CHAPTER ONE

1. INTRODUCTION

1.1 Background

Sudan lies in northeast Africa between latitudes 4 º and 22 º north and longitudes 22º and 38 º east, with a total area of 188 606 800 hectares or 1, 886,068 km².Sudan is mostly an arid country, within which five ecological zones can be identified: the desert in the extreme north, followed by the low rainfall savanna woodland, the high rainfall savanna woodland in the south, and the mountain zones (FAO, 2015). It has the second largest livestock population in Africa, estimated at over 133 million heads (FAO, 2009).

The agriculture sector is the most important economic sector in the country. According to the Central Bureau of Statistics, during the period 2009-2013, the Agriculture sector contributes on average about 34% of the country's Gross Domestic Product (GDP); ranging between 32.2% in 2009 and 34.4% in 2013(FAO, 2015).While the petroleum subsector contributed 4 %. It is to be noted that agriculture has been the engine of growth for most of the decades since the early 1900s. The exception was the period of 1999 to 2011 when the discovery of petroleum in the country resulted in oil-led growth. After the secession of South Sudan, where most of the oil is produced, oil took a back seat in driving the growth of the economy. Since the recent increase in gold mining activities, the mining sector has become a major source of growth and an important generator of foreign exchange (FAO, 2017).

In the republic of the Sudan, rangelands form an immense natural resource, occupy an area of 110 million hectares or about 46% of the country's total area before the South seceded and provide about 86% of feed for livestock (Fadlalla and Ahmed, 1997; Gaiballa, 2011).

Rangelands also host wildlife and play a vital role in soil and watershed protection, biological diversity, ecological balance and environmental conservation. In spite of its importance, most quantitative data relating to rangeland productivity in Sudan are based on experts' estimations and rarely based on large-scale surveys (Gaiballa, 2011).

According to the Ministry of Animal Resource, in 2004 Sudan had livestock estimated at more than 140 million heads. Sudan is the first among Arab countries according to the number of livestock (AOAD, 1996), though it must be said that most livestock population estimations in Sudan are based on the results of the census held in the 70's with a pre-determined rate of increase which may not be reliable under changing environmental conditions (for example, the drought of 1984). Sudan is ranked among the top countries according to the percentage of families that depend on livestock as a main component of their income, accounting for about 80% of those living in the rural areas (Gaiballa, 2011).

Pastoralism is an important livelihood system and is one of the major land uses world-wide (FAO, 2001) .pastoral production takes place on some 25% of the world's land area, supporting some 200 million pastoral households and herds of nearly a billion head of camel, cattle and small ruminants. Nomads in Sudan represent a significant portion of the population and amounted to 13 % of the total population of the country in the 1956 census, and to about 10 percent in 1973, 1983 and 1993 censuses (UNDP, 2006).

Southern and the middle parts of the West Kordofan State, has been known for its livestock husbandry until oil was discovered in the mid-seventies of the last century and exploitation started at the end of the nineties and the beginning of the current century (Leonard, 2007).

The rise of oil production in West Kordofan State has disrupted pastoral livelihoods in oil producing areas and diminished the importance of livestock production for the Sudanese economic (Leonard, 2007).

Oil exploration and production take place in Northern and Southern Sudan, i.e. kordofan, Darfur, Upper Nile, and is expected to cover many regions in the country in future. Therefore, investigation of the environmental management of oil production and processing is very essential for the evaluation of the environmental impacts, or for development of an effective and sustainable environmental management system in future.

Groundwater pollution is the biggest potential threat to livestock keepers from oil. In the 21st century, rangelands will play an increasingly vital role in providing energy, livestock products, water, wildlife, and ecosystem services to people around the world. The population will significantly increase the economic importance of rangelands, but the pressure of degradation on rangelands in the world is likely to increase. Energy development may be the biggest challenge facing rangeland managers in the 21st century (Holechek and Sawalhah 2014).

1.2 The Study Area:

1.2.1 Location:

The study was conducted around *Balila* area, which is located in the west Kordofan state, between latitudes (11^{0} 11^{-} $02^{''}$) north and longitudes (02^{0} 28^{-} $28^{''}$) east. It lies within the low rainfall woodland Savannah zone (Guuma, 2017).

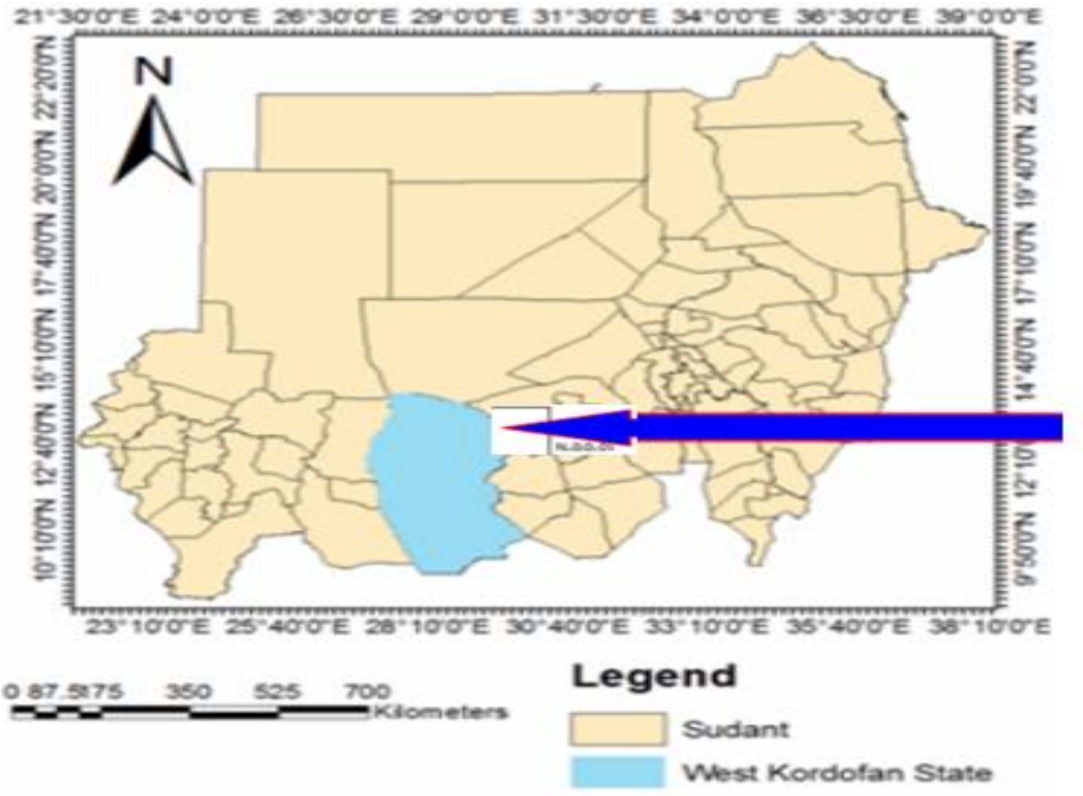


Figure (3.1) Location of the study area

(Guuma, 2017)

1.2.2 Population:

The inhabitants of the *Balila* area are mainly from the Baggara tribes, who are cattle herders. They consist of Falaita. They are nomads and they grow some crops besides their main grazing activity. It is located in Al Salam locality, which has an estimated population of (130,219), according to the 2015 census. Most of the population is nomadic; others grow millet, peanuts, watermelons, and more recently sorghum.

Generally, most of the population at the study area is found where water and other services are available. The people who are mainly farmers have either large or small numbers of animals, sometimes they send them outside the area with family herdsmen or rented herdsmen for good grazing management and livestock production. Small numbers of animals are kept for domestic use for production of meat and milk. Cows, donkeys, horses, camels and recently cars and (Tuktuk) are used for transport (Guuma, 2017).

1.2.3 Socio-economic aspects:

The economy of West Kordofan State is predominantly dependent on agricultural production consisting of rain fed cultivation and traditional livestock raising practiced by nomadic and semi-nomadic agro pastoral and sedentary groups. The main types of livelihood systems are nomadic and semi-nomadic pastoralist, sedentary agro-pastoralist, agriculture and forests based activities. The traditional land use pattern of *Meserya* tribes (the inhabitants of the area) was practicing open grazing. They are cattle breeders and few of them are farmers who cultivate some crops to be used for their daily uses. Recently their life began to change as a result of oil exploration which affected their livelihoods pattern economically, socially, and environmentally. In spite of the huge resources generated from the area still communities are lagging behind and suffering from the lack of basic social services such as health, education and clean water. It seems that oil companies and the concerned ministry did not take enough measures to upgrade the local communities' capacity and integrating them to grantee smooth and sustainable development (Mahir *et al.*, 2014).

1.2.4 Topography:

The area is almost flat. It is formed of Nubian sandstones granite and green series (Atia *et al.,* 2011); (Elham, 1988). Sand sheets and sand dunes covered the northern part of the area. The southern part is dominated by clay soil. Pockets of clay are found in narrow zones along the bank of Khors and Wadies. The major Wadies are *Shalango* and *Eligabish*.

1.2.5 The Climate:

The climate within the study area is divided into three distinct seasons. During November up to March the weather is cool, the daily temperature range between 17^o - 32^{o}C. This is followed by dry summer (April to June), and the temperature range between 23^o - 34^{o}C. The rainy season starts in June or July up to August and October. Annual rainfall ranges from less than 50 mm on the northern border to more than 350 mm on the southern border. In West Kordofan, the rainy season does not last for more than three months. Rains occur between May- October with the peak in August. Within the season and between seasons variation in rainfall amount and distribution is commonThe growing season (rainy season) is characterized by warm temperatures, and high relative humidity (El Tahir *et al*., 2010).

1.2.6 The Vegetation:

The vegetation of the area is a product of the plant material available and the environmental conditions prevailing. The latter includes the physical environment-land form, soil and climate-and other factors such as fire and grazing and the modification of the environment by the vegetation itself, through transpiration, circulation of minerals and plant decay. Furthermore, for a complete understanding of the vegetation, it is necessary to consider the past as well as the present, for each kind of vegetation has a history and a background of plant colonization and succession. Often, of course, the present vegetation composition represents a stage of succession. Due to vegetation misuses such as over grazing and fire burning the vegetation composition usually starts to be deteriorated. This is known as retrogression, (Boever et al, 1977).With regard to vegetation the region has diverse vegetation resulting from the variability in soils and rainfall. The north is generally covered with low desert and semi-desert scrub. The central sandy soils are covered with *Acacia senegal*savannah. Traditionally, the area is known for production of gum Arabic. In the Northern part of the State the dominant grasses and herbs (under storey vegetation) include: *Cenchrus biflorus, Eragrostis* *tremula, Aristida mutablis, Cyperus* .The dominant trees and bushes (over storey vegetation) include *Acaica tortilis A. mellifera, A. nilotica* and *Leptadenia pyrotechnica*. While in the southern parts the dominant grasses and herbs (under storey cover) include *Cenchrus biflorus, Fimbristylist dichotomo. Aristida mutablis, Zornia glochidiata,* and *Ipomea cordofana*. (RPA, 2008; El Tahir *et al*., 2010).

1.2.7 The Soil:

Soils in the area range from sandy in the north to clay and sandy clay in the south. The sandy soils cover an area of about 60 % of the total area, while the clay and sandy clay (gardud) cover 40 %. Sandy soils are stabilized by vegetation except in the vicinity of villages where overgrazing and extensive cultivation has destroyed the vegetation cover. Mineral nutrients and organic matter contents are naturally low, but the soil has high water permeability and relatively high availability of water during the dry season. Thus the vegetation, especially the perennial vegetation, is usually of better types than that found in soils with higher clay content. The clay soils shrink a drying out, and a net of wide and deep cracks is formed. At the onset of rains, water penetrates the soil through these cracks, which then close up, so that the soil, when moist is practically impermeable. Thus, under high rainfall the clay cannot absorb all the rain that fall on it and on leveled areas flooding occurs. In the dry season, the water available to plants in the upper layer of the soil is soon exhausted and these soils are then become very dry and compact (Pacheco *et al*., 1976).

1.2.8 The Water Sources:

In Kordofan permanent water supply is often a determining factor for the spatial organization of livestock and people. Rainfall is the main source of water supply in the area. During the rainy season, any water points that provide water supplies during the whole year becomes a focus of permanent settlements, as well as centers to which livestock are brought from the surrounding areas on a regular basis for watering and grazing.

In autumn all the ground is covered with green grasses. Small pools, which vanish almost as quickly as they appear, are found everywhere. Although they are temporary water points they play an important

1.3 Problem Statement:

There is no doubt that the exploitation of oil has many benefits to the national economy, but cannot lose sight of the effects it has on the environment and change the components of the natural resources of the area as well as its social and economic impacts. In similar areas of oil exploitation and production sites in other countries this activity of the exploitation and production of oil made huge changes to the natural environment and resulted in major changes of Irreversible nature; the west Kordofan traditionally been known as a breeding ground for livestock and a rich source of animal wealth, has been heavily influenced by the exploration and production of oil.

Pastoralists believe that the oil industry has contaminated water supplies and pastures, and say that their cattle are suffering as a result, especially as regards fertility. Their anger is palpable. So far, the authorities have refused to allow studies to determine the environmental impact of the oil industry, despite repeated requests by local people (Pantuliano *et al.*, 2009). Most of the livestock losses that occurred in the last few years were due to oil pollution. Contaminated water is said to be a threat to animal health, with livestock numbers steadily decreasing since digging began. Large-scale deforestation, pollution of pastures and soils, dispersal of naphtha (product of the oil industry) is toxic to humans and animals, the emergence of complex and previously unknown diseases between humans and livestock, and increased conflict between pastoralists and farmers due to difficult access to rangeland (Swarup *et al.*, 2002).

In order to mitigate the negative impacts and to preserve the natural and pastoral environment that is necessary for livestock, there is need to avail information that will help to develop good understanding about the this problem and that better inform decisions on actions to be taken. Standing on this, this study is aiming to investigate the impacts of oil activities on rangelands resources and pastoralism in West Kordofan State, and establishing good understanding to inform on means and approaches of addressing this problem.

The environment changes through the development of the petroleum industry. People are getting annoyed more and more about this problem, because it should not allow the industry to continue to develop and harm the environment. This way of thinking gave rise to the concept of sustainable development. This concept includes the continuous development of the industry in a way that has a minimal environmental impact. Changing the quality of the ecosystem leads to harmful effects of the pollutants present in the environment and thus increases the potential negative impacts on human, animal and plant health in several ways. This Study is aiming at providing information related to the impact of oil industry on pastoralism to inform actions required.

1.4 Objectives:

the main objective of the study the impacts of oil exploration activities on pastoralism in West Kordofan State, Sudan.

1.4.1 The specific objectives are:

A. To determine the impact of oil activities on range land resources (water, soil and vegetation).

B. To investigation the impact of activities on pastoralists and their herds practice).

C. To realize of means alleviating impacts of oil activities on pastoralism.

1.5 Hypothesis:

The oil exploration activities have negative impacts on rangelands resources and on pastoralism.

CHAPTER TWO

LITERATURE REVIEW

2.1. Range:

Range is defined as uncultivated grassland, shrubs land or forestland with an herbaceous and or shrub by under storey, particularly those areas producing forage for grazing and browsing by domestic and wild animals (Briske, 2008). Physical factors determine the kind of vegetation available, the manner and degree of possible use. Physical features include climate, soil and topography. Together they cause grass to grow in the plain, forests to grow in the mountains and shrub to grow in the deserts, (Stoddard *et al*, 1975).

Since the ancient time man has increasingly modified his surroundings and in fact, the whole history of man has been a struggle for dominance over the natural environment. With the passage of time, man has become more capable of utilizing certain aspects of nature to his own advantage. Stage by stage, his impact on the environment has increased, when the number and the technical skill of man become greater. Man was able to sweep away much of the wild vegetation. More than that, he changed the vegetation cover over vaster area by spreading fire. Only these plant species, which could withstand burning, are able to survive in these pastures. Directly and indirectly, man also transformed the soils as well as the vegetation; he applied his spade and his plough in order to crop, thus destroying many of the natural features of the soil. Furthermore, gradually he uttered the vegetation on the grazing lands, he automatically, but more gradually, changed the soil over these wide areas, (Elham, 1988), Stated that, equilibrium of the savannah ecosystem (i.e. areas receiving less than about 500-600 mm annual rainfall, in which grasses are the dominant partner and woody plants secondary) can only be found under natural conditions, with some grazing by lightning. As soon as man uses the savannah for grazing by his cattle, the equilibrium is radically distributed. As grazing intensifies and the grasses partially die out, the woody plants are able to propagate more easily.

Therefore, after several years we get dense thorn bushes in the savannah, often impenetrable by man and cattle.

The impact of man on the environment has increased during the last centuries, and this has become disastrous (degradation). As a result some environmental restraints on his population have been removed, but this has been at the expense of other organism and has brought out depletion and exhaustion of natural resources, (Elham, 1988).

2.2. Rangeland:

Rangeland is a kind of land on which the historic climax vegetation was predominantly grasses, grass-like plants and shrubs. Rangeland includes land regeneration naturally or artificially to provide a plant cover that is managed like native vegetation. Rangelands include natural grasslands, savannas, most deserts, tundra, alpine plant communities, coastal and fresh water marshes, and wet meadows (Gongbuzeren, 2015).

Rangeland are areas on which native vegetation is predominantly herbaceous and woody plants suitable for grazing and browsing by domesticated livestock and wildlife and areas unsuitable for agriculture (Fflolliott *et al*.,1995).

Throughout the world, rangelands are the major source of feed for both domestic and wild ruminant animals (FAO, 2012). Rangelands play a major role in supplying humans with animal products in all tropical regions of world not covered by ice. Rangeland account for about 16% of world food production compared to 77% for crop land and 7% for oceans. However, it is important to recognize that 80 to 90% of the food energy consumed by nomadic African herders comes from meat, milk and blood supplied by their livestock. The animals also serve as cash crop that can be used to buy food, and a large herd helps ensure that some animals will be left to restock the ranges after cessation of drought, (FAO, 2012).

Rangelands are those areas of the world, which by reasons of physical limitations such as low and erratic precipitation, rough topography, poor drainage, or cold temperature, are unsuited for cultivation and which are source of forage for free grazing for native and domestic animals as well as source of wood products, water and wildlife, (Stoddart *et al*, 1975). Rangeland is wild land not cultivated and in which multiple uses can be accommodated, (Darag and Suliman, 1988). Rangelands are the areas of the world that are not barren desert, cultivated or covered by solid, rock, ice, or concrete, (Holechek *et al*, 1989). Rangelands are the areas that have remained uncultivated for a long period and are capable of providing habitats for domestic and wild animals, (Maxwell, 1991).

Rangelands cover 47% of the earth's land surface, (Stoddart *et al*, 1975). Range resources include both tangible and intangible products, such as grazable forage, wildlife habitat, water, natural beauty, recreational opportunities, mineral, energy supplies, some wood products, germplasm for domestication and areas for the ecological study of natural system, (Barbour and Hand, 1987).

Rangeland ranks as a major land type whether measured by size, support for animal-based industries, or as a source of stream flow substantial portions of all major contents are rangelands. Worldwide, 30% of the world lands areas are grassland, (Stoddart *et al*, 1975). Amore useful measure of the importance of rangelands area is the contribution they make to animal production, (Box and Rayden, 1971). In United States the rangelands are classified into broad ecological divisions (tall) grasslands, open forest of the west and southern forest range.

Rangelands in Sudan are facing many problems that hinder their use and development. Some are user oriented whereas others are resource oriented. Most rangelands lie in fragile environments and facing frequent drought periods, seasonal bush fires, changing in species composition, increasing pressure on the range resource specially around water points, expanding cultivation, destruction of the local institutions and the gradual loss of the traditional knowledge, increase in animal population and low off-take, blockage of the livestock migration routes and lack of local community participation in the planning and execution of range programs, (Mustafa *et al*, 2000). Increasing the intensity of use of rangelands, has reduced plant diversity and wildlife habitats to a level which in some parts of the world, is regarded as damaging to the overall quality of life and in the arid and semi-arid regions has led to severe soil erosion, desertification and total loss of production potential, (Tueller, 1991).

Rangelands in many developing countries are under stress due to, increase in animal numbers, land tenure disputes, dry season grazing problems, and drought, (Jerry, 1989).

2.3 Methods of Vegetation Measurement:

Full information about the range resources are of vital importance to proper management. Range inventory should be carried periodically in a systematic way. Time is of importance and all the resource components should be measured, (Hussein *et al*, 1995).

Range inventory is the systematic evaluation and analysis of all factors (soil, vegetation, climate, etc) relating to the use of the range that precedes drafting a plan to manage the range resource effectively. From another point of view range inventory can be defined as the estimation and evaluation of the amount and the forage value of the vegetation present on the range and the basis according to which, the best use of forage can be determined, (Darag and Suliman, 1988).

The range evaluation is actual range vegetation species composition for the determination of range condition. Range evaluation also encounters the assessment of forage production for the determination of range carrying capacity and the stocking rate (Darag and Suliman, 1988).

This procedure, extensively used for twenty years in French speaking tropical countries in Africa, has made it possible to inventory a considerable area of rangeland and has permitted a better knowledge of this rangeland.

Earlier methods of measuring range condition and trend placed an emphasis on the succession status of rangelands. These methods express condition as a departure from a climax vegetative type. The climax approaches to measuring range condition assume that a climax or near-climax status represents an "excellent" range condition. Classified rangeland vegetation by the climax approach, grouping plants according to their responses to grazing. This approach is based upon the fact that overgrazing results in a somewhat orderly and predictable change in composition of plant species on a rangeland subjected to continued "heavy" grazing pressure. Plants were grouped into three categories, decreases, increasers and invaders, with the relative percentage of plants in each category then used to classify range condition (Fflolliott *et al.*, 1995).

2.3.1 Transects method:

An extension of a rectangular quadrate which may be tens of meters or even kilometers long. A belt transect usually consists of a tape or a string stretched across the vegetation, and species or individuals occurring within a specific distance

Perpendiculars to the tape or string are recorded. A simple form of belt transect in large paddocks is to drive a vehicle across the vegetation and record species or individuals occurring between the type tracks.

The vehicle must be driven along a predetermined course to avoid bias resulting from the driver avoiding difficult terrain (Whalley and Hardy, 2003).

2.3.2 Line transactions:

A. Loop method (parker ring):

Parker Loop (¾" diameter) was used to determine ground cover. Observation points were taken at one meter interval along transect by using the loop. Hits were recorded for plant when any portion of it occurred within the circumference of the loop (Parker, 1951; Lazim, 2009).

B. Quadrate method:

Simple quadrates of 50 cm × 50 cm or 1 m × 1 m are very commonly used for grassland studies but the size of the quadrate also depends on the vegetation type. In dense temperate grasslands, a commonly used size is 5 cm × 5 cm. These are easily constructed out of welded metal and are robust and useful in many situations. A suitable size of quadrate for many grassland situations is 1.0 m ×1.0 m (Whalley and Hardy, 2003).

2.4 Herbaceous vegetation:

2.4.1 Attributes

Attributes are the characteristics of the population by wish to measure during sampling, such as species composition, biomass, cover, density, or frequency, at a site. Other attributes of a vegetation community that we may need to describe include plant vigor, habitat quality, soil condition status, erosion potential, etc. Obviously, some attributes are easy to measure directly, while others depend on an indirect or subjective assessment of the characteristic (Cochran, 1977).

2.4.2 Botanical composition:

The botanical composition of grassland vegetation is a reflection of many factors, including past management. Changes in these factors will be reflected in changes in composition. There are many attributes of botanical composition that can be described or measured and the objective of the description or measurement dictates the methodology.

Monitoring which is a change over time by repeated sampling is a commonly used approach to detect environmental or management effects (Whalley and Hardy, 2003). Vegetation description or measurement can be very labors intensive and time consuming.

The resources invested depend on the purposes of the measurements and, essentially, the information collected is usually proportional to the resources invested but there is wide variation in the cost effectiveness of the different methods available (Whalley and Hardy, 2003).

Scale is also important and different methods must obviously be used for Vegetation measurement on a global scale compared with a small replicated experiment (Whalley and Hardy, 2003).

In grassland science, the characterization of vegetation in terms of its botanical composition is one of the most important aspects. The botanical composition of grassland reflects both the site conditions and management factors. Their changes affect the botanical composition, which in turns has an impact on yield and forage quality. Changes in the botanical composition over time provide relevant hints about the impact of environment and management on vegetation. As most of grassland vegetation is perennial or even permanent, vegetation dynamics enable to identify medium and long-term effects. For this reason, the description of the botanical composition of meadows and pastures is essential in grassland science and is therefore an indispensable part of monitoring and analysis both in field trials on field surveys. Grassland vegetation can be surveyed at different scaling levels: from a global point of view with the help of remote sensing up to small areas using different methods. It is possible to switch between these scales, whereas the aggregation of detailed data to a global scale is much easier rather than the other way round (Whalley and Hardy, 2000).

Some form of sampling is always involved in measuring the botanical composition of grasslands. The number, size and location of sampling units and the timing of the sampling are critical.

In small plot experiments, the whole population can sometimes be measured. The errors inherent in sampling vary enormously, depending not only on the spatial and temporal variation of the grassland attributes being measured but also on observer bias, and within and between the various sampling techniques. It is desirable to consult a statistician during the planning stages of any project involving grassland sampling to ensure that the sampling strategy is appropriate for the purpose and is statistically sound (Whalley and Hardy, 2003).

Types of Samples of the some common types of sampling device and the ways in which they have been used will provide an introduction to the wide range of samples types available for botanical composition. Different sampling methods are used for determination of botanical composition.

2.4.3 Cover:

Cover means the projection of plants or plant parts on the soil surface. Measurements of cover can be expressed either as the percentage of the soil surface covered by the plants or plant parts or can be broken down into the species or groups of species present. It can be measured as either 3+666canopy cover or basal cover (Smets, 2008).

2.4.4 Ground cover (plant percentage and litter %):

Cover or coverage is the percentage of quadrate area beneath the canopy of a given species, (Elwakeel, 2001). The vegetation cover is relative area covered by plant. It determines vegetation product, condition and soil protection, (Fadel Elmula and Ahmed, 1995). Cover is measured along the line transect in quadrates, so it can be estimated and observed, (Barbour, 1987). Abnormal vegetation cover may remain for many years, especially in instances where soil erosion follows destruction of the climax plants and induces sub-climax soil, (Stoddart *et al*, 1975).

Ground cover (vertical view) is the percentage of material, other than bare ground, that protects the soil surface from being hit directly by a raindrop. This would include first contact with plant canopy cover, biological crust, litter, surface fragments, bedrock, and water (Gongbuzeren, 2015).

Ground cover describes the proportion of the soil surface covered by some type of protective material, which usually includes litter, gravel, rocks, and microphysics' crusts, in addition to standing plant material. Unprotected bare soil can be determined as

Bare soil = 100% - Ground Cover (SRM, 1989).

2.4.5 Frequency and density of herbaceous plants:

Frequency is the percentage of the quadrate that contains at least one individual of certain species (Baxter, 2014). Species frequency is the probability of occurrence of species in randomly or systematically in placed quadrates (Hill, 2012). Plant frequency helps in determining plants distribution and their order of dominance (Darrag, 1996).

Density is the number of plants recorded within each quadrate. The average density per quadrate of each species can be extrapolated to any convenient unit area (Baxter, 2014). Density is the number of individual plants per unit area. Density is the number of plants recorded within each quadrate. The average density per quadrate of each species can be extrapolated to any convenient unit area, (Elawakeel, 2001). Density is the number of individual plants per unit area, (Stinsby and Cook, 1986). Density has a considerable influence upon the number and kind of stock, which can be introduced in to the grazing, lands without endangering it, (FAO, 1953).

2.4.6 Forage biomass of herbaceous plants:

Forage yield is the weight of forage production at a given area during a certain period of time (Darrag, 1996). Forage yield helps in determining range capacity and has a link with range condition. Biomass can be determined by using either direct or indirect sampling methods. Direct methods involve techniques that weight or estimate the actual biomass of plants in quadrates. Indirect methods are based on developing a relationship between plant weight and other attributes such as plant height, rainfall, or cover (Bonham, 1989, Lazim, 2009).

Biomass is weight of vegetation per unit area. It is measured by clipping all above plant ground dry matter, drying it in an oven and weighing it, (Elwakeel, 2001). Forage is the part of vegetation that is available and acceptable for animal's consumption, whether grazed by animals or harvested. Maximum production from a given range unit is dependent upon proper management and use of the resources. Of fundamental importance are:

(A) Grazing the range with the proper kind of animal.

(B) Balancing numbers of animals with forage resources.

(C) Grazing at the correct season of year.

(D) Obtaining proper distribution of livestock over the range variable production of forage must be anticipated in the management plan.

Even under conservation stocking based upon average production, certain subnormal years may be expected during which forage shortage will occur. The plant resource and grazing animals must be in balance at the times. If there is a temporary in balance, it should be in favor of the plant, rather than the animals, if long-term production is the manager's goal.

Usually 65 to 80 percent of average forage production is a safe base of calculating grazing capacity, (Stoddart *et al*, 1975).

2.5 Oil:

Oil gains a strategic and international importance, because it is still the main source of energy and, pre-requisite for many socio-economic activities. It constitutes source of income for many countries in the world today and, presents about 50% of the world energy supply. World use primary energy consumption oil and gas represent 63%, coal 27%, nuclear energy 7%, and hydro-electricity 3%. This indicates the huge amount of oil produced and consumed in the world (Wadi, 2011). Despite the global importance; the economic, socio-cultural, political and, environmental impacts of oil are the main challenges today (Wadi, 2011).

The oil processing may also affect the different water resources, due to the following operations: Drilling fluids cutting and treating chemical Wash and drainage wastes, Spills and leakage, Cooling water. Refining processing the above-mentioned operations produce large amounts of wastes, which contribute to the contamination of both surface, and underground water. For instance, ocean pollution, 12% of the oil that enters the oceans comes from tanker accidents; while over 70% of oil pollution at sea comes from routine shipping and from the oil people pour down drains on land. Here, heat increases temperature that results in the deaths of many aquatic organisms. Several billion salmon and herring eggs are also believed to have been destroyed (Wadi, 2011).

Increasing dependency on the production of crude oil products, crude oil water contamination problem becomes the major factor that can alter the natural consistency of the outstanding life source in a particular environment (Kuch and Bavumiragira, 2019).

The environmental impact of oil exploration and production emerged after Stockholm Conference in 1972 during which the United Nations

Organization for the environment was established. Since then the environment has become the focus of researchers, organizations, and the states at local, regional and global levels. For instance, The UNCED Conference in Rio in 1992 "The Earth Summit" focused World attention on the close link between environment and socioeconomic activities and called for the integration of the environment and development. Protection of the atmosphere and water, and managing land sustainability, are the main environmental issues in the Agenda 21. The World Summit on Climatic Changes in 2008 calls for promoting the environment, ascertaining the responsibility of the states towards the environment to reduce the activities that may cause climatic change. Generally, environmental challenges such as global warming and climatic change and, ozone (O3) depletion, have contributed to raise environmental awareness all over the world (Wadi, 2011).

Generally, investigation of environmental management of oil is very essential to evaluate its impacts and to encourage developing a sustainable environmental management system to avoid the oil curse in Sudan. Introduction of sustainable environmental strategy will contribute to improving environmental planning and performance as well as raising environmental awareness of the state, communities and oil companies to ascertain the responsibility of the stakeholders in oil activities. Moreover, developing sustainable environmental policy also promotes transparency and accountability of oil projects in Sudan (Wadi, 2011).

Drilling and production processes are destructive to environmental components surrounding the oil fields, which may cause deterioration of natural resources. For instance, Contamination of both water and soil are serious environmental impacts due to processing of oil in CPF (central processing factory) and concentration of heavy metal, which may affect surface and underground water. Most of oil in Sudan produces from ecologically sensitive areas near the White Nile and the Sudan tropical wetlands, which cover an area of 30,000 km². (11,500 square miles) of Southern Sudan. Therefore, the pollution of water in these areas not only affects the surroundings but also it may reach the River Nile in the North. Some reports raised the problem of contamination of water in *Mala* and *TarJath*. Oil fields in the Unity State covered 4,000 km². (1,500 square miles). (Wadi, 2011).

2.5.1 Impacts of oil on the environment:

Since the ancient time, man has increasingly modified his surroundings and in fact, the whole history of man has been a struggle for dominance over the natural environment. With the passage of time, man has become more capable of utilizing certain aspects of nature to his own advantage. Stage after stage, his impact on the environment has increased. When the number and the technical skill of man becomes greater, man was able to sweep away much of the wild vegetation. More than that, he changed the vegetation cover over vaster area by spreading fire. Only those plant species, which could withstand burning, are able to survive in these pastures. Directly and indirectly, man also transformed the soil as well as the vegetation; he applied his spade and his plough in order to cultivates. Thus, he destroyed many of the natural features of the soil. Furthermore, gradually he altered the vegetation on the grazing lands, he automatically, but more gradually, changed the soil over these wide areas, (Elham, 1988).

Over the years there have been increased concerns over the environmental effects of the petroleum industry. The environmental impacts of petroleum are mainly negative. This is due to the toxicity of petroleum which contributes to air pollution, acid rain, and various illnesses in humans. Petroleum also fuels climate change, due to the increased greenhouse gas emissions in its extraction, refinement.

Petroleum is a complex mixture of many components. These components include straight chained, branched, cyclic, monocyclic aromatic and polycyclic aromatic hydrocarbons. The toxicity of oils can be understood using the toxic potential or the toxicity of each individual component of oil at the water solubility of that component. (Kharaka and Otton, 2003).

Crude oil and petroleum distillates cause birth defects. Benzene is present in both crude oil and gasoline and is known to cause leukemia in humans. The compound is also known to lower the white blood cell count in humans, which would leave people exposed to it more susceptible to infections (Bahadar, *et al*., 2014; Kharaka and Otton, 2003).

2.6.2 Impacts on soil:

Traditionally, the causes of land degradation are enumerated in physical categories: Over population, over cultivation, over grazing, deforestation and climate factors, (Nelson, 1988). It is sometimes debated to what extent the causes of land degradation are man-made and to what extent natural factors are culprits, (Ahlerona, 1988).

The primary pollutants of concern in land and soil include heavy metals such as Lead, Mercury, Arsenic, Cadmium and Chromium, Persistent organic pollutants and other pesticides, and pharmaceuticals, such as antibiotics used for livestock management. These degrade soil biodiversity and functioning, and can reduce agricultural productivity, thus negatively impacting livelihoods, disease control and food security. They can also cause a variety of non-communicable diseases, and even death in humans and wildlife (Tóth *et al*. 2016).

The physical and chemical impacts on soils resulted from the following:

- Cutting of trees.
- Contamination resulting from spillage and leakage or oil waste.
-Crude oil pollution: It is estimated that 80% of crude oil pollution causes by spillage and its different proportion affected soil up to 120 cm deep.

- Physical disturbance.

The negative environmental impact of oil may create various disturbances to ecosystems including: fauna and flora. Wells, pipelines, roads, removal of plants affect soils and produce wastes that are hazardous to people, property and the environment -and should be managed properly (UNEP, 2017).

• It can alter metabolism of microorganisms and arthropods in a given soil environment; this may destroy some layers of the primary food chain, and thus have a negative effect on predator animal species

• Small life forms may consume harmful chemicals, which may then be passed up the food chain to larger animals; this may lead to increased mortality rates and even animal extinction reduces crop yields (UNEP, 2017).

2.5.3 Effects on vegetation:

Oil spillage always has significant short and long-term effects on aquatic ecosystems. Chemical toxicity of the oil affects the plant water relationship, affect metabolism, become toxic to cell, hampering the photosynthesis of aquatic plants, and interfere with oxygen intake from atmosphere and soils (Ko and Day, 2004).

During flood, spilled oil enter into the center of the forest floor, and plants leaves and stem become covered by oil which blocked the stomata, reduced oxygen diffusion to the roots, result will hamper the plant growth. Oil already mixed with soil has reduced oxygen resulting to anaerobic condition that in effect increases plant stress. Laboratory result showed that Plants with blocked leaves are more severely affected as compared to plants in contaminated soils (Ko and Day, 2004). In addition, clean-up process of the oil causes physical disturbance and complication of the vegetation and soil (Pezeshki *et al.,* 2000).

Seed germinations seem to be affected by oil at least in two ways. At high level of crude oil pollution, seed germination is prevented probably by oil soaking through the outer integument of the seeds. At low level of crude oil pollution, seed germination is retarded by the presence of oil. The effect of crude oil on plant is one that is of great concern as it causes damage to different parts of the plant that are vital for its well-being and survival and hence obstructs development and growth (Kuch and Bavumiragira, 2019).

2.5.4 Impact of crude oil on wildlife:

Despite varying levels of toxicity amongst different variants of oil, all petroleum -derived products have adverse impacts on human health and the ecosystem. Examples of adverse effects are oil emulsions in digestive systems in certain mammals might result in decreased ability to digest nutrients that might lead to death of certain mammals. Further symptoms include capillary ruptures and hemorrhages. Ecosystem food chains can be affected due to a decrease in algae productivity therefore threatening certain species. Oil is "acutely lethal" to fish - that is, it kills fish quickly, at a concentration of 4000 parts per million (ppm). The toxicity of petroleum related products threaten human health. Many compounds found in oil are highly toxic and can cause cancer (carcinogenic) as well as other diseases. Studies in Taiwan link proximity to oil refineries to premature births (USEPA, 2012).

Petrol is present in both crude oil and gasoline and is known to cause leukemia in humans (*kirkeleit, et al*, 2008). The compound is also known to lower the white blood cell count in humans, which would leave people exposed to it more susceptible to infections (kirkeleit, *et al*, 2008). "Studies have linked petrol exposure in the mere parts per billion (ppb) ranges to terminal leukemia, Hodgkin's lymphoma, and other blood and immunity system diseases within 5-15 years of exposure (McHale *et al.*, 2012).

The main sources of noise during the production of crude oil and natural gas would include compressor and pumping stations, producing wells (including occasional flaring), and vehicle traffic. Compressor stations produce noise levels between 64 and 86 dBA at the station to between 58 and 75 dBA at about 1 mile (1.6 kilometers) from the station[14].The primary impacts from noise would be localized disturbance to wildlife, recreationists, and residents. Noise associated with cavitations is a major concern for landowners, livestock, and wildlife (Kuch and Bavumiragira, 2019).

Wildlife habitats have been subjected to deterioration because of the expansion in MRF together with overgrazing by domestic livestock, drought, tree clearance and poaching. As a result 17 mammalian, 8 birds and at least one reptile species are deemed threatened. These, according to Nimir, (1983), include Oryx, Sommering, Dama and Addax gazelles, wild sheep, Wild ass and Cheetah.Another impact of one form of land use is evident in coastal regions. There deterioration of vegetation cover, particularly mangroves due to overgrazing and cutting has rendered corals, sharks, sea turtles, dugongs and some sea birds endangered. The impact of over-grazing and mangrove felling is compounded by pollution from urban and industrial source together with fishing and tourist boats, (Abdel Nour, 2000).

Oil spill have significant short and long-term negative effects on wildlife population of all trophic levels living in and around the aquatic ecosystems (Hugo and Mijanur, 2016).

Oil vapors can cause damage to an animal's central nervous system, liver and lungs. Animals are also at risk from ingesting oil, which can reduce the animal's ability to eat or digest its food by damaging cells in the intestinal tract (Hugo and Mijanur, 2016). From the very beginning of oil pollution the death of several wildlife species of Ecuadorian Amazon has been reported in different times (IUCN, 2015). Basically, Oil harms water birds and aquatic mammals in two major ways:

- Physical contact when fur or feathers come into contact with oil;
- Toxic contamination some species are susceptible to the toxic effects of inhaled or ingested oil. Oil vapors can cause damage to an animal's central nervous system, liver, and lungs. Animals are also at risk from ingesting oil (Gilbert, 2001).

The adverse impacts to ecological resources during production of crude oil and natural gas could occur from: disturbance of wildlife from noise and human activity; exposure of biota to contaminants; and mortality of biota from colliding with above ground facilities or vehicles. The presence of production wells, ancillary facilities and access road reduces the habitat quality, disturbs the biota and thus affects ecological resources (Macdonal and Gilman, 2007). The presence of an oil or gas field could also interfere with migratory and other behaviors of some wildlife. Discharge of produced water inappropriately onto soil or into surface water bodies can result in salinity levels too high to sustain plant growth. Wildlife is always prone to contact with petroleum-based products and other contaminants in reserve pits and water management facilities (Jones and Kiesecker, 2015).They can become entrapped in the oil and drown, ingest toxic quantities of oil by preening (birds) or licking their fur (mammals); or succumb to cold stress if the oil damages the insulation provided by feathers or fur. In locations where naturally occurring radioactive material (NORM)-bearing produced water and solid wastes are generated, mismanagement of these wastes can result in radiological contamination of soils or surface water bodies (Burton, 2014).

2.5.5 Effects on Agriculture:

Human activities in agriculture, livestock production and forestry have tangible ill effects on soil and/or other forms of land use. All three agricultural systems have by necessity come to being through clearance of tree cover. For instance, all the three agriculture have played a part in reducing biological diversity and destroying habitat for some forms of wildlife.

This negative impact on other forms of land use is perhaps more pronounced with mechanized rain fed farming and to a lesser extent with traditional rain fed farming.

2.5.6 Impacts on water resources:

The oil processing may also affect the different water resources, due to the following operations: Drilling fluids cutting and treating chemical, Wash and drainage wastes, Spills and leakage, cooling water and Refining processing (Sharif *et al*., 2017).

The above mentioned operations produce large amounts of wastes which contribute to the contamination of both surface and underground water.

Nutrient pollution (nitrogen, phosphates etc.) causes over growth of toxic algae eaten by other aquatic animals, and may cause death; nutrient pollution. Too much sodium chloride (ordinary salt) in water may kill animals, We also assume that some higher forms of non-aquatic animals may have similar effects from water pollution as those experienced by humans, as described above (Sharif *et al*., 2017).

2.6.7 Impacts on humans:

As states by Kuch and Bavumiragira, 2019.People who live in places with high levels of air pollutants have a 20% higher risk of death from lung cancer than people who live in less-polluted areas the specific effects vary depending on what pollutants enter the environment. Sometimes, water pollution causes an explosion of new plant growth by providing necessary nutrients and food. Other times, it can harm or kill plants by changing growing conditions, such as by raising or lowering the acidity.

Finally, air pollution can take the form of greenhouse gases, such as carbon dioxide or sulfur dioxide, which are warming the planet through the greenhouse effect according to the EPA; the greenhouse effect is when gases absorb the infrared radiation that is released from the Earth, preventing the heat from escaping. Air pollution causes damage to crops, animals, forests, and bodies of water.

Pollutants from the oil extraction industry have led to health problems, including rising rates of female infertility, increases in the number of miscarriages, birth defects, and eye infections and even blindness and skin problems these impacts are:

• Reduced lung functioning

• Irritation of eyes, nose, mouth and throat

• Asthma attacks

• Respiratory symptoms such as coughing and wheezing

• Increased respiratory disease such as bronchitis

• Reduced energy levels

• Headaches and dizziness 2

• Disruption of endocrine, reproductive and immune systems

• Neurobehavioral disorders

• Cardiovascular problems

• Cancer

• Premature death and decline in dairy animal's population and significant financial losses to farmers (Swarup *et al*., 2002).

2.6 Range Condition:

Range condition describes an evaluation of the status of rangeland vegetation. Range condition assessments provide the framework to register information obtained by range inventories on the basic status of existing vegetation, and to gauge changes or range trend through monitoring. In addition, range condition is used as a guide to ensure sustainable land use, to determine carrying capacity and adjust stocking rates, to identify potential responses to range improvement programs such as brush control or reseeding, and to evaluate the best locations of fences and water facilities to improve utilization within a pasture (Pieper, 1990). Range condition is the state and health of the range based on what that range is naturally capable of producing, (American Society of Range Management, 1964).

Range condition refers to the forage production of the current year, season or month as compared to the last year (or some other years). It is the response of forage cover and soil to the grazing practices taken in account and current climatic conditions. It can be known by comparing the expected percentage of the climax composition contributed by each species to the actual composition. Thus, the U. S. forest service's developed a four-factor system for quantifying range condition based on two vegetation factors, ground cover (both living vegetation and litter) and soil erosion.

The maximum number of points for each of the four factors is as follows: 60 for vegetal composition; 40 for plant production; 50 for ground cover; and 50 for an erosion index. If all factors were at their best, vegetation could receive 100 points and soil 100 points.

Point's totals for either vegetation or soil are converted to condition ratings based on the following scale:

Excellent	76% and more points.
Good	51%-75% points.
Fair	26%-50% points.
Poor	below 26%points.

(Stoddart *et al*, 1975).

In earlier days of rangeland management, range condition was a general term describing the status of resources at a site with particular reference to livestock grazing. Today, range condition usually carries a specific connotation, reflecting current status of the vegetation and soils occupying a site in comparison to the site potential expected if the climax vegetation was present. Therefore, an initial and critical step in evaluating range condition is to classify range sites to determine site potential (Pieper, 1990).

The best-known procedure to assess range condition is the Quantitative Climax Method, used by the Soil Conservation Service (now Natural Resources Conservation Service) since the 1950s. This method compares species or species groups in the existing vegetation with that expected in the climax vegetation, to give a percentage reflecting the similarity between the two. A value close to 100% indicates that species composition of the existing vegetation closely reflects the composition of the climax vegetation, whereas lower values indicate a greater level of departure from perceived climax conditions. Although range condition is evaluated on a continuous scale from 0% to 100%, arbitrary classes are generally reported to illustrate range condition (Pieper, 1990).

Table2.1 Range condition classes used in the Quantitative Climax Method

Range Condition Class	**Percent of Climax**
Excellent	76 -100
Good	50 - 75
Fair	26 - 50
Poor	0 -

(Stoddart *et al*, 1975).

2.7 Pastoralism:

Extensive pastoralism exists on all continents except Antarctica, mostly in the dry-lands or highlands, where intensive crop cultivation is physically not possible (FAO, 2001). Currently, pastoralism occurs in more than 100 countries on about 25 % of Earth’s land area and supports about 200 million households and herds of nearly a billion animals, including camels, cattle, and smaller livestock that account for about 10 % of the world's meat production (FAO, 2001). Pastoralism provides very important ecological services, such as primary production, biodiversity conservation, and erosion control. However, the social, economic, and environmental importance of worldwide pastoralism has been overlooked in the modern era. It is necessary to review the history, distribution, and importance of global pastoralism, especially in the developing world. Here, we provide an overview of global pastoralism and its human natural systems (FAO, 2001).

The definition of pastoralism varies greatly in terms of purposes and focuses (e.g., intentional, extensional, descriptive, stipulate, etc.). Basically, two common definitions derived from either the production perspective or the livelihood perspectives are broadly used for "pastoralism." In the dimension of production, pastoralism is animal husbandry, the branch of agriculture concerned with the care, tending, and use of grazing livestock in dry or cold rangeland areas. In the dimension of livelihood, pastoralism is a subsistence living pattern of tending herds of large animals (Blench, 2001) or a successful livelihood strategy on less productive lands through livestock herding (IFAD, 2008). Pastoralism, with the features of mobility, adaptation, flexibility, diversification, conservation, and mutual support, is "the finely-honed symbiotic relationship between local ecology, domesticated livestock and people." As the traditional rangeland management strategy, pastoralism represents a complex form of natural resource management, involving the direct interaction between natural resources and their users done within a larger geopolitical context (Pratt *et al.*, 1997, Dong *et al.*, 2016). Therefore, pastoralism can be understood as one of the coupled human–natural systems in the developing world (including remote and marginalized areas of developed countries).

The marginalization of pastoralists that began during colonial times continued after Sudan achieved independence in 1956. Successive post-independence governments implemented colonial-era policies that excluded pastoralists from areas that could be used for settlement or were demarcated for agricultural expansion (Ahmed, 2002).

Pastoralists, agro-pastoralists, and sedentary farmers own and manage approximately 90 percent of Sudan's livestock (Aklilu 2002; Monec, 2003; Leonard, 2007).

West Kordofan State has been affected by the continuing war in South Kordofan, the Darfur conflict and the civil war in South Sudan. The secession of South Sudan worsened the predicament of nomads in the area, as movements to the country were blocked. As a result, animals find themselves concentrated in a narrow area with limited resources during the dry season. Diseases that are preventable by vaccination are still considered major threats to animal production. Taking into account the lack of veterinary services in the area for a number of years, which has led to the spread of dangerous transboundary animal diseases, West Kordofan is considered a serious focus for the spread of diseases, undermining Sudan's role as an important livestock-exporting agent in the region. In this context, the project provided an opportunity to build the capacity of both veterinarians and veterinary institutions (FAO, 2019).

2.8 Range improvement:

The goal of range improvements is to use all grazing land to its optimum potential for vegetation and forage production. By using range improvement practices, a rancher can distribute grazing evenly across the land. This will minimize overuse and under use of the rangelands. Range improvements will result in healthier.

2.8.1 Vegetation manipulations:

Removable of noxious or other undesirable plants for purposes of favoring the establishment and growth of forage plants can be objective of vegetative manipulation to remove this plants includes use of mechanical, chemical, and biological methods and fire (Ali, 1988).The most commonly employed means of improving ranges are (a) Seeding (b) Fertilization. (c) Mechanical treatments designed to conserve precipitation and increase production.

(a) Seeding: A number of techniques are employed in seeding to make suitable seedbed and reduce competition. The advantages of seeding should be carefully weighed.

(b) Fertilization: fertilization has advantages over other means of range improvement. It requires no highly specialized equipment's; costs are less than seedling and a period of non use is unnecessary. Fertilization is undertaken primarily to increase forage production. The period between germination and establishment is a critical one for a plant; unless root development can proceed rapidly enough to maintain contact with moist soil. There is little chance that the seedling plant will survive. Fertilization has been tried as a means of stimulating growth and thus, survival, ((Ali, 1988).

2.8.2 Water development:

Water should be provided in plentiful quantity and good quality with accessibility in all pastures. While lakes and streams/rivers provide natural water sources, livestock can cause damage to shorelines and banks. Experts recommend that additional water supplies, such as stock tanks, dams, dugouts or other water sources, be available, especially in large pastures (FAO, 2019).

Methods of water development for livestock include construction of stock tanks, drilling of wells, and development of water-harvesting systems (Ffolliot, 1995).

CHAPTER THREE
MATERIALS AND METHODS

3.1 Description of Study Site:

This study was carried out in Balila area, southwest Elfula town, Elsalam locality, West Kordofan State. The many livelihood means extolled are traditional pastoralism and subsistence farming. Pastoralist communities in the area constitute may component includes both nomadic and semi-nomadic (transhumant) cattle, sheep and goat herders. They also practice farming for their livelihood.

3.2 Methodology:

Secondary data was collected from previous studies, while the primary data and information were collected along the following study components: that encompassed socioeconomic aspect and the impact of oil activities on pastoralism practices and rangeland resources includes vegetation, water and soil.

3.2.1 Cover percentage:

Using the $\frac{3''}{4}$ loop, for cover % include bare soil, litter, rock and plant species by using 100 meter transect tape (Parker, 1951).

The above parameters were calculated as follows:

Plant species % = $\frac{the\ total\ number\ of\ the\ plant\ appearance}{the\ total\ number\ of\ all\ readings}\ x\ 100$

Litter % = $\frac{the\ total\ number\ of\ the\ litter\ appearance}{the\ total\ number\ of\ all\ readings}\ x\ 100$

Bare soil % = $\frac{the\ total\ number\ of\ the\ bare\ soil\ appearance}{the\ total\ number\ of\ all\ reading}\ x\ 100$

Soil cover % = (plant sp. %) + (litter %) + (Rocks %) + (cow dropping and sheep pellets %).

Species relative frequency = $\frac{the\ total\ number\ of\ the\ species\ readings}{the\ total\ number\ of\ the\ all\ plant\ readings}\ x\ 100$

3.2.2 Sampling for rangeland measurement:

Three sites were selected based on releve as representing variation in Balila area. Within each site measurement were taken within 1x1 km areas where twenty transects 100 m long were measured randomly distributed. The loop was taken readings at rangelands components that were taken at a length of 1 meter internal. Soil sample at depth of 15 cm was fifteen by on augar to estimate pollution analysis (20 sample) as suggested by LSASD (2020). Using a quadrate 1 x 1 ($2m^2$), at 25 m interval between production was estimate (Bonham, 1989). Standard data were used to register data obtained. As state each equipment from used includes:

- Quadrate 1x1 (2 m^2)
- Meter tape (100m)
- $3/4^{inch}$ Loop

Parameters measured include:

- Rangeland component: (vegetation composition, litter, soil cover and rocks) by the by the $3/4^{inch}$ Loop.
- Plant frequency by the by the $3/4^{inch}$ Loop.
- Biomass productively by 1 m^2 quadrate.

3.3 Questionnaire and Family group discussion (FGD):

Data collection made use of both primary and secondary sources. Primary data relied on administration of 139 copies of structured questionnaire to inhabitants using simple random sampling, and one group's discussions with local leaders and relevant people in the targeted population. Three communities, *Balila*, *Elshaq* and *El-Firdus* villages were selected for the study. Secondary data were obtained from relevant sources.

The Balila village consists of 40 families who live around the companies. For the *Elshaq* village of, about 500 families live in it, which is located 25 km from the center of the *Balila* village and *El-Firdus* village, which is located to the east, 25 km from *Balila*, which has 700 families (Taherdoost, 2016).

Data were distributed based on the criteria for sampling; the questionnaires were distributed by taking 10% from each village. 4, 50 and 85 person from *Balila*, *Elshag* and *El-Firdus* respectively.

The information collected includes:

- Household characteristics.
- Livelihood aspects.
- Impact of oil industry on vegetation, water and soil.
- Herding pattern.
- Herding challenges.
- Challenges facing pastoralists.

3.4 Assessment of oil exploration on pastoralism:

These include:

- To assess the impact of exploration on pastoralist livelihood two approaches were used.

- Collection of information based on questionnaire and FGDs on temporal and spatial pattern of herding practices as related to livestock herding pattern. In addition to impact on rangelands use characteristics and condition recently and as an accumulation impact on the rangeland condition variables related to this part is included in the questionnaire.

3.4.1 Grazing pattern:

Mapping for the livestock routes crossed by the oil exploration structure was made based on geographical references obtained from-Google earth, and coordinate for selected scales including livestock routes, grazing and main pastoralist settlement areas. Points obtained were made in decimal you format and entered in GIS software for the production of maps that shows spatial relation between the different points of investigations.

3.5 Chemical analysis measurements of water and soil samples:

3.5.1 Water sampling:

Eight water samples were taken including six surface water samples from hafir and two groundwater samples (well). There were destructed:

- The *Balila* area was considered the center, where distances of 10, 20 and 30 km were determined for samples, from each direction and a sample from the middle.
- The North: Two samples were taken at a distance of 10 km and the other at 30 km.
- The East: Two samples were taken at a distance of 8 km and 10 km, as available.
- The South: One sample at 10 km.
- The West: No samples were taken from the western side due to security conditions.

- The two samples of underground water were taken from the well to drink *ElShaq* village, located 30 km from the center, and the other from which *El-Firdaus* village, and located in the central area (the companies).

A. Chemical analysis:

The chemical analysis was performed in the laboratories of the Sudan Petroleum Corporation (SPCL). The analysis was performed using standard methods, ICP (Inductively Coupled Plasma) techniques. It can be used for determination of concentration of almost all elements in the periodic table accurately and with the least interference. The elements were compared according to WHO and SSMO standards (Figure 3.3) (Abush *et al.*, 2020).

Figure (3.1) Chemical Parameters with SSMO and WHO guidelines:

Parameter	**Sample No.**						**SSMO Mg/l**	**WHO Mg/l**
	1	**2**	**3**	**4**	**5**	**6**		
pH	8	7.7	7.4	6.8	7.8		6.5-8.5	
Total Alkalinity	272	500	504	110	460	384	Less than 500 is preferred	
Total Hardness	224	248	252	80	223	410	Highest permissible level is 100	
Chloride	8	7	7	5	6	36	250	250
Fluoride	0.75	3.42	3.98	0.62	1.96	0.95	1.5	1.5-1.7
Nitrate	4.6	13.7	16.7	11.9	10.3	47.8	50	50
Calcium	37.6	36	21.6	17.6	38.4	93.6	Max. permissible limit is <75	
Magnesium	31.2	37.92	47.52		30.48	42.24	Max. permissible limit is <30	
Calcium	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	0.002	0.003
Copper	0.095	0.087	0.129	0.114	0.087	0.088	1.5	2
Lead	1.100	1.100	<0.010	<0.010	<0.010	0.290	0.007	0.01
Zinc	0.1726	0.1726	<0.010	<0.010	0.2537	<0.010	3	0.4

SSMO: Sudanese Standard and Meteorology Organization; **WHO:** World Health Organization

(Abush *et al.*, 2020).

3.5.2 Soil sampling:

It consists of five soil samples. Soil was collected according to the directions of *Balila* area (East, West, North and South), distance of 20 km from the center (4 samples), and the fifth sample was taken from the center. While soil sampling with depth of 15 cm using augar taken one sample from any transect and mixed with some per kilometer to be used for pollution analysis.

B. Soil analysis:

The soil was analyzed in the Petroleum Laboratories, Research & Studies (PLRS) at the Sudanese Petroleum Corporation (SPC) at the Ministry of Petroleum and Minerals, in October 2020.

Each sample is named according to the direction from which it was collected (North, South, East, West and Center).

Soil was analyzed based on some minerals (Fe, Cd, Cu, Ni and Pb). The analysis was done by Atomic Absorption Spectrometry (AAS), The sample is exposed to a source of radiation, which usually arises from a light source. This light source is tuned to specific wavelengths, and the metal atoms in the sample absorb these wavelengths (or do not). When absorption occurs, the result is a spectrum of light that has reduced the intensity of light in one or more of its regions. This low density is characteristic of a specific element and helps to identify it, as well as determine its concentration. The AAS instrument detector measures the wavelength intensity. Since element focus is a function of the wavelength intensity, the target element focus is determined. By establishing a reference system from known concentration standards, and (Fe) was analyzed quantitatively.

3.6 Data analysis

Descriptive statistics were used to analyses the collected data using Excel and SPSS software program (version 22). Data were presented on the basis of frequencies and percentages.

CHAPTER FOUR
4. RESULTS AND DISCUSSIONS

4.1 The impacts of oil exploration on rangelands plants

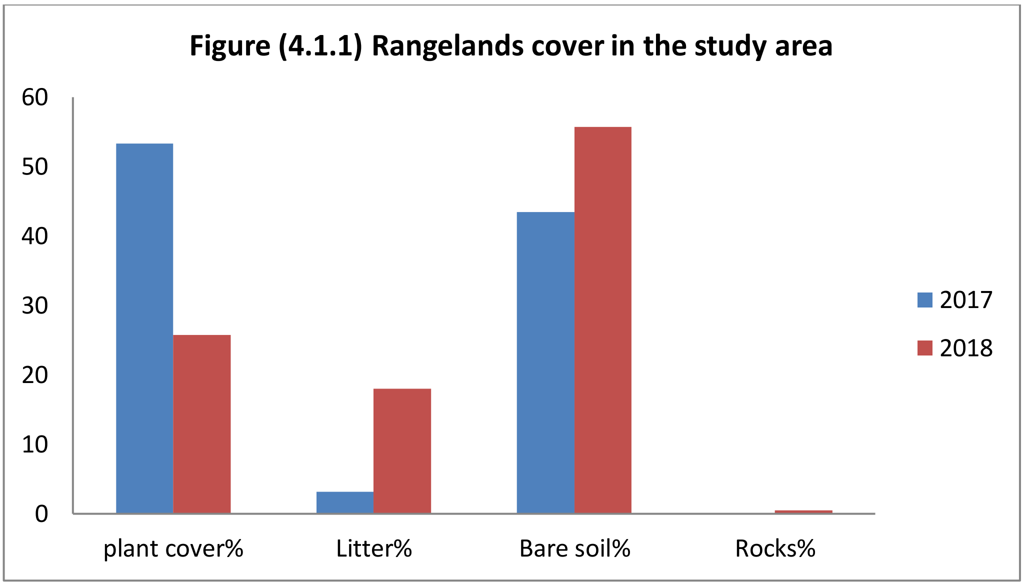


Figure (4.1.1) shows the rangeland attributes at Balila area. Plant species percentage was 53.3% in season 2017 and 25.8% in season 2018 this result showed relatively low vegetation cover for the two successive season which might resulted from intensive grazing at these areas due to shrinkage of rangelands the surrounding due to expansion of oil structure or exploration in the grazing areas. These results indicated that the rangelands in the area are subjected to erosion hazard. As rounding to area (Reiel and Love, 1950) bare soil (25-50) % indicated exposure to erosion hazards. Litter recorded 3.2% in season 2017 and increased to record 1.8% in season 2018.While bare soil showed 43.5% in season 2017 and increased to 55.7% in season 2018 in due to rounding to in the Ekekwe, 1981 stated that**,** pollution of grasslands and farms is a well-known phenomenon. The flow of oil over large areas of rangeland has had the effect of reducing and changing its flora (Wyszkowski and Ziolkowska, 2008). According to information obtained results could be explained by the fact that oil reduces the soil fertility such that most of the essential nutrients are no longer available for plant and crop production. Oil spills has adverse effects on nutrient level and fertility status of the soil (Abii and Nwosu, 2009). Abosede (2013) reported that oil pollution might affect soil physical properties. Pore space might be blocked which could reduce soil aeration and water infiltration and subsequently affect plant growth. Oil spills render the soil toxic and unproductive. Spilled oil which is denser than water reduces and restricts permeability: organic hydrocarbons which fill the soil pores expel water and air, thus depriving the plant roots the much-needed water and air. Brain, (1979). Adam *et al*., (2002); Clark, (2003) confirmed the adverse effects of oil on soil characteristic and vegetation cover. Accordingly, a necessity arises for the adoption of remediation technique to restore contaminated soil. The company (Petro energy) involved in oil production at Balila area treats the contaminated soil with cow droppings to break down pollutants. Kelechi, *et al*. (2008), reported that the addition of cow dung to oil contaminated soil make such contaminated soils useful for agricultural activities and improve growth performance of the plants. The interviewed herders stated that the livestock of the area is forced to practice intensive grazing causing range degradation due to the shrinkage in grazing area. This agreed with Rinehart, (2006) who mentioned that, overgrazing occurs when the grazing pressure exceeds the carrying capacity of the range plants. This condition is not really a function of how many animals are on a rangeland, but how long they remain there. In grazing management, time is the most important factor to consider in establishing a grazing system for sustained forage production. The problem of this isn't necessarily in the selective grazing activity, but in the fact that the grazed plant does not get the time to re-growth before it is grazed again. Overgrazing has a negative effect on plant diversity. Although several individual plant species are adapted to intensive grazing or seem to be favored due to the reduction of competition (Bergmeier, 1998) the overall impact of overgrazing is negative, particularly in grasslands (Papanastasis *et al.*, 2002). Overgrazing useful caused when the numbers of animals carried in a rangeland are more than its grazing capacity. The number of animals grazing in a rangeland or the grazing intensity, expressed as stocking rate, is a very important indicator of rangeland degradation (Papanastasis, 2009). Due to the different way that the various grazing animals collect the forage, their impact on vegetation is different (Rook *et al.*, 2004).The increase variation in bare soil percentage from 43.5% in season 2017 to 55.7% in season 2018 usually result from the response of non-equilibrium environment due to around variety in rainy. According to Idaho Association of Soil conservation, (IASC, 2010), soil degradation, primarily through accelerated erosion by wind and water, usually lead to poor rangeland health. Soil degradation not only damages the soil itself but also disrupts nutrient cycling, water infiltration, seed germination, seedling development, and other ecological processes that are important components of rangeland ecosystems. In addition, soil degradation damages watersheds, which leads to further degradation of rangeland ecosystems as well as water pollution. Indicators of soil stability and watershed function should be central to the evaluation of rangeland health.

Table (4. 1.1) Main plant species in the study area in 2017 and 2018.

No.	Local name	Habit	Scientific name	Type
1	Um aag	Annual	*Digitaria adscendens*	grass
2	Bano	Annual	*Eragrostis tremula*	grass
3	Gaw	Perennial	*Aristida adscensionis*	herb
4	Difera	Annual	*Echinocloa colonum*	grass
5	Hasskaneet naeem	perennial	*Cenchrus biflorus*	grass
6	Sheleny	Annual	*Zornia glochidiata*	grass
7	Danab Elkaleb	Annual	*Cynosurus echinatus*	grass
8	Areg Elnar	Annual	*Tormentilla officinalis*	herb
9	Umhemaro	perennial	*Aristida mutabilis*	grass
10	Um Dfufu	Annual	*Pennisetum pedicellatum*	grass
11	Um Fesifesa	Annual	*Fimbrirtlis dychotoma*	grass
12	Abu Asabea	Annual	*Dacteloctenium aegeptium*	grass
13	Dresa	Annual	*Tribulus terrestris*	grass
14	Lasag	perennial	*Forsskaolechecha tenacissima*	herb

Table (4.1.1) showed the main plant spp deserved during the season of 2017 and 2018 along transects. It is observed that 53.3 % in the 2017 and 25.8% in season 2018 of the types of plants observed are grasses and herbs. Ali, 1988 stated that, annuals are able to survive under harsh condition because of their efficient utilization of moisture and the fact that they usually mature and shed their seeds well ahead of the incidence of soil moisture. Nassra and Karamallah (2004) stated that, occurrence of high number of annuals and short living species is often an indicator of site disturbance. Wickense (1962) following the assessment of Range Vegetation Composition within Kordofan special fund area concluded that the major factors causing eradication of perennial species are overgrazing, fire, and the seasonal short-run fluctuation in soil moisture. He concluded that causes of denudation of natural vegetation include drought, wind, flood, bush, fire and over-grazing. It was concluded that under the stress of harsh environmental sequences, annual herbs are the only species that are able to survive because of their efficient utilization of the available soil surface water moisture, and the fact that annuals usually mature and shed their seeds well ahead before the incidence of soil moisture stress and seasonal fires out-break. This explained that shrinkage of rangelands due to expansion of oil infrastructure in one of key grazing areas has led to intensive grazing on the remaining rangelands.

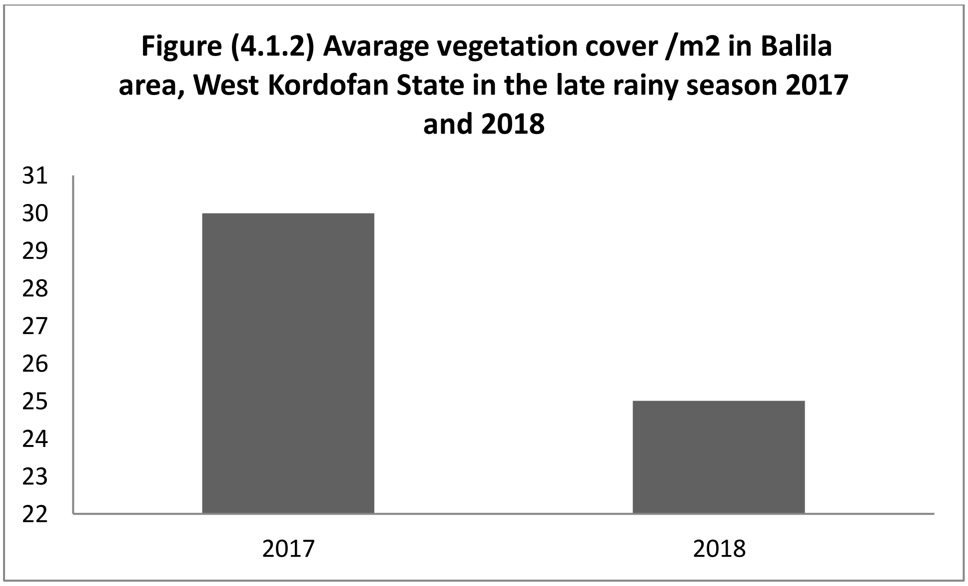
In 2017 and 2018 table (4.1.1) *Aristida adscensionis* showed the highest relative frequency 72% and78% respectively, while *Digitaria adscendens* showed the second highest relative frequency in season 2017 with 64% and declined to record the third highest in season 2018 with 50%. *Eragrostis tremulla* stands as the third percentage in the relative frequency 63.5% in season 2017 and increase to be the second highest relative frequency percentage 77% in 2018. While the fourth highest relative frequency in 2017 was *Pennisetum pedicellatum 28.5%* and increased in 2018 to be 44%., (tables 4.1.2 and 4.1.3).The fluctuations of the relative frequency of the different species may reflect the changes of species compositions that took place as a result of the intensive grazing which happened in the area as a result of early grazing and high stocking rates of livestock per unit area which may lead disturbance of dynamic of rangeland system due to disturbance of use balance of oil operations. Elnour (2001) stated that livestock grazing negatively affects the plants communities, then it’s not grazed in right time. He also mentioned that early livestock grazing consumes the plants in earlier stages before seed setting and tends to reduce the forage production. Grazing removes the biomass aboveground production if maintained at high intensity for sufficiently long period grazing can lead to, shifts in species composition or volatilization loss of soil nutrients (Steve and Chris, 2000). It also may be due to trees cutting that happened to the area as a result of oil explorations. This agreed with (Dregne and Chou, 1992) whom stated that, overgrazing and wood cutting by all measures is the principle cause of range degradation.

Table (4.1.2) Relative species frequency at Balila area,West Kordofan State for the two seasons 2017 and 2018

No.	Local name	Habit	Scientific name	2017	2018
1	Um aag	annual	*Digitaria adscendens*	64.0	50.0
2	Bano	annual	*Eragrostis tremula*	63.5	77
3	Gaw	perennial	*Aristida adscensionis*	72	78
4	Defra	annual	*Echinocloa colonum*	9	0
5	Hasskaneet naeem	perennial	*Cenchrus biflorus*	0.5	4
6	Sheleny	annual	*Zornia glochidiata*	20.8	2
7	Danab Elkaleb	annual	*Cynosurus echinatus*	4.5	0
8	Areg Elnar	annual	*Tormentilla officinalis*	17	0
9	Umhemaro	perennial	*Aristida mutabilis*	15.5	54
10	Um Dfufu	annual	*Pennisetum pedicellatum*	28.5	44
11	Um Fesifesa	annual	*Fimbrirtlis dychotoma*	15.5	0
12	Abu Asabea	annual	*Dacteloctenium aegeptium*	7.5	0
13	Dresa	annual	*Tribulus terrestris*	3	0
14	Lasag	perennial	*Forsskaolea tenacissima*	0	13

Table (4.1.3) The four dominant plant species for the two seasons (2017, 2018).

Order	2017	2018
1	*Aristida adscensionis*	*Aristida adscensionis*
2	*Digitaria adscendens*	*Eragrostis tremulla*
3	*Eragrostis tremula*	*Aristida mutabilis*
4	*Pennisetum pedicellatum*	*Digitaria adscendens*



In 2017 the average vegetation cover was 30%, while it was 25% in 2018 (Figure 4.1.2).The reduction of vegetation cover from 30% in 2017 to 25% in 2018 indicated that vegetation cover more deteriorated after coming of oil exploration usually occur due to seasonal variation . Dregne and Chou (1992) stated that, over grazing is responsible for most of the desertification of rangelands. Cutting woody species for forage, fuel, charcoal production, or construction materials is the other major cause of rangeland deterioration.

Table (4.1.4): Average herbage productin Ton/ha at Balila area, West Kordofan State in the rainy seasons.

Season	Ton/ha
2017	2.045
2018	0.7034

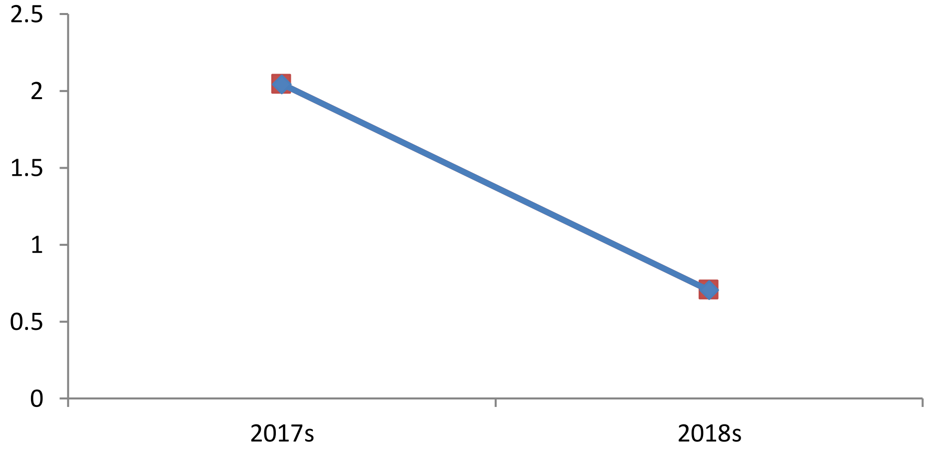


Figure (4.1.3) Avarage herbage biomass production Ton/ha at Balila area, West Kordofan State in rainy season.

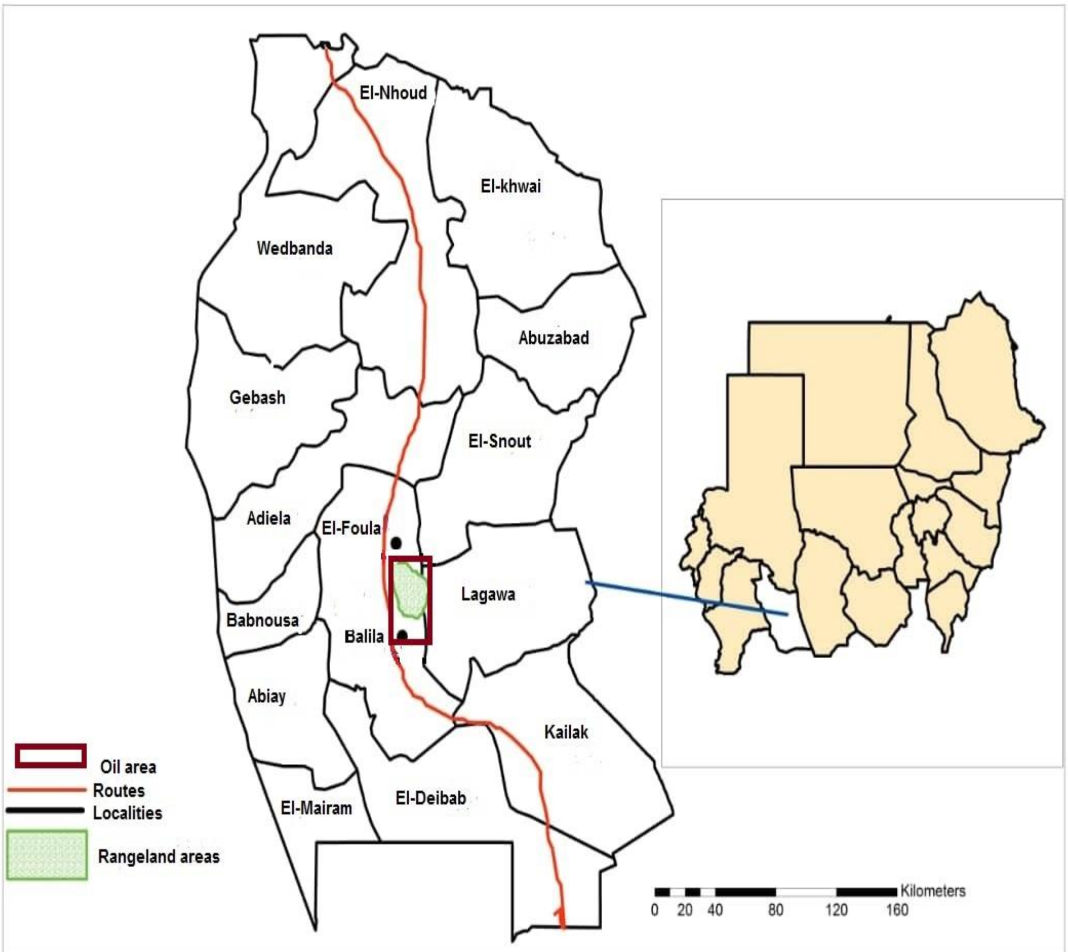
In 2017 the herbage biomass production showed 2.045 Ton/ha, and 0.7034 Ton/ha in 2018.The reduction and the high variability in herbage biomass production may occurred due to rainfall variety. However, on the hard disturbed animal movement due to activities of oil explorations may cause variability in herbage biomass production only which need to be considered in resources assessment operations in the area (table 4.2.6) and (Figure 4.2.3). Similar observations were reported by Suliman (1985) he mentioned that, in the base line survey of Kordofan and Darfur, the production and long term productivity of the herbaceous biomass have been consciously and constantly decreasing due to over used and environmental stress.

The extent of yield depression varies considerably according to the environment and characteristics of the vegetation. For example in Xinjiang (northwest China) the grazing considered in balance with livestock population until the mid – 1970s, during the 1980s productivity was reported to have decreased by about 3% as livestock population become high, with the decline in grass yield in some areas reported to 50% to 60% (FAO, 2000). Similarly in Balochitan (Pakistan), yield under excessive animal grazing have been estimated to be less than 30% of their products unit (Van Gils and Shabbir, 1992). The decrease may be also associated with decrease in soil seed bank due to early grazing resulted from shrinkage of grazing area Accumulating decrease in range productively will lead to decrease in soil seed bank and hence decrease in carrying capacity.

4.2 Livestock grazing pattern:

Grazing pattern is the way how livestock is herded. According to the discussion with the targeted groups, they stated that, their animals move between rainy season and summer grazing areas north- North- South as a best and environment friendly way of using grazing lands resources. They confirmed existence of infringement in the grazing areas and livestock routes by farmers and petroleum industry. Information obtained also showed that key traditional grazing areas including *Momo* camping area which is considered as one of the most important grazing areas, were closed with agricultural projects. *Um Marfain* summer camping is one of the most important camps for animals in the area and has now become the Heglig oil field. Map (4.2.1) shows how the main traditionally used live stock route is blocked by the oil industry area which enforced herders to and to camp at areas not to be used for these purposes before.

Based on these results agricultural expansion and oil have greatly impacted the livestock movement pattern which as explained have altered directions and duration that animal spent at specific time and at specific sites. This also has its impacts on rangelands productivity, seed bank and consequently soil organic matter. Surveyed groups stated that they move for (5-6) hours without stopping, due to the transformation of the rainy camps into farms, Agricultural expansion after the entry of petroleum became at the expense of rangeland areas, especially after the use of machinery in agriculture. Some pastoralists reduced the number of their animals and turned to farming.



(Sources: Kawthar, 2021)

Map (4.1.1) livestock routes in West Kordofan state

4.3 The Impacts of Oil exploration and production on Pastoralism at Balila area, West Kordofan State:

Human activities introduce them in large quantities into various ecological divisions. This reduces the ability of the environment to enhance life as human, animal and plant health becomes threatened. As a result of the presence of petroleum activities in the region, some changes have occurred in the region, and the overlapping local communities in the region have some opinions that lead to reforming them and avoiding some effects.

To answer this study to explore the use of independent data to answer the main questions raised by rural communities about the economic and social impact of rangelands in the petroleum area.

36.7% of the respondents were between the ages of (30-45) years, while (25.9%) were (45-55) years of age. The number of males sampled was higher (64%) as men are more willing to participate than women (Table 4.2.5). Results also indicated low human capital development in Balila area because the majority of the respondent (74.9%) had no regular education. This high rate of illiteracy may be attributed to unavailability of schools and lack of interest of many families to educate their sons. Social-economic aspect describes them as related to their activities and group pastoralism in the area. According to Table (4.2.5) herding constitutes the main occupation for almost 70.5% of the respondents whereas agro-pastoralists constituted about 23.0%. New jobs have appeared in the area such as casual labors working in the Oil Company and petty trade. Livestock selling constitute the main source of income (79.9%). In order to increase their purchasing power some herders liquidate some of their livestock resulting in reduce of herd number. Further, 14.4% of respondents agreed that selling agricultural crops such as watermelon and okra have greatly contributed to households' subsistence.

Table (4.2.6) shows the perception of respondents towards change in soil and plant due TO oil exploration and production. About 82.7% of respondents confirmed that their soil has been degraded. About 79.1% of respondents confirmed decrease in grassland production, whereas 70.5% agreed that there was reduction in crop production in farmlands. Pollution of grasslands and farms is a well-known phenomenon (Ekekwe, 1981). The flow of oil over large areas of rangeland has had the effect of reducing and changing its flora (Wyszkowski and Ziolkowska, 2008).

The obtained results could be explained by the fact that oil reduces the soil fertility such that most of the essential nutrients are no longer available for plant and crop production. Oil spills has adverse effects on nutrient level and fertility status of the soil (Abii and Nwosu, 2009). (Abosede, 2013) reported that oil pollution might affect soil physical properties. Pore space might be blocked which could reduce soil aeration and water infiltration and subsequently affect plant growth. Oil exploration and development at Balila area adversely affected the pastoral communities' livelihood by reducing the availability of pastures and hereby resulting in reduction in herds' number and increase of morbidity and mortality of livestock.

The adverse effects of oil activities on the environment arise from oil leakages, gas flaring and the escape of other chemicals used in the process. According to discussions groups local inhabitants have noticed the presence of chemical and chemical containers buried in the soil. Oil spills render the soil toxic and unproductive. Spilled oil which is denser than water reduces and restricts permeability: organic hydrocarbons which fill the soil pores expel water and air, thus depriving the plant roots the much-needed water and air (Brain, 1979). Adam *et al*., 2002; and Clark, 2003 confirmed the adverse effects of oil on soil characteristic and vegetation cover.

Accordingly, a necessity arises for the adoption of remediation technique to restore contaminated soil. The companies (Petro energy) involved in oil production at Balila area treat the contaminated soil with cow droppings to break down pollutants. (Kelechi, *et al*. 2008), reported that the addition of cow dung to oil contaminated soil make such contaminated soils useful for agricultural activities and improve growth performance of the plants.

Destruction and disappearance of some forest tree species was observed by majority of respondents (89.9%). noticed some changes in forests trees of the area. 23.2% of respondents confirmed disappearance of certain tree species such as *Albizia amara,* whereas 72.8% confirmed absence of natural regeneration. Forest destruction results from illegal tree cutting.

Percentages distribution of respondents according to the impact of oil exploration and production on water resources in Balila area was given in Table (4.2.7). A total of 89.2% of respondents agreed that wells and hafirs are the main water sources for humans and animals in Balila area. Moreover, about 79.9% of respondents noticed an increase in the number of water points since the beginning of the oil activities in the area.

Water availability might be considered as a positive contribution of oil activities to local communities. The oil company drilled more than 80 water wells in the area (Petro- Energy Company 2016). Moreover, the construction points dug by the company to obtain earth for road network construction served as additional water points.

According to (Pantuliano *et. al*., 2009) Pastoralists believe that the oil industry has contaminated water supplies and pastures, and say that their cattle are suffering as a result, especially in fertility. Table (4.2.7). Showed also, that about 47.5% of respondents confirmed change in the quality of the water. Further, 86.1% of respondents confirmed contamination of both surface and underground water as a result of oil activities. When oil spills occur it seeps into the ground and becomes mixed in the underground water system.

It has been found that polluted underground water no doubt takes many years before it can be remedied. Yet this underground water moves into streams and wells which are the only sources of local water supply in the community which results in the rise of water-borne diseases ((Kuch and Bavumiragira, 2019)

The drilling process is known for contaminating drinking water sources with chemicals that lead to some types of diseases such as cancer, birth defects and liver damage. During drilling operations, the seepage of effluent water to the surrounding areas is a major source of pollution. .Oil activities in pastoral areas altered the natural drainage system due to road construction against the normal cantor.

This on one hand leads to drying up of some seasonal water bodies and on the other hand accumulation of some petroleum materials on the sides of roads lead to death of trees and reduced cultivable land. Hence, rangeland farmland, forests and wildlife habitat were miserably affected (khaleel and Ahmed, 2014).

The perception of respondents towards the effects of oil industry activity on public health in Balila area was given in Table (4.10) About 86.4% of respondents confirmed appearance of some diseases as a result of oil activities and a total of 94.2% noticed increase in the number of patients while 89.9% of respondents confirmed increase in death rate in the community. Further, 97.1% of respondents confirmed appearance of unfamiliar diseases such as cancer, kidney failure, and skin irritation diseases.

Chemicals used and derived wastes in oil exploration and production operations proved to be highly harmful to human health (Maria, *et al*. 2017). Local inhabitants who live around Balila oil fields relate the emergence of such strange diseases and other serious conditions in themselves and their children to the activities of the oil industry. People who reside near oil exploration activities may be exposed to toxins from gas flares or oil spill and hence increasing the risk of developing certain types of cancer (Pauline, *et. al*.2019). Similarly, (Atubi, 2015), reported that in Nigeria, people living around oil fields agreed that they were vulnerable to health hazards.92.1% of respondents noticed the presence of fertility problems since the arrival of the oil industry in the area. (Atubi, 2015) who worked in Delta State in Nigeria reported that because of oil operations the release of toxic materials and disposal of industrial wastes may affect the fertility of the inhabitants in such away the fecundity fall and the birth of abnormal babies may increase. Rubbish pits dug by the operating company for disposing domestic and industrial wastes, such as empty chemical containers, are not properly managed. During rains these oil- derived wastes seep into the ground and become mixed with underground water or they are washed by runoffs into other water points leading to contamination of water resources. Some of the empty chemical-containers escape from the industry into the villages where they are used for storing drinking water. These containers could be a major source of water pollution.

Table (4.2.8) shows he impacts of oil activities in Balila area on animals. The majority of respondents agreed that there is decrease in livestock number; increase of diseases and increase in mortality rate among livestock (88.5%, 99.3% and 87.8% respectively) locals are convinced that oil activities have adversely affected rangeland, and that most livestock losses experienced in the last few years are due to water contamination and poor waste disposal. Polluted water is said to have become a threat to animal health with livestock numbers decreasing steadily since drilling began (Pantuliano *et. al*., 2009).

Table (4.2.5): Personal characteristic of respondents

Personal characteristics	Frequency	Percentage %
Age		
25-35	22	15.8
35-45	51	36.7
45-55	36	25.9
More than 55	30	21.6
sex		
Male	89	64
Female	50	36
Education		
Illiterate	104	74.9
Primary/Basic	31	22.3
Secondary	4	2.8
Occupation		
Herder	98	705
Agro-pastoralist	32	23.0
Casual labor	6	4.3
Trade	3	2.2
Sources of income		
Livestock sales	111	79.9
Crop sales	20	14.4
Petty trade	8	5.7

Table (4.2.6): Impact of oil activities on soil and plant in Balila area.

Criteria	Frequency	Percentage (%)
Soil contamination		
Yes	115	82.7
No	24	17.3
Grassland production		
decreased	110	**79.1**
increased	12	8.6
No change	17	12.3
Causes of grassland decline		
Oil activities	97	69.8
Reduce of rangeland area	32	23
Low rainfall	10	7.2
Farmland production		
decreased	98	**70.5**
increased	41	29.5
Forest tree cover		
changed	125	**89.9**
No change	14	10.1
Causes of change		
Destruction of tree species	48	34.5
Absence of natural regeneration	91	65.5
Purposes for tree cutting		
charcoal	52	**37.4**
Road construction	38	27.4
building	31	22.3
Oil pipe route	18	12.9

Table (4.2.7): Impact of oil activities on water sources in Balila area

Criteria	Frequency	Percentage (%)
Water sources		
Hafir	9	6.5
Wells	77	55.4
Rahad	3	2.2
Hafir and wells	38	27.3
Hafir, wells and Rahad	12	8.6
Water points:		
Increased	111	79.9
Decreased	15	10.8
No change	13	9.4
Water quality		
Changed	73	52.5
No change	66	47.5
Causes of water contamination		
Oil industry wastes	86	61.9
Oil spill	22	15.8
Use of the industry containers	31	22.3

Table (4.2.8): Impact of oil exploration and development on human health in Balila area

Criteria	**Frequency**	**Percentage (%)**
human diseases		
Increased	131	**94.2**
No change	8	5.8
Appearance of new diseases		
Yes	135	**97.1**
No	4	2.9
New diseases		
Cancer	42	31.1
Kidney failure	36	25.9
Skin irritation	34	24.5
Miscarriage	27	19.5
Appearance of fertility problems		
Yes	128	92.1
No	11	7.9
Human death rate		
Increased	125	**89.9**
No change	14	10.1

Table (4.2.9): Impacts of oil activities on animal in Balila area

Criteria	**Frequency**	**Percentage (%)**
livestock numbers		
declined	123	**88.5**
increased	16	11.5
Increase in livestock disease		
Yes	138	**99.3**
No	1	0.7
Mortality rate among livestock		
Increased	122	**87.8**
Decreased	17	12.2
Causes of morbidity and mortality		
Contaminated water	30	21.6
Oil derived wastes	9	6.5
Unknown	100	**71.9**
Wildlife		
Decreased	129	**92.8**
Increased	10	7.2

According to the discussion groups, their animals moving between north and south due to summer animal camping in the south and rainy camping in the north, there is a clear infringement on the camping areas and animal roads by farmers and petroleum.

Momo camping is considered one of the most important in the area and it was closed with agricultural projects, *Hamama* camping due to the gathering of the villages of (*El-Firdus, Elhegirat and Shag elneem*) because of the oil. Um Marfain summer camping is one of the most important camps for animals in the area and has now become the Heglig oil field.

Agricultural expansion and oil change the animal pattern, as it moves for a distance of (5-6) hours without stopping, due to the transformation of the rainy camps into farms, and they remain in the rainy camps for (2-3) months if there is additional fodder instead of (4-5), 6 months in summer camp, animals wandering the rest of the year, wandering depends on the availability of water and food. Agricultural expansion after the entry of petroleum became at the expense of land range, especially after the use of machinery in agriculture. Some pastoralist reduced the number of their animals and turned to farming.

4.3 Chemical analysis measurements of water and soil samples: Heavy metals are among the most investigated environmental pollutants. Almost any heavy metal and metalloid may be potentially toxic to biota depending upon the dose and duration of exposure. Many elements are classified into the category of heavy metals, but some are relevant in the environmental context (Barakat, 2011; Ali *et al.,* 2019).

4.3.1 Water sample analysis:

Contamination of water resources by heavy metals is a critical environmental issue which adversely affects plants, animals, and human health (Rezania *et al.,* 2016).

Water quality usually has its impact on pastoralists and rangelands of been polluted. The result in Table (4.12) using ICP analysis of drinking water for ground water indicated that, Na^{+} El-Firdaus water (6.50001mg/l) and Elshaq water (6.504 mg/l) compared with standard water (0.0018 mg/l), which is in the standard level, value water Mg^{+2} El-Firdaus (1.426 mg/l) and Elshaq (5.115 mg/l) compared with standard water (0.034 mg/l), according to a comparison with (SSMO) and (WHO), less than 30 the permissible limits.

While value water Ca^{+2} El-Firdaus (9.515 mg/l) and Elshaq (14.993 mg/l) compared with standard water (0.008 mg/l), according to a comparison with (SSMO) and (WHO), the value is less than 75 within the permissible limits, value water V^{+} El-Firdaus and Elshaq (0.104 mg/l) compared with standard water (0.1 mg/l), Fe^{+2} El-Firduas (0.11 mg/l) and Elshaq (0.131 mg/l), Ni El-Firdaus (0.11 mg/l) and Elshaq (0.108 mg/l), Cu^{+2} El-Firdaus and Elshaq (0.025 mg/l) compared with standard water (0.022 mg/l), according to a comparison with (SSMO) and (WHO), the value is less than 1.5 or 2 within the permissible limits.

As El-Firdaus value water (0.178 mg/l) and Elshaq (0.165 mg/l) compared with standard water (0.17 mg/l), Al^{+3} El-Firdaus (0.067 mg/l) and Elshaq (0.092 mg/l), Pb El-Firdaus (0.235 mg/l) and Elshaq (0.243 mg/l) compared with standard water (0.212 mg/l), base on the results all parameters were within the permissible limit of WHO and SSMO standards for drinking water.

The ground water contains high concentrations of Calcium compared to WHO and SSMO standards. Drinking water samples from groundwater for all the selected sites in the study areas have a high concentration of sodium, which is higher than the permissible limit recommended by the WHO (2011). This corresponds to (Jones and Kissker, 2015).

The resulting improper drainage of water into soil or surface water bodies can lead to very high levels of salinity that impede plant growth.

Table (4.3.10) ICP analysis of drinking water of Balila area (ground water).

Sample	**Na mg/l**	**Mg mg/l**	**Ca mg/l**	**V mg/l**	**Fe mg/l**	**Ni mg/l**	**Cu mg/l**	**As mg/l**	**Al mg/l**	**Pb mg/l**
D.W	**0.0018**	**0.034**	**0.008**	**0.1**	**0.102**	**0.105**	**0.022**	**0.17**	**0.047**	**0.212**
El-Firdaus	6.5001	1.426	9.515	0.104	0.11	0.11	0.025	0.178	0.067	0.235
ElShaq	6.504	5.115	14.993	0.104	0.131	0.108	0.025	0.165	0.092	0.243

- D.W : Drinking water

The result in Table (4.3.10) using ICP analysis for surface water (hafir) showed that , Al^{3+} samples North (20km), North (30km), center , East (10 km) and East (8km) were found to be (1.238, 5.837, 1.164, 6.84 and 8.458 mg/L) respectively have the highest concentrations of lead (1.10 mg/L) while others are less than 1, but even their results are higher than the permissible limit (0.01-0.05mg/L) of WHO 1983 and 1999 guidelines. WHO 1983 reported lead concentration 0.05 mg/L and WHO (1999) referred lead should be not more than 0.01 mg/L. Sudanese Standard and Meteorology Organization (SSMO) showed that the maximum permissible limit for lead is 0.007 mg/L for drinking water. Drinking water free of lead can be considered good since lead is poisonous. Pb^{2+} ion concentration was detected in all samples; these values are within the level compared with WHO guidelines. WHO (1983) considered drinking water containing lead at desirable level 0.5 mg/L, and the maximum permissible level 15 mg/L.

The results indicated that the elements present in surface water are higher than in groundwater, and this may be attributed to runoff and geological formation. The ground and surface waters of the area still maintain the permissible level for human and animal use. but more use lead will have its negative impact on human and vegetation.

Table (4.3.11) ICP analysis of surface water of Balila area (Hafir water).

Sample	Na mg/l	Mg mg/l	Ca mg/l	V mg/l	Fe mg/l	Ni mg/l	Cu mg/l	As mg/l	Al mg/l	Pb mg/l
D.W	**0.0018**	**0.034**	**0.008**	**0.1**	**0.1.02**	**0.105**	**0.022**	**0.17**	**0.047**	**0.212**
North (20km)	**3.105**	**2.129**	**5.713**	0.107	0.559	0.119	0.028	0.164	1.238	0.242
North (30km)	**1.117**	**2.293**	**17.573**	0.112	2.054	0.112	0.029	0.206	**5.837**	0.237
East (8km)	**3.937**	**2.314**	**5.621**	0.113	2.407	0.118	0.03	0.18	**8.458**	0.25
East (10 km)	**4.628**	**3.66**	**4.269**	0.115	3.532	0.116	0.031	0.167	**6.84**	0.257
South (10 km)	**7.514**	**4.107**	**10.035**	0.107	0.157	0.124	0.03	0.158	0.34	0.25
Center	**8.17**	**0.878**	**5.531**	0.107	0.363	0.11	0.026	0.168	1.164	0.236

D.W : Drinking water standard; **mg/l**: milligram per liter, **Na**: Sodium; **Mg**: Magnesium; **Ca**: Calcium; V: Vanadium; **Fe**: Ferrum; **Ni**: Nickel; **Cu:** Cupper; **As**: Arsenic; **Al**: Aluminum; **Pb**: Lead

4.3.2 Soil sample analysis:

The result in Table (4.2.12) for soil analysis indicated that, (Fe) showed a high presence in all sites, which is attributed to the fact that the Balila area soil is mostly Fe. Showed that it presence of (Cd) Cadmium in the area is less than (‹0.0100 Ppm), considered that the area not contaminated with this element and the quality of high quantities affects and is considered environmental pollution.

Copper (Cu) appeared higher in the southern (14.40 Ppm) and eastern (13.60 Ppm) sites of the area, and in smaller quantities in the middle (10.80 Ppm).

Nickel (Ni) in the area is less than (‹0.0600 Ppm) for all sites in area. Lead (Pb) is present in very large quantities in the Northern site of the area (287.8 Ppm), which poses a danger to the site and is considered one of the pollutants in the area. During the inhalation or swallowing process, lead causes particles of it or they are absorbed through the skin. The risk of lead poisoning is high when a person is exposed to lead over a long period of time.

Lead affects the production of red blood cells and may damage the brain, kidneys, or other organs in the body (Sanders *et al.*, 2010). Most victims of Lead poisoning also suffer from fatigue, headache, or muscle spasms in the stomach. Lead in the bones is released into the blood during pregnancy and becomes a source of exposure for the developing fetus.

There is no level of Lead exposure known to be without harmful effects. (WHO, 2020). Exposure of pregnant women to high levels of Lead can lead to miscarriage, premature labor and low birth weight, and this is consistent with (Amadi *et al.*, 2017). As an impact on pastoralist as they use Hafirs and wells.

Table (4.3.12) Analysis of soil of Balila area,West Kordofan

Elements	**Test methods**	**Unit**	**North**	**South**	**East**	**West**	**Center**
Fe	AAS	Wt%	**1.593**	**1.369**	**1.390**	**1.432**	**1.287**
Cd		Ppm	‹0.0100	‹0.0100	‹0.0100	‹0.0100	‹0.0100
Cu			**12.00**	**14.40**	**13.60**	**11.70**	**10.80**
Ni			‹0.0600	‹0.0600	‹0.0600	‹0.0600	‹0.0600
Pb			**287.8**	‹0.1800	‹0.1800	‹0.1800	‹0.1800

Fe: Ferru; **Cd**: Cadmium; **Cu**: Cupper; **Ni**: Nickel; **Pb**: Lead; **AAS**: Atomic Absorption Spectrometry . Ppm: Parts per million

CHAPTETR FIVE

5. CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

The following conclusions of the study are:

- The increase of bare soil percentage from 43.5% in season 2017 to 55.7% in season 2018.
- The decline in plant species from 53.3% in the 2017 season to 25.8% in the 2018 season.
- The high number of annuals in comparison with perennials.
- The presence of fluctuations in the relative frequency of different species in species composition
- The reduction of vegetation covers from 30% in 2017 to 25% in 2018.
- The nomads enter the area with their animals before the plants reach full maturity.
- The area of rangeland reduced because of oil activities in the area.
- The ground water contains high concentrations of Calcium compared to WHO and SSMO standards.
- Drinking water samples from groundwater for all the selected sites in the study areas have a high concentration of sodium, which is higher than the permissible limit recommended by the WHO (2011).
- The results indicated that the elements present in surface water are higher than in groundwater.
- (Fe) It showed a high presence in all sites.
- Lead (Pb) is present in very large quantities in the Northern site of the area (287.8 Ppm).

- It is showed that there was high rate of miscarriages, premature birth and low birth weight.
- The results also indicated a decrease in human capital development in the Balila area (74.9%).
- Herding constituted the main occupation for approximately (70.5%) of respondents while agricultural pastoralists constituted about (23.0%). New jobs have sprung up in the region, such as casual labor in the Oil and Small Trade Company.
- Selling livestock constitutes the main source of income.
- Agricultural expansion and oil exploration greatly affected the movement pattern of livestock which, it has been shown, has changed directions and how long the animal spends at a specific time and at specific locations.
- Respondents emphasized that there is a change in soil and vegetation due to oil exploration and production. And degradation of the soil. Decrease in grassland production and reduced crop production on farmland.
- The respondents confirmed the clear infringement on rangeland and animal routs by farmers and the petroleum industry.
- Oil exploration and development in the Balila area negatively affected the livelihood of pastoral communities by reducing the availability of pastures, which led to a decrease in the number of herds and an increase in morbidity and livestock mortality.
- The adverse effects of oil activities on the environment arise from oil leakages, gas flaring and the escape of other chemicals used in the process. According to groups discussions local inhabitants have noticed the presence of chemical and chemical containers buried in the soil.

- The destruction and disappearance of some forest tree species was observed by the majority of respondents and some changes in tree forests in the area.
- The wells and hafirs are the main water sources for humans and animals in Balila area.
- The emergence of some diseases as a result of oil activities. The respondents noticed an increase in the number of patients, while they emphasized the high death rate in the community. And the emergence of uncommon diseases such as cancer, kidney failure and skin irritation diseases.
- Impacts of oil activities in Balila area on animals. The majority of respondents agreed that there is decrease in livestock number; increase of diseases and increase in mortality rate among livestock.
- Oil activities have negatively affected rangeland, and most of the livestock losses that occurred in the past few years are caused by water pollution and poor waste disposal.
- The discussion groups emphasized that fertility problems appeared clearly in the lack of fertility and the frequent abortions.
- Information obtained also showed that traditional key grazing areas including *Momo* camping area is considered one of the most important grazing area, were closed with agricultural projects, *Hamama* camping due to the gathering of the villages of (*El-Firdus*, *Elhegirat and Shag elneem*) because of the oil.
- *Um Marfain* summer camping is one of the most important camps for animals in the area and has now become the *Heglig* oil field.
- The area of the oil industry that forced herders to go and camp in areas not used for these purposes before.

- Surveyed groups stated that they move for (5-6) hours without stopping, due to the transformation of the rainy camps into farms, and they remain in the rainy camps for (2-3) months if there is additional fodder instead of (4-5), 6 months in summer camp.
- Agricultural expansion after the entry of petroleum became at the expense of land range areas, especially after the use of machinery in agriculture. Some pastoralist reduced the number of their animals and turned to farming.
- Chemical containers are not disposed of properly, so they are used for household purposes.
- Increase in the number of water points since the start of oil activities in the area, water availability can be seen as a positive contribution to oil activities in local communities.

5.2 RECOMMENDATION

- To improve the soil properties cow manure should be added to oil-contaminated soil, this makes contaminated soil useful for agricultural activities and improves plant growth performance.
- The companies should establish annual seed propagation programs to ensure the sustainability of the range plants.
- Extensive studies should be done on the feasibility of establishing ranches in the area.
- Chemical containers should be disposed of properly. In order not to be used for household purposes.
- Intensification of extension campaigns in the area to educate citizens about the dangers of using oil waste and its derivatives.
- Increasing the effectiveness of women's participation in activities in the area, for the importance of its role in the development of community.

- Establishing early warning centers to monitor health changes for humans, animals and plants in the area.
- A study to make a Map of land use to facilitate the process of development programs and strategic plans in the area.
- Establishing tanks to save water and prevent it from mixing with treated water.
- Through discussion groups, the exposure of pregnant women to miscarriage, premature labor and low birth weight has emerged, and there are studies that there is a relationship between Lead exposure and miscarriages and premature labor. Extensive studies must be conducted.

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Appendix

Questionnaire

(The Impacts of Oil exploration and production on Pastrolism at *Balila* area, West Kordofan State)

State: …………… Location: ……………………. Village: …………

Name: ……………………………………

Age: 25-34 ( ) 35-44 ( ) 45-54 ( ) More than 55 ( )

Educational level: Illiterate ( ) Khelwa ( ) primary ( ) Secondary ( )

University ( ) above university ( )

Soil related impacts:

- Did you notice a change in the soil after the emergence of oil in the area? Yes ( ) No ( )
- If yes, what is the change ....
- Did you notice a burial of waste oil in the area? Yes ( ) No ( )
- If yes, specify ....

Water related impacts:

- The type of water source in the point:
  Hafir ( ) wells ( ) Rhod ( ) others ( )
- Did you notice an increase or decrease in the places where water collects? Increase ( ) Decrease ( ) constant ( )
- If the answer is increase or decrease, specify the reason
  ....
  ....
- Have you noticed wrong practices in the direction of the water in the area? Yes ( ) No ( )

- If the answer is yes, then what are the practices?

  ....
  ....

  - If there are wrong practices with regard to water, do they have clear effects on humans, animals and plants in the area?

  Yes (   ) No (   )

- If the answer is yes, determine its effect on:

  Human: …………… Animal: ……………. Plant: ……………….
- - Is the hafir water? Increase ( ) Decrease ( ) constant ( )
- Determine the reason in the case of:

  Increase .... Decrease ....
- - Did you notice a leak in the oil pipelines in the area?

  Yes ( ) No ( )
- Did you notice any accumulation of oils or any petroleum substance in the waterways? Yes ( ) No ( )

Human Related Effects:

- Has the human disease rate increased? Yes ( ) No ( )
- Did diseases that did not exist before appeared? Yes ( ) No ( )
- Select what ………………………………………………………
- Did procreation problems appear? Yes ( ) No ( )
- Has the death rate increased? Yes ( ) No ( )
- with the determination of the cause of death ....
- Has there been a change in methods of livelihood? Yes ( ) No ( )
- If yes, specify what ....
- Did the emergence of oil lead to social problems? Yes ( ) No ( )
- If yes, specify the type of problem ....

  ....
- Have community development services improved? Yes ( ) No ( )

- If yes, specify what ....

  - Do you know that there are (active) laws that protect all parties their rights? Yes ( ) No ( )

  - If yes, specify what ………………………………………………

  - The main source of income:

  Livestock ( ) farming ( ) livestock- farming ( ) other ……

Effects related to vegetation:

- Have you noticed the presence of plants or trees covered with oils? Yes ( ) No ( )

- The intensity of the growth of plants or trees:

  Change ( ) Constant ( )

- Specify the type of change..
- Did you notice that there are trees cutting in the area?

  Yes ( ) No ( )
- If yes, specify the reason..
- The productivity of range from feed:

  Increased ( ) Decreased ( ) Constant ( )
- Density and appearance of some plants:

  Increased ( ) Decreased ( ) Constant ( )
- In case of increase or decrease, specify the reason.........................
- The type of plants:…………………………………………………
- Have you noticed the emergence or disappearance of new plants in the area? Yes ( ) No ( )
- The answer is yes, specify ……………………………………………

Effects related to animals

- Has the disease rate of animals increased recently in the area?

Yes (   ) No (   )

- Determine the type of disease ………………………………….
- Are there cases of poisoning or death to some animals?

Yes (   ) No (   )

- If yes, specify the cause of poisoning or death................................
- Reproduction rate of animals:

Increased (   ) Decreased (   )   Constant (   )

- Is there wildlife in the area? Yea (   ) No (   )
- If yes, mention the existing types …………………………………….
- The number of wildlife has increased or decreased .... the reason ……………………………..

Chemical containers in the collection sites in Petroluim area –West Kordofan

Chemical containers and their elemination method

Treated petroleum water and how to dispose of it


Ponds of treated water distributed in un-controled areas


Treated petroleum water covers rangeland


Chemical containers that are used for drinking water in the *Balila* area

Discussion group in *Balila* area-West Kordofan

Rangeland inventory measures at *Balila* area- West Kordofan

The method of water samples used from the hafir of Balila area-West Kordofan

Deep trenches have been dug around the waterways of the Balila oil field
(sources Elzahra Jadallah, 2020**)**