potential regions in old Sudan into 15 Blocks. Blocks 1, 2 and 4 are located in the previous Bahr Al Gazal and Southern Kordofan Regions. These Blocks are the present producing Blocks (Muglad Basin).

Map4: Sudan Oil Fields and Blocks

Blocks 3 and 7 are located on the Upper Nile Region. These Blocks constitute oil proven Blocks. Blocks 5A and 5 B are also oil proven and located in Jungli State (Sudd area). Block 5A is operated by the Lundin oil Co. and Block 5B is operated Map

Most of these blocks are still under preliminary exploration efforts. Block 8 on the Blue Nile, Block 9 on Gazera, Khartoum and Atbara, Block 10 on Al Gedarif Region. Block 11is located on the Northern. Blocks 12 and 14 are located on the Northern States and Blocks 13 and 15 are located on the Red Sea.

Removal of tree cover and other vegetation for construction of different facilities; Roads, Pipelines, Camps, Field Processing Facilities (FPF), Central Processing Facilities (CPF), Workshops, Warehouses, and Wells: several hundreds of kilometres of grid line and feeder roads @ 50 meters width have been cut through prime forests & woodlands in the *Terminalia- Sclerocarya-Anogeissus- Prosopis* and *Acacia-Balanites* Associations LRWS.

Table 28: Estimation of Tree Cutting Rates

No.		Activity	Estimation Basis	Total Area km²
1		Land clearance for drilling activities	230 wells were drilled @ average estimated cutting of I km diameter	180
2		Army barracks and safety measures	Actual seen barracks each of 5 km² (estimated numbers are 10)	50 Km²
3		Fields and central production facilities	A circle of 5km diameter for two field and 15-km for one central facilities including the airports	25
4		Others	Including small villages and fuel wood cuttings areas, etc. estimated to be 5 km²	5
5		Roads, pipeline routes, pump stations, evaporation ponds, water ponds, etc.	Estimated length is 600 Km by 100-200-meter width	90
		Total Estimated		350

Source: Nimir and Acelsalam 2004

The advent of oil exploration in many areas of Sudan particularly in West Kordofan State was associated with serious negative impacts. Large areas which were rangelands were denied access to traditional pastoralist users. Moreover, and due to lack of adherence to international standards of the oil industry, huge amounts of water removed with oil from deep strata which contains heavy metals are drifted on to the rangelands leading to serious implications on the vegetation, livestock and people. Attempts to purify these waters are still in their infancy. Furthermore, the natural drainage systems have been trodden with the raised gravel roads that traverse the area. The consequence of this was some areas became inundated while others dried up leading to changes in vegetation composition and in biodiversity.

However, satellite imagery confirms that many roads are effectively acting as dams and preventing the natural flow of water. This leads to flooding in some areas and drought in others. In addition to construction of thousands of kilometers of pipelines and roads for heavy traffic, oil industry has come with heavy deforestation. By 2004, an estimated 579 million trees, mostly Acacia, had disappeared in the Blocks 1, 2 and 4 alone.3 in Heglig area where, most of the illegally logged wood is turned into charcoal table (29).

Table 29:Area deforested by oil industry in seven States

State	Affected area (faddan)	No of removal trees
White Nile	4798	126433
West Kordofan	1286513	568930850
South Kordofan	123	34846
Sennar	89,3	2132
North Kordofan	89,3	13395
Khartoum	48	400
Nile Sate	9,1	1200
Total	1,306,161	579,094,261

Source FNC reports

Gross impact of Petroleum Exploration is Estimated @10%[6]

Mining

The Fifth Direct Cause of Deforestation & Range Depletion in RoS in order of magnitude and chronology is Mining:
Non-hydrocarbon minerals of actual or potential commercial value in RoS include gold, chrome, copper, iron, manganese, asbestos, gypsum, mica, limestone and marble. Gold had been mined in the Red Sea Hills at Gebeit, Khor Ariab and several other mines near the Red Sea since ancient Egyptian & Sudanese times. In the last few years there is an outburst rush in gold mining both modern and traditional. More than 80 companies are involved in gold mining and extraction. On the other hand, there are more than one million miners in gold mining and extraction in traditional (Artisanal) mining. Activities now cover 14 out of the 18 the States,

Chrome ore was mined in the *Ingessana* Hills in Blue Nile State. Large gypsum deposits, estimated to contain reserves of some 220 million tons, were found along the Red Sea coast. Gypsum was used mostly in the production of cement and building industry at large . Limestone, found in substantial quantities in Sudan, was mined both for use in making cement and for other construction materials. Marble was also quarried for the latter purpose. 5.3. There has been some commercial mining of mica, exploitable deposits of which had been in Northern State. Manganese and iron ore, of which several large deposits exist in different parts of the country, have been mined at times but only on a small scale. There were more than 500 million tons of iron ore deposits in the Fodikwan area of the Red Sea Hills,

---

[6] Gross impact estimated by relating the total area from which tree have been removed or damaged by oil activities to the total area of woodlands & Forests

All these activities remove hundreds of thousands of square kilometers of vegetation mainly forests, range land and soils, interrupted ecosystem service flows, and resulted in inevitable and often permanent farmland loss. Mining activities also frequently result in toxic waste that causes water pollution which affects both fauna and flora with all the attendant health problems.

Deforestation: Mining replacing forests. Hattab Gravel Quarries N. East Khartoum (HOA).

Gross impact of Mining is Estimated@ 10%[7]

Refugees & Internally Displaced People:
The Sixth Direct Cause of Deforestation & Range Depletion in RoS is Refugees & Internally Displaced People (IDPs):
Over the past fifty years, RoS was inflicted with and experienced each and a combination of influxes of Refugees, IDPs and Migrants.

Refugees

Sudan has received across its borders massive waves of refugees fleeing from civil war and other natural calamities in the neighboring countries in particular, eastern, southern and western of Sudan. For the last three decades, eastern Sudan (Gedarif and Kassala States) has hosted refugees from Eritrea, Ethiopia and Somalia. The refugees' population reached 1.1 million they arrive in large scale between 1967 and 1985.

---

[7] Gross impact of mining calculated by relating the gross area of landscape tattered by surface mining to the total area of woodland & Forests

Approximately 45% are pastoral nomads, some 35% are sustainable farmers and remaining 20% are semi nomad/ seasonal subsistence farmers. On arrival, the refugees were placed by the government authorities in cooperation with the United Nations Commission for Refugees (UNHCR) in temporary camps outside Sudanese villages; this arrangement has almost doubled the existing numbers of people in each location. The pressure exerted on the limited natural and other resources and social services in and around the refugee's camps and adjacent villages. The result is intensive removal of the natural vegetation and associated soil erosion, which is resulted in environmental degradations. This continuous deterioration of the productive land around the refugee camps and the adjacent Sudanese villages forced the people and their livestock to travel long distances away from these camps and villages to cultivate and/ or graze small plots on marginal lands. (COR ,1988&UNHCR ,1999)

The highest numbers of refugees in RoS were recorded during the 1990s; in 1993, for example, Sudan was host to some 745,000 refugees, the majority from Eritrea (57 %), Chad (19 %) and Ethiopia (2 %).   A belated influx of Eritrean refugees has been steady since 2003. In addition, there are 29,000 refugees from Uganda, Democratic Republic of Congo, Somalia, Ethiopia and other countries

Currently, most of the refugees in RoS are found in the three eastern States of Kassala, Gedaref and Red Sea. These states are bordering Eritrea and Ethiopia and hence almost all of the refugees are from these two neighbouring countries.   85,234 refugees from the two countries are residing in seven camps in Kassala State and one camp in Gadaref State,

After secession of Republic of South Sudan (RoSS) in July 2011 many refugees from RoSS who entered RoS are found in White Nile, South Kordofan and South Darfur States. They arrived to RoS as a result the conflict between the government and the opposition of RoS . By the end of 2015 the total number of RoS refugees in RoS reached 194,000, some 92,165 are hosted in White Nile State (WNS) camps as shown in the table (30).

Table 30:Number of Refugees from RoSS in White Nile State Camps-RoS

Camp	Year Established	Population	Number of households
Al Alagaya	2014	15,698	3,306
Dabat Bosin	2015	2,409	500
Jouri	2014	10,524	2,640
El-Kashafa	2014	14,303	2,396
Er-Radees I	2014	18,229	3,276
Er-Radees II	2015	22,776	4,994
Um-Sangour	2015	8,226	1,638
Total		92,165	18,433

B. Internally Displaced People (IDPs):
IDPs from different parts of Sudan were forced by the climate change (C.C.) and drought to leave their domains and they exist in most of the States.

Sudan has also generated more IDPs than any other country in the world. Since 2003 and following the conflict that started in Darfur IDPs from Darfur were forced to leave their home villages and stay in camps in the five States of Darfur and some of them stay in other states of

the country while others left for Chad. During the past two decades, events in RoS generated more IDPs than any other country in the world – an estimated 5.14 as shown in table (31).

Table 31:Location and number of IDPs

#	State	Number of IDPs
1	Khartoum	2,000,000
2	Northern	200,000
3	Red Sea	277,000
4	Kassala	76,000
5	Gadaref	42,000
6	Sennar	60,000
7	Blue Nile	235,000
8	White Nile	110,000
9	Kordofan	189,000
10	Greater Darfur	1,950,000
	Total	**5,139,000**

Source: Sudan: Post-Conflict Environmental Assessment, UNEP 2006.

Impact of Refugees & IDPs

Refugees and IDPs in RoS have measurable negative impact on natural resources especially on forests and rangelands:
- They rely almost entirely on firewood and charcoal as the main source of energy cooking,
- They use wood from forest trees for construction of their homes,
- They rely on wood cutting & charcoal burning as sources of income generation.
- One of most significant environmental impacts of displaced population settlements is the severe deforestation that has occurred around the larger camps,

International refugees automatically qualify for assistance from UNHCR, while many IDPs do not. What is virtually never provided is the source of energy for cooking food, boiling water or heating. In addition, when no formal accommodation is supplied, timber is needed to construct temporary dwellings. As a result, people living in the camps and settlements are forced to find timber and fuel wood in the surrounding area. In addition to that brick making has become an important source of income for IDPs in Darfur, but has also caused considerable environmental damage around the camps. The impacts of the process include increased water consumption, damaged farmland and deforestation. UNEP's report refers to the point that there is no international agency working in Darfur with a specific mandate to consider or incorporate environmental issues in relief operations and peace efforts. This contrasts with the case for Darfur refugees in Chad, where UNHCR has a mandate to incorporate environmental issues into relief and return issues. In eastern Sudan camp-related deforestation has been occurring since early 1980s

In Darfur fuel wood collection is uncontrolled and camps residents must walk 15 km to find timber and the UNEP report also indicated that extensive deforestation is extending as far as 10 Km from the camps. Substantial deforestation around the camps has taken place during 2003 – 2006.

Tearfund Organization prepared a report in 2007, Darfur: Relief in a Vulnerable Environment. The report describes the environmental context of Darfur and makes practical recommendations for the relief effort. The report states that the most significant environmental impact of the crisis is associated with the new, concentrations of population as a result of the massive displacement of 1.97 million people. Examples of population concentration during the crises in Darfur are shown in table (32).

Table 32:Examples of Concentration of Population during the Crises in Darfur

Town	State	Pre-crises population (host population)	Current population
Masterei	West Darfur	3,595	20,574
Morne	West Darfur	11,216	72,250
Gereida	South Darfur	12,466	140,466
Kebkabiya	North Darfur	15,000	57,926
Kutum	North Darfur	22.199	43,939
Kass	South Darfur	25,000	114,895

Source: Tearfund, 2007.

Consumption of Wood & Non-wood Forest Products and by Refugees & IDPs in RoS & conversion thereof into forest & woodland areas cleared or degraded:

In Darfur, people harvest more than thousand hectares of forests for fuel wood and construction purposes. Large-scale population displacement has led to the concentrations of people causing environmental degradation, where vegetation rapidly exhausted with pressure on water resources. Restrictions on livestock migrations has further contributed to localized concentrations of livestock, causing over-grazing and acute pressures on water resources. The trade in firewood and grass for fodder is a hot issue in areas hosting large numbers of IDPs. In several areas, firewood collection has long represented a major threat to IDPs from violent attacks. The trade is lucrative and in some areas controlled by certain groups, thus parties to the conflict control access to these vital natural resources. Competition for pasture and water by nomadic herders and settled agricultural producers is an important problem. Prior to conflict there were eleven animal routes, which were designated as passages for nomads to pass through farmers' plots during their movements from south to north in the rainy seasons, and from north to south during the dry season. The Darfur local nomadic leaders and the settled farmers agreed upon this arrangement in the early 1950s. Due to the deteriorating environmental conditions, the cattle movements from south to north is limited, and also many animal grazing areas has turned into cultivation of crops, especially groundnuts and sesame, as sources of cash for the farmers (Darfur Joint Assessment Mission, Situation Analysis: Agriculture, Livestock and Rural Livelihoods in the Greater Darfur Region, November 2012).

The survey from South Darfur shows that IDPs consume an average of 5 kg of fuel wood per house hold per day. By extrapolation, 300,000 IDP households would use 1500 metric tons of fuel wood daily (Fuel Efficient Stoves Programs in IDPs Settings – Desk Study. USAID, January 2007).

Large-scale population displacement has led to the concentrations of people causing environmental degradation, where vegetation rapidly exhausted with pressure on water resources.

The amount of firewood needed by South Sudan refugees' families for cooking is calculated in table (33), which is amounting to some 10,125 tons of charcoal per year. At the current (March 2016) rate of needs this equates to the removal of about 5,268 feddans of forest each year.

Forest Degradation: Kondowa forest degraded by Internally Displaced People (Courtesy M. Gamri)

Table 33: Quantity of Charcoal needed by South Sudan refugees per Camp in White Nile State

Camp	Current Population	No. of HH	Amount of charcoal needed (kg per day)	Amount of charcoal needed (kg per month)	Total amount of charcoal needed (kg per year)
Al Alagaya	15,698	3306	4,959	148,770	1,785,240
Dabat Bosin	2409	500	750	22,500	270,000
Jouri	10524	2640	3,950	118,800	1,425,600
El-Kashafa	14303	2396	3,594	107,830	1,293,960
Er-Redaise I	18229	3276	4,914	147,420	1,769,040
Er-Redaise II	22776	4994	7,491	224,730	2,696,760
Um Sangour	8226	1638	2,457	73,710	884,520
Total	92,165	18,750	28,125	843,750	10,125,000

Underlying cause of Deforestation & Range Depletion

Animal Population Growth

The main underlying cause of Deforestation & Range Depletion in RoS is Human and Animal Population Growth
The population of Sudan reached 30.9 million people in the last population census (2008), and is projected to reach 39.7 people by 2016, growing at a 2.8% growth rate per annum. With this rate of increase, the population could double up in in about 16 years. High population growth in the country (2.4%) implies enormous challenges in terms of service
provision as well as environment sustainability and resource management. The country also characterized by rapid pace of urbanization (4%-6% overall, reaching 7% - 8% in some urban areas) during the past 20 years.
Sectoral distribution of the labor force shows that 44.6% of the population are employed in the agricultural sector while 40.1 are engaged in services sector activities. The industrial sector employs 15.3% of the population. Overall, two-thirds (64.4 percent) of the population of Sudan live in rural areas, with some states having higher or lower proportions of rural populations. For example, only 19.1 percent of the population of Khartoum state is rural, whereas 45 percent of the population in Red Sea state is rural. The rural fractions in the remaining states range from 67.8 percent in White Nile state to 82.3 percent in Northern state. However, Sudan is currently experiencing a phenomenal rural-urban migration driven in part by drought and desertification as well as by the better living conditions in the urban areas (UN-Habitat, 2014). The rapidly expanding population has direct relations to the loss of forests as shown in Figure 15.
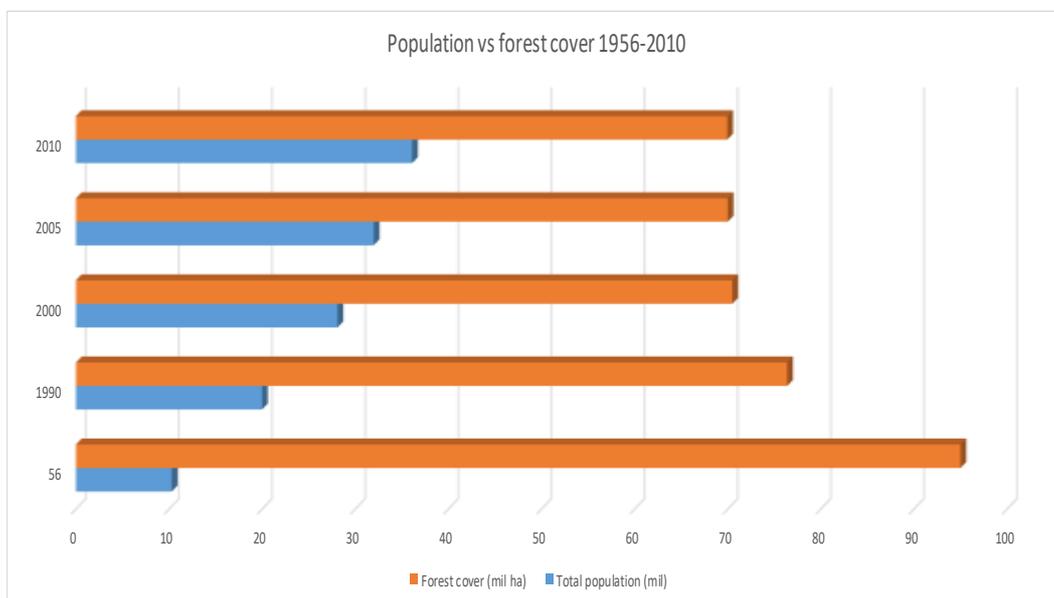
Figure 13:Population Vs Forest Cover in Ros 1956-2010

Increase in population has direct relation to the forest loss through:
- Energy consumption (fuel wood and charcoal)
- Housing (woody building material & non-woody building material Brick making)
- Practicing of Agriculture and other type of land use that cause deforestation
- Additional infrastructure and services

81

Animal "domestic & wild" numbers have increased from about 10 million head by the end of the Mahdiya era (1886-1898), to 32.6 million in 1975 to 106.6 million head in 2015, equivalent to 40.3 million tropical livestock units (TLU). Adding equine population, the total TLUs will be 44.4 million. The annual requirements of these animals (livestock and equine) are estimated at 133,3 million metric tons of dry matter forage. These requirements do not include those for wildlife,

Available feed resources from all sources (rangelands, cultivated forages, crop residues and industrial by-products) amount to 128.31million tons. Compared with requirements of 133.3 million tons there is a deficit of 5.1 million tons. The requirements identified here, do not include those for wildlife which are not available now. The feed production data shows wide temporal variations especially those from rangelands (e.g. 192 million tons for 2010 but only 35.0 million tons for 2011) showing that only 18% of the production in 2010 was obtained in 2011. This explains why in certain years there are huge mortalities

In addition to a decreased amount of feed produced from the rangelands the quality of feed witnessed degradation. In the rainy season grazing areas herbaceous range plants are intensively and selectively grazed before maturity and are not given a chance to set seeds. Also forest degradation is manifested in browsing of seedlings of shrubs and trees before reaching an age that they can tolerate browsing led to the disappearance of these shrubs/trees or at the best many of them are endangered. This led to a decline in productivity and quality of the range as desirable plants are the first to be grazed explaining the observed retrogression/degradation of the range in these areas and the disappearance of many of the plant species known to be desirable preferred. Looking to the existing available grazing and feed resources, it can be concluded that Rangeland degradation due to the overuse of shrinking resources is the most prominent environmental problem associated with livestock husbandry in Sudan. Although there is no systematic and quantitative inventory of rangeland conditions or rangeland carrying capacity on a national scale, discussions with national experts and various studies point to three negative trends:

- explosive growth in livestock numbers particularly in central Sudan;
- major reduction in the total area of available rangelands; and
- widespread deterioration of the remaining rangelands, caused largely by drought, climate change and overstocking.

Subsistence Agriculture

The second underlying cause of Deforestation & Range Depletion in RoS is Subsistence Agriculture:
Subsistence agriculture usually expands in areas which are previously rangelands. Although individual holdings may be small, the impact is huge when the millions of circles coalesce. Subsistence agriculture play a key role in the provision of food security, reduction of poverty, provision of employment opportunities, and stability for Sudanese citizens. In Sudan Fifty-eight percent of the active workforce is employed in agriculture, while 83 percent of the population depends on farming for its livelihood where, 70 percent depends on traditional rain-fed farming, 12 percent on irrigated agriculture and only 0.7 percent on mechanized agriculture.

Commercial agricultural activities are mostly concentrated in a belt at the center of the country, which extends approximately 1,100 km from east to west between latitudes 10o and

14o north, in the semi-arid dry savannah zone. Small-scale subsistence agriculture is found throughout Sudan, and is dominant in Western Sudan.

The main farming types indicated the wide prevalence of traditional agriculture (58%) and sizeable mechanized cropping (33%) (Hamid Faki et al, 2012). 8.37 million ha under traditional rain-fed cultivation and 5.44 million ha under mechanized farming (Shukri Ahmed, Getachew Diriba et al. 2007).

Crop production from traditional rain-fed farming has grown since the early 1990s; it has surpassed the level of semi-mechanized farming, which shrank during the same period.
Poor people who having neither the money nor the political power to acquire holdings on productive lands, use to clear the surrounding forest for short-term Subsistence agriculture. Sometime understory shrubbery is cleared first and then forest trees to be used as construction material of fuelwood.

Many people are practicing Subsistence agriculture in a non-rotational manner that fields do not have time to return to secondary forest as they do after natural disturbances.
The results of the present study highlight that commercial agriculture is the most prevalent deforestation driver. The other important land use is local/subsistence agriculture, which is with the commercial one related to 40% of deforestation in Sudan

Legal & Institutional Gaps

The third underlying cause of Deforestation & Range Depletion in RoS is Legal & Institutional Gaps:
Main findings of this study on Drivers of Deforestation & Forest Degradation agree with those by other consultants such as on Land Tenure in that the sheer absence of and / or the many loopholes in existing relevant legislation coupled with lack or weakness of enforcement thereof is a genuine underlying cause of Deforestation & Range Depletion in RoS
Despite Sudan has adequate legal and policy frameworks for forest conservation and management, stakeholders including local communities highlighted the following as indirect causes of Deforestation:
- Poor law enforcement leading to poor performance on forest protection and conservation and encouragement of illegal activities in Sudan
- Inadequate institutional capacity specially at local level
- low level of awareness
- Inadequate and limited coordination among different sectors responsible for natural resources utilization (Agriculture, Livestock)
- Lack of institutional framework benefit sharing mechanisms lead to limited community participation & involvement in forest management.

Lack of Stakeholder Participation

The fourth underlying cause of Deforestation & Range Depletion in RoS is Lack of Stakeholder Participation:
Here too, the main findings of this study coincide with those by other consultants such as on Benefit-Sharing in that the sheer absence of genuine stakeholder participation in forest management or decision making and in-adequacy of benefit -sharing mechanisms or

modalities is squarely behind the uncertainty, indifference if not the outright belligerent attitudes of forest neighbouring communities towards the resource and hence any desire to safeguard , protect or see it sustainably developed.

Realizing the importance of sustainable forest management and effective governance a forest policy was formulated and passed to promote greater participation of stakeholders in forest management and decision making. Existing forest law is also allowed for participatory forest management but still the levels of stakeholder participation and involvement in the forest sector is very low as highlighted by respondents.

An over-arching Cross -cutting Issues highlighted by respondents as underlying cause of Deforestation & Range Depletion includes:

- Natural Environmental Factors: In this context these encompass Climate Change & Desertification,
- Socio-economic Factors: Foremost of these Poverty and landlessness are over-arching cross-cutting issues underlying Deforestation & Range Depletion in RoS.

Drivers of Forest & Range Degradation

Unsustainable Wood Extraction for Energy & Other Purposes

The prime direct factor in Forest & Range Degradation in RoS as highlighted by respondents and indicated by the analysis of secondary data is Unsustainable Wood Extraction for Energy & Other Purposes:

Energy in this context refers to firewood & charcoal, while other purposes of wood-use encompass building poles, furniture and cosmetics.

Evidently, RoS is overcutting and eroding the forest resource capital in the ten States east of the Nile Basin namely Northern, River Nile, Khartoum, Red Sea, Kassala, Gadaref, Gezira, Sennar, Blue Nile & White Nile States and only in the eight States west of the Nile Basin (Greater Kordofan & Greater Darfur) that the total annual consumption of wood is within the annual allowable cut as shown in Figure 16.

Drivers of energy demand are demographic (and social) as well economic and environmental. Increased cost of securing adequate energy services across vast areas to all its population is a challenge. According to the national census (2008) and indicated growth rates of 2.8% the total population of RoS in 2017 is estimated to be around 42 million inhabitants of whom 34% are urban.

Another challenge is the energy requirement of economic growth. The pace of economic development is increasing rather higher compared to the historical conditions. Economic growth is a major energy demand driver. Energy is a critical input for achieving sustainable economic growth and is the key element in accelerating national economic development. Radical changes in the development of the whole economy are expected during the coming decades. Gross Domestic Product (GDP) growth rate per annum (Table34) increased significantly with an average growth rate of 4.45%.

Table 34:Sudan GDP growth in constant 2010 US$

Years	2000	2005	2010	2015
GDP in Billion US$	34.053	46.433	65.639	73.731

Source: World Bank national accounts data, and OECD National Accounts data files.

However, GDP per unit of energy shows improvement in the efficiency of energy use from 3 to 11 GDP value per unit of energy.

Future evolution of Sudan economy is the expected changes in the GDP share of the different economic sectors and more efficient use of energy.
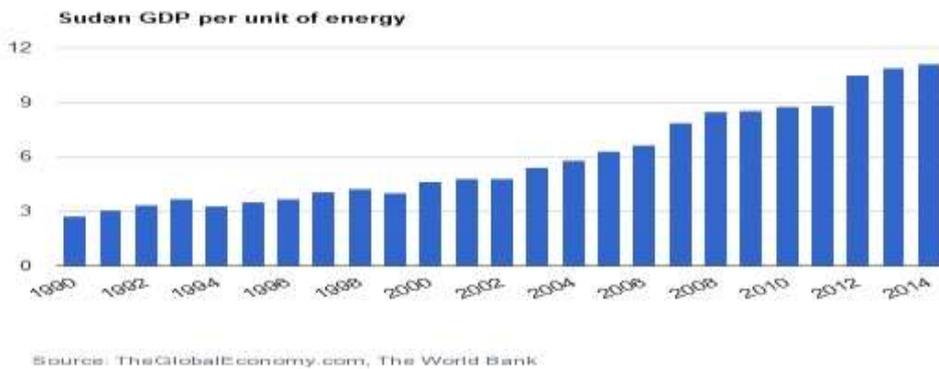
Figure 14:RoS GDP per unit energy

Energy consumption patterns and trends:
Figure (15) shows Sudan Energy balance for the year 2015 and depicts flow from different types of energy resources, conversion, transformation, distribution, losses through different processes and end user by sectors and type of final energy product consumption.

Primary energy Supply:
Total primary energy supply for the year 2015 amounted to 13.1 million ton of oil equivalent (TOE); where biomass represented 54% of the total primary energy supply followed by petroleum (40%) and hydro power (6.2%) including 1.5% imported through Ethiopian link power supply connection. (See figure 16).
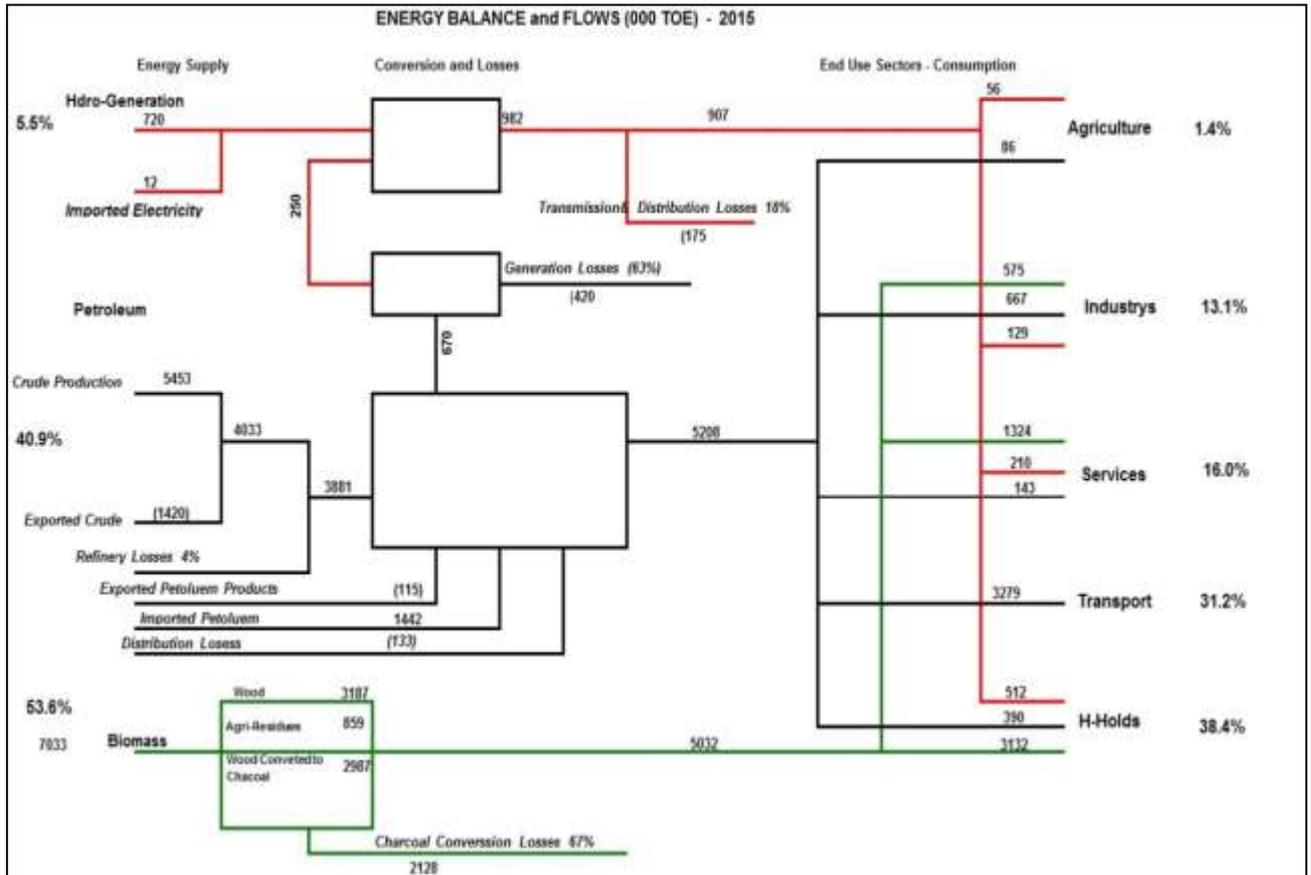
Figure 15:RoS Energy B2015 (Source General Directorate for National Energy Affairs – Ministry of petroleum)
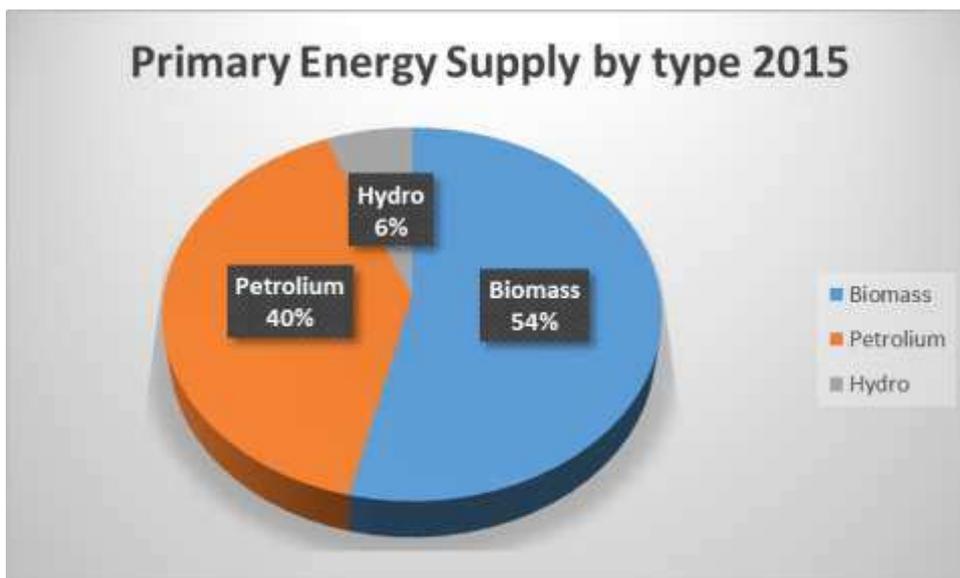
Figure 16:RoS Primary Energy Supply by type 2015 (Source General Directorate for National Energy Affairs – Ministry of petroleum)

Biomass continued to be a dominant primary energy supply sources with an insignificant decrease mainly to petroleum supplies. Table (35) shows contribution of biomass to the total primary energy supply during the last 15 years. There is a decrease of the percentage contribution of biomass from 80.4% in the year 2000 to 53.1% of total primary energy supply. This decline in percentage may be seen as a positive sign that could contribute to alleviation of hazardous impacts on environment by both reduction of forest and green cover removal. However, the total biomass input to primary energy supply has also increased in amount from six million TOE to seven million TOE, mostly from woody biomass. Programs are required to reduce both percent and quantities. Efforts on the demand side control by availing alternatives for example in cooking to reduce required supplies have faced disincentive due to removal of subsidies and liberalization of LPG markets leading to tremendous increase in prices. Policies to control tree cutting will not come to effect unless affordable alternatives are made available.

Table 35:RoS Primary Energy Supply 2000 - 2015 (000 TOE)

Source	2000	%	2004	%	2007	%	2010	%	2015	%
Petroleum	1361	17.9	2478	27.7	3090	31.7	3935	35.7	5361	40.8
Electricity	135	1.9	186	2.1	329	3.4	518	4.7	804	6.1
Biomass	6115	80.4	6288	70.2	6323	64.9	6565	59.6	6979	53.1
Total	7610	100	8953	100	9742	100	11018	100	13144	100

Source: General Directorate for National Energy Affairs – Ministry of Petroleum

Hydro power supply has increased significantly from 1.9% of total primary energy supply to 6.1% by establishment of Merwe hydro power generation. Hydro power generation also relieved primary petroleum which would have increased at higher rates to provide for power generation now supplied by hydro sources.

Crude oil and Petroleum products supply have increased significantly during the period 2000 – 2015 with the large-scale mining and oil exploration activities that required direct input as well supporting logistics mainly road transport in the absence of more efficient means e.g. railway and river vessels.

Total energy consumption and end use by sector:
Table (36) shows consumption of end use sectors by type of fuel and total energy consumption. It also shows consumption share of each end use sector from specific type of energy supply.

Table 36:RoS Final Energy Consumption by sector 2015 (000 TOE)

Sector	Elect.	%	Petrol.	%	Biomass	%	Total	%
Agriculture	56	6.2	86	1.9		0	142	1.4
Industry	129	14.2	667	14.6	575	11.4	1371	13.1

Services	210	23.2	143	3.1	1324	26.3	1677	16.0
Transport		0	3279	71.8		0	3279	31.2
Household	512	56.4	390	8.5	3132	62.3	4034	38.4
Total	**907**	**100**	**4565**	**100**	**5031**	**100**	**10503**	**100**

Source: General Directorate for National Energy Affairs – Ministry of petroleum

The main consumer of biomass is the household sector representing 62% of total biomass consumption or 4.4. million TOE. Over 60% of biomass supply comes from woody biomass and is used for cooking by households. This has serous implication on family's health through indoor pollution by smoke emitted from burning firewood in addition to its negative impact on general environment because of emitted carbon dioxide and tree cutting. World Health Organization (WHO) identified health impact of smoke resulting from cooking by wood, agricultural residues and charcoal as number one killer that affects women particularly in developing countries resulting in more immature deaths than those caused by Malaria, HIV, and *Tuberculosis* (TB) collectively. Recent study by National Energy Research Centre (NERC) (household energy situation 2015) revealed that 49% in urban areas and 85% in rural areas use firewood for cooking while 82% in urban areas and 65% in rural areas use charcoal for cooking. Same survey indicated that 76% of Sudan population use low efficiency three stones for cooking using firewood. Loss of energy occurs at transformation to charcoal as well use of low efficiency stoves for wood or charcoal use for cooking. Service sector comes second in the use of biomass (26.3) again mainly for cooking and water heating. The third consumer is industry representing 11.4%. Brickmaking is the main consumer of biomass within industry sector.

Household sector consumes the largest share of electricity (56.4%) mainly in urban centres. National level of access to electricity is 34% according to the Ministry of water resources and electricity but far less in rural areas where access to electric power – according to some estimates is below 20% (UNDP human Development report 2015). Electricity consumption per capita has been estimated by the Ministry of Electricity at 233 KWh/year. Service sector is the second largest consumer of electric power (23.2%) followed by industry (14.2%) and a smaller amount in agriculture.

Inadequate supply for industry leaves only private thermal generation for the sector while low level of input to agriculture coincides with the low level of productivity due to limited use of technology that electricity would have provided access for (e.g. storage, irrigation water pumping and processing).

Table (37) shows that during the period 2000 – 2015 woody biomass remained the main biomass fuel consumed representing over 83% when combined with charcoal from the same woody sources.

Table 37:Biomass Consumption by Fuel Type (Million TOE)

sector	2000	%	2004	%	2007	%	2010	%	2015	%
Wood	3.85	62.5	3.96	62.4	4.04	62.6	4.12	62.7	3.187	63.3
Charcoal	1.26	20.5	1.29	20.3	1.3	20.2	1.33	20.2	0.986	19.6
Residue	1.05	17.0	1.1	17.3	1.11	17.2	1.11	16.9	0.859	17.1
Total Biomass	6.16	100	6.35	100	6.45	100	6.57	100	5.032	100

Source General Directorate for National Energy Affairs – Ministry of petroleum

End use sectors by source of energy supply

Figure (17) shows relevant values of different energy sources on the total sector energy consumption in 2015. Total energy consumption of agricultural sector is represented from petroleum (60%) and electricity (40%). Main energy sources for industry are petroleum products (49%) and biomass (42%) while smaller portion of industry total energy consumption comes from grid electric power. This confirms what has been mentioned above about reliance of industry on thermal power generation and intense use of biomass in brick making industry,

Services sector relies on biomass for 79% of its total energy consumption mainly for cooking and water heating with 8.5% of consumption in petroleum products mainly LPG for cooking and small part (12.5%) of electricity consumption for lighting and equipment operation. 78% of household energy consumption comes from biomass which is used for cooking together 12.5% from electricity for lighting, refrigeration, kitchen equipment, water pumps and ventilation. The 9.7% of total household energy consumption which is supplied by petroleum is LPG and other products used for cooking in addition to lighting. Petroleum materials are seldom used for cooking.
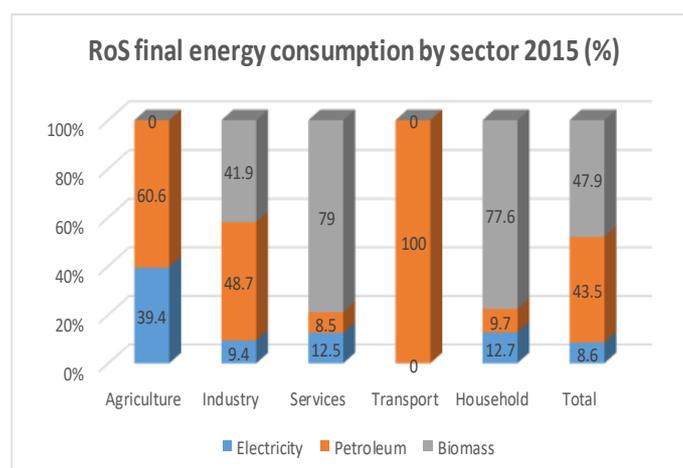
Figure 17:RoS Final Energy Consumption by Sector (2015) %

Household Energy Consumption:

There are mainly five types of energy that are used in households: Wood, charcoal, agriculture & animal residues, electricity and LPG. There are also four general appliances where energy is utilized. These are cooking, lighting, cooling (ceiling and portable fans, swamp coolers and kitchen and water refrigerators) and air conditioning and other appliances such as washing machines, recreation instruments (radio, TV sets, receivers, computers, etc.), water pumps, kitchen appliances, etc.

Generally cooking and lighting are in every household of the nomad, rural or urban. Others which reflect the city and urban behaviour may vary in the different districts of the city.

In 2012 the Higher Council for Environment and Natural Resources (HCENR) conducted a mitigation study in all energy sectors; the energy consumption by urban households, cooking represents a high percentage of the household energy consumption. The average cooking consumption is more than 50% fuel wood, 40.6 % is charcoal and the remainder 9.4% is LPG. Electricity usage in cooking is negligible. There is a sharp increase of LPG production between the year 2000 and 2006 which is reflected in increase of LPG usage from approximately 5 kg/household/year to 35 kg/household/year in 2006. This is about 700% increase in household LPG consumption in urban community. The huge change in household energy consumption in this period is attributed to the large amount produced by Khartoum Refinery (used to be flared because of the little consumption at that time). The government reduced the prices by almost half to encourage transfer to LPG.

Regarding energy consumption for cooking purposes in rural areas it was the same trend as in urban applies for rural, i.e., there is increase in household LPG use as substitute to biomass energy. The contribution of LPG increased in both quantities and percentage of the total energy utilized for cooking in rural areas in the year2006 compared to year 2000 (before the start of Khartoum Refinery production). This is a huge change which contributed considerably to different environmental and emission reduction issues.

Degradation: Unsustainable wood extraction for Energy (Firewood & charcoal).
Charcoal production Blue Nile State (HOA).

Per capita Household Energy Consumption by State:

A recent study by the National Energy Research Centre (NERC) named (Household Energy Situation in Sudan 2016) shows noticeable variation of per capita energy consumption by states from one hand and variation between fuels used on the other hand.

It is evident from the table (38) that Northern, River Nile, Sennar, White Nile, Khartoum and Gezira State, LPG consumption is the highest among other states due to their location near the supply centres. On the other hand, all Darfur States, West and East Kordofan and Blue Nile states have low per capita consumption of LPG but very high consumption of wood and charcoal as wood and charcoal supplies are very near to these states and where wood is used for both cooking and lighting in some cases. It is also noted that Khartoum total per capita consumption is very low since many people eat one or more meals outside their residence in restaurants It is also noted that the high consumption of wood is due to the inefficient three stones that used for wood and charcoal. It is recommended that:

(i). Introduction of improved stoves to these areas accompanied by training of artisans and awareness campaign

(ii). Introduction of alternative energy with affordable prices. This include LPG, kerosene and solar cookers. Also training and awareness is needed.

Table 38:Per capita consumption of energy for cooking by state (Kilos of oil equivalent (KOE) 2013.

State	LPG	Charcoal	Wood	Residues	Total
Northern	32.0	13.5	15.8	0.9	62.2
River Nile	23.9	13.7	18.8	0.3	56.7
Red Sea	6.4	48.2	32.6	1.2	88.4
Kassala	9.7	85.5	311.3	4.1	410.6
Gadaref	8.0	108.1	66.8	82.0	264.9
Khartoum	27.2	21.1	6.6	0.0	54.9
Gezira	29.5	69.1	21.0	5.7	125.3
White Nile	23.5	106.1	53.3	10.9	193.8
Sennar	29.8	90.3	160.8	21.3	302.2
Blue Nile	3.9	125.5	318.6	11.8	459.8
North	10.1	63.2	40.3	3.6	117.2

State	LPG	Charcoal	Wood	Residues	Total
Kordofan					
South Kordofan	1.3	60.6	48.8	2.5	113.2
West Kordofan	3.8	50.6	42.0	0.7	97.1
North Darfur	1.1	47.0	118.2	1.3	167.6
West Darfur	0.8	29.7	45.7	0.8	77.0
South Darfur	0.3	95.0	701.3	0.0	796.6
Central Darfur	0.4	35.8	64.7	0.1	101.0
North Darfur	0.7	33.6	264.9	5.3	304.5

Source: Household Energy Situation in Sudan, NERC& AfDP, March 2016

Sudan energy system and the environment:

Balancing energy and environment equation is a key input for attainment of the stated poverty reduction strategies in with the global SDGs and formulating sustainable programs and projects for poverty reduction. Sudan signed the UNFCCC in Rio1992 and ratified in November 1993 and signed the ratification of Kyoto Protocol in 2004. Sudan has a low per capita CO_2 emission rate of an average of 0.3 Mt (see table 7 Sudan indicators WB 2015) compared to per capita 17, 11, 14, 4.7 and 0.9 Mt United States, High-income OECD, Canada, Arab World and Sub-Saharan Africa (table 39). However, Sudan faces serious negative environmental and climate change impacts. Most of the Sudanese population livelihoods are natural resource base that is sensitive to changes in temperature and precipitation. Low and intermittent rain fall due to climate change leads to reduced crop production, poor range and animal condition and consequent food insecurity and conflicts. Dependence on biomass mainly wood for 60% of the country's energy supply mainly to meet household cooking and brick making requirements stand as a direct cause for forest removal, decreased rainfall and desert encroachment at the expense of cultivable areas.

Overall Current Energy Polices:

The current energy policy is designed to be consistent with the general economic liberalization and encouraging the private investments in energy sector development. Generally, these policies include:

Ending the state control over the energy services. The privatization of oil products and gas was adopted since 1996,

Encouraging the private sector through concessions including exemption from taxes for periods ranging from 5 to 10 years depends on size and type of energy investment,

Exemption of oil companies from taxes and duties on importation of equipment.

Removal of subsidies on all types of hydrocarbon fuels.
Ending the monopolization of NEC on electricity generation, transmission and distribution outside the national grid.
Priorities of electrical supply are given to the productive sectors agricultural and industrial.

- Encourage the use of renewable energy through exemption from taxes and duties on all renewable energy equipment.

Options for Sustainable Production of Fuel from Other Renewable Resources

Based on the analysis of secondary data and stakeholder response the following options for Sustainable Production of Fuel are recommended:
Energy from Agricultural Residues including

- Cotton Stalks, Groundnut Shells through combustion in an efficient manner

- Ethanol from sugar plants

- Livestock manure

Available data from RoS energy balance confirms that RoS energy system faces serious discrepancies that constrain its ability to avail sustainable energy services for all. Dependence on non-renewable biomass has serious impacts on environment and public health. The massive use of wood and charcoal contributes to decrease in forest resources. Unorganized and illicit cutting of trees for wood and charcoal production occurs throughout the country. However, the pressure is greater on the limited biomass resources. Shortage of biomass resources lead to higher prices of wood and charcoal and consume a high percent of poor family's incomes.

The Potential of Alternative Sources of Household Energy identified as follows:

- Renewable energy include wind, solar, agricultural residues, hydro power and geothermal

- Liquefied Petroleum Gas (LPG)

Gross Impact of Unsustainable Extraction of Wood for Energy & Other Purposes on Forest & Range Degradation in RoS is Estimated @ 40%[8]

Overgrazing

The second direct factor in Forest & Range Degradation in RoS in order of magnitude is Overgrazing
The present study is intended to compile data on drivers of deforestation and forest degradation that can be attributed mainly to livestock husbandry. The sources of information are quite diverse. The main source is secondary data obtained from reports by various government departments such as the Range and Pasture Directorate of the Ministry of Animal

---

[8] Gross impact estimated calculated by converting quantities of wood used in energy into areas at an average productivity per feddan of around 1.5 m³/feddan/annum -into forest & woodland area cleared related to total area of woodland and forest area

Resources, and other reports and publications such those of Western Sudan Agricultural Research Project (1985) and other literature from the relevant international communities. Consultations were also made with pastoral and other communities from the various states, in addition to key informant's experience and field observations.

Sudan has the second largest and most diversified animal population in Africa. The contribution of livestock to GDP amounts to more than 60% of the total contribution of agriculture. It also contributes 20-23% of the total revenues in hard/foreign currency. The fact that livestock plays an important role in supporting the livelihoods of a large portion of the rural population in Sudan need no emphasis. The national livestock herd was estimated at 106.6 million head of cattle, sheep goats and camels in 2015. Livestock numbers/estimates for the period 2009 -2015 are shown in Table (39). Livestock population has increased by 3.8 million in the last six years or by a rate of about 0.6 million every year. Livestock numbers by state for the year 2015 are shown in Table (40). The last and more reliable official livestock census was carried out in the year 1975 and it has shown that livestock population in that year was 32.6 million heads (Table 41). This shows an increase of 74 million head in 40 years or an increase of 327%, more than three folds. The 2015 livestock population was calculated to amount to 40.3 million tropical livestock unit (TLU).

Table 39:Estimates of animal numbers 2009-2015 (000 Head)

Year	Cattle	Sheep	Goats	Camels	Total
2009	29210	38744	30332	4521	102807
2010	29358	39137	30452	4623	103570
2011	29618	39296	30649	4715	104278
2012	29840	39483	30837	4751	104911
2013	30010	39568	30984	4773	105335
2014	30191	39846	31029	4792	105858
2015	30376	40210	31227	4809	106622

Source: Information Centre, Ministry of Animal Resources (Statistical Bulletin, Issue No. 25)

Table 40: Estimates of Livestock Population by states-2015

State	Cattle	Sheep	Goats	Camels	Total
North Kordofan	759,400	4141630	2654295	923328	8,478,653
South Kordofan	4,444,009	2171340	2123436	248144	8,986,929
West Kordofan	3,402,112	4282365	2373252	629979	10,687,708
North Darfur	707,761	3860588	2962333	601606	8,132,288
South Darfur	2,389,072	2171340	1690005	89135	6,339,552
East Darfur	1,954,696	1773261	1382732	72928	5183617
Central Darfur	1,877,237	1809450	2023510	195726	5,905,923
West Darfur	2,296,426	2203508	2476301	239007	7,215,242
El Gadarif	1,069,235	2192301	1082477	348172	4,692,184
Kassala	868,754	2074665	1710580	701633	5,355,632
Red Sea	139,730	427766	735015	291425	1,593,936
Blue Nile	2,074,681	4010306	463282	14427	6,562,696
Sinnar	1,628,154	1411628	1674943	118782	4,733,507

State	Cattle	Sheep	Goats	Camels	Total
Elgezira	2,554,622	2539860	2191681	125515	7,411,678
White Nile	3,599,556	2620066	2614871	36068	8,870,561
Northern	258,196	1005250	1176024	50014	2,489,484
River Nile	103,278	1058721	1233934	116378	2,512,311
Khartoum	249,083	454501	659286	6733	1,369,603
Total	**30,376,000**	**40,210,000**	**31,227,000**	**4,809,000**	**106,622,000**

Table 41:Livestock populations 1975

	Cattle	Sheep	Goats	Camels	Total
N. Dafur	907,081	1,409,533	1,193,613	226,103	3,736,330
S.Darfur	2,735,360	1,232,024	1,117,220	142,083	5,226,687
N. Kordofan	937,127	2,470,580	1,683,647	851,587	5,942,941
S. Kordofan	1,467,367	830,053	696,030	1,798	2,995,248
Kassala	642,883	1,589,532	925,009	567,949	3,725,373
Blue Nile	1,006,000	1,041,000	435,000	41,000	2,523,000
Gezira	503,916	216,321	1,143,711	146,051	2,009,999
White Nile	1,563,568	2,207,686	657,336	77,877	4,506,467
Northern	14,419	208,615	151,969	114,613	489,616
Nile province	43,717	272,488	263,030	59,058	638,293
Khartoum	56,871	269,920	429,969	13,740	770,500
Total	**9,878,309**	**11,747,752**	**8,696,534**	**2,241,859**	**32,564,454**

Source: Roy Behnke and Hala Mohammed Osman (2015). The contribution of livestock to the Sudanese economy, IGAD Livestock Policy Initiative, Working Paper No. 01-12

Livestock production systems:

The major production livestock production systems in Sudan were described by Fadlalla and Ahmed (1999) as under:

1. Nomadic: Livestock, mainly camels and sheep, with some goats, are raised entirely on natural rangelands. Households move with their animals and have no permanent land base on which to grow crops/fodders. They spend the rainy season in the northern, semi-desert zone and during the dry season, move further south into the savannah. Income is derived from the sale of animals, meat and milk in the form of white cheese. The historical dominance of this is on the decline.

2. Transhumant: In the transhumant agro-pastoral system, households depend mainly on livestock, mostly cattle, with some sheep and goats, although there is some cropping. In western Sudan, households migrate north during the rainy season and return to the savannah during the dry season. In the central and eastern states, migration is towards the Nile during the rainy season and back during the dry season.

3. Sedentary/village based: The sedentary system exists along the River Nile and its tributaries where irrigated agriculture is practiced and in areas of agro-silvo-pastoral and

traditional rain fed, arable farming in settled villages. Some livestock, mainly goats and sheep and a few cattle, are kept, but the animal raising activities are of less importance and are subsidiary to arable farming. Sorghum, sesame and cotton are grown on clay soils, and millet and groundnuts on sandy soils.

4. Sedentary/village based system in irrigated schemes: Permanently settled farmers in the irrigated areas of central Sudan grow cotton, sorghum, groundnut, sunflower, fodders and wheat, and also raise livestock, especially small ruminants. Livestock are a supplementary source of income, which is used to hire labour for agricultural work before the harvest. Productivity is low and animals depend heavily on crop residues, industrial by-products and the grazing of limited areas of fallow and along the irrigation canals. Intensive cow's milk production is becoming more common within the large irrigation schemes, and these are promising for future expansion of livestock production.

5. Other animal production systems include ranching, feedlot operations and peri-urban dairy production lots. Ranching is a recent trend in Sudan.

Constraints on production:
Despite the great potential of livestock and Sudan's self-sufficiency in meat and to a lesser degree in other livestock products/commodities, the following constraints on production are often witnessed:

- Expansion of agriculture, particularly semi- mechanized farming, into traditional grazing land, which has led to reduction in grazing areas and in many instances to the blocking of traditional migration routes and water points, causing conflicts between transhumant and settled farmers

- Overgrazing in some areas, particularly around settlements and villages, while vast areas are under-grazed because of unavailability of water for the animals

- The long distances that animals often must trek from water points to grazing grounds constitute an energy waste that was estimated by Fadlalla (1987) to represent 30% of the daily energy intake of lactating sheep during the dry season

- Seasonal nutritional deficiencies especially energy and protein that result in wasteful production and low reproductive rates.

- Prevalence of infectious and wasteful diseases, particularly tick-borne diseases, and parasites, and the reduced ability of veterinary services to combat them or the agents causing them.

- Inadequacy of veterinary services and the lack of an appropriate veterinary services delivery system

- Poor and none contemporary husbandry systems and practices and the low levels of technologies/interventions applied to upgrade these systems and practices.

- Inefficient and inadequate utilization of available feed resources namely range, crop residues and agro-industrial by-products as a result of weak integration of livestock in the prevalent agricultural and silvo-agro-pastoral systems (the rotation of acacia (*A. senegal*) and arable crops).

- Lack of processing of feeds and export of by-products,

- Difficulty of marketing and processing milk from 90% of the milking animals in nomadic and traditional systems, far from the centers of consumption

- Lack of infrastructure essential for the livestock sector development such as inputs, processing equipment, research, extension, roads, education, health services and livestock marketing and marketing facilities etc,

- Shrinkage of the rangeland area and loss of summer grazing grounds following cessation of South Sudan, oil explorations, mining and insecurity.

Rangelands biomass production estimates and utilization

The range and Pasture Directorate report for 2016 presented range production data by sector or regions instead of states as was the case in previous years (2010, 2011, and 2012). The sectors were the Western Sector which includes North Kordofan, South Kordofan, West Kordofan and White Nile States; Darfur Sector which includes North Darfur, South Darfur, East Darfur, Central Darfur and West Darfur states; Eastern Sector which includes El Gadaref , Kassala and Red Sea States; Central Sector which includes Blue Nile, Sennar and Gezira states; and Northern Sector which comprises Northern, Nile and Khartoum states. The average total forage biomass production from rangelands of these five Sectors over a five years period was estimated as 104.34 million metric tons (Table 42). Assuming a utilization factor of 75% the estimated rangelands forage available/accessible to domesticated large and small ruminants and equines biomass is calculated to amount to 78.26 million tons. Production of herbaceous fodder was estimated using conventional methods of range productivity determination. Browse fodder production was estimated in the reports of the Directorate of Range and Pasture (2014 and 2015) by assuming a productivity of fodder in the different ecological zones as follows:
Desert   0.1 ton/ha

Semi desert   1.5 ton/ha

Low rainfall savanna 1.5 ton/ha

High rainfall savanna 2.0 ton/ha

Due to the trans-ecological zones movement of nomadic and transhumant livestock herds it is assumed that all the fodder biomass produced is utilized.

Table 42:Total Rangelands Biomass Production (Million Tons)

State/Region	Year					Average
	2010	2011	2012	2014	2015	
North Kordofan	28.6	4.7	5.2	-	-	
South Kordofan	43.6	8.2	8.5	-	-	
West Kordofan	0	0	0	-	-	
White Nile	16.3	0.5	0.6	-	-	
Total Western Region	**88.5**	**13.4**	**14.3**	**66.6**	**58.1**	**48.18**
North Darfur	15.1	1.1	1.2	-	-	
South Darfur	27	0.5	1.5	-	-	

State/Region	Year					Average
	2010	2011	2012	2014	2015	
East Darfur	0	0	0	-	-	
Central Darfur	0	0	0	-	-	
West Darfur	11.7	12.1	9.3	-	-	
Total Darfur Region	**53.8**	**13.7**	**12.0**	**47.6**	**41.8**	**33.78**
ElGadaref	7.1	2.7	3	-	-	
Kassala	3.5	1.3	1.4	-	-	
Red Sea	1	0.4	0.3	-	-	
Total Eastern Region	**11.6**	**4.4**	**4.7**	**6.7**	**8.99**	**7.28**
Blue Nile	18.2	1.9	2.6	-	-	
Sennar	14	0.3	0.6	-	-	
El Gezira	1.9	0.5	0.5	-	-	
Total Central Region	**34.1**	**2.7**	**3.7**	**14.2**	**13.0**	**13.54**
Northern	0	0	0	-	-	
River Nile	3.1	0.4	0.4	-	-	
Khartoum	1	0.4	0.5	-	-	
Total Northern Region	**4.1**	**0.8**	**0.9**	**0.57**	**1.43**	**1.56**
Total	**192.1**	**35.0**	**35.6**	**135.6**	**123.32**	**104.34**

NB: *Data for 2010 obtained by multiplying productivity by area. Productivity taken from range and pasture administration report 2011. Data for 2014 and 2015 obtained from the Range and Pasture Administration Report 2015 and 2016 respectively. In these latter two years data were presented by Sector.*

The total contributions of each of the herbaceous and browse layers of the rangelands in years 2014 is presented in Tables 43. The average herbaceous and browse fodder production for the two years is shown in Table 44. The average contribution of browse to total rangelands fodder production in 2014 was 5.4% while it was 15.5% in 2015 showing an average of 10.5% of the total fodder biomass production from rangelands. Rangelands productivity varies spatially and temporally according the amount of rainfall received during that year. The quality of fodder produced from rangelands also fluctuates tremendously within the same year being very low during the dry season where protein content and dry matter digestibility drop sharply. Browse plays a significant role in mitigating the impact of dry season fodder quality as the green leaves and twigs of trees keep a reasonable level of their nutritional value that was found during rainy season.

Table 43:Herbaceous and browse fodder production for year 2014

Sector	Herbaceous	Browse	Total
Western	63.8	2.8	66.6
Darfur	44.6	3	47.6
Centre	13.3	0.9	14.2
Eastern	6.2	0.5	6.7
Northern	0.42	0.15	0.57
Total	**128.32**	**7.35**	**135.67**

Source: Feed Balance for livestock year 2014. Report of Range and Pasture Directorate, Ministry of Animal Resources (produced February 2015).

Table 44:Average Herbaceous and Browse Fodder Production for 2014 and 2015

		H	B	T
20014		128.3	7.35	135.67
2015		104.616	19.23	123.9
Average		**116.458**	**13.29**	**129.79**

Cultivated Forages:
Cultivated fodder production is given in Table 45 both as green and dry. The dry fodder was calculated from green fodder by assuming a dry matter of 30% of green fodder. Accordingly, the dry fodder production amounts to 3.26 million tons.

Crop Residues:
The total amount of crop residues produced is estimated at 18.8 million tons. This amount comes mainly from sorghum and millet stalks, groundnuts haulms and hulls and cotton leaves and stems.

Agro-industrial by-products
The total amount of **Agro-industrial byproducts** produced is 1.9 million tons obtained mainly from wheat bran, molasses, groundnut cake, cottonseed cake, sesame cake and sunflower cake. This component of livestock feed is of high quality as energy or protein source. However, these industrial by products are not all available to livestock. Molasses is being converted to ethanol which raised its price and made it difficult to acquire. Oil seed cakes are also being exported which led to a rise in their prices.

Herd dry matter and nutritional requirements/Fodder budget / carrying capacity:
When summing up feeds from all sources (rangelands, cultivated forages, crop residues and by products from industrial processing) feed production was 128.31million tons while the total livestock requirements excluding wildlife were 133.3, showing a shortage of 5.1 million tons. If we consider the large variations in production between years, the requirements of wildlife and inaccessibility of fodder in certain areas due to lack of water and insecurity we can understand the incidence of large mortality rates in certain years. Nonetheless, carrying capacity can be enhanced by better range management, reseeding of degraded areas together with water harvesting. Better distribution of water points may also have a positive effect on carrying capacity. The reduction of livestock numbers may be another option; however, this must be preceded by an animal census before adopting such an option.

Based on analysis of secondary data and respondents interview, overgrazing considered to be one of the major direct cause of range depletion particularly intensive grazing during growth stage and before seed set. This is found in rainy season grazing areas where saplings of grasses, forbs and shrubs are grazed prematurely thus reducing chances for future propagation, and over time many of these areas are now almost bare soil.

Insecurity

Gross Impact of Overgrazing on Forest & Range Degradation in RoS is Estimated@ 40%[9]
The third direct factor in Forest & Range Degradation in RoS is Insecurity
The insecurity which plagued RoS in the aftermath of civil strife in most peripheries necessitated the declaration of many regions as "military operation zones" such as the montane vegetation zones of South Blue Nile, South Kordofan and Jebel Marra area in East Darfur,
When such areas are declared, the first to leave is foresters, leaving no body to challenge illicit tree cutting & charcoal burning by speculators and some members of the Regular Forces.

Sizeable quantities of sawn timber, saw logs, building poles and charcoal are hauled out of such areas which if converted into denuded forest and woodlands could amount to thousands of feddans of areas completely deforested or at best greatly degraded.

Insecurity has negative impact on the natural resources especially on forests and rangelands species since it considered to be the main cause of influx of Refugees and movement of IDPs.

UNEP's report "Sudan: Post conflict Environmental Assessment, 2006" stated that some of the highest numbers of refugees in the country were recorded during the 1990s; in 1993, for example, Sudan was hosting to some 745,000 refugees the majority from Eritrea (57 %), Chad (19 %) and Ethiopia (2 %). The influx of Eritrean refugees has been steady since 2003, as tension has increased in that country. In addition, there are 29,000 refugees from Uganda, Democratic Republic of Congo, Somalia, Ethiopia and other countries.
Besides hosting hundreds of thousands of refugees, Sudan has also generated more IDPs than any other country in the world

Since the armed conflict began in 2003 in Darfur Region, approximately 2 million people have been displaced. About 1.8 million IDPs reside in Darfur and approximately 220,000 have fled to neighboring Chad (Fuel Efficient Stoves Programs in IDPs Settings – Desk Study. USAID, January 2007.)

Gross Impact of Insecurity on Forest & Range Degradation in RoS is Estimated@ 10%

Destructive Agents

The fourth direct factor in Forest & Range Degradation in RoS is Destructive Agents:
Disturbances are a natural and integral part of forest ecosystems. When they exceed their normal range of variation, however, the impacts on forests can be extreme affecting entire landscapes, causing large scale tree mortality and complete destruction of undergrowth and soils. Global climate change (C.C.) is exacerbating many of these impacts by making forests

---

[9] **Gross impact estimated by converting amounts of wood illegally harvested into areas of woodlands & Forests in the specific ecosystems and relating that to total areas of Woodlands & Forest.**

more prone to damage by altering the frequency, intensity and timing of some events such as cyclones, landslides, insect and disease outbreaks, heat waves and droughts which increase the risk of largescale fires.

Much more information is available on the impacts of biotic disturbances, such as pest outbreaks, on forests than on the impacts of abiotic disturbances, those caused by non-living factors such as storms, drought and tsunamis. FAO's Global Forest Resources Assessment (FRA), carried out at five-year intervals, provides the data and information needed to support policies, decisions and negotiations in all matters where forests and forestry play a part. For the first time ever, countries were asked to report on the area of forest damaged by abiotic disturbances for FRA2010. Information provided was sparse, mostly qualitative and did not allow for any trend analysis. To supplement the information in FRA 2010, and in acknowledgement of the increasing importance of abiotic influences on forest health, FAO prepared a more detailed study (FAO 2011).

Abiotic disturbances are expected to increase in intensity, quantity and frequency. Adaptive Forest Management is therefore essential to protect the world's forests resources. Effective management practices and policies are built upon relevant and timely information and accurate data on disturbances and their impacts on forests. This paper is a first step in synthesizing such information to assist with the management and protection of forest health. Taking care of the world's forests and effectively managing them not only ensures that they meet their objectives but also reduces the risk of damage from future abiotic disturbances and addresses global C.C. concerns.

Abiotic disturbances, disturbances caused by non-living factors, are a natural and integral part of forest ecosystems that have major impacts, positive and negative. They influence forest structure, composition and functioning and can be important for maintaining biological diversity and facilitating regeneration.

When disturbances exceed their normal range of variation, however, the impacts on forests can be extreme affecting entire landscapes, causing large scale tree mortality and complete destruction of undergrowth and soils. Global climate change is exacerbating many of these impacts by making forests more prone to damage by altering the frequency, intensity and timing of some events such as cyclones, storms, landslides, insect and disease outbreaks, and heat waves and droughts which increase the risk of large scale fires.

The FAO paper (FAO 2011) reviews the current knowledge on the impacts of abiotic disturbances. Events are discussed within five categories:

a. Meteorological: Cyclones, storms (wind, snow, ice and hail, dust and sand), tornadoes, and thunderstorms and lightning;

b. Climatological: Drought;

c. Hydrological: Floods and flash floods, avalanches, landslides and mudslides;

d. Geophysical: Tsunamis, earthquakes and volcanic eruptions;

e. Anthropogenic1: Fire, oils pills, air pollution and radioactive contamination.

Abiotic disturbances will continue to increase in intensity, quantity and frequency. Adaptive forest management is therefore essential to protect the world's forest resources. Activities

such as diversifying species, using windbreaks and mixed cropping patterns for resilience and not planting susceptible species in areas prone to abiotic disturbances can all help to reduce or divert potential impacts. Reducing the effects of disturbances on forests will contribute to countries' efforts to reduce carbon emissions from deforestation and forest degradation through forest conservation, sustainable forest management and enhancement of forest carbon stocks (REDD+). Taking care of the world's forests and effectively managing them not only ensures that they meet their objectives but also reduces the risk of damage from future abiotic disturbances and addresses global C.C Concerns.

Forests are presumed to be healthy when current or future management objectives are not threatened. Factors that influence forest health are biotic (i.e., fungi, insects) and abiotic (i.e., weather, pollution). On most occasions, two or more biotic and/or abiotic factors act together to influence forest conditions. Although forest conditions can be quantified and measured objectively, assessing forest health depends on subjective evaluations and value judgments that are drawn from management objectives. These objectives can contain wildlife, aesthetic, recreation, timber management, and even preservation components. Insects and diseases are an important part of the forest ecosystem and are fundamental agents of change in long-lived communities such as forests. The effects they have on forests vary from tree mortality to poor tree form to reduced resistance to other stresses. These effects impact human uses of the forest in positive and negative ways depending on the objectives. Loss of productivity due to mortality, decay, reduced growth rates, and increased risk to fire are negative impacts to timber management objectives. In addition, insects and diseases impact the recreational and aesthetic aspects of forest resources.

Positive effects include those on wildlife as insects and diseases can provide habitat such as tree cavities formed by fungal decay and/or food sources such as insect larvae. However, widespread pest outbreaks that kill many trees can reduce the value of the habitat for some wildlife species. Severe outbreaks are possible where natural checks and balances controlling a pest population do not function, or where no natural controls for an introduced pest exist.

Low vigour trees, particularly those stressed by drought, are most likely to be severely affected by insects and diseases. Species and age-class diversity within and among stands may reduce insect and disease impacts compared to large, continuous areas where host trees are similarly aged and of the same species. The main effects that can be assessed from increased forest management and timber harvesting are the resulting age class structure of forests and possible injury of trees due to harvesting activity.

Forest Susceptibility: Abiotic factors and forest conditions such as age, density, genetics, or growth rate influence the likelihood that trees will be affected (susceptibility) and the ability of the tree to recover from attack or infection (vulnerability).

As stands get older, they usually become more susceptible to damage and are at greater risk of infestation. However, some insects and diseases prefer to attack seedlings and young trees.

Forest management activities, if not carefully planned, may also increase the risk of a pest attack. Partial harvests, such as single tree removal and shelterbelt cutting, can damage residual trees (trees left during a harvesting operation for a special reason such as for wildlife habitat), leaving them open to attack by both insects and diseases. Finally, atmospheric pollutants can weaken or stress trees, potentially increasing both their susceptibility and vulnerability. The increased vigour of younger stands should decrease the prevalence of insects and diseases associated with older forests.

Impact of Natural & Man-made Disturbance on Forest Ecosystems

Global Context:

Globally, Earthquakes, various types of volcanic eruptions, tsunami, firestorms, impact events, climate change, and the devastating effects of human impact on the environment (anthropogenic **disturbances**) such as clear-cutting, **forest** clearing, and the introduction of invasive species can be considered major **disturbances** (Wikipedia).

Forest disturbances are major sources of carbon dioxide to the atmosphere and therefore impact climate. Bio geophysical attributes, such as albedo (reflectivity), further control the climate-regulating properties of forests. Using both tower-based and remotely sensed data sets, it can be shown that natural disturbances from wild land fires, beetle-outbreaks, hurricanes and wind-throw can significantly alter surface albedo and the associated radiative forcing either offsets or enhances the CO_2 forcing caused by reducing ecosystem carbon sequestration over multiple years. In the examined cases, the radiative forcing from albedo is on the same magnitude as the CO_2 forcing. The net radiative forcing resulting from these two factors leads to local heating effect in a hurricane-damaged mangrove forest in the subtropics, and a cooling effect following wildfires and mountain pine beetle attack in boreal forests with winter snow. Although natural forest disturbances currently represent less than half of gross forest cover loss, that area will probably increase in the future under climate change making it imperative to represent these processes accurately in climate modes. O'Halloran *et al* (2012).

Regional Context:

1. Forest disturbances and their impact on biodiversity in an African rainforest have been dwelt upon and reviewed by a group of researchers. Schleuning *et al* (2008).

2. FAO has recently reviewed Forest Fires and Pests & Diseases in the Near East. In the region, forest fires account for about one third of forest disturbances. Forest insects account for about half of the disturbances. The remainder is accounted for by diseases and by other forest disturbances. Transboundary movement and establishment of Pest species have directed attention to the negative effects of invasive pests on forests (Pests include insects, diseases and woody invasive species). Increase of trade and ease of travel between countries have increased the rate of spread of pests. (FAO 2007.a).
Forest fires have a serious impact on forest health in many countries in the region. It is estimated that an average of 350 million hectares of wild lands are burnt by fire each year. A clear majority of fires are, perhaps 90%, are human-caused. Some fires are set intentionally, either to clear land for agriculture or by arsonists. (FAO 2007.b).

FAO has recently executed a project on forest fires in Syria funded by Italy: "Participatory and Integrated Forest Fires- GCP⁄SYR⁄3045l⁄ITA". FAO has recently published a series of Working Papers on Forest Management. Working Paper FM17: A 'Fire Management: Voluntary Guidelines-Principles & Strategic Activities' has been translated into Arabic (FAO 2006).

3. The Arab Organization for Agricultural Development (AOAD), lead an initiative and sponsored extensive studies to appraise the status of forest resources in Arab region. The initiative covered temperate zone forests of North African Countries, the Mediterranean and

the Fertile Crescent as well as Tropical forests in the Nile Valley and the African Horn. Of the Class *Insecta*, the most destructive species to oaks, poplars, willows and pines is the gypsy moth *Limantaria dispar*, which is a serious defoliator. Other serious pests include the pine moth *haumetopoea pityocampa* and the eucalyptus wood borer *Phoracantha semipunctata* which attacks more than forty eucalyptus species. The damage inflicted by insects may be direct by destroying part of the tree or by deforming it or by arresting natural growth. Direct physical damage is caused by chewing caterpillars of moth (*Notuidae*), grubs of bark beetles (*Scollytidae, Buprestidae*) or wood-borers or wood borers (*Cerambycidae*).

As for diseases and other pests, AOAD study (AOAD 2010), enumerates some 2500 plants that live as parasites on other flowering plants. They vary in their dependence on parasitized host plants. Plants such as **Orchids** have a surface growth; have chlorophyll, roots and stem-like structures. They can therefore synthesize their own food from CO_2 and water but depend on the host for dissolved minerals. Other plants like **Mistletoe** have chlorophyll but no roots and therefore depend on host plants for water and all nutrients. Parasitic plants in Arab region are classified into four families viz:

a. *Convolvulaceae*, including such genera as *Custcuta* (Arabic: Hamoul),

b. *Loranthaceae*, including such species as *Loranthus acaciae* (Arabic: Anab)

c. *Orobanchaceae*, including such genus as *Orbanche* (Arabic: Halook)

d. *Scrophulariaceae*, including such genus as *Striga* (Arabic: Buda).

Sudanese context: Impact of Natural & Man-made Disturbance on Forest Ecosystems of the Republic of Sudan

Several post-graduate dissertations, research reports and publications in Sudanese academic & research institutions have dwelt into pests, diseases and other factors impacting forest health together with forest wood & Non-wood Products (NWFP): Safi (2011), Khalil *el al* (2011), Khalil (2009), Mohmed & Abdalla (2009), Mahgoub (2002, 1997), Mohamed (1999), Mustafa (1997), Mahgoub & Dafa Alla (1996), Ahmed (1995), El Bashir (1994), Awad (1987). Other works have touched on the matter since the mid-1990s: Bushara (1979), Peake (1952). Recent works have touched onto remedial measures such as Integrated Pest Management (IPM): Abdel Rahman (2013), Abdelnour (2008).
From literature review, reports on specific studies (Faris 2017), Gamri (2017), analysis of questionnaires specially designed for this study together with personal communications and interviews conducted in the context of the study, natural & man-made disturbances of a magnitude to reckon with in Republic of Sudan (RoS) unfolded as:

Destructive Agents of Forest Ecosystems, Trees & Forest Products in the Sudan:

Destructive agents to forest ecosystems, trees and products in the Sudan can be grouped into two categories; biotic and a biotic.

Biotic Agents:
The leading biotic agent is man followed by other vertebrates, invertebrates, plants and micro-organisms.

Man:

It is true that forests and trees, together with their products and services are favours bestowed on and subjected to man in Sudan and elsewhere. However, through irrational behaviour and misuse, man can be the cause of disappearance of favours; a form of misrepresentation of God on earth and ingratitude,

Contemporary history of Sudan indicates that at the turn of the twentieth century, tree cover was 34-36 % of the total surface area of the country. It dwindled to about 20% by the end of the century largely due to agricultural and urban expansion at the expense of tree cover and the almost complete dependence on forests as a source of energy for the domestic, services and industrial sectors. Not only that but advances in the management of some natural resources seemed to have negative impacts on others. The growth of the national livestock herd was at the expense of tree cover.

Vertebrates:
Vertebrates which have a negative impact on forests and trees in RoS include mammals and birds.

Mammals:
Some of the mammals with a negative impact on forests and trees are domestic. Others are wild.

Domestic mammals:
As far as damage to forests and trees, these encompass goats and camels in that order. Both browse on branches, twigs, leaves, leaflets, buds, flowers, fruit and seeds. Goats, however, add to that browsing on sprouts and seedlings. Cattle together with goats trample forest floor leading to soil compaction which impairs its permeability to water and air and consequently its suitability for seed germination and seedling development, thus hindering regeneration.

Wild mammals:
Forests and trees are habitat for elephants, giraffes and antelopes. They all browse tree parts like domestic mammals, but elephants can sometimes uproot or break trees or shrubs,
Wild mammals also include rabbits, baboons and monkeys which all devour sprouts and seedlings,
  * Warthogs can cause considerable damage to young tree plantations in the process of their excavation for roots and grubs.

Birds:
The most destructive birds to forests and trees are Sudan dioch =Zarzour, Gaddoum Ahmar (*Quelea quelea aethiopica*), especially when they roost or nest in huge numbers on young Sunt (*Acacia nilotica*) plantations, causing stems and branches to break under their weight. Such trees are rendered unsuitable for timber production which might necessitate their clearance and replanting. Plates (1) and (2),

Invertebrates:
The most destructive to forests and their products are insects, particularly of the orders *Coleoptera, Ispotera* and *Orthoptera.*

Coleopteran-beetles:
The most destructive to trees and products are:

- **Bruchid seed borers**: They damage *Acacia* seeds especially Sunt (*A. nilotica*), Hashab (*A. senegal*) to an extent that can impede afforestation/reforestation operations. **Plate (3),**
- **Dieback beetles** (**Buperestidae**) especially that cause dieback of Sunt (*Sphenoptera chalcicroa arenosa*) in the Riverine forests from Khartoum up to Roseires and on Dinder, Rahad and Abu Habil. In many instances, they lead to mortality of complete forests which may prompt their replanting with the looming danger. **Plates (4) and (5),**
- **Talh borer** (*Sinoxylon senegalense*) which infests Talh wood immediately after felling, turning it into powder in a short time, in such a manner as to render it useless even for firewood or charcoal let alone for building poles. The borer also infests sapwood of most wood species and bamboo. **Plates (6),**
- **Longhorn beetles** (*Cerambicydae*) which cause considerable damage to sawn hardwoods especially Homeid (*Sterculia setigera*). **Plate (7).**

Termites (*Isoptera*):
Some 30-termite species are known and have been classified in RoS. Some of them can harm trees at any stage, from seedling to a mature tree. They also destroy wood of most tree species. The most ferocious on seedlings, trees and wood are:
- Genus *Macrotermes*: Widely spread and their mounds (termiteria) can be seen in areas with annual rainfall of more than 400 mm.
- Genera *Microtermes*, *Odontotermes* and *Psammotermes*: All are subterranean with no obvious mounds. Widely spread all over the Sudan.

Termite damage to seedlings might reach such levels as to cause total failure of a tree planting season. Their damage to wood could impede its use without chemical treatment and/or mechanical barriers. **Plate (8) and (9),**

Orthoptera-locusts and crickets:
Those with the most negative impact in RoS:
Night wonderer- Sari el Lail (*Anacredium melanorhodon melanorhodon*). Its damage is limited to Gum Arabic production. When their leaves are prematurely removed by locusts, Hashab (*A. senegal)* trees respond to tapping operations by producing a new generation of leaves instead of oozing gum. Gum producers in the Gum Belt know this from experience and refrain from tapping during seasons of locust plague. **Plates (10) and (11).**
- ✓ **Crickets and Mole Crickets:** Some crickets devour newly germinating seeds and young seedlings to an extent that can hinder afforestation/reforestation operations in the season.

Plants:
Many plants, both indigenous and exotic have a negative impact on trees and forests in the Sudan. The modes and degrees of damage vary. Some plants impact trees through competition for water, soil nutrients and light. Others lean on the host, inflicting malform and deprive it of sunlight.
Indigenous Plants: These include:

- ❖ **Grasses and herbs** which compete with newly germinating seeds and seedlings, an effect that necessitates the removal of competing plants through weeding. They all pose permanent fire hazard. Examples of these include wild Sorghum = Addar (*Sorghum sudanense, S. lanceolatum*), Ankooj , Nageel and Siaada, Rubaa, and Soreib (*Phyllanthus spp.*), **Plate (12)**

- ❖ **Creepers:** Such as cucurbits in general especially water melon, pumpkin, leef (*Lufa aegyptiaca*) and others which compete with newly germinating seeds and seedlings for water and nutrients and subsequently spirally wind round shrubs and trees and lean on them in search of sunlight. That might weaken trees and can even spoil their form or break them outright. **Plate (13).**
- ❖ **Epiphytes,** especially (*Lorthanthus acaciae*) that grows on branch axils of such trees as Talh, Sunt, Heglig, Habil and others. It depends on the host for supply with water and nutrients. Although it synthesizes its own food through photosynthesis, it leans on the host for exposure to sunlight, which might weaken the host or completely smother it. **Plate (14) and (15),**
- ❖ **Ramtuk** (*Xanthium brasilicum*): It's indigenous to central Sudan but has recently spread invasively in Riverian forests to an extent that they threaten seeding and seedling transplanting and eventually cause failure to afforestation/reforestation operations. Besides, they reduce the quality and quantity of forage material. **Plates (16) and (17).**

Invasive Alien Species: These include:
Mesquite (*Prosopis spp.*):
Introduced early in the 20ᵗʰ century from Egypt and South Africa for sand dune stabilization but failed at the time. It was subsequently re-introduced to New Halfa and Port Sudan Areas where it spread in an invasive manner and seriously threatened New Half and Gash Agricultural Schemes. It even started to form a type of genetic pollution and displace indigenous plants. Plates (18) and (19),
Micro-organisms: Include bacteria and fungi.

Their damage is restricted to wood rot and sap-staining which weaken and discolour wood and render it unsuitable for some uses a matter that might necessitates chemical treatment of sawn timber.

A Biotic Agents
A-biotic factors which affect forests and trees in RoS include fire, wind, drought and floods.

Wild land /(forest fires):
It is perhaps the most destructive enemy of forests, trees, range plants. And other property.
Fires are mostly started by naturally or by humans through arson or negligence. In the latter cases, it is mostly fire:
Ignited by lightning and fanned by strong winds,
- ➢ Used for clearance of land or agricultural residues by farmers or by animal herders to control ticks or initiate fresh sprouting of grasses,

- ➢ From cigarette tubs from passers-by.

Whatever their cause, fires can devastate everything. Based on the analysis of data extracted from NASA Moderate Resolution Imaging Spectroradiometer- (MODIS) burned area products (MCD45), forests, woodlands & range tracts annually burned through seasonal wild land fires in Central Sudan exceed one million ha on average as depicted in table (46)

**Table 45:Annually burned area in forest, woodlands & range ecosystems in RoS, 2010 –
2015:**

Fire season	Burned area/ Ha
2010 - 2011	1,075,974.8
2011 - 2012	1,049,790.7
2012 - 2013	1,076,363.9
2013 - 2014	1,087,602.0
2014 - 2015	1,090,119.7

Winds can carry soil particles in the form of notorious dust storms "*Haboub*". They Can snap
stems and branches and might completely uproot and throw trees irrespective of their age or
size. Specific examples of wind throw of gum producing *Sclercarya birrea*. **Plates (22), (23)
and (25)**,

Drought spells:
These frequent Sudan in spells some of which could continue for years. Drought spells could
lead to mortality of entire forests or particular tree species. They can also lead to weakening
of trees or shrubs which can render them susceptible to secondary pests.

Floods:
These too frequent forest areas in Sudan repeatedly especially riverine forests. An individual
flood spell can bury seeds in the seed bed whether they have fallen naturally or seeded by
humans in the process of seeding by broadcasting or pit-sowing. Accumulation of silt from
high floods could bury depressions which are the natural habitats for tree species like Sunt (*A.
nilotica*). Moreover, accumulated silt buries beyond recovery the bottom log which is the
awaited rotation crop. In terms of carbon sequestration this could be appositive aspect.*Gross*

***Impact of Destructive Agents on Forest & Range Degradation in RoS is Estimated @
10%[10]***

Impacts of Drivers of Deforestation & Forest/Range Degradation on Forest & Range types in
RoS can be summarized as presented in Table 47.

**[10] Gross impact estimated by calculating the volumes of wood & biomass burnt or damaged by
biodeterioration agents, converting that into woodland & forest areas and relating that to total
Forest & Woodland Area**.

Table 46:Drivers of Deforestation & Forest Degradation Overlaid on Forest & Range types in RoS

Drivers	Forest & Range Types																		
	F.1	F.2	F.3	F.4	F.5	F.6	F.7	F.8	F.9	F.10	F.11	F.12	F.13	F.14	R.1	R.2.	R.3	R.4	R.5
I. Deforestation & Range Depletion																			
I.A. Proximate (Direct) Causes																			
I.A.1. Commercial Agri.		🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥					🟥	🟥	🟥	
I.A.2. Urban Sprawl	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥		🟥	🟥	🟥	
I.A.3 Infrastructure	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥		🟥	🟥	🟥	
I.A.4. Petroleum			🟥	🟥													🟥	🟥	
I.A.5. Mining	🟥	🟥							🟥	🟥						🟥	🟥		
I.A.6. Refugees & IDPs						🟥			🟥										
I.B. Underlying (Indirect) Causes																			
I.B.1. Human & Animal Population Growth	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	
I.B.2. Subsistence Agri.	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨				🟨	🟨	🟨	🟨	
I.B.3 Legal & Institutional Gaps	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	
I.B.4.Lack of Stakeholder Participation	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	🟨	
II. Forest & Range Degradation																			

Drivers	Forest & Range Types																		
	F.1	F.2	F.3	F.4	F.5	F.6	F.7	F.8	F.9	F.10	F.11	F.12	F.13	F.14	R.1	R.2.	R.3	R.4	R.5
II.1. Unsustainable Wood Extraction for Energy & other Purposes			red	red	red	red	red		red	red									
II.2. Overgrazing		red	red	red	red	red			red	red					red	red	red	red	
II.3. Insecurity				red	red	red			red										
II.4. Destructive Agents																			
II.4.1. Biotic Agents																			
Drivers	F.1	F.2	F.3	F.4	F.5	F.6	F.7	F.8	F.9	F.10	F.11	F.12	F.13	F.14	R.1	R.2.	R.3	R.4	R.5
II.4.1.1. Man	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow
II.4.1.2. Plants																			
II.4.2.1. Invasive local		yellow	yellow	yellow	yellow	yellow	yellow	yellow								red	red	red	
II.4.2.2. Invasive Alien	green	red	red	red	red					red	red	red	red				red		
II.4.2. A Biotic Agents																			
II.4.2.1. Wild land Fires			red	red	red	red	red		red					red		red	red	red	
II.4.2.2. Winds									red				red						
II.4.2.3. Climate Change		yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	
II.4.2.4. Floods								red											

Key: F.1. *A. tortilis-M. crassifolia* Semi Desert, F.2. *Acacia mellifera* Thornlands alternating with Grass in LRWS, on hill soils formed *in situ* associated with *Commiphora africana* and *Boscia senegalensis* and desert scrub F.3. *Acacia seyal-Balanites* alternating with grasses F.4. *Combretum cordofanum- Albizzia cericocephala - Dalbergia* LRWS on clay, F.5. *Terminalia-Sclerocarya-Anogeissus-Prosopis* HRWS, F.6. Forests in Protected Areas, National Parks & Game Reserves, F.7. Hashab''*Acacia senegal''and* Talh plantations F.8. Riverine Forests, F.9. Montane vegetation, F.10. Mangrove stands, F.11.Forest Plantations in Major Irrigated Agricultural Schemes, F.12. Shelter belts & Wind breaks, F.13. Urban & Peri-urban plantations, F.14. Alien Invasive Species, R.1. Rangelands in Desert (*Gizzu*), R.2. Rangelands in LRWS on clay, R.3. Rangelands in LRWS on sand, R.4. Rangelands in HRWS on sand, R.5. Alien & Native Invasive plants in Rangelands.

🟥	Proximal (Direct) Negative	🟨	Indirect Negative Impact	🟩	Positive Impact

Recommended Remedial Action

Table 47:Drivers of Deforestation, Range Depletion and Forest & Range Degradation, Recommended Remedial Action & Agencies Envisaged to take the Action

Driver	Recommended Remedial Action	Envisaged Agency
Proximate (Direct) Causes of Deforestation & Range Depletion		
1. The Main Direct Cause of Deforestation & Range Depletion in RoS is Commercial Agriculture Principally Large-Scale, Mechanized Rainfed Farming, together with Irrigated forms of Agriculture; estimated to account for 40% of Deforestation & Range Depletion.	1.1. To attain food security, secure sustainable livelihoods and conserve the environment, it is imperative to enhance agricultural productivity and avail alternative income generating sources for rural communities, 1.2. To enhance agricultural productivity, it is important to deploy a combination of interdependent activities such as technology promotion, applied research, targeted financing and institutional reforms. 1.3. To halt and ultimately reverse deforestation, range depletion and degradation, soil degradation, overall environmental deterioration, avoid conflict and consolidate social peace and ultimately achieve sustainable balanced rural development, it is prudent to transform the agricultural sector particularly the rain-	1.1.1. Ministries of Agriculture, Animal Resources and Social Security. 1.2.1. Agricultural Research Corporation of Ministry of Agriculture & Forests, Research arms of academic institutions, Extension & Technology Transfer Services, Private Sector, Farmer Associations, Finance Institutions. 1.3.1. The Federal Government, National & State Legislatures, Finance Institutions, Ministries of Agriculture and Animal Resources together with their subsidiaries: Forests National Corporation (FNC), Agricultural Research Corporation (ARC),

112

Driver	Recommended Remedial Action	Envisaged Agency
	Proximate (Direct) Causes of Deforestation & Range Depletion	
	fed thereof through**:**	Veterinary Research Corporation (VRC) etc.
	1.3.1. **I**mproved land use, sound environmental practices with wide participation from local communities,	
	1.3.2. Establishment of the Land Commission,	
	1.3.3. Completion and adherence to land use map for the country,	
	1.3.4. Legalization of the land rights of people,	
	1.3.5. Reform of macroeconomic and sectoral policies conducive to sustainable crop and livestock production,	
	1.3.6. Review of policies impairing market efficiency of crops and livestock,	
	1.3.7. Develop options for implementing the Forest Acts which call for the allocation of specified percentages of rainfed and irrigated schemes to forests in the form of woodlots, shelterbelts, windbreaks and agro-silvo-pastoral systems,	
	1.3.8. Priority States are Southern Kordofan, Blue Nile, Gedaref, White Nile and Sennar,	
	1.4. Improving the efficiency of the agricultural sector necessitates:	

Driver	Recommended Remedial Action	Envisaged Agency
	Proximate (Direct) Causes of Deforestation & Range Depletion	
	1.4.1. Investment in yield-enhancing inputs, 1.4.2. Improved access of producers in both rain-fed and irrigated sector to finance and technology and services, 1.4.3. Advances in research and innovative water delivery mechanism including water harvesting, extension services, integrated crop and livestock, and improved access to markets, 1.5. Scrutiny of RoS Renewable Natural Resources: Land, Water, Livestock, Wildlife, Forests, Range & Pasture.	1.4.1. Ministry of Agriculture and Subsidiaries ARC, Extension & Technology Transfer, Private Sector, Finance Institutions, Ministry of Water Resources, Irrigation & Electricity
	1.6. Enhance environmental awareness and encourage use of alternative energy sources and improved energy efficient use utensils,	1.5.1. Ministry of Agriculture & Forests, Ministry of Animal Resources, National Survey Authority, National Bureau of Statistics.
	1.7. Revision, Formulation a fresh and Activation of laws and legislations concerning forest and natural resource sector, 1.8. Support and enhance cultivation of Non-Wood Forest Products in all forest holdings and ownership	1.6.1. Line Ministries of Environment, Petroleum, Electricity & Dams, Information & Culture, Finance & National Economy.

Driver	Recommended Remedial Action	Envisaged Agency
Proximate (Direct) Causes of Deforestation & Range Depletion		
	1.9. Undertake scrutiny of training needs of entire agricultural, animal and wildlife sectors and conduct capacity building and upgrading for entire spectrum of people involved in production and management of the said sectors.	1.7.1. FNC, Federal Government, National & State Legislatures. 1.8.1. FNC, ARC, Institutes of Higher Forestry Education, Communities, Private Sector, Finance Institutions, Development Partners and Aid agencies. 1.9.1. Line Ministries of Agriculture, Animal Resources, FNC, ARC, VRC, Ministry of Human Resources and Institutes of Higher Education.
2. The Second Direct Cause of Deforestation & Range Depletion in RoS in order of magnitude and chronology is Urban Sprawl; estimated to account for 15% of Deforestation & Range Depletion.	2.1. The Federal Government is urged to adopt comprehensive environmentally -friendly population and town planning policies	2.1.1. Line Ministries of Environment, Social Security, Federal & State Legislatures.
3. The Third Direct Cause of Deforestation & Range Depletion in RoS in order of magnitude and chronology is	3.1. The Federal Government is urged to adopt comprehensive infrastructure planning policies preceded and followed by Environmental Impact Assessment (EIA).	3.1.1. Line Ministries of Transport & Haulage, Water Resources & Dams, Social Security & Environment together with Federal & State

Driver	Recommended Remedial Action	Envisaged Agency
Proximate (Direct) Causes of Deforestation & Range Depletion		
Infrastructure Development; estimated to account for 15% of Deforestation & Range Depletion.		Legislatures**.**
4. The Fourth Direct Cause of Deforestation & Range Depletion in RoS is Petroleum Exploration; estimated to account for 10% of Deforestation & Range Depletion.	4.1. Adhere to outcomes of prior and post- activities EIA, 4.1. Follow-up, assessment and upscaling of experience in Treatment of Produced Water in Greater Nile Petroleum Operating Company (GNPOC), in Block 1,2, & 4 and Petro/Energy E & P in Block 6.	4.1.1. Ministry of Petroleum**,** 4.1.2. Environment Regulatory Bodies in Government of RoS such as Ministry of Environment, HCENR, etc. 4.1.3. petroleum Exploration Companies 4.1.3. Beneficiary partner agencies such as Forests National Corporation and Range & Pasture Administration and Wildlife Corps
5. The Fifth Direct Cause of Deforestation & Range Depletion in RoS in order of magnitude and chronology is Mining; estimated to account for 10% of Deforestation & Range Depletion	5.1. The Federal Government is urged to adopt a comprehensive Natural & Mineral Resources Development & Utilization Policy, and adhere to outcomes of prior and post-activities EIA.	5.1.1. Line Ministries of Petroleum, Mining, Environment, Federal & State Legislatures**.**
6. The Sixth Direct Cause of Deforestation & Range Depletion in RoS is Refugees	6.1. Government of RoS is urged develop a National Policy towards Migrants, Refugees and Internally Displaced People, in-line with International Treaties, Regulations & Norms, embodying	6.1.1. Line Ministries of Interior, Social Security, Agriculture & Forests, and Defense together with subsidiaries

Driver	Recommended Remedial Action	Envisaged Agency
Proximate (Direct) Causes of Deforestation & Range Depletion		
& Internally Displaced People (IDPs); estimated to account for 10% of Deforestation & Range Depletion	the Government's concerns about the humanitarian & welfare of these categories, their sustainable livelihoods and those of recipient communities together with judicious management of natural resources and environmental conservation, 6.2. Such policies should cater for Refugees & IDPs requirements of food, shelter, building materials and energy particularly biomass energy from sustainable sources in RoS and alternatives such as Ethanol, 6.2.1. The policy statement should be developed through the most consultative, participatory and interactive approaches, subjected to wide popular discussion and subsequently pass it through Federal Council of Ministers, Legislature and ultimately the Presidency, 6.3. Government of RoS should formulate a comprehensive Programme to rehabilitate areas and sites affected by Refugees & IDPs and subsequently pledge partial national finance for the programme and seek complementary finance from regional and international organizations together with national, regional and international initiatives, 6.4. It might be prudent for Sudan REDD+ Project to incorporate	thereof such as Commissioner of Refugees, (CoR), FNC, Police and Immigration Authorities**.** 6.2.1. Line Ministries of Interior, Social Security, Agriculture &Forests, and Petroleum, together with subsidiaries thereof such as Commissioner of Refugees, (CoR), FNC, Police. Immigration Authorities, Energy Research Council, 6.3.1. Line Ministries of Interior, Social Security, Agriculture & Forests, Finance & National Economy and International Cooperation together with subsidiaries thereof such as Commissioner of Refugees, (CoR), FNC, Police. Immigration Authorities**,** International Relevant Organization such as United Nations High Commissioner for Refugees (UNHCR),

Driver	Recommended Remedial Action	Envisaged Agency
	Proximate (Direct) Causes of Deforestation & Range Depletion	
	the development of the Policy Note and Comprehensive Rehabilitation Programme as part of RoS REDD+ Preparation Process,	Development Partners.
		6.4.1. FNC, Sudan REDD+ Programme Management.
	6.5. Government of RoS should approach UNHCR and other development partners to support a pilot project for production of Ethanol, and ethanol-use devices and distribution to Refugees and IDPs in their camps to alleviate their dependency on firewood and charcoal. Eventually the project can be scaled-up to target small businesses, service and domestic sectors,	6.5.1. UNHCR, CoR, FNC, Sudan REDD+ Programme Management.
	6.6. Government of RoS should approach UNHCR and other development partners to scale-up success stories in sustainable livelihoods, environmental rehabilitation initiatives and use of alternative energy sources such as:	
	6.6.a. Wadi El Ku Catchment Management Project for Livelihoods Development and Sustainable Peace, funded by the EU Delegation in Sudan and implemented by UNEP and Practical Action Organization,	6.6.1. UNHCR, CoR, FNC, Recipient State Governments Sudan REDD+ Programme Management
	6.6.b. The Women Development Associations (WDAs) Network initiated by Practical Action Organization in Kassala and North Darfur States,	

Driver	Recommended Remedial Action	Envisaged Agency
Proximate (Direct) Causes of Deforestation & Range Depletion		
	6.6.c. Experience of El-Gandoul Rural Development Organization, Kassala State in removal of mesquite trees from Khor Talkouk, Kassala State, for replication elsewhere, 6.6.d. Water harvesting techniques for sustainable crop & animal production and tree planting, 6.6.e. Use of silt behind dams to be added to and mixed with sand on sandy sites like the experience of Mellit Dam. N. Darfur, 6.6.f. Replication of the experience of Community Habitat Foundation (CHF), the first International NGO that started Afforestation activities in Zamzam IDPs camp near El-Fasher. 6.6.g. Escalation of the experience of Oxfam GB and Practical Action Organizations who did some plantation activities within the IDPs camps around El-Fasher, 6.6.h. Escalation of the experience of Darfur Development and Reconstruction Agency (DRA) a national organization formed and registered with the objective of restoring and protecting the livelihood of IDPs, overcoming poverty and securing the wellbeing of their families through targeted practical assistance.	
Forest & Range Degradation		
1. The prime direct factor in Forest & Range Degradation in RoS is Unsustainable	1. Adoption and enforcement of overarching Legislative, & Administrative Measures:	

Driver	Recommended Remedial Action	Envisaged Agency
	Proximate (Direct) Causes of Deforestation & Range Depletion	
Wood Extraction for Energy & Other Purposes; estimated to account for 40% of Forest & Range Degradation.	**A. Legislative:** A.1.1. Environmentally-friendly Energy Policies that promote: A.1.1.1. Renewable Energy such as Solar & Wind Energy, A.1.1.2. Use of Liquid Petroleum Gas (LPG), A.1.1.3. Production and Use of Ethanol particularly in Household and Services Sectors, building on Ethiopian Experience, A.1.1.4. Energy Efficiency in Use such as Improved Stoves and Conversion such as Wood into Charcoal. **B. Management & Administrative:** B.1.2. Revision and update of National Forest Programme (nfp), inclusive of: B. 1.2.1. Revision of Forest Policy, B.1.2.2. Revision of Forest Acts which regulate division of authority of management of and sharing of revenue & other benefits from the entire forest and range estate of RoS,	A.1.1.1. Line Ministries of Petroleum, Water Resources, Irrigation & Electricity, Agriculture& Forests, Finance & National Economy, Environment, Physical Planning & Natural Resources. B.1.2.1. Line Ministries of Petroleum, Electricity, Agriculture& Forests, Finance & National Economy, Environment, Physical Planning & Natural Resources. Economic, Relevant International Organizations as FAO,

Driver	Recommended Remedial Action	Envisaged Agency
Proximate (Direct) Causes of Deforestation & Range Depletion		
	B.1.3. Accommodation and institutionalization of pressures and demands from State Governments and Federal Investment Authorities for utilization of Gerf lands for horticultural production particularly Bananas and Mangoes. *There are precedents of long-term leases at market rental prices,*	B.1.3.1. FNC, State Governments & Legislatures,
	B.1.4. Accommodation and institutionalization of pressures and demands from State Governments and Federal Investment Authorities for utilization of urban forests for recreation. *The precedence of the Golf Course in Soba is a living example,*	B.1.4.1. FNC, State Governments & Legislatures
	B.1.5. Accommodation and institutionalization of pressures and demands from State Governments and Federal Investment Authorities for utilization of FNC estate holdings in urban centres. *There are precedents of such,*	B.1.5.1. FNC, State Governments & Legislatures

Driver	Recommended Remedial Action	Envisaged Agency
Proximate (Direct) Causes of Deforestation & Range Depletion		
	B.1.6. Embedding such legislation in forthcoming Permanent Constitution of RoS,	B.1.6.1. Judiciary, Ministry of Agriculture & Forest, FNC, Federal & State Legislatures,
	B.1.7. Completion of National Forest Inventory,	B.1.7.1. Ministry of Finance & National Economy, Ministry of Agriculture & Forest, FNC, FAO and Sudan REDD+ Programmed Management,
	B.1.8.a. Reclassification and Assessment of the State-of-the Art of Forest and Woodland Ecosystems in RoS,	B. 1.8.1. FNC, FAO, UNEP, Sudan REDD+ Programme Management,
		B.1.9.1. Ministry of Higher Education

Driver	Recommended Remedial Action	Envisaged Agency
Proximate (Direct) Causes of Deforestation & Range Depletion		
		& Research, Universities,
	B.1.8.b. Resurvey of all Forest Reserves to ascertain boundaries, areas, registration and stocking,	B.1.10.1. ARC, VRC
	B.1.9. Appropriate Revision & Development of Curricula of Forestry Higher Education Institutions,	B.1.11.1. FNC, Sudan REDD+ Programme Management UNEP, FAO
	B.1.10. Appropriate Revision, Harmonization and Enhancement of Natural Resources Research Programmes,	
	B.1.11. Development & Capacity building of FNC together with other stake holders in Sudan REDD+ Programme on current and emerging issues and sciences of Climate Change, Carbon Trade, Green Economy, Accounting & Monetary Valuation of such aspects as Watersheds, Tourism & Recreation,	C.1.1. FNC, ARC, Academia Stake holders,

Driver	Recommended Remedial Action	Envisaged Agency
	Proximate (Direct) Causes of Deforestation & Range Depletion	
	C. Forest Management Measures: These include: C.1. Redefinition of designated forest and woodland functions to accommodate emerging and projected Environmental Variables & Societal Needs, C.1.1. Processing and endorsement of revised forest functions through Forest & Range Governing Bodies towards their application in Forest & Range Management Plans	C.1.1.1. FNC, R&PA C.2.1.FNC, Sudan REDD+ Programme Management, FAO, UNEP, Development partners.

Driver	Recommended Remedial Action	Envisaged Agency
	Proximate (Direct) Causes of Deforestation & Range Depletion	
	C.2. Reformulation of management plans of the entire forest estate of RoS: C.2.1. Through and with genuine people participation in governance and sharing of benefits and responsibilities, C. 2.2. Deployment of all enabling factors such as: C. 2.2.1. Well-articulated agro-forestry & agro-silvo-pastoral systems, C.2.2.2. Appropriate water-harvesting techniques, **D. Priority Areas for consideration for management & development to render tangible and non-tangible benefits:** 1. High Rainfall Woodland Savannah at large, 2. Riverine Ecosystems at large, 3. Resurveyed Forest Reserves, 4. Other forest holdings such as institutional, community and private forests with their proprietors' desire and willingness, **E. Immediate Focus on:** E.1. Finalization of formulation of model management plans for	E.1.1. FNC, Stakeholder States and Communities, Private Sector, Sudan REDD+ Programme Management

Driver	Recommended Remedial Action	Envisaged Agency
	Proximate (Direct) Causes of Deforestation & Range Depletion	
	forests specified by FNC namely: E.1.1. Management Plan for Riverine Forest in Blue Nile State for production of valuable timber + E.1.2. Management Plan for Riverine Forest in Blue Nile State for production of Fuelwood, Building poles and NWFPs, E.1.3. Management Plan for Riverine Forest in Sennar State for production of valuable timber E.1.4. Management Plan for Riverine Forest in Sennar State for production of Fuelwood, Building poles and NWFPs, E. 1.5. Management Plan for Nabag Forest in South Kordofan State. E.1.6. High lighting and appraisal of identified success stories in sustainable environmental and forest management in small holdings.	
2. The second direct factor in Forest & Range Degradation in RoS in order of magnitude is Overgrazing; estimated to account for 40% of Forest & Range Degradation.	2.1. Increase feed availability through: 2.1.1. Intensifying productivity of rangeland, 2.1.2. Increasing number and appropriate distribution of water points to facilitate access to under- utilized range tracks, 2.1.3. Regulate mining as well as other land -using activities and facilitate access into those areas,	2.1.1. Range & Pasture Administration, Wildlife Corps, FNC, ARC, VRC, Federal Government, Veterinary & Animal Production entities in Universities, Development Partners & Donor Community

Driver	Recommended Remedial Action	Envisaged Agency
	Proximate (Direct) Causes of Deforestation & Range Depletion	
	2.1.4. Demarcate, rehabilitate and protect livestock routes, watering spots, resting areas and rainy season grazing lands by legislation and community involvement,	
	2.1.5. Increase utilization of crop residues,	
	2.1.6. Control of fire through establishment and maintenance of National Fire Line Grids,	
	2.1.7. Promote total off-take ratio of the various livestock species raised in RoS with increased emphasis on browsing ruminants namely camels and goats,	
	2.2. Enhance feed quality through:	
	2.2.1. Reseeding of range with desirable plants,	
	2.2.2. Improve quality of crop residues through physical and chemical treatments,	
	2.2.3. Encourage cultivation of fodder crops particularly legume fodders,	
	2.2.4. Encourage small holder village-based agro-pastoralists to adopt fodder cultivation (fodder banks).	
	2.3. Accommodate pastoralists in a land tenure strategy of the	

Driver	Recommended Remedial Action	Envisaged Agency
Proximate (Direct) Causes of Deforestation & Range Depletion		
	country, 2.4. Encourage planting of multi-purpose trees and shrubs tolerant to browsing activities and of reasonable feeding value, 4.5. Support genuine original scientific research on the feeding value of non-conventional feed resources, browse and diet selection by browser/grazer ruminants 2.6. Conduct a national livestock census.	
3. The third direct factor in Forest & Range Degradation in RoS is Insecurity; estimated to account for 10% of Forest & range Degradation	3.1. The Federal Government, State Governments, Communities, Civil Society Organizations, Regional & International Communities should collate efforts to consolidate social peace and resolve territorial and other conflicts in RoS.	3.1.1. Federal Government, National & State Legislatures, Line Ministries Especially Information & Culture, Traditional Leadership,
4. The fourth direct factor in Forest & Range Degradation in RoS is Destructive Agents; estimated to account for 10% of Forest & range Degradation	4.1. In the context of RoS Preparatory phase for REDD+: Commission targeted research in Research Institutions and Academic Circles to Ascertain, Verify & Quantify Deforestation and Forest Degradation in RoS together with all attendant Repercussions on the country, its Inhabitants and Environs, 4.2. In view of all environmental, socio-economic & political	4.1.1. FNC, ARC, Research Arms in Institutions of Natural Resources Higher Education, Development Partners and Donor community such as FAO, REDD+, etc.

Driver	Recommended Remedial Action	Envisaged Agency
Proximate (Direct) Causes of Deforestation & Range Depletion		
	happenings RoS should approach all development partners to pursue a revision of Sudan national forest programme to pigeonhole all aspects of natural and other resources in their appropriate perspective, inclusive of Revision of Forest Policy & Supporting Legislations, Capacity Appraisal & Building. 4.3. RoS Forestry Sector including Forest Service, Research and Academic circles need to go back to the drawing table and re-plan the entire spectrum of sustainable forest management inclusive of: 4.3.1. Formulation of Management Plans for all Forest Estate in accordance with newly established Forest Functions & Objectives of Management, 4.3.2. Application of all established scientific principles of cultural operations from Forest Sites Reclassification, Choice of Appropriate Tree/shrub species, Tree Formations & Alignment, Nursery Techniques, Water Harvesting, Cultural Operations and Wood & Non-Wood Products Harvesting & Processing Techniques, 4.3.3. Formulation of National Community-Based Wildland & Forest Fire Management Project.	
Underlying (Indirect) Causes		
1. The main underlying cause of Deforestation & Range Depletion in RoS is	1.1. The entire Agriculture & Animal production sectors are urged to adopt a sustainable crop and animal production policy supported by appropriate enabling legislation & economic	1.1.1 Line Ministries of Agriculture & Animal Wealth, Ministry of Finance & Economic Planning, Private Sector,

Driver	Recommended Remedial Action	Envisaged Agency
Proximate (Direct) Causes of Deforestation & Range Depletion		
Human and Animal Population Growth	incentives,	Farmer & Animal Producer Associations
2. The second underlying cause of Deforestation & Range Depletion in RoS is Subsistence Agriculture	1.2. To halt and ultimately reverse deforestation, range depletion and degradation, soil degradation, overall environmental deterioration, avoid conflict and consolidate social peace and ultimately achieve sustainable balance rural development , it is prudent to transform the agricultural sector particularly the rain-fed thereof through**:** 1.3.1. **I**mproved land use, sound environmental practices with wide participation from local communities, 1.3.2. Establishment of the Land Commission, 1.3.3. Completion and adherence to land use map for the country, 1.3.4. Legalization of the land rights of people, 1.3.5. Reform of macroeconomic and sectoral policies conducive to sustainable crop and livestock production, 1.3.6. Review of policies impairing market efficiency of crops and livestock, 1.3.7. Develop options for implementing the Forest Acts which call for the allocation of specified percentages of rainfed and irrigated schemes to forests in the form of woodlots, shelterbelts,	1.2.1. The Federal Government, National & State Legislatures, Finance Institutions, Ministries of Agriculture and Animal Resources together with their subsidiaries: Forests National Corporation (FNC), Agricultural Research Corporation (ARC), Veterinary Research Corporation (VRC), Farmer &Animal Production Associations, Private Sector, Civil Society Organizations.

Driver	Recommended Remedial Action	Envisaged Agency
	Proximate (Direct) Causes of Deforestation & Range Depletion	
	windbreaks and agro-silvo-pastoral systems,	
	1.3.8. Priority states are Southern Kordofan, Blue Nile, Gadaref, White Nile and Sennar,	
	1.4. Improving the efficiency of the agricultural sector necessitates:	
	1.4.1. Investment in yield-enhancing inputs,	
	1.4.2. Improved access of producers in both rain-fed and irrigated sector to finance and technology and services,	
	1.4.3. Advances in research and innovative water delivery mechanism including water harvesting, extension services, integrated crop and livestock, and improved access to markets,	
	1.5. Scrutiny of RoS Renewable Natural Resources: Land, Water, Livestock, Wildlife, Forests, Range & Pasture.	
3. The third underlying cause of Deforestation & Range Depletion in RoS is Legal & Institutional Gaps:	3.1. The Ministry of Agriculture and FNC are urged to address Legal & Institutional Gaps and shortcomings in the context of legal reform within the sought nfp Revision	3.1.1. Ministry of Agriculture, Ministry of Justice, FNC, Federal & State Legislatures
4. The fourth underlying cause of Deforestation &	4.1. Revision of Forest & Other Natural Resources Acts which regulate division of authority of management of and sharing of	4.1.1. Line Ministries of Agriculture & Forests, Animal Resources, Wildlife

Driver	Recommended Remedial Action	Envisaged Agency
Proximate (Direct) Causes of Deforestation & Range Depletion		
Range Depletion in RoS is Lack of Stakeholder Participation	revenue & other benefits from the entire Natural Resources Sectors, particularly the forest and range estate of RoS,	Administration, State & National Legislature.

Bibliography

Abbas Ahmed El Sheikh Mohamed, 1999. Effect of Storage Conditions and Botanicals on the Infestation of Seeds of *Acacia nilotica* (L. Will ex Del) and *Acacia seyal* (Del.) var *seyal* Brenan, by Some Bruchids. M.Sc. thesis. Faculty of Forestry, University of Khartoum.

Abdelnour, H.O., 2008. Integrated Pest Managemnt in Sudan's Forests: A Strategy to Protect What is Left of Sudan's Forests A&E. Gloriuos Quraan Printing House, Khartoum, Sudan,

Abdelrasoul Fadlelmula Mustafa,1997. Regeneration of *Acacia seyal* Forests on the Dry-land of the Sudan Clay Plain. Ph.D. thesis. Faculty of Agriculture and Forestry. University of Helsinki, Finland

Africa Infrastructure Country Diagnostic (AICD) , 2011. Country Report: Sudan's Infrastructure: A Continental Perspective

Ahmed Ismail Ahmed Safi, 2011. Assessment of Damage by the Tree Locust (*Anacridium melanorhodon melanorhodon*) on Gum Arabic Tree (*Acacia senegal*) using Ground Surveys and Remote Sensing Data. Ph.D. Thesis, Faculty of Agriculture, University of Khartoum,

Allen, V.G, Batello, C. Berretta, E.J., Hodgson, J., Kothmann, M., Li, X., McIvor, J., Milne, J, Moris, C., Peeters, A. and Sanderson, M., 2011. An international terminology for grazing lands and grazing animals. Blackwell Publishing Ltd. The Forage and Grazing Terminology Committee. Grass and Forage Science, 66, 2–28

Amira Awad Mohamed Salih,1987. Investigations into Seed Germination and Early Seedling Development of Talih. (*Acacia seyal* var. *seyal* Del). M.Sc. Thesis. Faculty of Agriculture. University of Khartoum.

Anon, 1999. Report of the International Expert Consultation, Role of Planted Forests in Sustainable Forest Management, Santiago, Chile, April 6-10 1999.

Arab Organization for Agricultural Development AOAD ,1998. *Arab Agriculture Statistics Year book*., Khartoum

Boverly A. Moore and Gillian Allard, 2011. A Biotic Disturbances and Their Influences on Forest Health. Forest Health & Biosecurity Working Paper FBS/35E. FAO, Rome, Italy.

Buma, B.; Wessman, C. A., 2011. "Disturbance interactions can impact resilience mechanisms of forests". Ecosphere. **2** (5),

Dale, V.; Joyce, L.; McNulty, S.; Neilson, R.; Ayres, M.; Flannigan, M.; Hanson, P.; Irland, L.; Lugo, A.; Peterson, C.; Simberloff, D.; Swanson, F.; Stocks, B.; Wotton, B., 2001. "Climate Change and Forest Disturbances". *BioScience*. **51** (9): 723–734.

ECORYS, 2010. Study on the evolution of some deforestation drivers and their potential impacts on the costs of an avoiding deforestation scheme

El Tigani El Tom Ahmed, 1995. The Effect of some **Bruchids** on the Viability of Seeds of *Acacia spp* and *Prosopis* and Their Control. M. Sc. Thesis. University of Khartoum.

El Zain Mohamed El Bashir, 1994. The Impact of Defoliation by the Tree Locust (*Anacridium melanorhodon*) on the Gum Arabic Production by Hashab Trees (*Acacia*

senegal). M.Sc. Thesis, University of Khartoum.

F.H. Garcia, M. Kaib, J.M. Kirika1, M. Kraemer, T. Kraus, L. Kühne, T. Lung, I. Malombe, N. Mitchell, W. Musila, M.K. Peters, G. Schaab, I. Theisen, H. Todt, D. Uster, J.W. Wägele, K. Yeshitela, K. Böhning-Gaese, 2008. "Biodiversity of Africa - Observation and Sustainable Management for our Future!", International Congress, 29 September – 3 October 2008, at Spier, RSA.

Fadlalla, B., 1987. The dry season nutritional status of transhumant Baggara sheep, Sudan. Proceedings of the International Conference on Animal Production in Arid Zones (ICAPAZ) held at Damascus, Syria, 7-12 September 1985. Part Two, pp. 834-844. Organized by the Arab Centre for the Studies of Arid Zones and Dry Lands (ACSAD) and the Arab Organization for Agricultural Development (AOAD).

Fadlalla, B. and Ahmed, F.A. 1999. Sudan Country Paper: Livestock production systems in Sudan- research needs and priorities. In Thomson E.F., von Kaufmann R., Li Pun H., Treacher T. and van Houren H. 1999. Global Agenda for Livestock Research. Proceedings of a Consultation on Setting Livestock Research Priorities in West Asia and North Africa (WANA) Region, International Center for Agricultural Research in Dry Areas, Aleppo, Syria, 12 - 16 Nov., 1997. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp.77-83.

FAO, 2012. Land cover Atlas of Sudan. FAO. Rome

FAO 2007.a. The Near East Forestry Commission. Forestry Protection in the Near East. 1. Forest Fires Situation. Food & Agriculture Organization of the United Nations. Regional Office for the Near East- Cairo (2007).
FAO 2007.b. The Near East Forestry Commission. Forestry Protection in the Near East. 2. Forest Pests & Diseases. Food & Agriculture Organization of the United Nations. Regional Office for the Near East- Cairo (2007).
Forests National Corporation (FNC), 1988. Sudan National Forests Inventory, Khartoum,

Forests National Corporation (FNC), 1995. Forests Products Consumption Survey in Sudan. Forestry Development Project. FAO-GCP/SUD/047/NET. Khartoum. May 1995.

Forests National Corporation (FNC). 2011. Forest plantations/woodlots in the eastern and north-eastern African countries of Kenya, Tanzania, Uganda, Burundi, Rwanda, Ethiopia and Sudan. Sudan Report. Commissioned by AFF

Forests National Corporation, 1995. FOREST PRODUCTS CONSUMPTION SURVEY IN THE SUDAN. FINAL REPORT. Forestry Development Project FAO GCP/SUD/047/NET. Khartoum- Sudan. May 1995.

GIZ, 2012. Analysis of Key Drivers of Deforestation and Forest Degradation in the Philippines

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

Ham, D.L., Hertel, G.D., 1984. Integrated Pest Management of the Southern Pine Beetle in the Urban Setting. Journal of Arboriculture 10, 10: 279-282.

Hamid Faki, E. M. N., Abdelaziz Abdelfattah, Aden A Aw-Hassan, 2012. Poverty Assessment Northern Sudan. Aleppo, ICARDA**:**62.

Harrison, M.N. and J.K. Jackson, 1958. Ecological classification of the vegetation of the Sudan. Forest Bull. No 2. (New series) Forest Dept. Khartoum

Heady, H. and Child, R. D. (1994). Rangeland Ecology and Management. ISBN-13: 978-0813320526

http://www.fao.org/agriculture/crops/thematic- sitemap/theme/pests/ipm/en/
http://www.government.nl/topics/grant-programmes/contents/addressing-root-causes-fund)

Ibrahim M. Eltom*, Ahmed H. I. Elfaig*, Abdarhiem A.M. Salih, 2013. Urban Development and Deforestation: Evidences from El-Obeid Town (1970-2010), Western Sudan, International Journal of Scientific and Research Publications, Volume 3, Issue 10, October 2013 1ISSN 2250-3153

Ibrahim M. Mohamed and Abdalla A. Abd Alla, 2009. Studies on Bio-ecology of the Tree Locust (*Anacridium melanorhodon melanorhodon) on* Gum Arabic Tree *Acacia senegal*.Willd. in Kordofan, Sudan. Third Conference on Pest Management in Sudan. Feb. 3-4th, 2004. Wad Medani. Sudan. P.30.

IPCC, 2007. Climate Change 2007: Synthesis Report. Summary for Policymakers. 22 p.

Lars Graudal, 1986. The Supply of Forest Tree Seed in Sudan with Special Emphasis on *Acacia seyal* and Small-Scale Seed Storage Facilities. Fuel Wood Development for Energy in Sudan, FNC, Field Document No. (16), 1986.

Lucia Morales-Barquero , Margaret Skutsch , Enrique J. Jardel-Peláez , Adrian Ghilardi , Christoph Kleinn and John R. Healey 2014. Operationalizing the Definition of Forest Degradation for REDD+, with Application to Mexico, *Forests* , *5*, 1653-1681; doi:10.3390/f5071653

M. Schleuning, N. Farwig, A. Althof, D. Berens, T. Bergsdorf, B. Bleher1, A. Brenner, H. Dalitz, E. Fischer, G. Fischer, W. Freund, M.W. Gikungu, R. Gliniars, M. Hagen, Mock, K.E., Bentz, B.J., O'Neill, E.M., Chong, J.P., Orwin, J., Pfrender, M.E. 2007. Landscape-scale genetic variation in a forest outbreak species, the mountain pine beetle (*Dendroctonus ponderosae*). Molecular Ecology 16: 553–568.

Mohamed Gumaa Bushara, 1979. Some Aspects of the Biology of the Acacia Wood Borer Sinoxylon *senegalense* Karsch**. Bostrychidae-Coleoptera.** M. Sc. Thesis, Zoology Department, Faculty of Science. University of Khartoum.

Nabuurs, G.J., Masera, O., Andrasko, K., Benitez-Ponce, P., Boer, R., Dutschke, M., Elsiddig, E., Ford-Robertson, J., Frumhoff, P., Karjalainen, T., Krankina, O., Kurz, W.A., Matsumoto, M., Oyhantcabal, W., Ravindranath, N.H., Sanz Sanchez, M.J. & Zhang, X. 2007. Forestry. In: Climate Change 2007. Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge. p 541–584.

National Energy Research Centre (NERC). household energy situation 2015

National Range and Pasture Handbook, 2003. USDA, NRCS, Grazing Lands Technology Institute. Issued 1997; Revised 2003.

Nimir, Mutasim and , Abdel Salam Ahmed, 2004. Effect of Oil Industry in Forestry Sector in Sudan, paper presented in the Forestry Conference

O'Halloran, Thomas L., Law, Beverly E., Goulden, Michael L., Wang, Zhuosen, Barr, Jordan G., Schaaf Crystal, Brown Mathew, Fuentes, José D., Göckede Mathias, Black Andrew and Engel, Vic., 2012. Radiative forcing of natural forest disturbances. Global Change Biology. Vol. 18. Issue 2. John Wiley & Sons, Ltd

Peake, F.G.G., 1952. A Bruchid Seed-borer in Acacia Arabica. Memoirs of Research Division No 29. Agricultural Publications Committee. Ministry of Agriculture. Sudan Government. Khartoum.

Sayda Mahgoub, 1997. Bulk Seed Collection of *Acacia seyal* Del.var.*seyal* Brenan in Sudan (Unpublished).

Sayda Mahgoub, 2002. Physiological, Environmental and Biochemical Factors Affecting the Germinability of Seeds of some Forestry Species. Ph.D. thesis. University of Khartoum. Sayda Mahgoub and Talaat Dafaa Alla (1996). *Acacia seyal* Del. var *seyal* Brenan Seed Handling and Silvicultural Operations. NTSC Publication No (10). Khartoum, Sudan.

Sayeda A.A. Khalil, H. A. Atta and I.M.Aref, 2011. Increased gum arabic production after infestation of *Acacia senegal* with *Aspergillus flavus* and *Pseudomonas pseudoalcaligenses* transmitted by *Agrilus nuboculosus*. African Journal of Biotechnology, Vol. 10 (37). PP 7166l173

Sayeda Ahmed Ali Khalil, 2009. Effect of Methyl Jasmonate and Insect Infection on Gum Production of *Acacia senegal* (Wild.) Ph.D. Thesis, Faculty of Science, University of Khartoum.

Shukri Ahmed, 2007. FAO/WFP Crop and Food Supply Assessment Mission to Sudan Special Report. Rome, FAO.

Steve H. Dreistadt, 2004. Pests of Landscape Trees and Shrubs: An Integrated Pest Management Guide. UCANR Publications. ISBN 978-1-879906-61-7
Sudan National Energy Assessment (NEA), 1982.. National Energy Administration. Khartoum,

Sudan: Land of Opportunities. Ministry of Information & Culture 2011. Khartoum, Sudan

Sudan: Land of Opportunities. Ministry of Information & Culture 2011. Khartoum, Sudan

Sudan's Second National Communication 2013, under the United Nations Framework Convention on Climate Change

Tearfund Organization, 2007. Report: Darfur: Relief in a Vulnerable Environment

UNDP, 2015. human Development report

UNEP, 2006. Report: Sudan: Post conflict Environmental Assessment

UNFCCC, 2011. United Nations Framework Convention on Climate Change. Report of the Conference of the Parties on its seventeenth session, held in Durban from 28 November to 11 December 2011. Part one: Proceedings.

UNFCCC, 2011 Guidance on systems for providing information on how safeguards are addressed and respected and modalities relating to forest reference emission levels as referred to in decision 1/CP.16 Decision CP.17

UN-Habitat, 2014. Sudan Report For United Nations' Third Conference On Housing and Sustainable Urban Development, (Habitat III), 2016

UNHCR, 2016. SAFE Access to Fuel and Energy, Sudan Strategy

UNHCR, March 2016, SAFE Access to Fuel and Energy, Sudan Strategy, UNHCR/UNDP, 2014. TSI Baseline Assessment

USAID, January 2007. Fuel Efficient Stoves Programs in IDPs Settings Darfur Sudan - Desk Study.

Wickens, G.E. 1991. Management issues for development of non-timber forest products. *Unasylva* 42 (165):3-8.

www.unesco.org/new/en/social-and-human-ciences/themes/.../glossary/migrant/

www.unesco.org/new/en/social-and-human-ciences/themes/.../glossary/migrant/

www.unrefugees.org/what-is-a-refugee/

www.unrefugees.org/what-is-a-refugee/

Yasar Arfat, 2010. Master degree thesis in the Division of Physical Geography and Ecosystems Analysis, Department of Earth and Ecosystem Sciences. Lund University

FNC

FOREST CARBON PARTNERSHIP FACILITY

WBG

REDD+ SUDAN

Reducing Emissions from Deforestation and Forest Degradation (REDD+) Readiness Program