FOOD AND AGRICULTURE ORGANIZATION (FAO)

ASSESSMENT OF VULNERABILITY OF LIVESTOCK AND RANGELANDS TO CLIMATE CHANGE IMPACTS IN SUDAN

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TERMS OF REFERENCE FOR THE CONSULTANCY (Programme/Project Number: GCP/SUD/082/GCR)

a) GENERAL DESCRIPTION OF TASKS AND OBJECTIVES TO BE ACHIEVED

The government of Sudan represented by the Higher Council for Environment and Natural Resources (HCNER) has received fund from the GCF in support of National Adaptation Plan (NAP) Readiness through the Food and Agriculture Organization of the United Nations (FAO) under the programme titled **"strengthening adaptation planning processes and capacity for implementation of adaptation actions in agricultural and water sectors in the Sudan".**

The NAP Readiness, with a focus on agriculture and water, addresses gaps in the 2016 NAP of the Republic of the Sudan, including an identified lack of Climate Change (CC) data and information and impact assessments, well-designed training opportunities for climate change impact modelling at the State and federal levels, and Capacities of State-level Technical Committees for CC adaptation planning and implementation.

The NAP Readiness project gives emphasis to study of non-climatic drivers and provide space for assessment of key national and State-level non-climatic (socio-economic) drivers of vulnerability. The assessment tends to present the drivers' information disaggregated into impacts on women as compared to men for the three sectors under the study.

b) DUTIES AND RESPONSIBILITIES

The DUTIES AND RESPONSIBILITIES for this consultancy set in the TOR are to:

(a) assess vulnerability livestock and rangelands to climate change impacts in Sudan based on the main national adaptation documents.

(b) review key national and State-level assessments of non-climatic (socio-economic) drivers of vulnerability related to agriculture sector based on adaptation documents.

c) METHODOLOG FOR DATA COLLECTION

In this report vulnerability assessments are based on available literature. Both climatic and non-climatic factors are considered in assessing the vulnerability of livestock and rangeland at the state levels, as undertaken in the following reports:

i. Sudan's First National Communication (SFNC, 2002)
ii. National Adaptation Program of Action (NAPA, 2007),
iii. United Nations Environment Program (UNEP, 2007).
iv. Sudan National Communication (SNC, 2013),
v. National Adaptation Plan (NAP, 2016),
vi. Intended Nationally Determined Contributions (INDCs, 2018),
vii. National Council for Combating Desertification (NCCD, 2018).
viii. Assessment of Impact and Adaptation to Climate Change (AIACC)
ix. Higher Council for the Environment and Natural Resources (HCENR)
x. In addition to other national studies and research.

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LIST OF ABBREVIATIONS AND ACRONYMS

AIACC	Assessment of Impact and Adaptation to Climate Change
ARC	Agriculture Research Corporation
CAHWs	Community animal health workers
CBD	Sudan's Fourth National Report to the Convention on Biological Diversity
CBRR	Community-Based Rangeland Rehabilitation
DHP	Dry Land Husbandry Project
FAO	Food and Agriculture Organization of the United Nations
FEWS NET	Famine Early Warning Systems Network
GCF	Green Climate Fund
HCENR	Higher Council for the Environment and Natural Resources
IAS	Invasive alien species
IDDRSI	Drought Disaster Resilience and Sustainability Initiative
IFAD	International Fund for Agricultural Development
IGAD	Inter-Governmental Authority on Development
INDCs	Intended Nationally Determined Contributions
IPRSP	Interim Poverty Reduction Strategy
LRWS	Low rainfall wood savannah
LSMA	Large-scale mechanized agriculture
MARF	Ministry of Animal Resources and Fisheries
MENA	Middle East and North African countries
NAPA	National Adaptation Program of Action
NAP	National Adaptation Plan
NCCD	National Council for Combating Desertification
OIE	World Organization for Animal Health
OSSREA	Organization for Social Science Research in Eastern and Southern Africa
PRSP	Poverty Reduction Strategy
RPGD	Range and Pasture General Directorate
SPS	Sanitary and Phyto-sanitary
SECS	Sudanese Environment Conservation Society
SFNC	Sudan’s First National Communication
Sida	Swedish International Development Corporation Agency
SKAP	Southern Kassala Agricultural Project
SNC	Sudan National Communication
TLU	Tropical Livestock Unit
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
UNFPA	United Nations Population Fund
WTO	World Trade Organization

1. BACKGROUND

This section represents **Sudan livestock sector and rangelands activity data.** It includes animal populations, livestock and feed production systems, data used in national statistics/Ministry of Animal Resources statistics, including historical data and trends.

The country's total area (1.87 million km2), about 1.25 million km2 (66.8%) is desert and semi desert; the remaining 0.68 million km2 (36.8%) is divided between low rainfall savannah (300- 500 mm of annual rainfall) and the rich savannah (over 500 annual mm rainfall) that extends extensively in the Republic of South Sudan. Sudan is a dry country exhibiting typical Sahelian zone with its characteristic of low level of rainfall, scarcity of water, and short agricultural season (3-4 month) (Sudan National Drought Plan, 2018).

1.1.Livestock production systems in Sudan

1.1.1. Livestock grassland-based system – Livestock only

This system is based on extensive management and comprises *pastoral nomadic, semi-nomadic, agro pastoralism* and *sedentary* management systems.

Sudan is the home to a large concentrations of pastoralists, estimated around 13% of total population (Barbara Casciarri, 2009). Pastoral nomadic, semi-nomadic agro and pastoralism groups own 80- 90% of the total number of cattle, 100% of camels, 80% of sheep and 60% of the goats of the country **(Table 1.1).** Given the importance of the livestock to the national economy, the contribution of these zones is significant since they host about 90% of livestock country wide (FAO, 2002).

Moreover, these systems are the main sources of meat for the local demand and for export (CBD, 2009).

**A note on agro pastoralism:* This subsystem is classified by FAO (2015) as rain-fed mixed system and its main characteristics are:

- both agriculture and livestock production are practiced,
- Livestock mobility is for short distances, e.g. Baggara (cattle herders) and Butana tribes in the western and central part of eastern Sudan.
- Subsistence agriculture is practiced e.g. Sorghum & millet and types of livestock raised are cattle& sheep (Baggara tribes).

Sedentary management system: It is a subsystem that is based on extensive management of cattle and small livestock that reared in close proximity to villages, mainly in the central belt from Gedaref to Kordofan & Darfur (UNEP, 1998).

1.1.2 Mixed production system

This system prevails in Khartoum State, Gezira irrigated agricultural scheme and Red sea region. Probable future areas are: Halfa & Rahad and other irrigated agricultural schemes.

In Gezira irrigated agricultural scheme famous dairy cattle keepers (Kenana & Butana breeds) use this system to support their herds during dry season. Small ruminants are also raised.

Table 1.1: Livestock Production Systems Management in different Ecosystems, Sudan

Agro-ecological Zone	**Livestock grassland-based management system**			**Mixed production system**	**landless production system**
Management production system	*pastoral nomadic*	*semi-nomadic*	*agro pastoralism**	Irrigated	2. Large commercial dairy & poultry enterprises in peri-urban areas 3. Dairy Cooperatives.
Cattle	**90%**			**10%**	
Camels					
Sheep					
Goats					

Source: based on Wilson, 2018.

*classified by FAO (2015) as rain-fed mixed system

- *Unspecialized fattening operations:*

This comprises unspecialized fattening operations targeting maintenance and reconditioning of sheep herds e.g. Dubasi breed are conducted in some States (Gazira, White Nile, Blue Nile, Gadarif & Kassala) (Krätli *et al*., 2013). Nutrition is based on agro-industrial by-products.

Fossil fuels are used for the transportation of agricultural inputs and livestock and livestock products.

1.1.3 Landless production system (Industrial)

This system is mainly based on intensive and semi-intensive management and it comprises large commercial dairy & poultry enterprises located in peri-urban areas around large cities e.g. Khartoum and other large towns in the States, in addition to dairy cooperatives (FAO, 2015).

Most (97.3%) of fresh milk produced in landless production system available in market is produced in Khartoum and Gazeira States.

- *Specialized fattening operations:*

For fattening cattle and sheep trekked for long distances from the Western States of the country namely Darfur and Kurdofan States to urban areas and markets. Western Baggara cattle breed and desert sheep breeds are the most common pastoral breeds used in feedlots.

1.2 Population per livestock category/ region/Agro-ecological zone

The last national livestock census had taken place during 1976-77 and the official estimates of the size of Sudan's livestock populations are produced by Ministry of Animal Resources and Fisheries (MARF) based on a herd growth model.

The differentiation of cattle and other livestock types by breed was not possible as there was no statistical information available by sex, breed or function. **Table (1.2)** represents the estimates of livestock population by States in 2019.

Table 1.2: Estimates of Livestock Population by States in 2019

States	Cattle	Sheep	Goats	Camels	Total
North Kordofan	787225	4212288	2722720	939840	8,662,073
South Kordofan	4606841	2208384	2178176	252582	9,245,983
West Kordofan	3526768	4355424	2434432	641245	10,957,869
North Darfur	733694	3926451	3038699	612365	8311208
South Darfur	2476610	2208384	1733572	90729	6509295
East Darfur	2026317	1803514	1418377	74233	5322440
Middle Darfur	1946020	1840320	2075674	199227	6061240
West Darfur	2380568	2241101	2540138	243282	7405088
Elgadarif	1108413	2229702	1110382	354398	4802895
Kassala	900585	2110060	1754677	714181	5479503
Red sea	144849	435064	753963	296637	1630513
Blue Nile	2150699	4078723	475225	14685	6719332
Sennar	1687810	1435711	1718122	120907	4962549
Elgazira	2648225	2583191	2248180	127760	7607356
White Nile	3731447	2664766	2682280	36713	9115205
Northern	267657	1022400	1206341	50908	2547305
River Nile	107063	1076783	1265744	118459	2568048
Khartoum	258210	462255	676282	6853	1403600
Total	**31489000**	**40896000**	**32032000**	**4895000**	**109312000**

Source: Statistical Bulletin for Animal Resources. Issue No 27, 2020

Table (1.3) shows total number of livestock population and the average annual growth rate (%) for 2015 and 2019 for Sudan.

Table 1.3. Estimates of animal population (in 000 head) in Sudan from 2015 to 2019.

Year	Cattle	Sheep	Goats	Camels
2015	30376	40210	31227	4809
2019	31489	40896	32032	4895
Average annual growth rate %	3.6	3.9	2.9	2.4

Source: Statistical Bulletin for Animal Resources. Issue No 25, 2016 and Issue No 19

The data of livestock population estimated by FAO (2002) which expressed the total livestock population of both countries of Sudan and South Sudan is used to estimate livestock population in agro-ecological zones of Sudan for the preceded years. **Table (1.4)** represents population per livestock category per agro-ecological zone.

Table 1.4: Estimate of Livestock population per Ecological Zones of Sudan in 2019

Eco- zone	Area Km2 (000)	Avg. Rainfall mm/annum	Live Stock Population (000)			
			Cattle	Sheep	Goats	Camels
Desert			629.78	2,862.72	2,242.24	489.5
Semi-desert			5,668.02	11,041.92	8,008	2,496.45
Low rain Savannah			8,187.14	9815.04	7,047.04	1,174.8
High rain Savannah			12,280.71	15131.52	12,492.48	489.5
Mount.			4,723.35	2,044.8	2,242.24	244.75
TOTAL			**31,489**	**40,896**	**32,032**	**4,895**

Source: Statistical Bulletin for Animal Resources. Adapted from FAO (2002).

1. 3. Land Use and Potential Carrying Capacity of the various Ecological Zones of Sudan

1.3.1 Ecological Zones of Sudan

Sudan has six fairly distinct agro-ecological zones, which are differentiated in a fairly regular sequence from the north to the south of the country. These are: Desert, Semi-desert, Low Savannah, High Savannah and Equatorial regions (Harrison and Jackson, 1958).

Northern Sudan is sandy desert crossed through its length by the Nile Valley. Rainfall is infrequent and there are limited feed resources that support small number of animals, mostly camels and small ruminants.

Western Sudan (850 km2) is the home of large numbers of all kind of livestock such as camels, sheep, goats and cattle. The animals are maintained under extensive migratory system of husbandry.

The central clay plain is the site of rainfed and irrigated agriculture. It is rich in feed resources (forage, agricultural residues and by agro-industrial by-products) that can be used for intensive livestock production.
North of the central clay plain lies eastern Sudan, which includes Al Butana, Gash delta, Red Sea hills and the coastal plain.
The most significant climatic variables are rainfall and the length of the dry season. From January to March there is no rain country wide. In early April the moist southern westerly winds reach South Sudan bringing heavy rain for nine months. By July the same winds reach northern Sudan (annual average of 161mm in Khartoum). The plant cover is associated with rainfall and soil type. In the desert (north of 14°N) vegetation is absent except near water sources.

The semi-desert zone contains mixed vegetation, grass, herb, shrub and some trees mainly Acacia spp and the grasses are mainly annuals.
In the woodland grass savannah zone trees are with broad leaves and grasses are perennials. In areas with heavy rains forests predominate. Generally, in most climatic regions rapid deteriorations in the quantity and quality of the grass occurs with the onset of the dry season (Hussein, 2008).
Climatic regions are characterized by different climatology (especially rainfall) and soil fertility. Within the various ecozone farming systems in terms of land use and practices are fairly homogenous. Many of these crops have direct bearing on livestock production by providing useful postharvest residues or agro-industrial by-product in various part of the country.

The common farming system in the arid zone is the traditional pastoral nomadism, semi-nomadism or transhumant pastoralism based upon communal grazing suited to the sharp annual seasonal rainfall patterns that require migration to where forage and water pond are plenty and fly pests are few.

Table (1.5) represents a considerable variation in dry matter availability ranging from an obvious deficit in the desert zone to a serious problem in the semi-desert zone. These two zones carry more than their optimal carrying capacities. The excess capacities account for about 42% and 69% for the two zones, respectively.
On the other hand, in the low Savannah, high Savannah and Equatorial regions there is under stocking as they carry less than their optimal carrying capacities by about -58%, -42%, and -98% for the three zones, respectively.

Table 1.5: Estimate of Productivity and Potential Carrying Capacity of the various Ecological Zones of Sudan (2001).

Eco-zone	Area Km2 (000)	Avg. Rainfall mm/annum	Live Stock Population (000)				Biomass TLU, KG(000)	Dry matter/ year(000)	Ha./DM	Optimal (000)	Excess%
			Cattle	Sheep	Goats	Camels					
Desert	725	38	692.8	3284	3007.4	364.8	1802.8	8224.4	18.8	1272.8	42
Semi desert	492	188	7988.4	13288.1	10952.2	1706	10965.1	50028.1	3.8	6474.7	69
Low rain Savannah	689	550	11892.2	11833.5	8994.1	784.9	12265.8	55921.7	1.3	27179.2	- 58
High rain Savannah	347	1050	17533	18205.4	16613.1	322	17858.4	81478.8	0.7	30605.4	- 42
Equatorial+ Mount.	252.5	1050	196.6	342.9	327.2	-	236.3	1078.1	0.7	12248.8	- 98
TOTAL	**2505.5**		**38303**	**46936.5**	**39894**	**3177.7**	**4319.2**	**196731.1**		**79780.9**	

Source: FAO, 2002.

TLU≡ Tropical Livestock Unit.1 TLU= 500 kg live weight i.e. 50000 kg DM a year. DM yield= 7 kg dry matter/ ha. /mm rainfall. DM rate of utilization varies from 33% to 60% depending on the eco-system.

1.4 Livestock feeding system

The following are the major feeding systems in the Sudan:

1.4.1 Free grazing feeding system

Mobility is one of the most prominent features of pastoralism in the Sudan. This movement is one of the best adapted and effective means to provide for livestock needs in a variable environment. According to Niamir (1991) livestock mobility is one of the major ways in which African pastoralists have managed uncertainty and risk in arid lands. It is the only way that enables nomads to cope with (or benefit most from) the variation and to manage or escape drought (Oba and Lusigi, 1987). Pasture, water and forestry are the most crucial natural resources for pastoralism – which is often defined as a form of land-use system that depends mainly on livestock raising using these interdependent natural resources (Karamalla, 2011).

National feed resources rangelands form an immense natural resource and the major source of feed for the national herd as grazing and browsing. Almost 90% of the national herd depends on the natural rangeland. Other feed sources include crop residues and agricultural by-product, irrigated forage agro-industrial by-products, and concentrates

Whereas pasture is well available during the wet season, it declines in both quantity and quality to the extent that it fails to satisfy the minimum requirements of the grazing animals. For example: *Cenchrus biflorus* and *Eragrostis tremula* that constitute the main grazing natural forage in western Kordofan, have crude protein (CP) content of about 3.4% (Jaddalla, 1994).

The role of fodder trees and shrubs (*Acacia*, *Cadaba*, *Maerua* etc) as a dry season source of feed (pods, leaves and twigs) should not be under-estimated. They are particularly valuable in the Semi-desert and Low Rainfall Savanna zones.

Multi-purpose trees and shrubs, which are utilized within farming areas and in rangelands, provide dry season feed and supplement the dry grass with nutrition browse and pods. The trials of the Agriculture Research Corporation (ARC) with Leucaena for forage production and the efforts of the Community-Based Rangeland Rehabilitation for Carbon sequestration and Biodiversity Project, to produce and distribute seedlings of *A. senegal, A. albida* and *Ziziphus spina-christi* to be used in rangeland and for other purposes, can be mentioned in this regards (Darag and Madibo, 1994).

Musa et al. (2006) reported that herdsmen (nomads and transhumant) supplement their grazing herds with crop residues, agro-industrial by-products, irrigated fodder and purchased concentrates. These feeds are collected and stored for the dry season.

1.4.2 The cut-and-carry feeding system

According to Zaroug (2000) the small-scale irrigated farms (<1-5 ha) where the cut-and-carry feeding system prevails, produce fodder crops like sorghum and alfalfa; crop residues may also be used in these farms.

1.4.3 Stall feeding

This system is practiced mainly in commercial dairies, poultry and fattening operations. Cecilia Kulneff (2006) noted that in Khartoum State lactating cows are given more concentrate than dry cows. El Dierani (1986) reported that Sorghum grain, crop residues and agro-industrial by-products are used in finishing beef cattle and sheep in feedlots in Sudan.

1.5 Feed production

Sudan total available livestock feed were estimated at 151 million tons of dry matter in the year 2015, of which natural range land resources produce about 126 million tons that account for about 83.65%, of total fodder.

Table (1.6) reveals forage production in (000) tons countrywide. Crop residues and crop by-products provided about 20, 5 million tons in 2015, accounting for about 13.5% of total fodder. Consideration should be given to integration of livestock in different farming systems.

Green fodder crop contributed about 4.2 million tons, which represented about 2.8% of the total available feeds (Statistical Bulletin-MARF, 2016).

Table 1.6: Forage production per State (000)T 2015

State	Concentrates (grains and cakes)	Irrigated green fodder	Crops residues	Rangeland	Total
Kassala	-	-	751,000	4,800.000	755,800
Elgedarif	-	94,200	2611,000	4,800.000	2710,000
Red sea	-	-	67,000	2,610.000	69,610
Northern	-	203,300	181,000	0.21	384,510
Khartoum	- -	2216,600	0.000	0.060	2216,660
River Nile	-	1001,580	159,000	1,160.000	1161,740
Blue Nile	-	-	2196,000	8,500	2204,500
Sennar	-	-	2996,000	3,80	2999.800
Elgezira	-	511,900	1775,000	0.700	2287,600
White Nile	-	79,700	901,000	2,300	983,000
North Kordofan	-	-	710,000	16,200	726,200
South Kordofan	-	-	2943,100	39,600	2982,700
West Kordo an	-	-	1471,000	-	1471,000
South Darfur	-	53,40	1593,300	27,100	1673,800
East Darfur	-	-	480,000	-	480,000
Middle Darfur	- -	-	450,000	-	450,000
West Darfur	-	-	860,000	6,100	866,100
North Darfur	-	-	314,500	8,600	323,100
Total		**4,160.680 (2.75%)**	**20,459.100 (13.52%)**	**126,540.000 (83.65%)**	**151,273.780**

Source: Statistical Bulletin for Animal Resources. Issue No 25, 2016

1.5.1 Rangelands

The two terms range and pasture are used interchangeably in many texts even within some publications of wide coverage, but there is a difference between them as detailed in the second expert meeting on harmonizing forest-related definitions for use by various stakeholders (FAO, 2002).

Rangelands are mainly natural, native and have social, economic and environmental importance; while pasture is more influenced by human activity (planted or intensively altered by management) with an objective oriented more towards animal production.

Rangelands in the Sudan form a huge natural resource; they constitute various types of grazing lands, which vary from open grasslands to seasonal watercourses, flood plains, river banks and associated islands, woodlands, hills and mountain slopes (Zaroug, 2000).

The natural rangelands include herbaceous (mainly grass and forbs) and shrubby covers, and naturally forested areas. Vegetation intensity and diversity become richer from north to south, across the different ecological zones of semi desert, low and high rainfall savannah, flood plains and mountain areas.

The rangelands for traditional livestock raising are confined to the semi–desert, low rainfall savannah, and the northern fringes of the high rainfall areas. According to ecological zone national feed resources can be classified into different zones as seen in **Table (1.7)** below (RPGD, 2012).

Free grazing of rangelands is the most common feeding system for livestock. The natural range (herbs and grass) most important feed source, in term of an area and production, it provides feed during wet season (August to December).

During the short wet season grasses grow and mature rapidly producing abundant biomass where herbs and grass characterized by its succulence as foliated with a high crude protein content, low fiber in the beginning of the wet season.

The body condition of the grazing animal is at its best during this period and by the end of growing rainy season protein content declined fiber% increase as low grass quality and quantity (less than 5% protein and 50% digestibility).

In the semi- desert the plant cover is a mixture of grasses and herbaceous plants intermingled with Acacia trees and shrubs representing the main grazing areas for camel and sheep.

Table 1.7: Vegetation of Ecological Zones, Arable and Range Lands				
Zone	**Mean annual rainfall (mm)**	**Wet season**	**Dry season**	**Main land use types**
Desert	<75	July to September	October to June	- Irrigated agriculture - Grazing along seasonal water courses
Semi-desert	75-300	July-September	November-June	- Irrigated agriculture - Dryland farming in conjunction with water harvesting -
		November-January	March-September	Pastoral
Low rainfall savannah	300-800	May-September	November-April	- Irrigated agriculture - Rainfed traditional cultivation - Mechanical farming - Pastoral - Forestry
High rainfall savannah	800-1500	April-October	December-February	- Rainfed traditional cultivation - Mechanical farming - Pastoral - Forestry
Flood region	600-1000	May-October	December-April	- Traditional cultivation - Pastoral - Wildlife
Mountain vegetation	300-1000	Variable	Variable	- Traditional cultivation - Pastoral - Forestry - Horticulture

Source: RPGD, 2012 (quoted from Harrison and Jackson 1958)

Two areas of pure grassland form a distinct feature of this rangeland type namely, the Butana plains (grassland on clay) central Sudan and Baja area (grassland on sand) located in the south western part of the country.
The Low rainfall savannah on clay and sand have a plant cover of a mixture of Acacia's spp, shrubs and a number of herbaceous plants (RPGD, 2012).

1.5.2 Browsing (Fodder trees and shrubs)

Browse species (fodder trees and shrubs) are important components of the natural rangelands upon which livestock and wildlife depends during dry season. Among the leguminous tree and shrubs, 75 percent serve as fodder source. It supplies **33 percent** of the total feed requirement of the national herd (ILCA, 1980), which estimated at about 104, 9 million head (MARF, 2012).

Trees provide an important part of the animal feed in semi-arid and savannah areas, especially during the summer. They are the main source of feed for browsing animals, mainly camels and goats. Acacia trees mainly "seyal"5F 6Acacia tortilis, "talih" Acacia seyal, and "Kitir" Acacia melifera are among known browse trees in these areas. Browsing is not only confined to forested areas, it also includes other areas of herbaceous cover intermingled with scattered trees and shrubs (Karamalla, 2011).
According to the pastoral lands survey conducted in the different ecological zones during 2011 (RPGD, 2012), it was estimated that total livestock feed DM availability in the country was 49.67 million tonnes of which 34.77 million tonnes shared by natural pasture lands ,14.15 million tons from crop residues and 0 .54 million tons from both Agro-industrial by- products and cereals **(Table 1.8).**
Range & Animal Feed Rangelands: Rangelands cover an estimated area of 96.4 million (M) ha composed of 53.4 M ha of grassland and 43.0 M ha of woodlands containing scattered trees and shrubs (Afri-cover 2003). This vast area encompasses different ecological zones extending from desert and semi-desert in the north to the low rainfall wood Savanna (LRWS) to the south and south west. Nearly 80% of all rangelands are located in semi-desert and LRWS ecological zones which are characterized by variable and unpredictable rainfall. Rangelands are estimated to have a total production of 34.8 million tons of dry matter. Total available feed is 50 million tons (dry matter) composed of 34.8, 14.1, 0.5 and 0.2 million tons of forage from rangelands, crop residues, irrigated pastures and concentrates, respectively (RPGD, 2012).

Table 1.8: Available animal feed dry matter (million tonnes) in Sudan 2011

Region/ecological zone	Agro-industrial by-products	Cereals	Irrigated Pasture	Crop residues	Rangelands	Total
Eastern (Semi-desert Zone	0.05	0.34	0.029	5.16	4.38	9.619
Northern(Semi-desert Zone)	0.02		0.335	0.33	0.77	1.4559
Central (Low Rainfall Savanna Zone)	0.05		0.05	4.67	2.65	7.42
Western (Low and High Rainfall Savanna Zone)	0.06		0.131	3.1	13.36	16.651
Darfur (Low and High Rainfall Savanna Zone)	0.02		0.006	0.887	13.61	14.5234
Total	0.2	0.34	0.551	14.147	34.77	49.67

Source: RPGD, 2012, Sudan Feed Sources Report for 2011/2012

2. ASSESSMENT OF VULNERABILITY OF LIVESTOCK AND RANGELANDS TO CLIMATE CHANGE IMPACTS IN SUDAN

2.1 Overview on drought intensity in different regions and its impact on livestock and rangelands sectors

Climate scenario analyses conducted by Sudan's First National Communication (SFNC, 2002) to the UNFCCC indicates that average temperatures are expected to rise significantly relative to the baseline (1961-1990). By 2060, average temperatures are expected to rise from between 1.5o C and 3.1o C above the baseline during August, and from between 1.1o C to 2.1o C during January. Climate change is also projected to reduce average rainfall by about 6mm per month during the rainy season. Such changes in temperature and precipitation are likely to undermine the development progress that is occurring in many sectors in Sudan.

According to the National Adaptation Program of Action (NAPA) in Sudan (NAPA, 2007), the current major climate hazards consist of drought and extreme flooding events **(Tale 2.1).**

In addition, there are other climate related phenomena such as dust storms, thunderstorms, and heat waves whose occurrences, though less frequent, still pose serious threat to local livelihoods.

The table clearly illustrates that extreme weather and climate events impact on livestock and rangelands are mainly drought and floods in addition to heat waves that cause heat stroke in animals.

Table 2.1: Extreme weather and climate events in Sudan types, frequency, sectors affected, and impact categories (Source: Government of Sudan, 2007

Event	Occurrence	Vulnerable areas	sectors	Impacts
Drought	Frequent	North & Western Sudan (North Kordofan and Darfur), Kassala State and some parts of the rain-fed areas in central Sudan.	Agriculture, livestock, water resources and health.	Loss of crops and livestock (food shortage), decline in the hydroelectric power, displacement wildfire.
Floods	Frequent	Areas within the River Nile basin and low areas from extreme South to far North. Mountain areas along Red Sea.	Agriculture, livestock, water resources and health.	Loss of life, crops, livestock; insects & plant diseases, epidemic/vector diseases, decline in hydro power; damage to infrastructure & settlement areas
Dust storms	Frequent	Central and northern parts of Sudan	Transport (aviation and land traffic)	Air and land traffic accidents and health.
Thunder - storms	Infrequent	Rain-fed areas throughout all Sudan	Aviation	Loss of lives and properties.
Heat waves	Rare	Northern, central parts of Sudan besides the Red Sea State.	Health, agriculture & livestock.	Loss of live, livestock and crops.
Wind-storms	Rare	Central and north central Sudan	Settlements and service infrastructure	Loss in lives, property; damage to infrastructure (electricity and telephone lines)

Source: NAPA, 2007

Key vulnerabilities due to climate change impacts and variability are also shown in **Table (2.2),** Sudan (INDCs, 2018).

Table 2.2: Sudan's Vulnerability to Climate Change

Climate Change Impacts and Variability	Key vulnerabilities
Variable Rains (INC, 2003, Sudan NAPA, 2007)**:** • A decrease of annual rainfall of about 0.5% per year. • Coefficient of variability increased by 2.0 % per year • More frequent and intense drought trend • Changes in precipitation are more uncertain results showing both wetter and drier conditions (NAP, 2013).	• Shifting agro-climatic zones southwards • Water deficit • Declining, and failure of, crop production • Loss of range resources and livestock • Desertification • Poverty • Food insecurity and famines • Loss of livelihoods • Competition over resources and conflicts • Human displacement and suffering
Temperature (Sudan INC, 2003): • By 2060, projected warming ranges from 1.5 - 3.1 C0 during August to between 1.1o - 2.1 C0 during January. • Climate scenario for Kordofan indicates an increase in average temperature • Temperature clearly show substantial warming (climate scenarios (NAP, 2013).	• Increased water loss • Negative impact on the winter season crops • Decline wheat production • Increases weeds, pests and diseases (e.g. white fly, root rottenness) • Increase risk of malaria and diseases
Floods (Sudan NAPA, 2007): • Floods caused by torrential rains with overflow of the Nile River and its tributaries • Flash flooding due to heavy localized	• Damage crops production systems • Damage human settlements and properties • Increase risk of malaria and other diseases • Loss of livelihoods

Source: Sudan, INDC, 2018

2.2 Vulnerability to climate hazards in different States

2.2.1 Definition of Vulnerability

Vulnerability is the potential to be adversely affected by an event or a change and the ability to cope with or recover from its impacts. The extent to which climate change may damage or harm a system depends on the system's sensitivity and ability to adapt to new conditions. Physical vulnerability refers to exposure to stress and crises resulting from physical hazards, while social vulnerability refers to the inability of individuals and communities to respond to physical impacts. Vulnerability may be considered at many levels, including the individual, household, national or regional level (Oriandi and Zakieldeen, 2006).

HCENR & SECS (2005) analysed 11 indicators of environmental hazards that have negative impacts on the welfare of communities in Sudan. These are: human diseases, industrial pollution, overgrazing, deforestation, desertification, shortage of domestic water, unsafe domestic water, lack of safe sanitation, conflicts, urban problems and the effect of agrochemicals.

The analysis showed that certain states are at very high risk of environmental hazards (Red Sea, Kassala, North Kordofan, and Khartoum States).
Certain states are poorer than the national average: Kordofan, Blue Nile, Kassala and Red Sea, and coupled with that, also had a very high, and increasing, rainfall CV between 1971 and 2000 along with decreasing average rainfall. These states are repeatedly classified as vulnerable based on the following criteria: average rainfall and coefficient of variability; population distribution; poverty; extreme events (drought, floods); and other environmental hazards **(Figure 2.1).**

Furthermore, the analysis showed that these areas are frequently affected by drought and/or floods; findings which were also confirmed in the NAPA. The SFNC (2002) assessment indicated that Kordofan State was particularly vulnerable in certain sectors (water, agriculture, forestry and health).

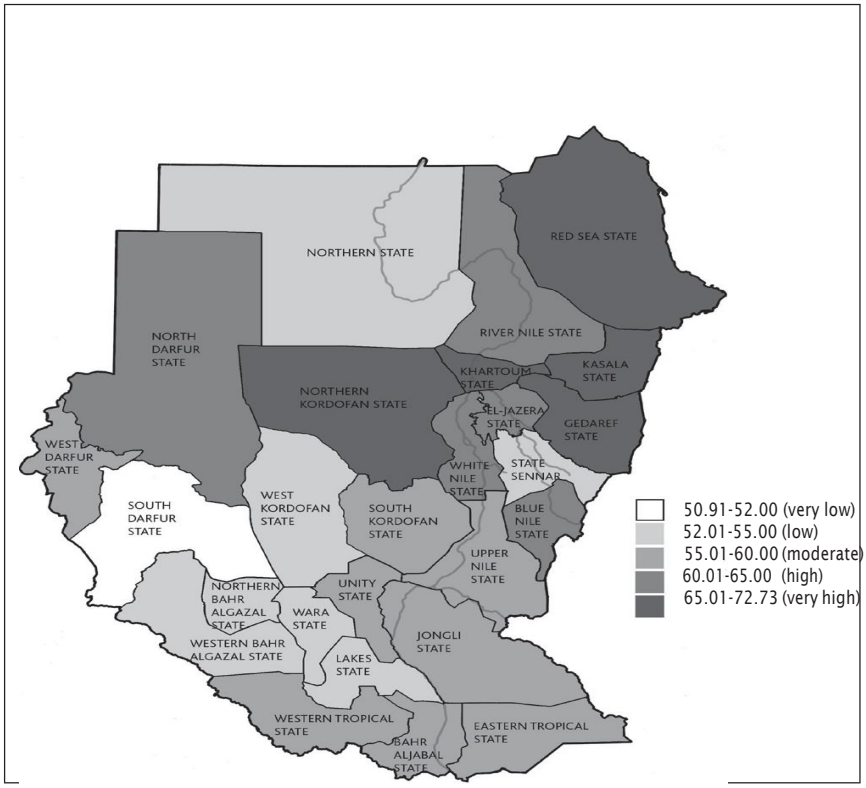

Figure 2.1: Risk of environmental hazards in Sudan by States
Source: SECS & HCENR, 2005

2.3 Effects of drought on rangelands area and production

Land sat STM map of 1983/84 showed that the semi desert (455,000 sq. km) and some parts of the northern fringes of the low rainfall wood land savannah were severely affected by drought and environmental degradation. Range and pasture administration report noted that 177 million feddans of range lands area is considered as severely degraded lands (Abdelrahman, 2008).
The study conducted by UNEP-ICRAF (2007) illustrate the changes in rangeland cover at sites across Sudan **(Table 2.3).**

Most of the agriculture in Africa and Sudan is not an exception, is rain-fed and, therefore, very susceptible to climate variability, that is characterized by frequent droughts and occasional floods, that at times destroys crops and livestock. At such times the rural communities increase their reliance on the forests and woodlands for wild foods and other products (Kowero et al, 2009).
Tieten and Jeltsch (2007) described how more intense precipitation phenomena, with no change in the amount of precipitation can lead to lower soil moisture

content. Additionally, higher temperatures are likely to increase pressure on the water by increasing evaporation. As a result, net primary production above ground is reduced. This decrease is accompanied by a decrease in the carrying capacity of livestock, which can lead to overgrazing. Thus, livestock in dry environments will face a serious shortage of nutrients.

Sudan history of drought is so frequent, such as 1906 famine, 1984/5 famine and different droughts during the seasons of 1989, 1990, 1997, 2000, and 2011 (NCCD, 2018).

The total area considered as drought prone in Sudan is about 69,000 sq. Km and this area produces 90% of the cultivated food crops and 85% of the fire wood. Over 70% of the 39 million Sudan's population lives in rural areas, depending on agriculture and livestock for livelihood (NCCD, 2018).
These resources are deteriorating very rapidly.
A report by Abdel Ati (2002) revealed that 50.5% of the total area of Sudan suffers from desertification, and Sudan has been classified as an arid country with 92%, most of which are excessively arid, dry and semi-arid areas (UNSO/UNDP, 1997; Ayoub, 1998a).
Climate changes, successive droughts, population pressure and chronic food shortages are the major threats in many parts of Sudan.

The drought in North and Western Sudan, North Kordofan and Darfur, Kassala State and some parts of the rain-fed areas in central Sudan are influencing agriculture, forestry, livestock, water resources and human health (NAPA, 2007). In fact, nomadic and pastoral groups in the semi-arid regions of Sudan are severely affected.

In the case of central Sudan, however, the eighteen recorded years of drought within the last half century are certain to have had a major influence on the vegetation profile and soil conditions where, the livestock prices decrease during drought periods, indicating disposal of assets on a large and widespread scale (UNEP, 2007).
Yagoub et al. (2017) stated that drought conditions may dramatically degrade natural vegetation cover, crops' production, and livestock production consistent with the currently observed losses in many areas of Sudan. They also confirmed that, losses in agricultural production occurred in Sudan in 1984, 1991 and 2000, those were the years of highest drought intensity.

2.4 The evidence for rangeland degradation in different States of the Sudan

Though the degradation of rangelands has not been quantified, it has been extensively documented and was again confirmed by UNEP and ICRAF fieldwork and satellite image analysis in 2006 (UNEP, 2007).

A host of factors have enabled uncontrolled overgrazing to develop, but there are two critical forces driving this process: explosive growth in livestock numbers over the last fifty years, resulting directly in overstocking and overgrazing; and a reduction in available grazing land due to desertification and unfavourable land use changes.

Overgrazing is an important factor leading to rangeland degradation. The most visible indicator of overgrazing is simply less forage and more exposed earth. The second indicator of overgrazing is the marked replacement of palatable perennial grasses by annuals of low environmental and nutritional value. This has been confirmed by technical studies in at least six states (Northern, Gedaref, Kassala, Northern Kordofan and Northern Darfur).

In Gedaref, the Range and Pasture Administration estimates that 50 percent of the state's rangelands are in a degraded state, with a severe incidence of invasive species.

There are reports of valuable range species vanishing, including *Blepharis edulis* in Butana, *Andropogon gayanus* in western Kordofan, *Blepharis lenarrifolia* in Northern Kordofan and *Aritida paposa* in Northern Darfur.

Some heavily grazed areas have undergone a notable shift from grassland to woody thickets. The encroachment of mesquite in rangelands in Kassala, Red Sea state and Gedaref, for instance, is linked to overgrazing not only because its seed is carried in droppings, but also because degraded landscapes favour the spread of such competitive pioneer species.

The second cause of overgrazing is the major reduction in rangelands in central and northern Sudan. Concurrent with the increase in livestock, a substantial reduction in rangeland areas has occurred over the past several decades due to three factors: uncontrolled expansion of mechanized and traditional rain-fed agriculture; desertification; and expansion of irrigation schemes (a lesser issue).

This major reduction in the amount, quality and accessibility of grazing land is considered to be a root cause of conflict between pastoralist and agriculturalist societies throughout the drier parts of Sudan.

2.5 Impact of drought on livestock and pastoral livelihoods

Less pasture and water availability will lead to deteriorating livestock body conditions, disruptions and changes to seasonal livestock migration patterns, and increase the risk of crop destruction by livestock and resource-based conflicts in eastern, central, and western Sudan (NCCD, 2018).

Droughts, high temperatures and fluctuation in rain fall together with its concentration into a short rainy period impacts adversely on rain-fed cultivation as well as on range vegetation growth and productivity. The ultimate consequence is threats to livelihoods and food security prospects of both pastoral groups and traditional farmers.

NAPA (2007) reported that natural disasters that threaten animal production and resilience of production systems are droughts and high temperatures.
In the mid-eighties, the Hawaweer, a nomadic pastoralist group inhabiting the northern part of Sudan, were forced to migrate because of drought and hunger (Haug, 2002).

2.6 Impact of drought on water resources

Droughts and other climate disasters have had high implications on pastoralist development in accelerating the deterioration of water resources (Hermance, 2014).

Elasha and El Sanjak (2009) reported that predicted changes in the climate may increase competition between farmers and pastoralists and consequently compromising the provision of potable water.

Climate change is expected to affect Sudan's water resources through reduced groundwater recharge brought about by decreased precipitation and/or increased temperatures and evaporation. It has been shown that soil moisture is also likely to decline under future climate change. When coupled with increased water consumption, population growth and high rainfall variability, these effects mean that the country could face a serious water crisis (SFNC, 2002; NAPA, 2007).
Drought occurrence has imposed heavy losses to the water resources, agriculture, livestock, and the ecosystem as well as the socioeconomic fabric of the rural society. For example, the abrupt decline in rainfall caused a complete drying off of the surface drinking water resources and decreased the water output from boreholes and wells. This caused water to drop in most of the valleys. Consequently, green valleys were converted into arid zones. This all had direct or indirect effect on the livestock sector, since, more than 68% of the livestock herds

consist of sheep and goat therefore they are the most affected due to lack of area for grazing and drinking water.

2.7 The effects of drought on over exploitation of rangelands

Drought conditions which resulted in reduction of available pasture and drinking water are considered the single threat to livestock survival. The arid and semiarid lands have rainfall patterns that are highly variable, both temporally and spatially, making pasture and water availability for livestock unpredictable (RPA, 2009). There was a decrease in rainfall from 425 ml/yr during 1941-1970 to 360 ml/yr during 1970-2000 (RPA, 2009). This constituted an average reduction of 0.5% annually.

The impact of climate change on rangelands was clearly reflected by the reduction of the range productivity per unit area, from 1.2 t/ha in 1980s to 0.2 t/ha in 2009 (RPA, 2009). This has threatened the resilience of pastoral production systems in many parts of the country.

Table 2.3. Changes in rangeland cover at UNEP-ICRAF study sites across Sudan

Study area and state	Original and current pasture land (% of total area)	Annual linear rate + (period loss)	Comments
North, east and central Sudan			
Ed Damazin, **Blue Nile**	18.5 to 0.6 from 1972 to 1999	- (96.7 %)	Loss due to the **expansion of mechanized agriculture** and increase in bush and shrub land
El Obeid, **Northern Kordofan**	50.4 to 33.5 from 1973 to 1999	- (33.5 %)	Loss due to the **expansion of mechanized agriculture**, increase in closed forests
Gedaref and **Kassala** states	13.0 to 8.2 from 1972 to 1999	- (37 %)	Decrease due to **expansion of rain-fed agriculture** and increase in closed forests
Kassala	36.1 to 26.4 from 1972 to 2000	- (2.6 %)	Increase in wetland, loss of soil fertility due to wind erosion resulting in loss of pasture lands
Sunjukaya, **Southern Kordofan**	39.2 to 13.7 from 1972 to 2002	- (34 %)	Loss due to the **expansion of mechanized agriculture,** increase in bush and shrubland, riverine vegetation and wooded grassland
Tokar delta, **Red Sea** state	10.0 to 11.7 from 1972 to 2001	+ (1.7 %)	Increase in wooded grassland, and decrease in bush and shrubland, flooded/wetland and riverine vegetation
North-east and central Sudan		**- (50 %)**	**Highly variable but a major loss of rangeland overall due to <u>agricultural expansion</u>**
Darfur			
Jebel Marra, **Western Darfur**	5.9 to 23.0 from 1973 to 2001	+ (289 %)	Increase in open forest land, decrease in closed forest and bush and shrubland

Timbisquo, **Southern Darfur**	65.4 to 59.3 from 1973 to 2000	- (9.3 %)	Loss due to the **expansion of mechanized agriculture**, bush and shrubland, and flood and wetland
Um Chelluta, **Southern Darfur**	42.4 to 32.7 from 1973 to 2000	- (65 %)	Loss due to the **expansion of mechanized agriculture**, increase in degraded areas and flooded land, and decrease in grassland area
Darfur		**NA**	**No simple trend: Jebel Marra anomalous, Southern Darfur similar to Southern Sudan with agricultural expansion**

Source: UNEP, 2007

2.8 The impact of climate change on the spread of livestock diseases and parasites in Sudan

There are many invasive alien plants, insect and animal species in Sudan introduced accidentally or deliberately for various purposes.

The prevalence of diseases in Sudan limits livestock productivity through morbidity and mortality, resulting in the loss of animal products e.g. meat, milk, eggs and by-products e.g. wool, skin and hides, manure and services e.g. animal traction (FAO, 2010).

Rainfall fluctuations can result in drought and the loss of livestock, or endemic diseases accompanied by heavy parasitic infestations that lower productivity and prevent livestock exports (FAO, 2010). Due to conflicts between sedentary farmers and pastoralists mobility of livestock herds was restricted to some areas e.g. the case of camel herders south of Mara'a Plateau. This restriction had resulted in animal health implications and epidemics due to malnutrition (Jaspars and O‟Callaghan, 2008). Pastoral migration through international borders also exposed national herds to contract infectious diseases.

The remoteness of pastoralist areas with few or no veterinary services, lack of livestock movement control within Sudan and with neighbouring countries, lack of livestock disease control strategy (even if it is, is not practical), resulted in to series of disease outbreaks in pastoral areas.

Moreover, the shortage of vaccines and drugs are also an impediment to reduce the impact of preventable and treatable diseases. The recurrent drought in rangelands areas will result in to poor body conditioned animals that are susceptible to diseases. Lack or shortage of active and passive diseases surveillance is also a major gap in terms of diseases control and amongst the major issue that should be fulfilled to access WTO.

Uncontrolled borders crossed by livestock & game animals from neighboring countries constitute a great hazard in disease transmission to the national livestock flocks. Game animals proved to be reservoirs of trypansomiasis which is a wasting and killing disease transmitted by tsetse flies. Livestock disease outbreaks in North Darfur have been reduced due to vaccination campaigns carried out by FAO and CAHWs through training (FAO, 2012).

LESP SLSP (2015-2017) reported that Transboundary animal diseases (TADs) would automatically cause Sudan to lose export markets, and hence producers (pastoralists and smallholders) would lose a key source of income. TADs include the Rift Valley Fever, peste des petits ruminants (PPR), sheep and goat pox (SGP),

foot and mouth disease (FMD), brucellosis, and contagious bovine pleuropneumonia (CBPP).
Salih et al. (2009) reported that in 15 states located in northern Sudan, FMD, Rift Valley Fever (RVF), Brucellosis, Black Quarter, Smallpox, Contagious Bovine Pleuro Pneumonia (CBPP) and tick-borne diseases are the most important livestock diseases.

There are species of trypanosomes that cause animal trypanosomiasis. The high prevalence of more and more glossina species is always the biggest epidemic across the African continent with serious economic consequences. Pastoralists suffer from great mortality and poor productivity of their animals due to this disease, and this deprived them of benefiting from the pastures, and some of them lost their livestock and others turned to land cultivation, as well as others moved to graze in locations far from the fly belt. This disease led to the high use and cost of veterinary medicines (Kabayo, 2004).
Hall et al. (1983) in a survey on the relative importance of controlling tsetse and tabanids as carriers of bovine trypanosomiasis in southern Darfur and southern Sudan states reported that the distribution of extant species (*Glossina morsitans submorsitans*) did not change significantly over 10 years. The density of the insect groups was the most in the south of the Um Belacha Valley but a milder infestation was found in the bushes north to latitude 15° 10 N of this river system.

Evidence indicates that the tsetse flies are extremely important in that livestock are most at risk of the disease during the southward migrations during the dry season especially during migrations at the beginning of the rainy season.
Trypanosoma disease is also present in other areas of Sudan. The survey conducted on the cows of the Sudanese Arab Kunaf Company near Abu Naama, indicated high mortality and abortions, it was found that 50.3% of the herds examined were infected with Trypanosoma vivax (Abdalla et al., 2005).

Also El Hussein et al. (2004) reported that the most important ticks borne diseases in cattle, especially imported and cross-bred cows, and cause huge economic losses, which negatively affects the development of the livestock sector, are: babesiosis, tropical theileriosis, cowdriosis, anaplasmosis.

This is evident from the types of diseases that the Ministry of Animal Resources and Fisheries is vaccinating against, namely bovine tuberculosis, anthrax, rift valley fever, septicemia, CBPP, and rabies. These diseases cause huge economic losses to the national herd, and recently Sudan succeeded in eradicating rinderpest

disease (OIE, 2006). Some of these diseases are transmitted to humans (anthrax, brucellosis, bovine tuberculosis and rabies), especially animal owners and workers in the livestock field, which causes a large segment of them to be disabled from work and causes heavy economic losses.

2.9 The impact of drought on women activities

2.9.1 Effects of drought on socioeconomic aspects of pastoralist women

women are the most affected groups during drought cycles. This can be exemplified by Shukriya women during 1984 drought in Butana plains in central Sudan. Women with illiteracy rate of 95% were considered the most affected groups because men migrated to urban centres leaving them shouldering the heavy responsibilities of the households (HHs) and face scarcity of drinking water in summer season (Ahmed and Musa, 2014).

Famines and diseases caused by malnutrition are spreading among the pastoral communities. Another group of nomads is the Rashaida tribe in the eastern part of the Sudan, had been stricken by the drought of 1970s and lost their camels and their behavior of keeping large numbers of animals for export had then changed (Ahmed and Musa, 2014).

For more information, refer to Chapter 4: Gender issues p39.

3. KEY NATIONAL AND STATE LEVEL ASSESSMENTS OF NON-CLIMATIC (SOCIO-ECONOMIC) DRIVERS OF VULNERABILITY RELATED TO LIVESTOCK AND RANGELANDS

Non climatic factors contribute to increased vulnerability, especially in rural areas and local communities. Studies from the preparation of the Sudan National Program of Action (NAPA) identified and assessed the communities and/or sub-regions within each of the five ecological zones where communities may be acutely vulnerable to climatic shocks.

NAPA also identified factors, together with other specific non-climatic factors contribute to increased vulnerability of local communities during climatic shock. These are: Deep poverty levels; Lack of income diversity; Lack of agricultural inputs; Resource mismanagement; Land over-cultivation; Fragile land/water resources; Poor soil fertility; Deforestation; Natural resource conflicts; Poor extension services; Community displacement and Poor sanitation/health services (NAPA, 2007).

Appendix (1) illustrates national and State-level assessments of non-climatic (socio-economic) drivers of vulnerability related to livestock and rangelands.

In this section non-climatic factors are highlighted.

3.1 Rangelands deterioration and area reduction

Desertification is considered the most serious constraint that had affected livestock development in landless system. During the sixties "1968/69", seventies "1972/73" and eighties "1984/85" many species of grasses were lost, some of which are of high nutritive value.

Many families lost their total herds and others migrated to new areas. An example is Bani Hussien tribe (cattle herders) at the Northern Darfur who are now transferred to Kubum in Southern Darfur with the resultant displacement and tribal conflicts. Another example is the Fuga cattle (sub-breed) herders that shifted from Northern Kordofan to Western Kordofan.

Rangelands cover an estimated area of 96.4 million (M) ha composed of 53.4 M ha of grassland and 43.0 M ha of woodlands containing scattered trees and shrubs (Afri-cover, 2003). This vast area encompasses different ecological zones extending from desert and semi-desert in the north to the low rainfall wood savannah (LRWS) to the south and south west.

Nearly 80% of all rangelands are located in semi-desert and low rain savannah ecological zones which are characterized by variable and unpredictable rainfall.

The reduction of pasture lands in North-east and central States of Sudan as % of total area from 1972-2002 was - 50 %. Though it was highly variable from State to another but a major loss of rangeland overall due to agricultural expansion (UNEP, 2007) (**see table 2.3 above**).

3.1.1 Specific threats to rangeland

3.1.1.1 Seasonal wildfire out-breaks

The annual burning practised by pastoralist societies to renew grass and suppress shrubs and tree seedlings has a major impact on tree cover.

Increased wild fire hazard is associated with low humidity, high fuel loads and the presence of moving grazers. This is the case to the destruction of 1030% of the standing dry forage in different ecological zones, loss of seeds and erosion.

3.1.1.2 Over- exploitation

Abdel Magid and Badi (2008) mentioned that natural resources have been overexploited for the purpose of agriculture, logging for fuel and overgrazing to the point that a large patch of land extends bare of vegetation in areas accessible from the capital and the Gazeera State such as White Nile State and North Kordofan and Darfur States, which are considered one of the most affected areas as a result of erosion factors (Biodiversity stocktaking report, 2014).

Trees felling for various domestic uses threatens biodiversity. For example, about 5% of forests, equivalent to 30,000 square kilometers, were cut down between 2000 and 2005 (World Bank, 2007a), and it is certain that the removal of trees and other types of vegetation will lead to lower rates of rainfall and enhance drought.

Over exploitation and extensive utilization of the diminished natural resource in production activities has led to rangeland degradation and the latter was considered the most prominent environmental problem associated with livestock husbandry in Sudan (UNEP, 2007).

Accordingly, agro ecological-zones shifted southwards and this affected pasture production. Abduljabbar Abdalla Fadul (2009) stated that reduction in rainfall in Darfur had led to changes in the composition of range plants, for example after 1986, the number of range plants had decreased in one area first from 12 to 6 and to 1 in the present time. This was due to seed gene bank depletion and over exploitation of land due to overgrazing.

The natural forest vegetation has been subjected to heavy over-exploitation for agriculture through the removal of tree cover for crop production (Abdel Magid and Badi, 2008).

The spreading of the IAS such as mesquite (*Prosopis juliflora*) and the increase in planting of the toxic shrub *Jatropha curcas* are expected to have negative impacts on forests genetic diversity.

3.1.1.3 Deforestation

The survival of the pastoralists and agropastorlists depends on the sustained yield of the green browse for their livestock during the dry season. Besides the well-known specie *Faidherbia albida*, is a dependable supply of browse for livestock (Abdel Magid and Badi, 2008).

Due to horizontal expansion of mechanized farming in central clay plains 241 of trees or shrubs species are considered seriously threatened, which showed marked retreat in their distribution and/or regeneration due to climatic conditions and also due to the intensity of their removal for wood, fodder or clearance for cultivation. Also endangered are 43 exotic shrubs or tree species.

3.1.1.4 Practices leading to soil and water degradation (Pollution from petroleum, mining, cement and other industries):

These are expected to have negative impacts on forests and rangeland genetic diversity. Forests fires are a serious problem in nearly all forest areas in the Sudan.
Vast areas of rangelands were shifted to several investment activities such as sugar industry in White Nile State, petroleum explorations in Kordofan states, and mining in Butana area and other states. In addition to reduction of land area, the highly polluted drain waters may affect range plants and cause death to livestock in some cases (Fifth national report submitted to the CBD, 2014)

Expansion in oil and mineral industry Oil drilling and traditional gold mining have become new threat to the state of biodiversity in many production systems throughout the Sudan particularly systems pastoral system. Lands that had been source of pastures and forests are abandoned in favour of the new industries. The traditional grazing routes were blocked Vallies and streams, the sources of water in the desert areas became at high risk of blocking and pollution (FAO, 2015).

3.1.1.5 Extensive tree browsing

Another issue is the use of foliage for camel fodder, which is a particular problem in areas like Southern Kordofan and Northern Darfur, where camel herders have migrated into land occupied by cattle herders and farmers. Some slow-growing species such as mangrove forests in Red Sea state have been devastated by camel browsing (UNEP, 2007).

3.2 Natural resources mismanagement (Deterioration of rangelands)

3.2.1 Uncontrolled expansion of large-scale development and mechanized schemes

The past decades have seen rapid expansion of land under cultivation and intensification of agriculture (in both the traditional rainfed and mechanized sector), causing the rangelands to shrink. Land under mechanized agriculture increased from about two million hectares in 1954 to about 14 million in 1994, and has more recently been claimed to be the main factor contributing to deforestation and land degradation (Sulieman and Buchroithner, 2009; Glover, 2005).

Due to the uncontrolled expansion of large-scale development schemes and mechanized and traditional rain-fed agriculture on the account of grazing lands, most of the land used for grazing in the savannah belt started to shrink (Shazali and Ahmed, 1999). Among the most visible adverse implications of this expansion are the following: loss and fragmentation of rangelands, induced sedentarization of pastoralists and radical reduction in livestock

numbers (Abbink et al. 2014), and breakdown of customary social systems and social insecurity (Ahmed 2008; Sulieman, 2015). According to Krätli et al. (2013), unless investments are made to develop pastoralism rather than to replace it, the threats to food security will go beyond the boundaries of the drylands.

Although Sudan has been ranked among the countries that have large pastoral population size (Markakis 1998; Egemi 2008), it stands as a distinct example of the failure of a state to secure the rights of pastoralists (Babiker 2008; Sulieman 2015). After totally occupying land designated for large-scale mechanized agriculture, (LSMA) in Sudan has been encroaching into the semi-arid regions of the country, which are recognized as excellent rangelands and traditionally managed as communal natural resources (Sulieman 2015).

Moreover, Sudan has been identified as particularly vulnerable to the effects of climate change in Africa (Müller et al. 2014). Under such conditions, LSMA in marginal areas for agricultural production such as the semi-arid land of Butana is expected to accelerate the process of land degradation.

The land-use planning report of the Southern Kassala Agricultural Project (SKAP, 1992) cautioned against the spread of LSMA in Gadarif State onto land which is marginally suitable in terms of environmental protection and agricultural sustainability. The report recommended confining agriculture to already demarcated limits and trying to improve productivity through proper husbandry rather than by horizontal expansion. Earlier work by Vitanen (1982) showed that the spread of agriculture to areas with little or uncertain rainfall was the main cause of desertification in North Kordofan, western Sudan. The ploughing of dryland pastures has resulted in desertification mainly by wind erosion. The loss of pasture has led to increased pressure on remaining pastures.

The rangeland vegetation cover in Sudan has severely deteriorated, particularly in semi desert and low rainfall savannah ecological zones, which constitute 80% of the total rangeland areas (Muna et.al, 2004). According to HCENR (2003) the deterioration is attributed to expansion of mechanized and traditional rain-fed cultivation, seasonal fires which remove 15-30% of the annual production of range plants, deforestation, excessive grazing by large livestock populations concentrated around perennial sources of water and wet season grazing areas and recurrent droughts. In addition to overall vegetation change and decline, there is also a decline of some key species like perennial *Andropogon gayanus* or some species which have become endangered such as *Belephairs linarifolia*.

3.2.2 Effect of expansion of agricultural projects on livestock migration routes

According to Calkins (2009), access to productive resources among pastoral communities in the lower Atbra area of northern Sudan is being progressively limited by expanding agriculture and large infrastructural projects, leading to resource contraction and is considered among the major forces driving the transformation of livelihood systems. Abusas (2009) states that most of the transhumance routes in the Blue Nile area have

disappeared during the last fifty years as a result of being taken up by a number of development projects.

It is one of the main factors affecting pastoralism, evident through blocked transhumance routes, closing of watering areas, the enlargement of rain-fed and irrigation agricultural schemes such as in the Gedarif area in eastern Sudan and in the Blue Nile area. The establishment of a big project like the Kennana sugar plantation between Blue Nile and White Nile is an example of how grazing lands are fragmented and reduce, and how transhumance routes are blocked. Also the routes of Kenna and Rufaa tribes in central Sudan were lost, and according to Bakhtan (2006) rangelands and routes of the Misserya tribe were blocked by oil fields around El Muglad town.

3.3 Local conflicts over natural resources

3.3.1 Unequal land access

The rational use of rangelands through mobile livestock husbandry has long been defined as the most effective strategy for extracting value out of otherwise marginal lands (Galaty 2013; Abbink et al. 2014). As a result, in contrast to large-scale mechanized agriculture (LSMA), pastoralism maintains and secures livelihoods in these marginal lands (Krätli et al. 2013).

Babiker (2008) summarized that increasing scarcity of land in the presence of high rates of population growth, along with a historical legacy of discrimination and highly unequal land access, implies that many past and contemporary conflicts in Sudan have their roots in disputes over land.

3.3.2 Local conflicts and loss of agro biodiversity

Local conflicts are experienced in different parts of the country, where considerable areas that are rich in agricultural biodiversity in Sudan are under unrest or political conflict conditions such as Darfur, South Kordofan and Blue Nile states. The consequences of such situations result in loss of agro biodiversity, either by inhabitant displacement and hence no more productive activities (farming or rearing animals) are practiced or by losing wealth of crops and animals due to violence activities (FAO, 2015).

3.3.3 Effects of civil instability on livestock and pasture breed-mix

There are many factors that have affected the inherited traditional knowledge in preserving local breeds. The unfavorable conditions for civil instability and consequently the unprecedented movement among rural people with their animals in all directions for sake of security and the tribal conflicts and raids resulted in armed robbery especially of livestock. The result was a considerable breed-mix (Sudan's Fourth National Report to the Convention on Biological Diversity (CBD) 2009). Herd mixing also occurred as a result of the migration of nomadic pastoralist to neighboring countries.

Abduljabbar Abdalla Fadul (2009) stated that reduction in rainfall in Darfur had led to changes in the composition of range plants, for example after 1986, the number of range

plants had decreased in one area first from 12 to 6 and to 1 in the present time. This was due to seed gene bank depletion and over exploitation of land due to overgrazing.

3.3.4 Community displacement

The nomadic groups in the East and West of the country make up 9.1% of the population. There are historically high levels of labour migration and a significant nomadic population and those displaced by conflicts or natural disaster had lost or sold their animals. Migration between states has increased by 5 times during the last 52 years, predominantly from rural to urban areas, thus weakening the rural productive capacity.

West and South Kordofan and Blue Nile States have also become the hosting areas for about half of the 3.1 million internally displaced people and refugees in Sudan. Among them, there are at least a hundred thousand livestock-raising families who have been affected by armed conflicts and inter-tribal fighting in Darfur and areas along the country border with South Sudan (LESP SLSP, 2015-2017).

Furthermore, about 3.7 million people reported migrating in 2008, the year of the last census (United Nations Population Fund (UNFPA).

3.4 Deep poverty

3.4.1 National poverty level

Sudan ranked 168th of 189 countries on the Human Development Index (2019) with a rating of 0.507 falling in the low human development category. The national poverty level stands at 52.3 per cent according to the United Nations Development Programme (UNDP, 2019). Rural poverty is much higher at 58 per cent in the rainfed sector due to fragility, remoteness, limited employment opportunities, and poor natural resource management and governance.

The vast majority of the population is poor, with an average per capita income of less than US$400 a year. However, this low level masks wide regional disparities in economic and social development. Certain states are below the national rural poverty average (Kordofan, Blue Nile, Kassala and Red Sea states). Educational levels in these states are low and the burden of disease is heavy and widespread (NAPA, 2007).

Infrastructure (roads, river traffic, railways power, water, telecommunications as well as irrigation facilities) is either non-existent or underdeveloped and inadequate; the little that exists is run down due to prolonged neglect (PRSP, 2004).

3.4.2. Poverty Reduction Strategy

3.4.2.1 The Sudan Interim Poverty Reduction Strategy Paper Status Report (SIPRS)

A Joint World Bank Group and Sudan's Ministry of Finance and Economic Planning Assessment (2012–2014) November, 2016 1701823_Sudan_FlipBook_FM.indd 1.

All indicators derived from Sudan National Baseline Household Survey (NBHS) of 2009 point to the importance of agriculture to poverty in Sudan.

About 57.6 percent of the households below the poverty line live in the rural areas that are dominated by agriculture as the main source of livelihood.

States at the bottom of the poverty rely on agriculture. For example, about 74 percent of North Darfur population, being the poorest state (with 69.4 percent of its population live below the poverty line) derives their livelihood from agriculture and livestock. About seventy per cent of the labor force is principally employed in agricultural or agriculture related activities.

3.4.2.2 Steps towards modernizing livestock sector

Although, livestock shows remarkable performance in terms of production and resilience in response to climate change. However, on the other hand, it is facing serious challenges that threaten its existence **(Table 3.1).**

Below are the main threats and weaknesses:

Threats:

- The inherent volatility of the sector, being exposed to frequent drought and diseases, is apparent.
- The nomadic system often leads to conflicts among parties competing for grazing, water and space.
- The gradual expansion of agriculture, minerals explorations and the situation is exacerbated by the land degradation.
- Due to secession of the South livestock population fell by only 28 percent and natural rangeland resources upon which they depend fell by 40 percent.

Weaknesses:

- Issues of quality are also a concern that affects commercialization and competitiveness of the sector.
- Live sheep exports which dominate the livestock exports in Sudan have limited markets which are risky.
- The future demand for livestock products is based on food quality, including food safety and animal welfare, while modern systems of production greatly benefit from genetic improvement in grass and animals which are both difficult to meet in traditional production systems.
- The traditional livestock sector is now lacking the required services of water, veterinary, education, rangelands rehabilitation and stock route demarcation.
- Low livestock productivity and off-take rates.
- Nomadic livestock herders continue to increase their herd numbers beyond the grazing capacity as a coping mechanism against the risks of diseases and drought.

- The traditional management system is lacking business orientation, thus limiting breeding, exploitation of markets and improved value chains.
- There is little use of improved technologies such as artificial insemination.
- Access to technology or extension services is poor and research is crippled by the small funding.
- The land tenure system—besides being a source of conflict—does not encourage sustainable use of land.
- This situation is exacerbated by weak market access due to poor infrastructure and high taxes particularly at the sub national governments level.

Therefore, for the mobile system of nomadic livestock production to properly function and produce, the above mentioned constraints should be solved.

Table 3.1: Interim Poverty Reduction Strategy (IPRSP)

Area/Sector	Objectives and Targets	Policy Measures/Programs
Productivity and Growth in livestock and rangelands	To revitalize the livestock sector, increase its contribution to growth, exports and poverty reduction. The target would be a growth above 5 percent.	- Regulate the stocking rates in Sudan's most vulnerable grazing environments such as North Darfur and North Kordofan to regenerate that pasture and other forage vegetation. - Facilitate livestock marketing by improving the quality of stock routes and rehabilitating unloading and loading for road transport associated with movement of livestock and enforce regulation of handling and transport to reduce death and weight loss. - Establish new and upgrade old livestock training centers for multidisciplinary extension agents and community animal health workers (CAHWs) focused on rangeland management, feed crop production, animal health, animal production and hygiene in domestic meat production. - Enhance livestock research and facilities and ensure dissemination of research results; - Protect natural resources by protecting forests promoting reforestation, the development of pastures and rangelands and the establishment of vegetative cover; strengthen efforts to halt and reverse desertification.

Source: SIPRS, 2016

3.5 Policies and their effects on pastoral communities

3.5.1 Policies regarding land use

Pastoralists are generally considered a vulnerable group because they are not supported by policies and are poorly represented among decision makers (Kipuri and Ridgewell, 2008) with weak recognition of their rights among policy-makers and government authorities (Morton 2008). This situation raises the need to address the subject of natural resources governance.

Pasture and water are two linked resources while land constitutes the spatial dimension for them. Pastoralists need land where both pasture and water are available at the right times. Land tenure, the way in which land is held or owned, therefore is the key issue to resource use (Elhadary, 2010). Competition among farmers and herders over land or natural resources more generally are considered by many authors to be among the main reasons local level conflict and violence occur (Siddig et.al, 2007).

Some government policies, particularly agricultural policies and those that encourage investment in the rain-fed subsector, pricing policies and different types of fees had negatively impacted the pastoral sector (Zaroug, 2006). With increasing alarming rate of desertification and encroachment of farming land by farmers and in the name of investment, the pastoralists are losing their dry season grazing reserve. Dry Season Grazing Reserves - very few areas (less than 1% in any country) where pastoralists migrate during severe drought when all routine dry season grazing reserve fails to support. A 100 hectare of dry season grazing reserve land taken out of pastoral production makes 500 hectares of wet season grazing unproductive which is >5 times in terms of loss of productivity. But the loss of all critical seasonal habitats - Drought Period Grazing reserve will create wreaking havoc to pastoralism and thereby the whole livestock export of Sudan.

- It is less than 1% in the country where pastoralists migrate during severe drought when all routine pasture areas fails to support the livestock.
- The humanitarian organization can only support few animals during drought (less than one percent) and more 99 % of the animals survive because of the dry season grazing reserve.
- Dry season grazing reserves are utilized intensively over long periods, receiving disproportionate grazing pressure during times that allow no other option.
- In the long run, if it is not rehabilitated losing dry season grazing reserves will create wreaking havoc to pastoralism.

Livestock and wildlife have great social and economic importance for Sudanese poor communities, but there has been little progress incorporating livestock into development policies and projects. There is no defined breeding policy in the country as well as lack of organizational body for AnGR management. Most of the policies favor disease control.

Policy and governance also have effects on pastoralists. Sandford (2006) stated that pastoralists did not adapt to climate change due to policy and governance which blocked pastoral development. ElashaOsman (2008) and Elasha-Osman & Sanjak (2007) also stated

that policies followed in the past to address climate-related disasters focused on short term solutions e.g. emergency relief. In the Darfur region, expansion and intensification of agriculture combined with the erosion of local customary authorities, have brought about changes in land tenure regimes, which together have seriously undermined the mutual interdependencies between pastoralists and farmers (Osman, 2013).

The former widespread practice of shifting crop cultivation has evolved into a continuous and expanding land use, accompanied by a fencing movement, widespread adoption of agricultural inputs and the abandonment of previous mutual interdependencies between pastoralism and cultivation (manuring, sharing of crop residues, animal transport of crops) (Manger, 2005).The dual land tenure systems, including both federal law and customary tenure based on usufruct rights, have evolved into an individualized control system that disrupts claims by multiple users, including pastoralists, at different times of year. This represents a major policy challenge given the dual land tenure system, the erosion of the customary authorities and the evolution of individual tenure (Manger 2005).

Livestock marketing is a forgotten opportunity that if properly mobilized could be used to improve pastoralists' livelihoods. According to a comprehensive study held by PAN African program (Yacob, 2002) covering Sudan, Ethiopia and Kenya, livestock marketing is an important dimension in rural development, yet has long been neglected. They emphasize the critical internal information gap on livestock marketing, and inadequate provision of animal healthcare.

3.5.2 Effects of political issues on livestock mobility

Social life of pastoralists in some areas is affected by political issues. A good example of this is the increased tensions in the border regions between Sudan and South Sudan in February 2013 where about 37,500 Umbararo Falata cattle herders of South Darfur were forced to settle in Tulus and Dimso after they were expelled from South Sudan. Large numbers of cattle that normally graze in South Sudan during the hot dry season were reportedly confined just north of the border (FEWS NET, 2012).

3.5.3 Changing economic, socio-political and cultural factors

Economy plays a significant role in shaping human preference. Moving surplus food products to food-deficit areas is constrained by poor infrastructure. Disruption of trade routes and communication reflected in high transport costs inhibits trade and the distribution of food and production inputs (FAO, 2012). Shifting to activities that generate higher and quick incomes other than cultivation of crops has also been a trend in the last few years, in addition to migration of rural people, which are mostly belonging to farmers‟ and pastoralists‟ communities to the capital city in Khartoum and other big towns. This phenomenon might have been affecting negatively the diversity of agricultural plants.

4. GENDER ISSUES

4.1 Gender Inequality Index

Sudan ranked 140th of 159 countries in the UNDP Gender Inequality Index. Women earn significantly less than men (UNDP, 2019). About 50 per cent of rural young women in Sudan are literate. Women's participation in the labour market is 24.3 per cent compared to 72.2 per cent for men. Women comprise 78 per cent of the economically active population working in agriculture compared to just 57 per cent for men.

The Government of Sudan is committed to gender equality through its National Policy for the Empowerment of Women (2007), formulated by the Ministry of Social Welfare, Women and Child.

4.2 Women employment

According to FAO, women represent 49% of the farmers in the irrigated sector and 57% in the rainfed traditional sector in Sudan. Women in the rainfed sector are primarily subsistence farmers but they also work as seasonal wage labourers in the rainfed mechanized sector, and as hired or unpaid family labourers in the irrigated sector.

4.3 Gender Analysis in pastoral systems in Sudan

For the purpose of this report the gender issue is identified following the approach of Pasteur (2002) as recorded in IFAD (2020). **Appendix (2)** shows gender analysis in pastoral systems in Sudan.

To effectively analyze gender issues in pastoral management system, the following parameters are identified:

- Social relations (normative roles, duties and responsibilities);
- Activities (division of labour within the HH and community);
- Access and control over resources, services and decision making; and
- Gender needs both practical (current), and strategic (what needs to change).

4.4 Pastoralist mobility and gender

Gender influences the roles and gender practices in pastoral societies related to mobility, in particular labour practices: in a 'traditional' pastoralist system a household (HH) or family is often split, with men migrating seasonally with the main herd and women left with pregnant, sick, weak or young animals, plus responsibility for caring for the rest of the HH – children, the elderly as well as a farm plot. In some nomadic groups (e.g. Shanabla), women are responsible for the household shelter (shugag) and organizing its transport when the camp is moved.

In fisheries, women participate in processing and marketing (HCENR, 2016).

This is not always the case however, and women also undertake seasonal herding in some locations.

Male children between 7 and 15 assist men in the care of the herds, especially during the rains and in the following season. This work commitment reduces the expenses on hired

labour and enables the men to engage in other jobs. Today, many young men waiting to start their own family leave in search of quick gains with gold mining.

Adult men manage the large herds of camels and sheep especially during the dry season and the transition to the rainy season, as well as during the long migration to al gizu areas in the north (UNEP, 2013).

The most senior (aged 45–60) play a key role in identifying better pasture sites (dour) to move to and supervise the shepherds (ideally the elder sons) in all herding related activities. When pastoral labour demand is lower (e.g. during the rainy season and approximately until October), these men often engage in other incomegenerating activities such as seasonal jobs elsewhere (UNEP, 2013).

Older men (70 years old and over) usually remain at the main camp for consultation and supervision of household activities. There are well-established forms of co-operation with regard to executing major tasks such as washing and shearing of animals, branding, treating sick animals, and providing help (al faza) in the form of 'gatherings' (nafeer) against robberies (UNEP, 2013).

Pastoralist production also depends on opportunities, for example moving livestock to take advantage of feed and fodder availability, and therefore the system as a whole is highly dynamic and requires women and men to undertake unique and different roles and risks. These roles are normally complementary and strengthen the production system. This also depends on complicated and dynamic extended families and social networks that have particular importance during drought when support is given and received between households and even communities (IFAD, 2020).

4.5 Gender and management, ownership and control over pastoral livestock and production outputs

Pastoralists manage their herds both in terms of types of animals of different sex and ages, as well as types of livestock (e.g. cattle, sheep, goats, camels). Though pastoralists have always managed their herds, the diversification of livestock types has increased in recent years as it has become riskier to depend on one particular livestock type alone, due to increased incidences of drought, variable rangeland quality and quantity, market accessibility and demand and other factors (Catley et al, 2013).

The patterns of change in pastoral areas are complex and non-linear, with a mix of 'push and pull' factors driving sedentarization and diversification (Catley et al, 2013).

These changes make herd management more complex and will likely mean a greater role for women and children to share responsibilities with men: high levels of livestock diversification require flexible arrangements in family and homestead composition, and spatially extensive social networks to accommodate the different grazing needs at different times of the year (IFAD, 2018b).

Women will usually have responsibility for small stock (sheep/goats) and/or the larger livestock that is kept around the household e.g. milking, sick or young animals, particularly

if men are migrating. However, an increase in small stock may mean that men take over greater control of them, pushing out women who previously were responsible. Women also participate in milking and processing milk products (HCENR, 2016).

Across pastoral areas more men now migrate for non-pastoralist related work, meaning many women are taking over traditional 'men's tasks' and often becoming the de facto heads of their households i.e. there can be a feminization of livestock keeping. Normally this means that women will also have decision making authority, though this may not always be the case with men maintaining authority over decisions such as sale of livestock despite living at a distance.

It is normally the man who takes livestock to market and receives the payment – this may make it difficult for women to access the money

An increased commercialisation of livestock can have an impact on women's access to livestock, and unless managed well can make it more difficult. Increased social stratification and uneven wealth distribution, recurring drought and other issues, is forcing some pastoralists out of pastoralism; and with limited opportunities for livelihood diversification this can have negative impacts on the household and social relations, including between men and women (IFAD, 2020).

4.6 Gender and rights and/or access to natural resources

Rights of access to water, grazing and other natural resources within pastoralist rangelands are governed by pastoralist institutions, usually through communal tenure systems based on patrilineal kinship. These can be complex, of different types, overlapping and dynamic (Flintan, 2008).

Some communal tenure systems are breaking down under changing systems of land use and ownership, with adverse environmental and social consequences: though this might be a point for the establishment of more gender equitable management organizations, without the knowledge, respect, or contextual functionality that existed in previous more customary institutions they are unlikely to succeed in the long-term

4.7 Gender and access to markets in pastoralist areas

The processing and marketing of livestock products is vital for sustainable livestock production. Men tend to dominate in the sale of large livestock, whilst women can play a key role in the marketing of small livestock (sheep and goats for example) as well as dairy products.

The income raised from dairy products though small can provide an important regular income for purchase of non-livestock-based food items and other.

Gaining access to markets to both sell pastoralist products and purchase other food items, remains a particular challenge however for remote pastoral communities. Additionally, women are likely to find it more difficult to travel far away to the larger markets in towns where better prices for livestock and/or livestock products may be earned.

Women may also have less experience of bargaining and/or negotiating good prices from buyers and middle-men, though some women can be highly skilled in this regard (IFAD, 2020).

Economic diversification into non-livestock alternatives can result in a range of trade-offs including the empowerment or disempowerment of women, depending on whether the change was a consequence of the loss of livestock, or was a deliberate strategy, and whether or not it is forcing women into undertaking greater workloads.

Whilst increasing sedentarization has allowed some pastoralist women to successfully diversify into alternative livelihoods, there are very few opportunities for pastoralist women to compete with men and become successful livestock producers and traders.

Many pastoral communities also still rely heavily on non-monetary, informal bartering systems. This important aspect of pastoral livelihoods should not be ignored, particularly if development interventions may risk destroying them.

4.7.1 Marketing services such as information on prices and markets

Projects should enable pastoral women to become more market oriented by supporting market access, and pro-poor livestock value chains, through improved livestock marketing services such as information on prices and markets. Women should also be provided with training, such as negotiating skills, appropriate technology, credit and access to networks through locally managed credit schemes, and support for running small businesses (IFAD 2012b).

4.7.2 Livestock extension provision and veterinary services

Livestock extension provision and veterinary services specifically targeted for pastoralists are more limited than in other livestock systems. The advisory and information services that exist are generally provided by men and are mainly designed by men for men.

Whilst pastoralist men tend to have considerable ethnoveterinary knowledge for managing their herds, and typically deal with diagnosis and the choice of treatment, it is generally women who are responsible for collecting and preparing the various herbs used in traditional remedies.

As women also do the milking of animals, they are often the first to notice behavioural changes and other initials signs of disease. Women also tend to be the carers for the young stock and have a good understanding of their disease issues.

Gender blind veterinary and extension interventions risk marginalizing women's role in livestock health and their active involvement in production.

4.8 Gender and access to livestock services, finance and information sources

Livestock extension provision and veterinary services specifically targeted for pastoralists are more limited than in other livestock systems. The advisory and information services that exist are generally provided by men and are mainly designed by men for men. Support targeted at pastoralist women's involvement in livestock production is almost non-existent.

Whilst pastoralist men tend to have considerable ethnoveterinary knowledge for managing

their herds, and typically deal with diagnosis and the choice of treatment, it is generally women who are responsible for collecting and preparing the various herbs used in traditional remedies.

As women also do the milking of animals, they are often the first to notice behavioural changes and other initials signs of disease. Women also tend to be the carers for the young stock and have a good understanding of their disease issues. Gender blind veterinary and extension interventions risk marginalizing women's role in livestock health and their active involvement in production.

Modern technology means that service provision to pastoralist communities no longer needs to be so constrained by distance and cost. Access to mobile financial services for example has ensured pastoralists no longer depend on cash and can access credit as long as they have a mobile phone (something more men than women have).

Further, instant access to information on prices, weather systems and pasture conditions supports far more effective decision making. In some places privatized community-based animal health workers (CAHW) have taken the place of government veterinary systems, providing a valuable community-based system in remote locations, though the numbers of female CAHWs is limited.

4.9 Gender-specific risks for pastoralist women

4.9.1 High risk activities

In pastoralist communities, customary labour arrangements mean women spend considerably more of their time than men on domestic tasks (walking to collect water, fire wood and grass for small-stock, as well as such as cooking and child care) and have limited time for revenue-generating tasks (IFAD, 2020; HCENR, 2012).

Time spent walking in pastoral areas can be a high-risk activity with levels of theft, rape and violence seriously impacting pastoralist women.

The current drivers of change in rangeland areas including insecurities are creating ever more risks, with fewer and sparser resources (due to climate change and rangeland fragmentation) requiring them to travel ever further.

One of the key dimensions of women's empowerment is addressing the issue of time spent on reproductive tasks, often non-renumerated. A risk often occurring within development interventions is that they do not consider time burdens and add yet more tasks for women.

IFAD projects frequently try to address the gender inequalities that see women perform much of the unpaid, time-consuming and least productive work (IFAD, 2016).

Efforts need to be directed in reducing time poverty and strategies for reducing women's workload, including a more systematic focus on reducing women's workload (HCENR, 2016).

Recommended approaches are to invest in labour saving technologies that genuinely save time, are low cost and low maintenance; and to engage and involve men as much as possible in all stages as their approval is often essential to project success (IFAD, 2012b).

Labour saving technologies that might help reduce pastoral women's need to access communal natural resources for biomass energy and water, might be fuel efficient stoves, solar pumps/boreholes for drinking water, or alternative housing materials.

Besides the resulting increase in workloads, women are particularly affected by the migration of growing numbers of men. As environmental conditions worsen, more men migrate for longer periods, sometimes even permanently. Meanwhile, household and farm chores are becoming not only more difficult, but also more crucial to survival.

4.9.2 Gender and conflict

Conflict can be an innate part of life in pastoral areas whether due to such as cattle-raiding, disagreements between land users such as pastoralists and farmers, or between clans over territory and/or resources.

Pastoral women can also play a key role in peacebuilding – not only through educating children and the community in a culture of peace, but also through participating in peace dialogues, crusades, protests and other actions.

Women also contribute to this through their social capital building, networking and reciprocal relations sharing resources and food in times of need (IFAD, 2016).

5. MANAGEMENT ADAPTATION STRATEGIES OF LIVESTOCK AND RANGELANDS TO CLIMATE CHANGE

In this section non-climatic drivers of vulnerability information on the status of publication (ongoing versus completed) and methodological approach used for the assessments is covered **(Appendix 3).**

5.1 Adaptation related to livestock and rangelands

5.1.1 Improving rangeland management

Pilling and Hoffmann (2011) noted that climate directly affects the quality and quantity of green forage that can be produced in a given area, and that higher temperatures tend to increase lignins in plant tissues, and thus reduce the digestibility of green forage.

Improving rangeland management (eg restoring soil organic matter, reducing erosion and reducing biomass losses from fires and overgrazing has positive environmental effects (eg sequestration of soil carbon and biodiversity) and a positive impact on livestock productivity (Smith et al., 2007).

Also, technical solutions are available, for example the beneficial use of forage trees, shrubs and cacti has been proven to be effective (Salem and Smith, 2008). Conservation through silage and the use of forage cubes and pelleted feed gives greater efficiency in the use of a wide range of agricultural by-products However, the adoption of these products has been slow and often due to a lack of knowledge on the part of farmers (Salem and Smith, 2008).

The critical dry season grazing reserves that are not conflict prone areas with crop farmers should be targeted and the major modalities of rehabilitation will be public work using cash of food for work depending on the preference of the communities. The injection of cash and/or food (in terms of cereals) will improve the resilience of the pastoralist and prevent stress sell (negative terms of trade = livestock against grain) of animals in dry season.

Major Activities in participatory rangelands management

Step 1: Identifying rangeland resources and users;

- Understanding rangeland resources.
- Understanding rangeland users.

Step 2: Strengthening rangeland management institutions;

- Exiting Legal authority.
- Existing Local authority.
- Capacity development of legal and local authorities.

Step 3: Defining the rangeland management unit and preparing the rangeland resource assessment;

- The rangeland management unit.
- The rangeland resource assessment.

Step 4: Developing the rangeland management plan.
Step 5: Establishing the rangeland management agreement with roles for communities and rangeland management unit.
Step 6: Arresting and reversing declining rangeland productivity based on participatory rangelands management through reseeding of native grass/forage, bush clearing, etc.
Step 7: Participatory monitoring and evaluation to assess and provide timely corrective actions on the improvement of the dry season grazing reserve.

5.1.2 Herd diversification as a buffer against climatic and economic adversity

Many livestock keepers in Sudan use herds of multiple species and breeds as a strategy to maintain a high degree of diversity in farm-level activities and as a buffer against climatic and economic adversity (FAO, 2009a). Hoffmann (2010a) argues that such traditional diversified practices are useful for adapting to climate change.

During periods of drought, large livestock losses occur due to a decrease in the availability of feed with large increases in the price of feed. Herd management includes various strategies including herd diversification, maintenance of high female herds, large herds and herd division (Lalani and AlZein, 2011).

Pastoralists keep all animal species that graze on the bottom layer (such as cows and sheep) or those that use upper grazing (such as camels and goats) in a conscious view of achieving the optimum use of pasture resources and ensuring the preservation of the pasture ecosystem. By raising more than one type of livestock, pastoralists can harvest a wide variety of animal products, use more available fodder, different ecological activities, and obtain animal products in different seasons.

5.1.3 Production and marketing strategies

Mc Dermott et al. (2010) described a number of challenges that must be overcome in order to enhance market success. These challenges include technical inputs such as fodder, weak regulatory link between farm and market, and public investments in infrastructure (in Africa, etc.). Rischkowsky et al.

(2008) discussed issues related to product quality and safety; Both have become so important that they may limit smallholders' access to markets. In order to meet demand and respond effectively to export market demands, small-scale producers have to deal with trade restrictions related to the health of small ruminants, poor market infrastructure and lack of information on export markets and policies (Aw-Hassan et al., 2005).

As Sudan is still not a member of WTO, the livestock marketing is a buyers' market, i.e. they are selling through brokers not directly between Sudan and other Gulf states and are not in a position to negotiate legally. That is why many livestock are returned from Gulf state with or without any issue of livestock diseases.

Therefore, improving the sanitary and phyto-sanitary (SPS) and start the accession of WTO membership that will radically improve the livestock marketing problems through improving the status of Sudan negotiating ability at equal level with the importers of Middle East and North African countries (MENA).

McDermott et al. (2010) described how most small-scale producers sell their livestock products to low-income consumers through informal markets. However, increasing urbanization and rising income levels are increasing the length and complexity of livestock value chains and the quality and safety standards required in livestock markets.

Arrangements between producers of raw materials, manufacturers and distributors will necessarily become more complex. It is argued that for small-scale livestock producers (on small mixed farms) to become more competitive, a shift to intensification and the ability to offer higher value products must be made.

The main limitations, however, are the higher costs of quality inputs (eg improved animal species and feed) and the knowledge needed for more efficient production. Public investment has a role in overcoming these constraints through knowledge and technologies that provide quality feed, ensure animal health, improve breeding and provide technical advice and other services (McDermott et al., 2010).

Heat stress is known to alter organ functions in livestock, reduce production and fertility of both males and females, and lead to increased mortality rates. Water requirements of animals increase with increasing temperature, while heat stress suppresses appetite and feed consumption (Nardone et al., 2010). Heat stress is the main source of production loss in the dairy and beef industries. Rising temperatures will increase this problem, and therefore adjustments are required in production management and strategies (Nardone et al., 2010).

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Appendix 1. National and State-level assessments of non-climatic (socio-economic) drivers of vulnerability related to livestock and rangelands.

State	Sector	Climate Factors	Effects of Climate Factors	Non Climate Factors	Adaptation activities	Source
Darfur States:						
North **Darfur**	Livestock & Rangelands & Forest browse	• Recurrent drought. • Scarce and uneven distribution of rainfall.	• **Overstocking**: Widespread deterioration of the remaining rangelands, caused largely by drought, climate change and overstocking. (UNEP, 2007) • **Overexploitation** (World Bank, 2007a; UNEP, 2007) • **Southward shift in agro-climatic zones** • **Reduced groundwater** recharge rates. • Major **reduction** in the total area of available **rangelands** (UNEP, 2007) • **Reduced water** and fodder availability in the dry seasons (NAP, 2007).	• Uncontrolled **livestock diseases**. • **Overgrazing** (replacement of palatable perennial grasses by annuals of low environmental and nutritional value e.g. *Aritida paposa* (UNEP, 2007). • **Poverty** among small pastoral households. • **Pastoralists movements** hindered. • Armed **conflicts**. • **Displacement**. • **Extensive Tree browsing** (UNEP, 2007). • **Unequal land access** Babiker (2008). • **Unjust policies in land tenure regimes** (Osman, 2013).	- Project to improve prevention measures against livestock **diseases**. - Private sector and cooperatives to **invest** in livestock markets and **veterinary services**. - Project to improve **feed supplementation** and small herds nutrition by physically or chemically treated agricultural by-products. - **Maintaining** livestock **routes** - **Water harvesting** projects for livestock drinking - **Maintenance** of forests and **range lands**. - Establish pastoral **women** development programme.	NAP, 2016 SFNC, 2002 NAPA, 2007 UNEP, 2007

State	Sector	Climate Factors	Effects of Climate Factors	Non Climate Factors	Adaptation activities	Source
West Darfur	Livestock & Rangelands & Forest browse	• Increasing temperatures • Decrease of rainfall amount and variability of rainfall • Drought • Increase of wind speed	• **Overstocking** • **Decrease** of **production** and productivity • **Deterioration of rangelands** • **Deterioration of forest cover** • **Disappearance of some rangelands' plants** • **Depletion of groundwater resources** • **Migration of wild animals**	• **Uncontrolled** livestock **diseases** due to overstocking. • **Overgrazing** • **Deforestation** • Tribal **conflicts** • **Poverty** among small pastoral households. • **Unequal land access** Babiker (2008). • **Unjust policies in land tenure regimes** (Osman, 2013).	- Project to **improve** prevention **measures** against livestock **diseases**. - Private sector and cooperatives to **invest** in livestock **markets** and **veterinary services**. - Project to improve **feed supplementation** small herds nutrition by physically or chemically treated agricultural by-products for pastoral herds. - Maintaining livestock **routes** - **Water harvesting** projects. - **Technology transfer** and know how on livestock product processing. - Proposals for **research** on the effects of **climate change** on livestock production systems.	NAP, 2016

State	Sector	Climate Factors	Effects of Climate Factors	Non Climate Factors	Adaptation activities	Source
***South Darfur**	Livestock & Rangelands & Forest browse	• Shortage of rainfall (amount and distribution) • High temperatures • Activity and speed of the wind • Droughts • Heavy rains and floods	• **Animal production** and productivity are **threatened**. • **Expansion of cultivated areas** at the expense of rangelands and forest cover. • **Shifting climates** may hasten the disappearance of palatable rangeland species such as *Blepharis linariifolia* (Beghail) and *Dactyloctenium aegyptium* (Abu Assabi) and appearance of other invasive species.	• **Weakness** of **veterinary services** and inputs. • **Poor livestock infrastructure** e.g. markets • **Resources mismanagement** (Severe deforestation caused by expand cultivated area and **over grazing**) • Tribal **conflicts** (Competition over natural resources) • **Communities displacement** and out migration • Extreme **poverty** among small pastoral households. **Unequal land access** Babiker (2008) **Unjust policies in land tenure regimes** (Osman, 2013).	- Project to **improve** prevention **measures** against livestock **diseases**. - Encourage private sector and cooperatives to **invest** in livestock **markets** and **veterinary services.** - Project to improve **feed supplementation** and improve small herds nutrition by physically or chemically treated agricultural by-products for pastoral herds. - Maintaining livestock **routes** - Water **harvesting** - Research projects to **improve** small ruminants **production** and **productivity**. - **Management** and protection of **forests and grasslands.**	NAP, 2016

* Though South Darfur has a less extreme climate than other areas of Darfur, the region will still face more erratic rainfall and more frequent dry spells. Contour maps between isohyets in 1946-1955 and 1976-1985 show that 400 mm of rain have shifted southward of Nyala and maximum rainfall in the Marrah Mountains has decreased from 900 mm to 600 mm per year (NAP, 2016).

State	Sector	Climate Factors	Effects of Climate Factors	Non Climate Factors	Adaptation activities	Source
Central Darfur	Livestock & Rangelands & Forest browse	• Increasing temperature and rainfall variability • Increase frequency of drought. • Long duration of dry spell. • Increase frequency of floods.	• **Overstocking** (A growing misuse of resources). • **Land degradation.**	• Uncontrolled livestock **diseases** due to overstocking. • **Poor** livestock **infrastructure** e.g. markets • **Weakness** of **veterinary services** and inputs • **Resources mismanagement:** ***Overgrazing*** and denuding of forests ***deforestation*** e.g. cutting of trees for fuel, constriction etc. • **Poverty** among small pastoral households (more vulnerable). • **Unequal land access** Babiker (2008)	• Project to **improve** prevention **measures** against livestock **diseases**. • Encourage private sector and cooperatives **to invest** in livestock **markets** and **veterinary services.** • **Raising** health **awareness** and combating disease vectors. - Project to improve **feed supplementation to** improve small herds nutrition by treated agricultural by-products. • Raising community **awareness** regarding conservation of natural resources and utilization of ecosystems. • Adoption of **Legislations** for protection of natural resource. • Implementation of **water harvesting** systems training. • improvement of **extension services** particular with regard to agroforestry and range and pasture.	NAP, 2016

State	Sector	Climate Factors	Effects of Climate Factors	Non Climate Factors	Adaptation activities	Source
East Darfur	Livestock & Rangelands & Forest browse	• Decreasing annual rainfall and increasing variability • Increase in temperature • Drought • Wind and dust storms	• **Overstocking** (A growing misuse of resources and livestock routes blockage). • **Decrease** in animal **productivity**. • Nomads **herds feed** on **lower quality tree leaves**; or moving across the border to South Sudan. • Serious **degradation of rangelands** and in some cases, the disappearance of certain grasses and herbs. • **Deterioration of forests**.	• Uncontrolled livestock **diseases** due to overstocking. • **Poor** livestock **infrastructure** e.g. markets. • **Weakness of veterinary** services and inputs. • **Overgrazing** and forests **deforestation** (Illegal tree cutting). • **Poverty** among small pastoral households (more vulnerable). • **Lack of awareness** regarding livestock disease vectors. • **Unequal land access** Babiker (2008)	• Project to **improve prevention** measures against livestock **diseases**. - Encourage private sector and cooperatives to **invest** in livestock **markets and veterinary services.** • Raising livestock **health awareness** and combating disease vectors. - Project to improve **feed supplementation and** improve small herds nutrition by physically or chemically treated agricultural by-products for pastoral herds. • Expansion of **water harvesting** techniques (pastures). • Encourage community forests for livestock browsing.	NAP, 2016

State	Sector	Climate Factors	Effects of Climate Factors	Non Climate Factors	Adaptation activities	Source
Kordofan States:						
North Kordofan	Livestock & Rangelands & Forest browse	• Low and unevenly distribution of rainfall and short rainy seasons. • Extreme temperatures. • Increase of droughts. • Increase of floods cycles.	• **Infestation** of **internal** and **external parasites**. • High % of animals' **mortality**. • **Drop** in animal **productivity**. • **Overstocking** (poor pasture and diminished rangelands areas). • **Overexploitation** (World Bank, 2007a; UNEP, 2007) • **Desertification.** • **Deterioration of rangelands** and forests. • Increased **food insecurity** (low rainfall only allows for small scale farming, which produces a mix of livestock and cash crops). • **Water shortage** and high prices for water purchase.	• **Weakness of veterinary services** and inputs. • **Poor** livestock **infrastructure** e.g. markets • **Resources mismanagement**. • **Overgrazing** (replacement of palatable perennial grasses by annuals of low environmental and nutritional value e.g. *Blepharis lenarrifolia.* (UNEP, 2007). • **Weak extension services** (lack of technologies and technical know how about production technologies). • **Poverty** below the national rural poverty average). (NAPA, 200; PRSP, 2004). • Poverty among small pastoral households (more vulnerable). • **Low income & high % of illiteracy** among pastoral communities. • Tribal **conflicts**.	• Project to **improve prevention measures** against livestock **diseases**. - Encourage **private sector** and cooperatives to **invest in livestock markets and veterinary services.** • **Raising** livestock health **awareness** and combating diseases and disease vectors. - Project to improve **feed supplementation** and Improve small herds nutrition by physically or chemically treated agricultural by-products for pastoral herds. • Expansion of **water harvesting techniques** (for rangelands production). • Encourage community forests for livestock browsing. • Introduction of early mature varieties of rangelands. • Establishment of **early warning system**, • **Capacity building** of pastoral communities.	NAP, 2016 UNEP, 2007

				• Practices leading to **soil and water degradation** (Pollution from petroleum, mining, and other industries (CBD, 2014) (FAO, 2015). • **Uncontrolled expansion of large-scale development and mechanized schemes** (UNEP, 2007; HCENR, 2003). • **Poor Infrastructure** (roads, river traffic, railways power, water, telecommunications as well as irrigation facilities) (PRSP, 2004). • **Displacement** of people and migration to cities.	• Finance **herd restocking** for those who lost their herds.	

State	Sector	Climate Factors	Effects of Climate Factors	Non Climate Factors	Adaptation activities	Source
South Kordofan	Livestock & Rangelands & Forest browse	• Temperature rise and evaporation. • Fluctuation of rainfall, and low rainfall. • Wind. • Soil erosion. • Drought. • Floods.	• Livestock **diseases** and **outbreaks** • **Overstocking** (A growing misuse of resources such as cutting trees; and livestock routes blockage). • Increasing weeds, unwanted tree species and death of trees. • Serious **grassland degradation**. • Forced **migration** and influx of climate refugees. • **Desertification.**	• **Weakness of veterinary services and inputs.** • **Poor** livestock **infrastructure** e.g. markets • **Resources mismanagement**. • **Overgrazing** due to crop expansion. • **Civil war** and tribal conflicts on the limited resources. • **Poverty** below the national rural poverty average). (NAPA, 200; PRSP, 2004). • **Lack of jobs** among small pastoral households. • Practices leading to **soil and water degradation** (Pollution from petroleum, mining, cement and other industries (CBD, 2014) (FAO, 2015). • **Extensive Tree browsing** (UNEP, 2007).	• Project to **improve prevention** measures against livestock **diseases**. - Encourage private sector and cooperatives **to invest** in livestock **markets** and **veterinary services.** • **Raising** livestock health **awareness** and combating diseases and disease vectors. - Project to improve **feed supplementation** and improve small herds nutrition by physically or chemically treated agricultural by-products for pastoral herds. • Expansion of **water harvesting techniques** (for rangelands production). • Encourage community forests for livestock browsing. • Introduction of early mature varieties of rangelands. • Establishment of **early warning system,**	NAP, 2016

				• **Poor Infrastructure** (roads, river traffic, railways power, water, telecommunications as well as irrigation facilities) (PRSP, 2004).	• **Capacity building** of pastoral communities. • Finance herd restocking for those who lost their herds.	
State	**Sector**	**Climate Factors**	**Effects of Climate Factors**	**Non Climate Factors**	**Adaptation activities**	**Source**
Western Kordofan	Livestock & Rangelands & Forest browse	• Higher temperature. • Increased rainfall variability. • Drought, heat, low humidity. • Floods.	• **Overstocking**. • Livestock **disease outbreaks.** • A **higher** incidence of certain climate-related **epidemics**. • **Grassland degradation**. • **Diminished** levels of potable **drinking water.** • **Out-migration** by farmers.	• **Weakness** of **veterinary services** and inputs. • **Poor** livestock **infrastructure** e.g. markets • **Resources mismanagement**. • **Overgrazing** (replacement of palatable perennial grasses by annuals of low environmental and nutritional value e.g. *Andropogon gayanus* (UNEP, 2007). • **War and tribal conflicts** over limited resources. • **Poverty** below the national rural	• Project to **improve prevention measures** against livestock **diseases**. - Encourage private sector and cooperatives **to invest** in livestock **markets** and **veterinary services.** • **Raising** livestock health **awareness** and combating diseases and disease vectors. - Project to improve **feed supplementation;** improve small herds nutrition by physically or chemically treated agricultural by-products for pastoral herds. • Expansion of **water harvesting techniques**	NAP, 2016 UNEP, 2007

				poverty average). (NAPA, 200; PRSP, 2004). • **Poverty**, hunger and diseases among small pastoral households. • Practices leading to **soil and water degradation** (Pollution from petroleum, mining, cement and other industries (CBD, 2014) (FAO, 2015). • **Poor Infrastructure** (roads, river traffic, railways power, water, telecommunications as well as irrigation facilities) (PRSP, 2004).	(for rangelands production). • Encourage community forests for livestock browsing. • Health awareness, rehabilitation of rangelands (seeds dispersal/ distribution, water harvesting).	

State	Sector	Climate Factors	Effects of Climate Factors	Non Climate Factors	Adaptation activities	Source
Eastern States:						
Kassala	Livestock & Rangelands & Forest browse	• Fluctuation of rain fall. • Increase frequency of drought (in semi-desert zones) and flood cycle. • Rise of temperature.	• **Reduction** of animal **production**. • Subsistence farmers and pastoralists - most at risk • Frequent **seasonal flooding** from the Gash and Atbara rivers in the western part of the state. • **Desertification** and Spread of mesquite trees.	• **Weakness** of **veterinary services** and inputs. • **Poor** livestock **infrastructure** e.g. markets • **Resources mismanagement.** • **Overgrazing** (Some heavily grazed areas have undergone a notable shift from grassland to woody thickets. The encroachment of mesquite in rangelands in Kassala, Red Sea state and Gedaref, for instance, is linked to overgrazing not only because its seed is carried in droppings, but also because degraded landscapes favour the spread of such competitive pioneer species) (UNEP, 2007). • Increment of **poverty** rate. • **Civil war** in the eastern region and neighbouring countries. • Refugees influx and ***internal displacement***.	• Project to improve prevention measures against livestock **diseases**. - Encourage private sector and cooperatives **to invest** in livestock **markets** and **veterinary services.** • **Raising** livestock health **awareness** and combating diseases and disease vectors. - Project to improve **feed supplementation;** improve small herds nutrition by physically or chemically treated agricultural by-products for pastoral herds. • **Water harvesting** and spreading. • **Range Improvement**. • Introduction of community forest and utilization of short maturing varieties.	NAP, 2016 UNEP, 2007

				• **Migration** of rural residents to urban areas. • **Poverty** below the national rural poverty average). (NAPA, 200; PRSP, 2004). • **Epidemic disease** like tuberculosis. • High percentage of illiteracy within rural people. • Uncontrolled **expansion** of large-scale development and **mechanized schemes** (UNEP, 2007; HCENR, 2003). • **Poor Infrastructure** (roads, river traffic, railways power, water, telecommunications as well as irrigation facilities) (PRSP, 2004).	• **Capacity development** of rural people to mitigate poverty. • **Empowerment of pastoral women** within the community by organizing pastoralists in productive associations and cooperatives.	

State	Sector	Climate Factors	Effects of Climate Factors	Non Climate Factors	Adaptation activities	Source
Gadaref	Livestock & Rangelands & Forest browse	• Increase of temperature. • Increase in frequency of drought and floods. • Scarcity and fluctuation of rainfall	• Increase in animal **mortalities**. • **Deterioration of pastures** and appearance of unpalatable species. • Decline of tree cover and pasture species • **Deterioration of livestock routes** with regards to spread of weeds, water scarcity, lack of veterinary services and narrow tracks).	• **Spread of animal diseases**. • **Weakness of veterinary services** and inputs. • **Poor** livestock **infrastructure** e.g. markets • **Pastoral high load capacity** • Increase in **fires incidents** in grasslands • **Overgrazing**. • Some heavily grazed areas have undergone a notable shift from grassland to woody thickets. The encroachment of mesquite in rangelands in Kassala, Red Sea state and Gedaref, for instance, is linked to overgrazing not only because its seed is carried in droppings, but also because degraded landscapes favour the spread of such competitive pioneer species (UNEP, 2007). • **Felling of trees.** • **Poverty**, hunger and diseases among small pastoral households (more vulnerable). • **Uncontrolled expansion of large-scale** development and mechanized schemes	• Program for **improving veterinary services**. The components are: procure mobile clinics; provision of vaccines; control of animal and infectious diseases. • Encourage private sector and cooperatives **to invest** in livestock **markets** and **veterinary services.** • Program for **improvement of animal and fish production**. The components are: Provision of production tools and equipment (poultry, goats, fisheries nets and others). • Program of **maintenance and rehabilitation of pastures:** the components are: collection of seeds and broacasting of grasslands; establishment of pastoral farms and nurseries; opening of fire lines; arrangement	NAP, 2016 UNEP, 2007

				(UNEP, 2007; HCENR, 2003). • **Blockage of livestock migration routes** (Bakhtan, 2006)	for pastoralists groups; awareness raising; pasture protection and strengthening of laws and legislation. • **Raising** livestock health **awareness** and combating diseases and disease vectors. - Project to improve **feed supplementation;** improve small herds nutrition by physically or chemically treated agricultural by-products for pastoral herds. • **Empowerment of pastoral women** within the community by organizing pastoralists in productive associations and cooperatives. • Establishment of **reservoirs and dams** within pastoral routes and rangelands areas.	

State	Sector	Climate Factors	Effects of Climate Factors	Non Climate Factors	Adaptation activities	Source
Red Sea	Livestock & Rangelands & Forest browse	• Drought. • Rainfall variability. • Extreme temperatures.	• Increase in sea surface temperature and sea level rise.	• **Poor Vet. Services**. • **Poor** inputs to livestock **production**. • **Overgrazing**. Some heavily grazed areas have undergone a notable shift from grassland to woody thickets. The encroachment of mesquite in rangelands in Kassala, Red Sea state and Gedaref, for instance, is linked to overgrazing not only because its seed is carried in droppings, but also because degraded landscapes favour the spread of such competitive pioneer species (UNEP, 2007). • **Hindered pastoralists movements** due to livestock routes problems. • **Deforestation** for wood and charcoal production. • Invasion of miskeet trees. • Poor coordination between institutions. • **Poverty** below the national rural poverty average). (NAPA, 200; PRSP, 2004).	• Program for **improving veterinary services**. The components are: procure mobile clinics; provision of vaccines; control of animal and infectious diseases; raising livestock health awareness and combating diseases and disease vectors. • Encourage private sector and cooperatives **to invest** in livestock **markets** and **veterinary services.** - Program for **improvement of animal and fish production**. The components are: provision of production tools and equipment (fisheries nets and others); procure **feed supplementation;** improve small herds nutrition by physically or chemically treated agricultural by-products for pastoral herds. • Program of **maintenance and**	NAP, 2016 UNEP, 2007

				Poor Infrastructure (roads, river traffic, railways power, water, telecommunications as well as irrigation facilities) (PRSP, 2004).	**rehabilitation of pastures**: the components are: collection of seeds and broacasting of grasslands; establishment of pastoral farms and nurseries; awareness raising; pasture protection and strengthening of laws and legislation. • **Empowerment of pastoral women** within the community by organizing pastoralists in productive associations and cooperatives. • Establishment of **reservoirs and dams** within pastoral routes and rangelands areas.	

State	Sector	Climate Factors	Effects of Climate Factors	Non Climate Factors	Adaptation activities	Source
Nile States:						
River Nile	Livestock & Rangelands & Forest browse	• Rising temperatures. • High wind speeds and shifting sand dunes. • Decreasing annual flow rates of the River Atbara. • Increasing temperatures, floods and drought.	• **Lower** animal **productivity**. • Increase of **desertification**. • Domination of un palatable grasses and disappearance of palatable species.	• **Low** animals' **productivity**. • **Over grazing** of rangelands. • **Deforestation** and Illegal cutting of trees. • **Absence** of environmental **effective laws** and legislations. • **Migration** to cities. • **Lack of finance.** • **Lack of supporting policies.** • Increase of **poverty rate.** • **Blockage of livestock migration routes** (Calkins, 2009) • **Increase** of **production costs** of livestock. • Increased **displacement**.	• Program for **improving veterinary services**. The components are: procure mobile clinics; provision of vaccines; control of animal and infectious diseases; raising livestock health awareness and combating diseases and disease vectors. • Adopting **livestock restocking policies**. • **Water harvesting** program; wells drilling and installation of pumps (Provision of pumping sets). • **Capacity development** of rural people and pastoralists to mitigate poverty. • Improve **small herds nutrition** by physically or chemically treated agricultural by-products.	NAP, 2016

State	Sector	Climate Factors	Effects of Climate Factors	Non Climate Factors	Adaptation activities	Source
North State	Livestock & Rangelands & Forest browse	• Low and irregular rainfall. • High temperature. • Floods. • Reduction in the length of growing seasons. • Increased frequency of drought. • Hand excessive evaporation. • Severe winds. • High humidity.	• **Reduction of livestock population.** • **Decrease of rangelands area.** • **Migration** affected by sand accumulation. • **Desertification**. • Migration of fishes	• **Low** livestock **productivity**. • **Mismanagement of natural resources** • **Replacement of some rangelands with crops and wheat.** • **Degraded soil** (gold mining). • Poverty (low income).	• Program for **improving veterinary services**. The components are: procure mobile clinics; provision of vaccines; control of animal and infectious diseases; raising livestock health awareness and combating diseases and disease vectors. • Program for **improvement of animal and fish production**. The components are: provision of production tools and equipment (fisheries nets and others); procure **feed supplementation** for pastoral and sedentary herds. • Establishment of shelter belt and community forest\private forest; seed broadcasting (trees\shrub\ species.	NAP, 2016

					• Use of advanced **water harvesting** techniques. • Improve **small herds nutrition** by treated agricultural by-products.	
State	**Sector**	**Climate Factors**	**Effects of Climate Factors**	**Non Climate Factors**	**Adaptation activities**	**Source**
Khartoum	Livestock & Rangelands & Forest browse	• Rainfall variability (amount and distribution). • Increase in frequency of floods. • Drought. • Fluctuation in the Nile water (due to fluctuation of rainfall in the Ethiopian plateau.	• **Low** livestock **productivity**. • Insufficient quantities **and high cost of animal products.** • **Range lands degradation**. • Increase in frequency of **floods** leading to loss of property, infrastructure, irrigation channels, negative impacts on water services and spread of water borne diseases.	• **Insufficiency** in **milk and meat**. • **Overgrazing** (expansion of mechanized agriculture on the account of rangelands). • **Deforestation** due to expansion of physical planning and other reasons and forest cover loss of 28% in 2011. • **Large scale migration.** • **Poverty.**	- Project to **improve prevention** measures against livestock **diseases**. - Encourage **private sector** and cooperatives **to invest** in livestock, poultry and fisheries production and processing and **markets** and **veterinary services**. - Improve rural **water harvesting.** - Strengthen **extension tools** and technology transfer to improve dairy cattle productivity (Artificial insemination and embryo transfer). - **Upgrade green fodder and feed concentrates** sectors.	NAP, 2016

					- Improve **small herds nutrition** by physically or chemically treated agricultural by-products.	

State	Sector	Climate Factors	Effects of Climate Factors	Non Climate Factors	Adaptation activities	Source
Central States:						
Gezera	Livestock & Rangelands & Forest browse	• Increase temperatures, particularly during winter season. • Rainfall (low or fluctuation); Shorter rainy season. • Increase evaporation. • High wind speed. • Short winter season. • Floods. • Drought.	• **Low** livestock **productivity**. • **Land degradation,** • **Overexploitation** (World Bank, 2007a; UNEP, 2007). • **Desertification** • **Weaken** livestock keepers **production** capacity.	• **High production cost** e.g. veterinary drugs and animal feeds. • **Over use of external inputs e.g. antibiotics,** • **Poverty.** • **Lack of tech. know how in livestock management.** • **Poor livestock practices,** • **Lack of strategies** & absence of rationale plans, • **Weak link between research & extension,** • **Migration** to urban areas,	**Integration of livestock in farming systems** especially irrigated schemes and encourage green fodder production. **Use of agro-industrial by-products** in livestock feeding. Strengthen **extension tools** and technology transfer to improve dairy cattle productivity (Artificial insemination and embryo transfer). - Encourage private sector and cooperatives **to invest** in livestock, poultry and fisheries production and processing and	NAP, 2016

					markets and **veterinary services**. - Program of **maintenance and rehabilitation of pastures.**	
State	**Sector**	**Climate Factors**	**Effects of Climate Factors**	**Non Climate Factors**	**Adaptation activities**	**Source**
Sennar	Livestock & Rangelands & Forest browse	• Fluctuation of rainfall. • Increase in temperature. • Increase in frequency of floods and drought incidents. • Increase of wind speed. • Increase in frequency of drought.	• Change of animal types • **Deterioration of rangelands.** • **Deterioration of vegetation cover.** • **Desertification** • Reduction of forest areas and decrease of forest production. • **Decrease of farmers' income**. • Lack of drinking water.	• Animals **malnutrition**. • Spread of poisonous **invasive rangelands species.** • **Overgrazing**. • **Expansion** of **agric. schemes** over grazing lands. • **Deforestation**; Over cutting of forest. • **Poverty** and illiteracy of livestock herders	• Improvement of **veterinary services** • Improvement of animal species • **Rangelands Rehabilitation** projects for enhancing biodiversity (broadcasting of ranges' seeds) • **Water harvesting** • **Awareness raising** programme and **capacity building** for livestock keepers. • Rehabilitation **livestock routes** • Establishment of rangelands enclosures • **Para vet training** • Introduction **of solar energy** for improvement of veterinary services.	NAP, 2016

State	Sector	Climate Factors	Effects of Climate Factors	Non Climate Factors	Adaptation activities	Source
Blue Nile	Livestock & Rangelands & Forest browse	• Fluctuation of rain fall and distribution. • Floods and water runoff. • High temperatures. • Activity and speed of the wind.	• **Low livestock production** and productivity. • The **disappearance of desirable types of range** land plants. • **Migration** from the rural areas to cities.	• Spread of **livestock diseases.** • **Over grazing** in large areas of the western state. • Weak **extension coverage**. • Blockage of livestock migration routes (Bakhtan, 2006). • **Conflicts** between pastoralists and farmers. • **Poverty** below the national rural poverty average). (NAPA, 200; PRSP, 2004). • **Poor Infrastructure** (roads, river traffic, railways power, water, telecommunications as well as irrigation facilities) (PRSP, 2004). • **Removal of forests.**	• Improvement of **veterinary services** Provision of **moving means for the Nomads (Mobile link)** Organizing the communities in the form of cooperative societies to use **modern technologies in livestock production**. Organization of women in the form of **women's operative societies** to provide the Extension services. **Rangelands Rehabilitation**	NAP, 2016

State	Sector	Climate Factors	Effects of Climate Factors	Non Climate Factors	Adaptation activities	Source
White Nile	Livestock & Rangelands & Forest browse	• Rainfall fluctuation and delay of rainy seasons. • Increasing temperature. • Winds and storms. • **Droughts.**	• **Spread of animal diseases** and increase mortalities. • Deterioration in **animal health.** • Low animal productivity. • **Overexploitation** • (World Bank, 2007a; UNEP, 2007) • **Decrease in fodder and rangeland area.** • Death of rangeland seedlings. • Disappearance of wildlife • Decrease in forests products. • Ecological imbalance. • Spread of forest fire.	• **Low** animal **productivity**. • **Low training and awareness of livestock keepers.** • **Illegal felling.** • Poverty and low income resources • **Migration from rural to urban areas.** • Practices leading to **soil and water degradation** (Pollution from petroleum, mining, cement and other industries (CBD, 2014) (FAO, 2015)	• Establishment of **veterinary care centers** (Project vaccination; rehabilitation of slaughterhouse) • **Veterinary extension**. • Establishment of **fish farms** • Provision of **water** for grazing animals in rangeland. • Improve **small herds nutrition** by physically or chemically treated agricultural by-products. • **Awareness raising** campaign. • **Activation of Rangeland Protection Act.**	NAP, 2016

Appendix 2: Gender Analysis in Pastoral Systems in Sudan							
Gender indicators	**Men**	**Women**	**Both/Community**	**Difficulties and constraints**	**Gender-specific risks for pastoralist women**	**Adaptation strategies**	**Source**
a) Social relations (normative roles, duties and responsibilities)	Responsibility for large stock (cattle/camel).	Responsibility for small stock (sheep/goats), pregnant, sick, weak or young animals, plus responsibility for caring for the rest of the HH – children, the elderly as well as a farm plot.					IFAD, 2020 HCENR, 2012
b) Activities (division of labour within the HH and community)	• Migrating seasonally with the main herd. • Marketing large livestock and receive the payment.	• Seasonal herding in some locations. • Moving and rebuilding the house and all Household (HH) possessions.	• The pastoral production system as a whole is highly dynamic and requires women and men to undertake unique and different roles and risks.	• More difficult for women to travel far away to the larger markets in towns where better prices for	• Time spent walking in pastoral areas can be a high-risk activity with levels of theft, rape and violence	• Projects to enable pastoral women to become more market oriented by supporting market access, and pro-poor livestock value chains, through improved livestock marketing services such as information	IFAD, 2020 Catley et al, 2013 IFAD, 2012b.

		• Marketing small stock, as well as dairy products. • When there is an increase in small stock, men take over greater control of them (pushing out women)	• These roles are normally complementary and strengthen the production system.	livestock and/or livestock products may be earned. • Women may have less experience of bargaining and/or negotiating good prices from buyers and middle-men.	seriously impacting pastoralist women. • The current drivers of climate change in rangeland areas requiring women to travel ever further. • Conflicts in many areas compound the risks.	on prices and markets. • Provide women with training, such as negotiating skills, appropriate technology, credit and access to networks through locally managed credit schemes, and support for running small businesses. • Labour saving technologies that might help reduce pastoral women's need to access communal natural resources for biomass energy and water, might be fuel efficient stoves, solar pumps/boreholes for drinking water, or alternative housing materials. • Provide pastoral women with training that enable them to	IFAD, 2016

						play a key role in peace building through educating children and the community in a culture of peace, and through participating in peace dialogues, crusades, protests and other actions.	
c) **Access and control over resources, services and decision making**	As men market large livestock and receive the payment, they are the ones involved in decision making.	• During long migration of men major decisions, such as the purchase or sale of livestock or changes in cropping patterns will return to women. • Degraded rangelands close to home stead, make small stock to be moved further away,	• Rights of access to water, grazing and other natural resources are governed by pastoralist institutions, usually through communal tenure systems based on patrilineal kinship (Flintan, 2008). • In fisheries, women participate in processing and marketing.			Projects such as Lactoperoxidase System of milk preservation to enable pastoral women to own simple technologies (in-pouch pasteurization unit or MILK PRO) that help in pastoral milk processing and marketing during wet seasons (FAO-CAC/GL 13-1991). Projects to enable pastoral women to own simple technologies that might help in fish processing and marketing.	Flintan, 2008 HCENR, 2016 FAO, 2000

		so women can not access the animals for milking					
d) Gender needs both practical (current), and strategic (what needs to change)				Service provision to pastoralist constrained by distance and cost.		• Privatized community-based animal health workers (CAHW) to provide services in remote locations. • Access to modern technology e.g. mobile financial services (access credit by phone). • Access to information on prices, weather systems and pasture conditions supports effective decision making.	IFAD, 2020

Adapted from IFAD (2020)

Appendix 3: Non-climatic drivers of vulnerability information on the status of publication (ongoing versus completed)

State	Project name/ date	Objectives	Finance	Target group	Outcomes	Source
West Kordofan, North Kordofan, White Nile, Sennar and Blue Nile	Livestock Marketing and Resilience Programme **(LMRP)** (Sudan)	**The overall goal** of the programme is increased food security, incomes and climate resilience for poor households in pastoralist communities. **The development objective** is increased earning opportunities and improved living conditions in livestock-based communities.	FIDA, GEF, Central Bank of Sudan, Local banks, pro-poor public-private partnership (PPP).	Population comprises economically marginalized and poor households living in pastoralist and agropastoralist communities. The programme will target: (i) rural poor women and young men responding to incomegenerating opportunities, (ii) common interest groups, and (iii) village development structures.	Poor households in 1,000 villages in five states will be eligible to participate in programme communal activities, with a target direct outreach of 100,000 households. Secondary target groups will include private-sector value adders, service providers and operators in the principal livestock value chains.	IFAD
Kassala	The Dry Land Husbandry Project (**DHP**) 1995-2003	To **involve women** in the maintenance and use of **biodiversity** for food and agriculture	Swedish International Development Corporation Agency (Sida/SAREC)	Rashaida pastoralist women. Beja pastoral woman (20 young women)	Taught to be more responsible for animal raising and development of milk processing into sour milk and ghee and handicrafts.	Ahmed and Musa, 2014

		To **improve food security** and sustainability for **women**	and Organization for Social Science Research in Eastern and Southern Africa (OSSREA)		Taught how to process surplus milk into three fine cheese, dry cheese, and mozzarella. Process yoghurt and a thick type of sour milk (mish). Trained in paravet training program and equipped with drug kits and a revolving fund was allocated for purchasing the drugs.	Ahmed and Musa, 2014
State	**Project name/ date**	**Objectives**	**Finance**	**Target group**	**Outcomes**	**Source**
North Kordofan	Community-Based Rangeland Rehabilitation (**CBRR**) for Carbon Sequestration' 1992	to implement a simple model of community-based **natural resource management** to **prevent over-exploitation and degradation** of marginal lands and rehabilitate rangelands for the purpose of carbon sequestration.	UNDP/GEF project	17 villages in the Central Bara Province	- Human capital for more efficient management of natural resources was increased through training and other capacity building activities. - Physical capital benefits include improved food storage facilities and increased stores of grain for dry periods. - Financial capital was increased by improved access to local and	Elasha-Osman et al -2006

					national markets, production of marketable sheep, and greater access to credit through revolving credit funds. - Social capital benefits include enhanced living conditions of women through participation in community gardens and other activities.	
State	**Project name/ date**	**Objectives**	**Finance**	**Target group**	**Outcomes**	**Source**
Eastern Sudan North Darfur	Community animal health workers (**CAHWs**) 2007	Community contribution **in disease prevention and treatment**	FAO	Community of livestock keepers.	Provided efficient veterinary services. Increased awareness of CAHWs importance among livestock keepers. Helped herders increasing their herd size and diversifying the types of animals they raise. Livestock disease outbreaks in North Darfur have been reduced due to vaccination campaigns.	FAO, 2012

State	Project name/ date	Objectives	Finance	Target group	Outcomes	Source
South Darfur State	Route Delineation– Darfur States (**ACRD-DS**) in partnership with the World Initiative for Sustainable Pastoralism (WISP)	to demarcate the transhumance **routes** facilitate services and development.	Global Environment Facility implemented by UNDP and executed by IUCN.	Pastoral communities	Eight main routes and thirty-seven branches, amounting to 2299 km in length, were designated for demarcation. Amendment of existing laws and local orders include the revision and amendment of the Organization of Farming and Herding Law (1996) of South Darfur State.	PAS, 2007
State	**Project name/ date**	**Objectives**	**Finance**	**Target group**	**Outcomes**	**Source**
• Gedaref, • Kassala, • Sennar, • Blue Nile, • White Nile, • North, • South, and • West Kordofan	Livestock Epidemio-Surveillance Project to Support Livelihoods of vulnerable rural smallholders and pastoralists (LESP SLSP). 2015-2017	**The overall objective** is to contribute to the improvement of livelihoods and resilience of vulnerable rural smallholders and pastoralists . **The specific objective** is to support the trade and export of livestock	EU Trust Fund	• approximately 500,000 of vulnerable rural smallholders and pastoralists, • rural women, • Veterinary professionals and paraprofessionals	• Technical and diagnostic capacities for coordinated epidemio-surveillance of trade sensitive animal diseases are enhanced in the target areas. • Sudan's compliance of zoo-sanitary measures for exportation of livestock with OIE standards is strengthened.	LESP SLSP (2015-2017) sudan-livestock-support-livelihoods-rural-smallholders-pastoralists_en.pdf

					• Increased awareness and skills of rural livestock producers, veterinary professionals, para-professionals and other stakeholders concerning trade-sensitive livestock diseases, animal welfare and livestock exportation; as well as of technical staff from the relevant State Ministries on management of epidemio-surveillance and disease control.	
State	**Project name/ date**	**Objectives**	**Finance**	**Target group**	**Outcomes**	**Source**
• North Kordofan • West Kordofan • White Nile • Sennar • Blue Nile	Livestock Marketing and Resilience Programme (LMRP). 2012 – UP TO DATE	To increase the food security, incomes and climate resilience of poor households in pastoralist communities. For livestock industry, the project will focus on improvements to underperforming value chains.	• IFAD • ASAP • LDCF-GEF • Central Bank of Sudan • LDCF-GEF • Local Banks • Government of Sudan • PPP Partners • Beneficiaries	• Poor households in pastoralist communities.	• At least 40,320 households will receive pro-poor livestock business development. • LMRP will also establish 300 community adaptation plans, which incorporate the needs and priorities of poor women and men in all target villages. • LMRP will also support the development of a	IFAD, 2015

		For livestock business development activities, small scale farmers are provided with market access and information. To employ pro-poor public-private partnership (PPP) business models to enhance the livestock industry. To improve practices such as: rainwater harvesting, rangeland rehabilitation, eradication of invasive species, water points, dispute mediation and stock route restoration.			national sectoral adaptation strategy for the livestock sector • that can reduce conflicts. • Diversification of livelihoods	