CHAPTER ONE

INTRODUCTION

1.1 Background

Rangelands are these areas of the world which by reasons of physical limitations such as low and erratic precipitation, rough topography, poor drainage, and high or cold temperatures - are unsuited to cultivation and which are a source of forage for free-roaming native and domestic animals, as well as a source of wood products, water and habitats of wildlife (Holechek *et al*, 1995). About half of the terrestrial land resource on the globe can be classified as range, (Holechek *et al*, 1995). In Sudan, about two thirds of the country is rangelands and forest lands. That indicates the importance of rangelands in Sudan since forests are partially used as source for grazing (both understory and overstory (Abusuwar, 2007).

Rangelands dominate these areas providing primary products of grasses, legumes, browse from shrubs and scattered trees associations in some depressed areas. Ecosystems of these rangelands are complex and dynamic, and interact with each other. For monitoring these ecosystems, decisions about where to measure to overcome the difficulty of patchy distribution of plant and soil components are important (Wright *et al*, 2003).

Rangeland in the Sudan is facing many problems that hinder their use and development. Most rangelands lay within fragile environment and facing frequent drought periods, seasonal bush fires, change in species composition, increasing pressure on the range resource especially around water points. In addition to expanding cultivation, destruction of local institutions and the gradual loss of the traditional knowledge, increase in animal population low off take, blockage of livestock migration routes and lack of local communities' participation in planning and implementation of range programs (Mustafa *et al*., 2000). For example, during autumn camping "*Makhraf*", at Eldebeibat area, 65% of the South Kordofan State's livestock concentrated at this area; the high numbers of animals concentrate in certain area could destroy the natural vegetation leads to overgrazing and hence deterioration of the pasture (Musa, 2001).

In the Sudan rangelands form an immense natural resource, occupy an area of 110 million hectares before country secession and provide about 86% of feed for livestock (Fadlalla and Ahmed, 1997). South Kordofan state has a wide area of rangeland, about 11,335,000 feddan, (4,760,700 ha) 15% of the Sudan rangelands. These rangelands give about 23.6% with total fodders produce from natural rangelands, (RPA, 2011). The rangelands in Sudan are varied from poor to rich according to the ecological zones, especially in South Kordofan State in western and central regions, including Nuba mountains area. (Bashir and El Tahir, 2006).

Developing countries with rapidly increasing human population, such as Sudan, have experienced large-scale increases in range livestock number; it's expected in next 25 years to increase further more, and more herders share a declining land base due to conversion of rangelands to croplands. This will place tremendous pressure on rangelands in these countries and necessitate major changes in grazing practices to prevent widespread rangeland degradation.

In Sudan over thousands years, grazing has been one of the major land use activities and continue to remain an important activity. Often grazing have been poorly managed and has lead to a large - scale soil loss. Currently, many rangelands show signs of either degradation or overgrazing; both conditions lead to reduced vegetation cover and water absorption in the soil. This in turn, leads to accelerated rangelands environmental degradation (Darrag *et al*, 1995).

As it is known that livestock form an important component of the agricultural sector, with production mainly based on traditional pastoral systems (90% of the livestock in the Sudan belong to the traditional pastoral production systems) (FAO, 2005).In the Sudan livestock are raised mainly by pastoral and agro-pastoral groups. (Darrag *et al*, 1995). Livestock raising in South Kordofan is practiced under two systems, the first one is villages – based adapted by the settled communities whereby livestock is kept throughout the year grazing near settlements. The second type is an open range seasonal grazing system followed by nomads and semi- nomads and livestock is driven to distant rangelands. The pastoralist nomads are increasingly responding in large by changing the nomadic way of life, through sedenterization in large areas in El Dilling locality. The concentration of people raises some problems like rangeland environment degradation in northern parts; particular that concentration resulted by insecurity situation in southern parts of State. Therefore traditional open grazing system implies excessive pressure on rangeland by animals and expansions of marginal farming which accelerate environmental degradation, (Abdallah.1982). Good management of rangeland resources requires many techniques of measurements and sampling used in range inventory and monitoring programs to determine the proper use of range resources. Because the inventory and monitoring are essential features of a range management process and plan, they can be as detailed as necessary to meet the objectives of the plan. (Holechek *et al,* 2004).

1.2 Problem Statement

Rangelands in South Kordofan State are suffering from the expansion of farming on rangelands and intensive use resulted from existence of the nomads for long-time in some areas because of the conflicts at the borders. According to Musa (2001) the high number of animals concentrated in some places during rainy season, causes overgrazing.

Livestock in El Dilling locality depend mainly on rangelands vegetation (herbaceous and woody species) and on crop residues as second animals' feeding source during dry seasons. These may be due to the availability of crop residues in the area of rangelands (Nefzaoui, 2002).

Livelihood in the area depends mainly on livestock raising and farming, these problems enforced large numbers of farmers and herders to migrate from their villages to search for water and fodder.

Very heavy grazing results in a decline in the number of species; changes in vegetation also have an impact on soil properties, including soil fauna. In addition to, concentrating a large number of animals in smaller grazing area that have recently received high intensity can cause soil compaction and decrease infiltration rates of water. (Howery and Sprinkle, 2006).

Generally apparent effects of these threats include loss of biodiversity, rapid deterioration in land cover and depletion of water availability through destruction of catchments; semi-arid areas are vulnerable to continuous degradation. Vegetation cover of these ecological zones has been changed qualitatively and quantitatively by many factors such as low rainfall, overstocking, improper agricultural practices, seasonal fire outbreaks, frequent droughts, wind and water erosion (Darag and Yousif, 1996). Continuous overgrazing, through shrubs removal and complete consumption of grasses and herbs especially before maturity, has resulted in an overall land degradation. The top soil surface is often covered and resistant to water infiltration, which may result in germination failure. The native vegetation is mostly composed of annual grasses and occasional shrubs plant sparsely scattered in the area and some annual broad leaves, while the perennial species had completely been eradicated, (Abusuwar and Mohammed, 2011).

The rangelands and forests resources in the southern parts of the South Kordofan State are constantly being reduced by uncontrolled fires, which destroy up to 60% of range annually and addition to insecurity situation, particularly in recent decade all of these factors forces the nomads to stay a long time in the northern parts of the State, thereby leading to deterioration of rangelands in these parts (UNDP, 2006).

The spatial patterns of plant distribution are the result of processes that operate on multiple scales, including topography, soil quality, availability of ground water and nutrients (Couteron and Lejeune, 2001), rainfall which differ in intensity, duration, and timing (Dörgeloh, 1999), plant distribution (Pacala and Silander, 1985), interactions among individuals (Cale *et al*., 1989, Alonso *et al*., 2002) and human activities (Levin and Paine, 1974). The patches of vegetation that result can be homogeneous, periodic, scattered, or bare ground, this variation need to be understood and used as a base for range management.

1.3 Objectives

1.3.1 The main Objective

The research aimed to study impact of site's characteristics on vegetation attributes under the rangelands management practicing and to suggest the suitable management for sustainable one.

1.3.2 Specific Objectives

1. To identify the sites' characteristics and its impact on the vegetation attributes.

2. To assess the herding practices in relation to rangelands sites' characteristics.

3. To evaluate the impact of rangelands management on the vegetation pattern using spatial and temporal variation of the sites.

1.4 Hypothesis

The rangelands sites in the study area have different sites' characteristics and the practicing management is not suitable therefore, a suggested different management prescriptions is needed.

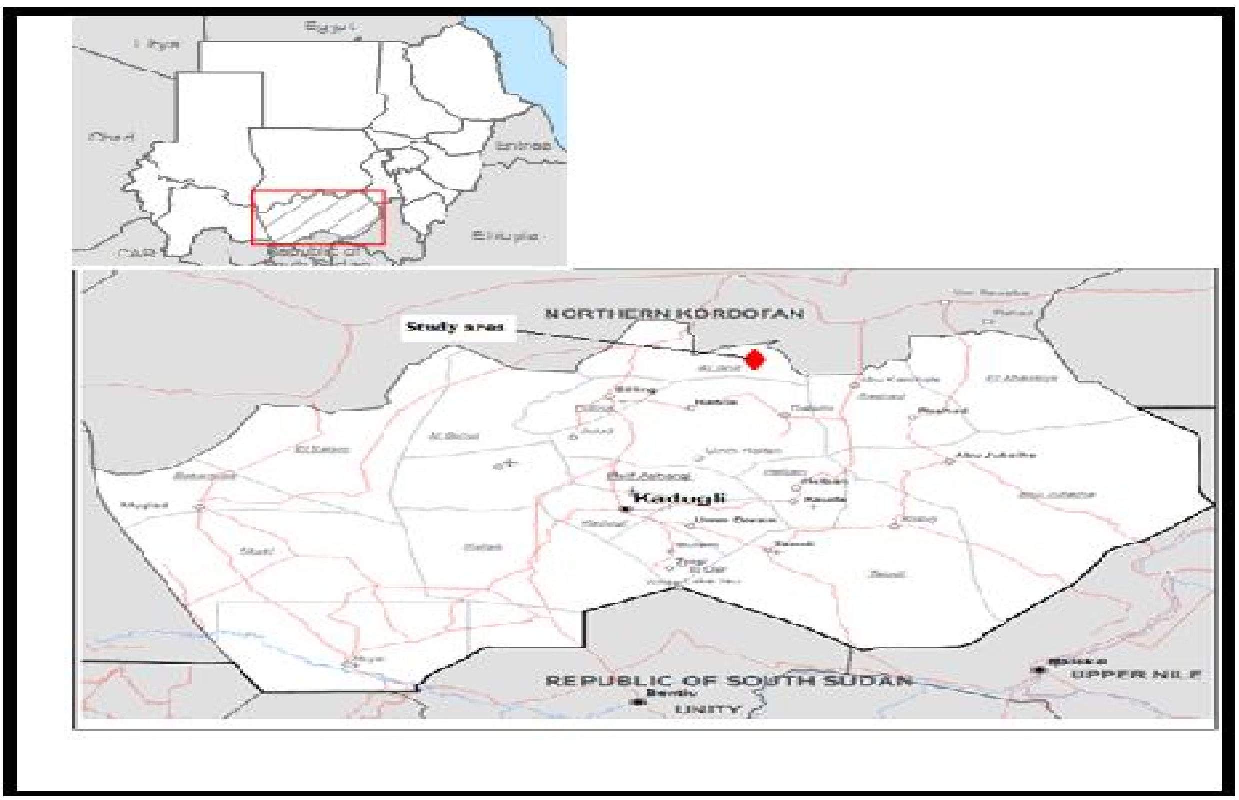
CHAPTER TWO

Study Area

2.1 Location

Eldebeibat area located in South Kordofan State at 380m above sea level, remote from capital of Sudan about 700km, Elobeid capital of North Kordofan State approximately 100km, El Dilling 60km and far from capital of State Kadugli about186km.The area lies between latitude 11° 45′ – 12° 49′ N and longitude 25º 29′ – 30° 0 E, it is about 5700Km^2 in area and constitute 7.3% of the total area of the South Kordofan State (Musa, 2001).

Figure (1.2) Map of Sudan and South Kordofan State illustrates the study area



Source: (OCHA, 2013)

2.2 Topography

Generally the topography of north parts of South Kordofan State is flat. A few areas close to El Dilling are a mixture of sand and clay. The topography of Eldebeibat is flat with sandy soil occupying most parts of the area. The nomads prefer using the north parts of the State particularly in rainy seasons, because these areas are suitable for livestock's movement, free from flies and rich by good plants species (IFAD, 2006).

Three main types of soil prevail in South Kordofan, namely:

A. Heavy cracking clay soils in small area close to El Dilling locality. (Finger area) These areas have a high potential for cultivation, as they are rich in minerals, but are difficult to work with traditional farming practices due to their hardness.

B. Gardud soils these are non-cracking clay soils, which are also fertile and have good moisture-holding capacity.

C. Qoz or Sandy soils **t**his type of soil characterizes most of the northern parts of South Kordofan, and it is also suitable for certain kinds of traditional agriculture and livestock staying during the rainy season (IFAD, 2006).

2.3 Water sources

Water sources in the area is mainly surface water which is collected in natural depressions "*Ruhud*" in the rainy season, this water is used for human and animal's consumption. The water is normally diminishes early in the dry season and before the next rainy season, for these reasons transhumant return early to southern parts of the State. "But in summer the sedentary depend on wells and water yards sometimes within villages or in other locations" (IFAD, 2006).

2.4 Climate

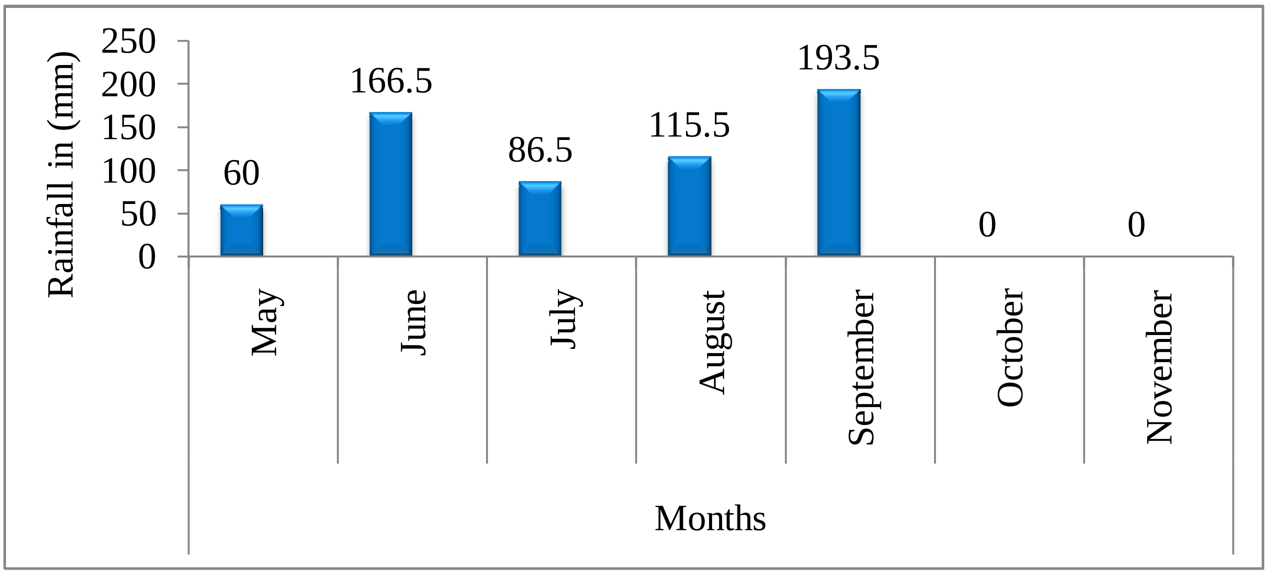
The climate of the study area is typical low rainfall savannah. The area is affected by the seasonal wind. The observed variations are attributed partly to the topographic nature of the Nuba mountains area and partly to the terrain and flood plain of the northern area. The climate is semi-humid in large parts of South Kordofan State (IFAD, 2006).

The distribution of average monthly maximum temperature is bimodal. Two peak values are observed to occur in April and October. They are about 39ºC in April and 34ºC in October. Maximum temperatures are low in the middle of the rainy season (about 32ºC in August) but they are lower in mid winter (about 30.5ºC in January) (IFAD, 2006).

Rainfall in the Basin of "*Abu habil*" area starts in April (about 5mm) and reaches 20 - 25 mm in May. It exceeds 90 mm in July, reaching 120 mm in some places, and attains the average maximum value in the range of 105 - 140 mm in August. The average maximum amount of rainfall in the Basin is received in August. It is about 140 mm in El Dilling. Rainfall tends to cease by the end of October or early November. The high amount of rainfall recorded in one day in July and in August was about 74% of the average total rainfall for the month. However, in June and September, the maximum amount showed considerably higher percentages but this was rather irrelevant because the amount of rainfall was very small, (IFAD, 2006).

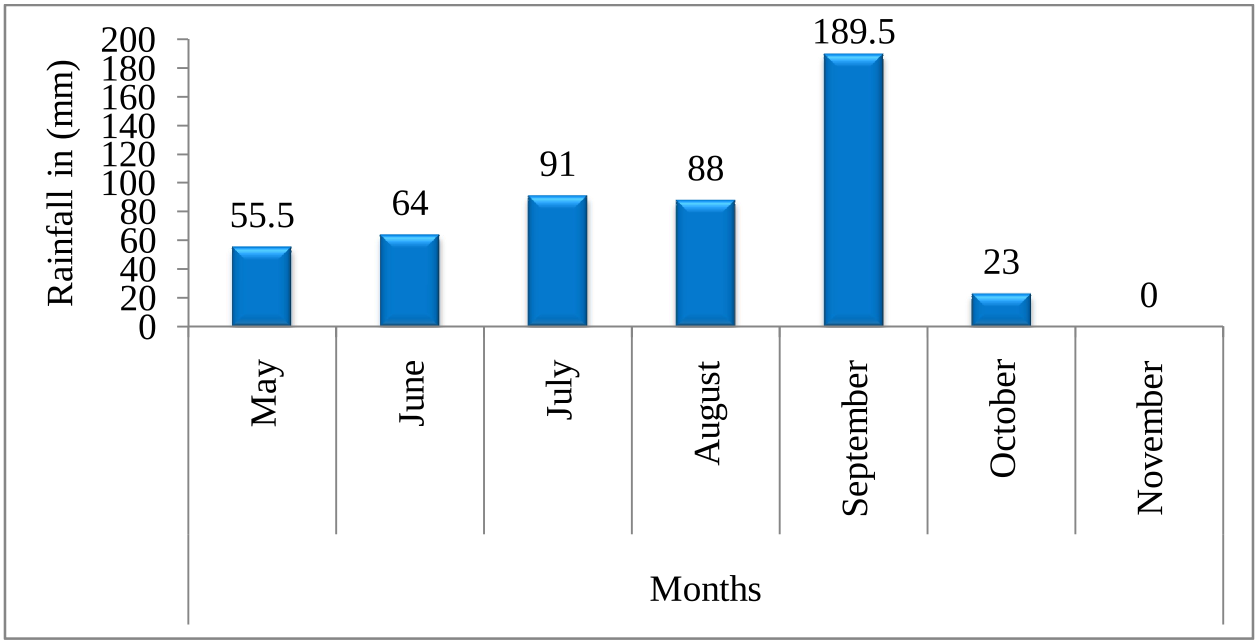
The rain fall in the study area had variation in the two rainy seasons 2013/2014 among months in the same year. The rain fall starting in May and increased gradually reaching its peak in September (Fig 2.2 and 2.3) (AMA, 2013 and 2014).

Figure (2.2) Average rainfall mms/month season (2013) at the study area



Source: Administration of Mechanized Agriculture in El Dilling locality (2015).

Fig (2.3) Average rainfall mms/month season (2014) at the study area



Source: Administration of Mechanized Agriculture in El Dilling locality (2015).

2.5 Vegetation cover in the study area

The study area lies within the North parts of the low rainfall savannah. The natural vegetation is a function of rainfall and soil types. The North parts lie in the low rainfall savannah, where natural vegetation varies south wards due to variation in the rainfall and soil type, (Anonymous, 1999). In the northern part the vegetation, consists of annual and perennial grasses, trees and shrubs.

The study area is characterized by relatively a sparse cover of trees and shrubs, but its southern parts is characterized by more thick cover of tall grasses, trees and shrubs. The dominant trees in the area are Higlig (*Balanites aegyptiaca)*, Siddr (*Ziziphus spina- christi*), Arad (*Albizzia amara),* Sarah (*Maeura crassifolia*), Talih (*Acacia seyal*) and Hashab (*Acacia senegal*) in addition to shrubs such as Kitter (*Acacia mellifera*), lout (*Acacia oerfota),*Korsan (*Boscia senegalensis*), Ushar (*Calotropis procera*) and

Kharoub (*Pilostigma reteculata)*. The understory is dominated by *Zornia glochidiata*, *Eragrostis spp*, *Digitaria spp, Dactyloctenium aegyptium, Cenchrus spp, Senna occidentalis, Senna obtusifolia, Chloris gayana, Ipomoea spp, Abutilon angulatum, Fimbristyls dichotomo, Commelina subulata*, *Cyperus rotundus, Corchorus olitorius, Abutilon spp, Schoenfeldia gracilis, Solanum dubium, Oldenlandia senegalensis, Sida cordofolia,Waltheria indica, Corchorus fasicularis, Echinochloa colona, Gegeria alata, Xanthium brasilicom, Setaria sphacelata, Setaria verticillata, Sesamum alatum, Acanthospermum hispidum,Brachiaria obtusiflora,Indegofera spp,Ipomea cordofana*, *Zaleya pentandara*,*Geogaria alata* and *Stylosanthus flavicanus* (Ibrahim,2009).

According to the census of 2008 the population of the area estimated as 22000 settled people in Eldebeibat area and 2000 families of nomads grazing the area in the rainy season.

85% of the resident population practice both agriculture and animals production. The number of farmers is estimated 57,000. 55% of the areas were cultivated by cash crops and 45% by food crops (Musa, 2001).

The area accommodates 65% of the State’s livestock during the rainy season (Musa, 2001). The high numbers of animals concentrate in this area due to presence of autumn camping area “Makhraf”.

CHAPTER THREE

LITERATURE REVIEW

3.1General

Many studies have shown that biotic environmental factors, such as topographic parameters, can be important sources of variation of plant diversity (Bennie *et al.*, 2006; Marini Lorenzo *et al.*, 2007). Grassland diversity is strongly affected by environmental factors; e.g. soil and topography (Cristofoli, 2010).

In order to understand the relationships between ecological elements of rangeland and improved principles of rangelands management, it is necessary to study plant species diversity (Marini Lorenzo *et al.*, 2007). Species diversity of plants can be divided into two main components: ‘richness’, which represents the number of species in a given area, and ‘evenness’, which represents the variability in species abundance (Magurran, 2006; Triin Reitalu *et al*., 2009). Species richness is considered as a prominent factor of productivity and stability (Cristofoli, 2010; X. Gonga *et al.*, 2008) and predominantly controlled by local factors, and only secondarily by factors operating at the landscape level (Wright *et al.*, 2003; Marini Lorenzo *et al.*, 2007).

Species diversity is regarded as one of the most central criteria in biodiversity assessments and in decisions about management priorities for grasslands. However, the majority of studies on the impact of landscape and environmental variables on plant species diversity in grasslands have focused on the assessment of species richness (Lindborg and Eriksson, 2004; Helm *et al.*, 2006; Cousins *et al.*, 2007; Oster *et al.*, 2007; Johansson *et al.*, 2008).On slopes, differences in species composition were explained by resource availability, especially water (Badano *et al.*, 2005; X. Gonga *et al.*, 2008). By monitoring long-term vegetation change, due to the edaphic factors, south-facing slopes maintained more stress-tolerant and light-demanding flora in British chalk grasslands (Bennie *et al.*, 2006; X. Gonga *et al.*, 2008). The difference of plant species composition and productivity, long-term operating soil weathering, and erosion processes are usually accelerated on south facing slopes (Rech *et al.*, 2001), resulting in different soil properties of north- and south directed slopes (Bochet and García-Fayos, 2004; X. Gonga *et al.*, 2008). Given this background, in order to assess the relevance of the environmental factors (soil properties and aspects) and species diversity, we surveyed vegetation parameters and soil characteristics of northern, eastern, southern and western slopes of Zagros mountainous rangelands (vegetation type: grass-shrub) under local management practices in 2009. We hypothesized that species diversity depended strongly not only on soil characteristics, but also on topography.

The rangeland all over the world is subjected to be intensively used due to increasing animal and human population, ecological changes and increase in human demands and over economical activities. These factors cause severe rangeland deterioration (Abdalla, 2008). The livestock; cattle, sheep and goats that owned by the nomads are the main consumers of rangeland plants vegetation and grazing are considered a natural influence on rangeland environment. Rangelands are grazed heavily by their animals since no rule to recognize grazing practices, which lead to rangeland deterioration. Grazing is not simply the removal of leaf material from grass plants. But the impacts of leaf material by grazing are complex. In this manner different grazing management treatment causes diverse change in plants growth, and these changes affect the quantity and quality of the aboveground biomass produced on rangelands. Grazing can change plant species composition, manipulate some plant and ecosystem processes, and alter levels and rates of plant growth. Repeated heavy grazing removes a great amount of the leaf area and causes long- term reductions in the total rangeland production (Manske, 2004). Livestock have a major impact on rangeland vegetation composition and stability of grassland, if over exploitation by grazing animals desired plants could change by other undesired plants species (Cordon, 2007). There is a need to understand the responds of plants to the intensity and frequency of livestock impacts in relation to rangeland environmental conditions and the animal factors, which affects not only the intensity and frequency of impact, but also the distribution of those impacts.

The impact of grazing by domestic stock on plant communities has received considerable attention. Very heavy grazing results in a decline in the number of species; changes in vegetation also have an impact on soil properties, including soil fauna. In addition, concentrating a large number of animals in smaller grazing land that have recently received high intensity can caused soil compaction and decrease infiltration rates of water from rainfall. Increased trail density around water points has been problematic in rangelands that have been partitioned around a central water point (Howery and Sprinkle, 2006).

Tate *et al*., (2004) found that soil compaction increased along a gradient from long-term grazing exclusion to long-term heavy cattle grazing intensity on oak savannah. Grazing has also changed the abundance and distribution of grasses. Many species are only affected by very heavy grazing and some species are sensitive to grazing over a rangeland (Lands berg *et al.*, 1997).

3.2 Rangelands

Rangelands are defined as the areas of the world which by reasons of physical limitations-low and erratic precipitation, rough topography, poor drainage, or cold temperatures- are unsuited for cultivation and which are a source of forage for free ranging native and domestic animals, as well as source of wood products, water and wildlife (Miller, 1997). Their historic climax vegetation was predominantly grasses, grass-like plants, forbs, or shrubs (Butler *et al.,* 2003). It account for about 70% of all land surface (Fuhlendorf and Engle, 2001 and Holechek, 2001). Rangeland supports different vegetation types including shrub lands such as deserts, steppes, temporarily treeless areas in forests, and whatever grows on land today, sandy, rocky, saline, or wet soils, and steep topography for commercial farm and timber crops (Grice *et al.,* 2008). Rangeland vegetation may be naturally stable or temporarily derived from other types of vegetation, especially following fire, timber harvest, brush clearing, or abandonment from cultivation (Heady and Child, 1994) and it managed, typically, for livestock production (Holechek *et al.,* 2004). In the Sudan rangelands form an immense natural resource, occupy an area of 110 million hectares and provide about 86% of feed for livestock (Fadlalla and Ahmed, 1997).

The terms range and rangeland have often been misused in the sense that they are often equated with livestock use and production alone. An important distinction is that range is a kind of land with many uses - it is not a land use. The multiple values of rangeland include forage for domestic and wild animals, water, wood fuels, and wildlife cover. There are many competing uses for rangelands - uses that are increasing with population growth, increasing urbanization and interests in preservation (Heady and Child, 1994).

Droughts are an intrinsic part of arid and semi - arid system (Müller, 2005). Because of the short growing periods (1-74 and 75-119 growing days, respectively) (Sidahmed, 199). The livelihood of a vast majority of people in these areas is earned by livestock farming (Müller, 2005). In the Sudan, the arid and semi-arid lands cover an area cover an area of 1.78 million km^2 (kilo equal 0.42 ha) which represents about 72% of the total area of the country (Sudan National Action Program, 2006).

Rangelands are wild forage-producing areas under native and/or annual grasses used, among other things, for livestock, wildlife and watershed maintenance. The rangeland-dominating arid and semi- arid areas provided primary products (grasses, legumes and shrubs) which were converted into animal protein. Use of the resources for other purposes, such as fuel and building materials, intensified with the increase in human population and with sedenterization. These rangelands maintained an ecological balance as a result of the natural defensive mechanisms typical of uncertain and high erratic climates. Seasonal fluctuations influence the concentration and mix of herbivores, and multi-year droughts reduce the number of animals (Sidahmed, 1996).

All through the world, rangelands are the major source of feed for both domestic and wild ruminant animals (FAO, 2000). Rangelands play a major role in supplying humans with animal's products in the all tropical region of world not covered by ice. Rangeland account for about 16% of World food production compared to 77% for crop land 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 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, 2000). Amore useful measure of importance of rangelands is the contribution they make to animal production. In some countries like Australia, one third of cattle and sheep population are supported by rangelands (Box and Perry, 1971). In United States, it has been estimated that 54% of the feed units consumed by beef cattle come from natural rangelands (Hodgoson, 1972) added to their feed. Rangelands are important resources in Africa, North and South Africa, Asia, Australia and many parts of Europe, rangelands effectively contributes to the economic well being of rural community, and they are valued as a source of plant and natural wildlife diversity (Maxwell, 1991).

The traditional grazing of livestock, mainly cattle and sheep is generally acceptable to the public if properly applied, using sound principles of range management. It produces food and fiber for people uses and enjoyment and contributes to economic (Tixier, 1991) stated that rangeland is habitat for wildlife as well as livestock which compete for forage and space to varying degrees.

Hunters and anglers, hiker, backpackers, equestrians, off road- vehicle users and many other enjoy the out of doors of rangelands, both public and private, just as used forest and parks. Rangelands are just important as and usually more accessible than those more popular areas (Tixier, 1991). Mineral production from rangelands economically important and with proper harmonization and provision for reclamation is a very compatible use (Tixier, 1991).

Fisher (1994) has discovered that deep- rooted grasses in the South America savannas are removing billions of tons of CO_2 from the Atmosphere, this countering the predictions of global warming, and many remove as much as 2 billion tons of carbon dioxide- greenhouse gas- from atmosphere yearly.

Green plants are small factories that use carbon dioxide (CO_2) and sunlight to produce organic matter. The perennial grasses such as *Andropogon gayana* and *Brachiaria humidicola* convert as 53 tons of CO_2 per hectare yearly to organic matter, that's as much CO_2 as gas – guzzling in 133,000 miles (Fisher, 1994).

In the Sudan natural rangelands contribute about 77% of feed available to livestock (Abusuwar and Darag, 2002). Not only that, importers of beef and mutton in Gulf States preferred Sudanese sheep and cattle because of the fact that livestock depend on natural forage with no chemical additives of chemical origins.

The main problem associated with rangelands is some stocking leading to progressive reduction in biomass production and plant cover, and in arid and semi -arid leads to soil degradation (Strang, 1980).

Frequent occurrence of drought period of 1964/ 84 and 1990/ 91 in Sahel (RPA, 1993) further accentuates rangeland deterioration. Over stocking coupled with severe intermittent and prolonged drought further exacerbate the problem of low forage a viability and therefore, poor animals production.

The over exploitation of trees for fuel associated with increased human population, and more intensive use of the grazing by increased numbers of domestic livestock, is a major problem in many parts of Africa (Harrington *et al.*, 1983). An increase in human population also leads to increasing urbanization and cultivation of rangelands.

In Sudan these had resulted in substantial reduction in rangeland area, estimated at about 19.6% of the total area of the country (RPA, 1993). According to Jerry and Holechek (1989) the amount of rangeland in the World is expected to decline substantially in the next 30 years, and large amount of rangeland in Africa and South America, has already been converted to farm land. The main problem of Africa rangeland is the expansion of agriculture into nomadic grazing areas (Garcia, 1981).

Rangeland in the Sudan is facing many problems that hinder their use and development. Most rangeland lay within fragile environment and facing frequent drought period, seasonal bush fires, change in species composition increasing pressure on the range resource especially around water points, expanding cultivation, destruction of local institutions and the gradual loss of the traditional knowledge, increase in animal population low off take, blockage of livestock migration routes and lack of local community participation in planning and execution of range programs (Mustafa *et al.*, 2000).

3.3 The socio - economic aspects of rangelands' use

Rangelands of the world are renewable nature resource, vital to survival of human and animal population; they occupy between 45 – 50% of the land area of this plant, with a large part of it found in Africa, Asia, Australia and Europe (Busby, 1987).

The nomads are people who derive most income from keeping domestic livestock in conditions where most of the animal feed is natural forage rather than cultivated crops. Nomadism is mobile form of land use, involve irregular movement of livestock by nomads living in transportable forms of housing or transhumance that involve fairly regular and predictable movement by the livestock owning people who may live for much of the year in fixed and permanent houses(Sanford,1976).

Between 1990, and 2000, cattle population in the world increased about 3%, while sheep populations declined 10%. Developing countries with rapidly increasing human population, such as Sudan, have experienced large scale increase in range livestock number, whereas developed countries with low human population growth rates, such as the United States and many European nations, have had declines or have reached stability in cattle population (FAO, 2000).

Darrag and Suliman (1988) stated nomadic tribes of eastern Sudan mainly utilize the desert and semi desert region in Sudan, which constitute about 48% of the total area. The nomadic tribes are well adapted to climatic fluctuation of sahelian zone because of their high mobility over vast area. They follow the rainfall but with a delay that permits grasses and herbs to grow before their arrival. Traditional grazing routes run in a north –south direction. Most dry grasslands of eastern Africa are characterized by frequent drought and high levels of risk of production for pastoral people (IFAD, 1995).In the Sudan pastoral nomadism is an important economic activity that involves between 2 – 3million people. They utilize different ecological zones, which affect their nomadic characteristic (ElArifi, 1975).

Cattle, camels, sheep, goats are the main livestock species and are kept by the nomads for subsistence for their milk; meat and traction. Holechek *et al* (1989) stated those mixed herds of animals are efficient in exploiting range resources. Although sale of livestock is major source of income for the nomads today, wide spread sale of livestock only become common in the last century, with colonialism. (Coppock, 1994).Traditionally, herders consume large part of the milk produce; any surplus is shared with neighbors, exchanged in barter or sold in urban areas. In Somalia, a commercial milk chain through a cooperative has been established the nomads for market, camel milk in Mogadishu as source of income to buy sugar, clothes and medicines (Herren, 1990).

3.4 The Soil of the Rangelands

The word soil refers, in general to natural surface layer of earth crust in which plants grow. It's porous medium, comprising minerals and organic materials. Living organisms, water, and grass are other constitutes of soil. Whether climate or soil is more important in governing plant growth is material, since both are necessary (Dudal, 1970). Also soil is defined as the dynamic natural body of the surface of the earth in which plant grows (Brady and Weil, 1996).

The most severe consequence of rangeland mismanagement or overgrazing is the loss of soil; this is because soil is the primary factor determining the potential for forage production of an area within particular climate (Brady and Weil, 1996). Soil formation is very slowly process a thousand years or more are required to form an inch of soil (Brady and Weil, 1996). However under poorly controlled grazing, this same inch of soil can be lost by erosion within a few years. It is therefore the knowledge of soil characteristics and classification is essential for the rangelands managers (Brady and Weil, 1996).

Soil is the basic component of rangeland ecosystems and is associated with nearly all ecosystem processes; it provides a medium to support plant growth and is the home for innumerable insects and microorganisms (USDA, 2001). In terms of human life-spans, it is a nonrenewable resource and should be treated as such. Soil is a product of parent material, climate, living organisms, topography, and time. The soil formation processes work slowly, especially in arid and semi - arid climates. It is believed to take several hundred years to replace an inch of top soil lost by erosion. No management decision should be made without a careful consideration of its impact on the soil (IASC, 2010 and USDA, 2001).

The type of soil present in a range management unit is important to both the kind and amount of forage produced and the type of management that is possible or appropriate. The chemical and physical characteristics of a soil determine: its ability to furnish plant nutrients; the rate and depth of water penetration and the amount of water the soil can hold and its availability to plants. Fine-textured soils, especially without plant or residue cover, tend to reduce water infiltration. Coarse-textured soils may have high infiltration rates but dry to deeper depths than do the fine-textured soils (IASC, 2010: and USDA, 2001).

Changes in soil quality that occur as a result of management affect: the amount of water from rainfall and snow melt that is available for plant growth; run-off, water infiltration, and the potential for erosion, the availability of nutrients for plant growth, the conditions needed for germination, seedling establishment, vegetative reproduction, and root growth and the ability of the soil to act as a filter and protect water and air quality, (Donkor, *et al*., 2001 IASC, 2010; and USDA, 2001). Soil quality on rangeland can effects plant production, reproduction, mortality, erosion, water yields, water quality, wildlife habitat, carbon sequestration, vegetation changes, establishment, and growth of invasive plants and rangeland health **(**USDA, 2000).

Soil quality indicators are used to increase the value and accuracy of rangeland assessments and trend analysis. Assessments help to identify areas where problems occur and areas of special interest. Land managers can use this information and other inventory and monitoring data to make management decisions, which, in turn, affect soil quality. When assessments or comparisons are made, the rangeland ecological site description is used as the standard. For the soils associated with a given ecological site, the properties that change in response to management or climate are used as indicators of change. **(**USDA, 2001).

Soil quality is the capacity of a specific kind of soil to function within natural or managed ecosystem boundaries, sustain plant and animal productivity, maintain or enhance the quality of water and air, and support human health and habitation. Changes in the capacity of soil to function are reflected in soil properties that change in response to management or climate (IASC, 2010: and USDA, 2001).

Rangeland health and soil quality are interdependent. Rangeland health is characterized by the functioning of both the soil and the plant communities. The capacity of the soil to function affects ecological processes, including the capture, storage, and redistribution of water; the growth of plants; and the cycling of plant nutrients. For example, increased physical crusting decreases the infiltration capacity of the soil and thus the amount of water available to plants. As the availability of water decreases, plant production declines, some plant species may disappear, and the less desirable species may increase in abundance. Changes in vegetation may precede or follow changes in soil properties and processes. Significant shifts in vegetation generally are associated with changes in soil properties and processes and/or the redistribution of soil resources across the landscape. In some cases, such as accelerated erosion resulting in a change in the soil profile, this shift may be irreversible, while in others, recovery is possible **(**USDA, 2001).

Ecological processes on rangeland are evaluated with soil and vegetation indicators. Evaluations made through assessment and monitoring provide information about the functional status of soil and rangeland. Soil quality indicators are properties that change in response to management, climate, or both and reflect the current functional status. Functions include maintaining soil and site stability, distributing, storing, and supplying water and plant nutrients, and maintaining a healthy plant community **(**USDA, 2000).

3.5 Rangelands in arid and semi - arid areas

Arid and semi-arid areas are defined as areas falling within the rainfall zones of 0-300 mm and 300-600 mm, respectively (FAO, 1987). It cover one third of earth's land surface (UNCCD, 2004). Arid and semi-arid areas are characterized by low annual mean but extreme fluctuations in rainfall (Sullivan and Rohde, 2002). Droughts are an intrinsic part of arid and semi - arid system (Müller, 2005). Because of the short growing periods (1-74 and 75-119 growing days, respectively), these areas are not suitable for cultivation (Sidahmed, 1996). The livelihood of a vast majority of people in these areas is earned by livestock farming (Müller, 2005). Rangelands are wild forage-producing areas under native and/or annual grasses used, among other things, for livestock, wildlife and watershed maintenance. The rangeland-dominating arid and semi-arid areas provided primary products (grasses, legumes and shrubs) which were converted into animal protein. Use of the resources for other purposes, such as fuel and building materials, intensified with the increase in human population and with sedenterization. These rangelands maintained an ecological balance as a result of the natural defensive mechanisms typical of uncertain and high erratic climates. Seasonal fluctuations influence the concentration and mix of herbivores, and multi-year droughts reduce the number of animals (Sidahmed, 1996).

In the Sudan, the arid and semi-arid lands cover an area cover an area of 1.78 million km^2, which represents about 72% of the total area of the country (Sudan National Action Program, 2006). Rangelands in the Sudan forms a huge natural resource; it constitutes various types of grazing lands vary from open grasslands to seasonal water courses, flood plains, rivers banks and associated islands, woodlands, hills and mountain slopes (Zaroug, 2000). In arid zone the natural vegetation was virtually absent except on water courses, consists essentially of ephemeral grasses and herbs known as ‘Gizu’. These succulent plants provide grazing, mainly for camels, during the dry period from November to February (Harrison and Jackson, 1958 and Wickens, 1991).

The semi-arid vegetation was mainly scrub and grassland. Dominant trees and shrubs include *Acacia tortilis*, *Capparis decidua*, *Leptadonia pyrotechnica*, *Maerua crassifolia* and *Salvadora persica* with A*cacia mellifera*, *Balanites aegyptiaca*, *Capparis decidua* and *Ziziphus spina-christi* on clay soils and water courses. Herbaceous species include *Aristida spp*., *Blepharis spp*, *Cenchrus spp*, *Cymbopogon nervatus*, *Panicum turgidum* and *Schoenfeldia gracilis* (Harrison and Jackson, 1958 and Wickens, 1991).

About 35% of the Earth‘s land surface is covered by arid and semi-arid lands, however these areas are widespread and constitute a very important component of the total land area of the world. Arid and semi-arid are characterized by low erratic rainfall of up to 700mm per annum, periodic droughts and different associations of vegetative cover and soils. Inter annual rainfall varies from 50-100% in the arid zones of the world with averages of up to 350 mm. In the semi-arid zones, inter annual rainfall varies from 20-50% with averages of up to 700 mm. Livestock production plays a vital role in the production systems and in the livelihood of the people in the arid and semi - arid zones (Le Houérou, 1980). The rangeland provides one of the most important resources of the worlds arid and semi-arid (dry lands) areas. Rangelands in the arid and semi-arid zones carry over 70% of Sudan’s livestock. This is more than double their carrying capacity (Ayoub, 1998).

The most common vegetation pattern found in semi-arid areas is usually referred to as spotted or stippled and consists of dense vegetation clusters that are irregular in shape and surrounded by bare soil (Ludwig *et al*., 1999). Seasonal vegetation dynamics are largely regulated by the availability of water so vegetation in these areas is scarce and spatially heterogeneous. Sala and Martin (1995) concluded that the spatial heterogeneity is generally created by the action of vegetation and animals mainly through the redistribution of resources and seeds may result in an increase in production in particular, and ecosystem functioning in general, at the level of whole ecosystem. Due to climate-soil moisture variability in arid and semi-arid climates, vegetation has developed adaptation strategies to survive at decreasing or null water availability.

Semi-arid zones are more extensive and occur in all the continents, and cover up to 18 % of the land surface. They have high seasonal rainfall regimes and a mean rainfall of up to 500 mm in winter-rainfall areas and up to 800 mm in summer-rainfall areas. With other annual variability of 25–50 percent, grazing and cultivation are both vulnerable, and population distribution depends heavily upon water availability (FAO, 2004).

The semi - arid areas exhibit ecological constraints which set limits to nomadic pastoralist and settled agriculture. According to Saleh and Ahmed (1993) these constraints include: Rainfall are erratic, a high rate of potential evapotranspiration and weeds growing more vigorously than cultivated crops and competing for scarce reserves of moisture and etc. Indigenous peoples of these areas have lived within these constraints and they have existed on the productivity provided locally and have used their knowledge to devise coping and adaptive strategies.

The ability of the nomads to survive has traditionally depended on their adoption of opportunistic mobility and adaptive strategies and drought management techniques. Some of the strategies are ecologically based such as the raising of mixed species of livestock with different preferences for the standing vegetation (Sidahmed, 1993).According to the non equilibrium theory, livestock grazing has a limited effect on long-term vegetation productivity of semi - arid rangelands, which is largely determined by rainfall **(**Konrad *et al*., 2007).

Semi-arid areas in the Sudan constitute the main areas of rain-fed and irrigated crop production. Moreover, its open rangelands provide a good source for feeding a huge numbers of animals, therefore, these areas are considered economically very important for the agro-pastoral sector in the Sudan. Due to population growth in the Sudan, more land has been cultivated to meet the growing demand for food (Suliman and Darag, 1983). Elhassan (1981) stated that due to open grazing system, which is considered as a form of range utilization by nomads, intensive grazing and the soils around water sources lost their cover and gradually most of the grazing areas may become have bare soil as a result of overgrazing.

3.6 Change in species composition and abundance

The most obvious generalization is that abundance, and species composition and richness respond to the season of sampling and changes in the architecture and species composition of vegetation that result from grazing (Perkins**,** 1993; Lanta, 2009). The physical structure of plant communities is often changed by grazing, a number of examples where defoliation by grazing herbivores altered plant height and canopy cover, and changed species composition to include structurally different types of plants. Trampling may also change the structure of plant communities by breaking and beating down vegetation.

Most studies to document changes in species composition, abundance or community structure of vegetation along a gradient of grazing intensity. When heavy grazing removes competition from palatable species, or those sensitive to trampling damage, "increaser" species establish. These are typically species with "annual" life histories that flourish after rain, or unpalatable perennial shrubs (Chewings, *et al*., 1992).Changes in vegetation also have an impact on soil properties, including soil fauna, with consequences for the scale of redistribution of water and nutrients leading to accelerated environmental degradation in rangeland. Because stocking rates in rangelands are generally high, these indirect effects on soil are likely to outweigh more direct effects such as trampling, except in high-use areas such as near watering points (Walker *et al*., 1997). Grazing affects the species composition of a plant community through herbivores selecting or avoiding specific plants, and through differential tolerance of plants to grazing. Continued selective grazing can reduce the competitive vigor of grazed plants and release un-grazed species from competition. Trampling can also indiscriminately injure plants, and may reduce their competitive and reproductive capacities within the plant community (Lanta, 2007).

(Chewings, 1992**;** Walker, 1997and Lands berg *et al*., 1997) reported that the effect of grazing by domestic stock on plant communities has received considerable attention. Most studies have examined the effect of a fixed grazing intensity, mostly in non-arid environments. Two general trends emerge from these studies: (1) grazing at moderate densities leads to higher within-habitat species richness compared with grazing at low or high densities, (2) very heavy grazing results in a decline in the number of species, a reduction in abundance of the remaining species and dominance by a few species. In addition species close to the water point, with substantial disruption to the soil surface, and unpalatable species dominated. With increasing distance from the water, abundance of palatable grasses increased and unpalatable species decreased.

3.7 Grazing resources and grazing systems

Rangelands comprise about 50% of the worlds land area and include natural grassland, scrublands, savannas and deserts provide the majority of rangeland ecosystems. In most African countries, rangeland livestock production is a form of extensive grazing systems practiced by nomads of the arid and semi-arid regions, considering the demand for foodstuffs due to the growing human population, increasing livestock productivity gains importance particularly under harsh environmental condition in arid and semi – arid areas, (Kamau, 2004).

Rangelands form an immense natural resource and the major of feed for national herd in Sudan. The various types of grazing land vary from open grasslands to seasonal water courses, flood plains, rivers banks, woodlands, hills, and mountain slopes (Zaroug, 2006).

In South Kordofan the nomadism was the traditional mode of rangeland resources utilization, but the society is experiencing profound changes throughout the last decades. These changes are visible through the regression of animal mobility and sedenterization of the population, rangelands are subjected to increasing pressure leading to their degradation (Nefzaoui, 2008).

3.8 Definition of some grazing patterns

3.8.1 Nomadic

Livestock, mainly camels and sheep, with some goats, are raised entirely on natural rangelands. Households move with their animals and have no permanent base on which to grow crops. They spend the rainy season in the northern, semi-desert zone and during the dry season, move further south into the savannah. Income is derived from the sale of animals, meat, and milk in the form of white cheese (Fadlalla and Ahmed, 1999: UNDP, 2006).

3.8.2 Transhumant

In the transhumant agro-pastoral system, households depend mainly on livestock, mostly cattle, with some sheep and goats, although there is some cropping. In western Sudan, households migrate north during the rainy season and return to the savannah during the dry season. In the central and eastern states, migration is towards the Nile during the rainy season and back during the dry season. (Fadlalla and Ahmed, 1999: FAO, 2000: UNDP, 2006).

3.8.3 Sedentary

The sedentary system exists where there is rain-fed, arable farming in settled villages. Some livestock, mainly small ruminants, are kept, but the animals are less important than the crops. Sorghum and sesame are grown on clay soils, and millet and groundnuts on sandy soils (Fadlalla and Ahmed, 1999).

Livestock systems in which more than 90 percent of dry matter fed to animals comes from rangelands, pastures, annual forages and purchased feeds and less than 10 percent of the total value of production comes from non-livestock farming activities (FAO, 2000 :Zaroug, 2006).

Subset of solely livestock production systems in which more than 10 percent of the dry matter fed to animals is farm-produced and in which annual average stocking rates are less than ten LU per hectare of agricultural land (FAO, 2000).

3.8.4 Other systems

Ranching is a recent trend in Sudan. Animals are raised for meat on natural rangelands in western Sudan in Kordofan and Darfur, and in Butana in Kassala State. Feedlots have existed for over 30 years. Animals, mainly beef cattle, are brought on the hoof from western Sudan and fattened in Khartoum State on sorghum grain, oilseed cakes and roughage, with gains of up to 1 kg/day in cattle and 0.35 kg in sheep. Near and within urban areas, goats and poultry fed on household waste are kept for domestic supply. Also, there are few systems that have been able to consistently demonstrate sustainable production and economic benefits (Fadlalla and Ahmed, 1999).

3.9 Livestock grazing system in South Kordofan State

In fact, pastoralism in Sudan is a traditional way of life. It is a product of climatic and environmental factors that has become a form of natural resource use and management. Pastoralism comprises a variety of movements ranging from pure nomadism characterized by year-around camel breeding and long-distance migration, to seasonal movements over shorter distances in combination with some form of agricultural activities (UNDP, 2006). Free grazing of rangelands is the most common feeding system for livestock in Southern Kordofan State. During the short wet season grasses grow and mature rapidly producing abundant biomass. The body condition of the grazing animal is its best during this period, while when onset of the dry season both quantity and quality of the rangeland herbage decline and fail to meet the maintenance requirements of grazing animals. In Southern Kordofan, where dry season grazing is composed mainly of grasses like *Cenchrus spp* and *Eragrostis spp* the crude protein content of the natural forage is about 3.4%, much below the minimum required for maintenance (Jaddalla, 1994: Zaroug, 2006). The nutritional inadequacy of the dry season grazing imposes a major constraint on sustainable livestock production under traditional systems where grazing constitutes the only source of feed for livestock. The non-availability of forage during the dry season affects sedentary livestock more in El Dilling locality, as they lack the advantage of mobility exercised in the transhumant and nomadic systems (Zaroug, 2006). Livestock raising is practiced under two systems. The first one is the village-based adapted by the settled communities whereby livestock are keeping throughout the year grazing near their settlements. The second type is an open range seasonal grazing system followed by nomads and semi-nomads and livestock is driven to distant pasture. For village based livestock, herders would look for distant grazing if there is inadequate pasture and\or water supply around the villages, or for fear of damaging crops particularly when they have large herds. IFAD report in 2006 noted that sedentary livestock raising is practiced primarily by Nuba who mainly practice cultivation with livestock as of secondary importance. In addition to cattle they also possess sheep and goats and the animal move not longer than 10-15 Km from the center of their residence throughout the year. Their seasonal pattern of the grazing generally involves a movement from the mountains and foot slopes which are grazed during the rainy season, downward the cracking clay plains after the main sorghum harvest. In some places, this is no longer so as some "*Baggara*" are now settled and some tribes of the Nuba are practicing long seasonal movement. It is also looks as if the seasonal pattern of grazing has changed as some settled especially in the eastern mountains depend mainly on mountains during the dry season.

Nomadic production relies on a generally north/south movement. The transhumance pastoralism could be looked at as deferred systems of the grazing since many parts of the rangeland are grazed after seed setting and dispersal. The southern parts of South Kordofan State and the part of the central rangelands, grazing is delayed until the onset of the dry season, while transitional areas of the central parts are partially grazed on the south/north and north/south movement (Zaroug, 2006: UNDP, 2006). nomads spend the rainy season in the northern parts of the State (Rashad, Abbassiya, Elqatar, Kurmalay, and Um Arroos,etc) while some proceed further north to Kordofan Goz (around Elobeid, El Rahad, Jebel Addayir).In all these areas, grazing is practiced during the growing period a process that is very detrimental to the greatest proportions of the range, which predominantly manuals (IFAD,2006).

3.10 Rangelands management

Range management is the science and art optimizing the return from rangeland, in that combination most desired by, and suitable to society through the manipulation of range ecosystem (Stoddart, *et al*., 1975). Rangelands management is at once a biological, physical, and social science. It is biological because it deals with response of the animals which harvest the crop, physical because climate, topographic and hydrological factors determine the kind and degree of use that can be made of range and social because, the need of society determines the uses to which range resources are put (Stoddart, *et al*., 1975). Range management is defined as the manipulation of rangeland component to obtain optimum combination of goods and services on a sustained basis (Jerry, 1989). Range management that provides for multiple- use of rangeland resource base, without diminution of capacity of the rangeland ecosystem to reproduce of itself on sustained yield basis when resources are extracted from ecosystem (Tueller, 1991).

Sound range management plays an important role in insuring the never ending chain of human needs. The soil is the basic resources, producing forage that converted by animals into products for human consumption. One third of the expenditure of food and clothing is from animal products, (meat, milk, fat, leather and wool). The main link of this chain of human needs is soil development and maintenance for continuous production of desirable forage, and grazing domestic and wild animals. The chain is disrupted when the top soil is eroded away by unwise grazing practice (Aurther and Sampson, 1959). Range management provides for multiple- use of rangeland resource base, without diminution of capacity of the rangeland ecosystem to reproduce of itself on sustained yield basis when resources are extracted from ecosystem (Tueller, 1991).

3.10.1 Practices of rangelands management

Early range management practices concern with manipulation of livestock grazing intensity, timing, and frequency to meliorate adverse grazing impact on soil and vegetation. More recently management has been broadened to include manipulation of many components of rangeland ecosystem other than livestock such as wildlife (Jerry and Holechek, 1989). Maximum production from the given range unit is dependent upon a proper management and use of sources. Of fundamental importance are grazing the range with a proper kind of animals, balancing number of animals with forage resources, and obtain proper distribution of livestock over the rangeland (Mohammed, 1996).

3.10.2 The scope of rangelands management

Because of population growth over the past few decades, the demand for goods and services from the natural resources of the semi arid regions has increased beyond the ability of the traditional management systems to meet them. Conflicts between various users of these resources are increasing as they are diminishing (Bellefontaine, 2000). Overcutting of forests, overgrazing and land clearance for agriculture reduce numerous functions and services previously provided by semiarid forests. There is an urgent need for responsible management of the natural resources of these regions of the world.

Ground data and socio-economic studies are key information to explain the change or degradation mechanism in the semi arid rangeland. Moreover, land degradation monitoring needs to be carried out in a holistic way by linking remote sensing with human activity in order to evaluate land use management options for sustainability or rehabilitation of the natural resource base (Weicheng, 2009). Understanding the circumstances of people who are the traditional users of the rangelands is crucial if any meaningful improvement and development of the unpredictably fluctuating resources of the dry land areas is to be achieved.

Rinehart (2006) showed that there are several key issues to consider when thinking about how many animals a rangeland will support. Consideration must be given to forage production potential; utilization patterns by livestock; the nutrient content of the forage and forage growth patterns; the plant species that comprise the rangeland; species diversity of the rangeland plant community; and seasonal variations in temperature and moisture.

Management or manipulations of rangeland components for obtain optimum combination of goods and services for society on a sustained basis. Rangeland resource managers should become familiar with and keep up with new remote sensing technologies in order to utilize them for good rangeland resources management. In addition, legislation should be drawn up to identify the roles and responsibilities of the absentee livestock owners in supporting efforts for proper management of the range resources. In many arid and semi-arid rangelands of the tropics with large variations in rainfall from year to year, the stocking rates of livestock cannot be constant. However, a conservative stocking rate can reduce the risks of degradation of rangelands and give better production per animal compared to higher stocking rates Rinehart (2006).

Rangeland management in arid and semi arid areas has historically required range surveys to determine forage productivity and carrying capacity. This is still an important consideration in many parts of the world. Good management of rangeland resources requires that the range is evenly grazed over large areas. The distribution and timing of grazing is necessary for the implementation of useful intensive grazing management systems. It is necessary to periodically evaluate the forage utilization on portions of pastures or grazing allotments (NRS, 2008).

Assessing changes in rangeland condition requires an understanding of rangelands as ecological and social systems, their ‘states-and-transitions’, stability, resilience and what rangeland condition means in relation to these concepts (Friedel *et al,* 2000). To achieve sustainability of arid and semi-arid lands require constant adaptation to change, not only utilizing the opportunities, but also using resources at a sustainable rate, so that they remain available year after year.

In a study of Land Tenure and Natural Resource Management in Semi-Arid Areas, Kenya made by Mwakubo (2002), the results had showed the importance of secure land tenure towards investments into sustainable land use. This illustrates the need for polices aimed at titling of land hand in hand with other relevant complementary policies if sustainable land use is to be achieved. Sustainability of rangeland used for livestock grazing requires effective management, which is dependent upon accurate and timely inventory data to support assessment and monitoring (West and Smith, 1997).

Stuth and Maraschin (2000) stated that sustainability of grazed ecosystems into the future will require greater linkages between the human decision-making process, ecological processes, economic systems and political systems across the several temporal and sustainable managements of pasture and rangelands spatial scales. The only way we can hope to achieve this goal is to begin developing information infrastructures that link the knowledge generator with the knowledge purveyor and knowledge seeker.

Arid and semi-arid rangelands are characterized by erratic rainfall and high rate of vegetation dynamics (Herlocker, 1999 and Dahdough *et al*, 2002). Each semiarid region of the world is unique in a number of ways such as climate, soils, vegetation, animals, traditional management, and people's activities (Ffolliott *et al.*, 1995). The dynamics of plant species over time affects the biological diversity and productivity of rangelands, mainly due to continuous and complex interactions of the plant communities with their environment (Solomon *et al.*, 2006). In this regard, human interferences and climatic variations form common driving forces in bringing changes to the environment.

The final outcome of this process is modification of the rangeland use/cover patterns, probably associated with a general decline in productivity of the rangeland environment. Worldwide, 3 600 million hectares or 70% of the world's arid lands, are degraded, and 10 million hectares of arable land deteriorates every year (Essahli and Sokona, 2008). Then the problem becomes worse in semi-arid lands where with other factors there will not be enough vegetation cover to protect the land both from wind and water erosion processes.

Measuring rates of dry-land degradation is a big challenge owing to the complex interactions between fluctuations in rainfall of semi-arid lands and anthropogenic changes (e.g. overgrazing, over exploitation of water sheds, etc) on vegetation cover (Ayana and Oba, 2007). Taha and Khidr (2011) pointed that In Africa, overgrazing has reduced range productivity virtually. However, it is necessary to avoid the deterioration of the rangelands from the grazing pressure; some procedures should be carried out to ensure the integration and balancing of the bio system elements such as determining the suitable carrying capacity and stocking rate of the rangeland, use of suitable grazing system, multi species grazing, optimizing pasture utilization and supplemental feeding.

Zziwa *et al* (2012) they concluded that maintaining native vegetation cover of the rangelands and increasing levels of limiting nutrients are the major strategies for increasing rangeland production in semi-arid rangelands.

The key issue of concern in most arid and a semi arid region of the world is Sustainable grazing management. Then, to progress towards the achievement of sustainable rangeland management systems, requires an adaptive and integrated approach to decision making process (Umrani**,** 1998). This challenge is particularly formidable in arid rangeland environment, because of the inherent seasonal constraints. The main factor influencing sustainable rangeland management is the number of plants per unit area, their longevity, palatability and resistance to grazing, and stocking rate of livestock (Umrani, 1998).

Hussain and Durrani (2007) pointed that there is a potential for improving range vegetation, biomass and habitat of rangeland through blending the traditional and modern methods of range management with the participation of local communities.

3.11 Spatial and temporal variation of rangelands

Behnke (1992) reported three propositions regarding the ecological functioning of grazing systems, if proven correct, each of these ecological hypotheses entailed changes in current communal rangelands management policy. These three propositions and their associated management implications are as follows:

Hypothesis (I) the Spatial Heterogeneity of Rangeland Resources

African rangelands are ecologically heterogeneous at a variety of different spatial scales. Locally, heterogeneity may be expressed in terms of the patchy distribution of pockets of high and low range productivity, up-slope and down slope, on different soils within a single drainage system. At the other extreme, heterogeneity may be expressed on a regional scale in terms of soil moisture and fertility gradients which control the quality and quantity of forage production over vast areas, as in the transition from the dry northern Sahel to the wetter Savanna zones across West Africa. A model of savanna vegetation based on the relative balance of available moisture versus available nutrients for plant growth may reveal the underlying biological processes which produce both local vegetation patches and regional variations in vegetation types. It would appear that animal movements—seasonal and annual, local and long-distance, by both wild and domestic herbivores exploit this variability.

Herd movement is one of the principal techniques employed by African livestock producers to exploit environmental heterogeneity. The preservation of herd mobility requires the legal recognition of existing customary tenure arrangements, especially those which provide for the intermittent or seasonal use of a wide variety of ecological resources. In this context, formal programs of land use planning should attempt to coordinate movement and regulate access by different user groups, rather than restrict movement. Since movement takes place at a variety of different spatial scales, regulation of this movement will require the development of a hierarchy of management institutions with the authority to resolve conflicting claims to key resources at local, regional and national levels.

Hypothesis (II) Grazing Ecologies not at Equilibrium

In Africa's dry savannas, rainfall variability and other episodic events control both plant and animal populations. The animal and plant populations which these systems can sustain will fluctuate unpredictably with annual shifts in the amount, timing and spatial distribution of rainfall, fire, disease outbreaks, etc. These grazing systems may be in constant disequilibrium.

Conceived of as a single, safe stocking rate, the concept of carrying capacity is not appropriate to the management of grazing systems not at equilibrium.

Policy makers and administrators may instead strive to maintain the ability of herd managers to ‘track’ short term swings in feed supply by responding quickly and flexibly to unpredictable events. Effectively tracking fluctuations in rangeland productivity would require the ability to rapidly destock and restock rangelands, the provision of feed supplements to cover temporary shortfalls in forage production from natural rangelands, and the provision of credit, insurance or other social security measures which will dampen the economic impact of unavoidable environmental fluctuations. Planning for drought and the provision of a degree of security against impoverishment will be essential features of administration in regions where producers are exposed to unusual environmental hazard.

Hypothesis (III) Ecological and Economic Carrying Capacity

Misleading carrying capacity estimates are often based on confusion between ecological and economic carrying capacity. Ecological carrying capacity can be defined as the point at which livestock populations cease to grow because limited feed supplies produce death rates equal to birth rates. Most livestock owners and range managers find it profitable to hold their livestock populations somewhere short of this ecological ceiling. What constitutes an economically optimal stocking rate will vary, however, according to producers’ husbandry practices and management objectives.

In Africa a variety of different livestock production systems co-exist. The nomads engaged in alternative systems of production will find it advantageous to maintain stocking rates appropriate to each system. Determination of the ’correct’ stocking rates in a particular area will be a process of reconciling these multiple objectives. Administrators and technicians can provide assistance in arbitrating the potentially conflicting demands of different classes of producers. The persistent inability of outside agencies to effectively control stocking rates suggests, however, that local communities must ultimately be responsible for enforcing agreements on stock numbers. This implies the devolution of authority over these matters and the provision of technical assistance to local communities, rather than the attempt to impose centralized control.

A striking feature of most plant communities is that the organisms are unevenly distributed in nature (Agrawal *et al.,* 2006). This phenomenon, which occurs across all spatial scales, has the additional consequence that the strength and identity of interactions between species show high degree of spatial variability. As a consequence of individuals moving across space or from spatial variability in population growth rates, individuals of the same species typically encounter different interactions at different sites (Agrawal *et al.,* 2006).

The term heterogeneity can have many meanings (Kolsa and Pickett 1991). The simplest definition of spatial heterogeneity is a 'departure from randomness of distribution' (Greig-Smith, 1979). However, with respect to point patterns, spatial heterogeneity refers to density variation among locations, whereas in the context of surface patterns, spatial heterogeneity 'refers to variation over space of the observed values of a qualitative or quantitative descriptor' (Dutilleul and Legendre, 1993). Locally, heterogeneity may be expressed in the term of patchy distribution of pockets of high and low productivity, up-slope and down slope, on different soils within a single drainage system. At the other extreme, heterogeneity my be expressed on a regional scale in term of soil moisture and fertility gradient which control the quality and quantity of forage production over vast areas, as the transition from the dry North Sahel to the wetter savannah zones west Africa (Behnke, 1992).

3.12 Vegetation attributes

Vegetation attributes are quantitative features or characteristics of vegetation that describe how many, how much, or what kind of plant species is present. The major vegetation attributes measured include cover, density, frequency, structure, and biomass. The vegetation cover as defined by Barbour *et al* (1987) is the relative area covered by plants inside a designated area. *Cover* describes the percent of an area that is covered by vegetation, rocks, and litter (Rasmussen *et al*., 2001).

It was measured along the line transect inside the quadrate and also measured by visual estimates. Cover is regarded as an important indicator of ecological and management processes within the vegetation, through many of the direct relationships still have to be quantified and it is considered the best indicator of protection of the landscape against erosion.

Frequency and density are two additional vegetative measurements. Frequency measures the percentage of species or life forms in an area. It is dependent on the size and shape of the plot used (Rasmussen *et al*, 2001) and it describes the abundance and distribution of species and is useful to detect changes in a plant community over time and its ease and speed of data collection means that frequency is suited to large areas.

The probability is based on the occurrence of that species in a series of sample units. Frequency is a simple vegetation attribute to measure because it only requires identification of the species in each quadrate, and does not require that individuals are distinguished, measured, or counted and it values are determined for individual species because an overall frequency for the entire vegetation cannot obtained, in contrast to other attributes such as biomass, cover, or density (Susan and Mitchel, 1997).

Density is basically the number of individuals per unit area. The term refers to the closeness of individual plants to one another. According to Susan and Mitchel (1997) density is often used as a baseline inventory of structure of rangeland of forest vegetation, by quantifying different species or various ages within single species and it can provide useful indicators in an inventory and monitoring program to determine range condition and range trend because it remains relatively stable from year to year.

Abusuwar (2007) defined productivity as the total weight of dry matter produced by all green plant growing in particular area. Productivity can be considered as primary productivity which is the total amount of dry matter produced including all losses of carbohydrates used during respiration. Biomass data may be collected on an individual species basis, as species group, or as total weight for the vegetation (Susan and Mitchel, 1997). Net productivity is measured by clipping or cutting the growing plant and the productivity or forge yield is measured by using one square meter quadrate.

The vegetation within the quadrate was cut and weight after the moisture within the plant material has been extracted.

Forage yield is the weight of the useable part of the plant that is produced within a designated period of time (usually a year) on a given area. Forage productivity estimates are essential for the determination of range carrying capacity. Sampling forage yield is done using the one square meter quadrate. Number of samples can be determined using the species-area-curve methods (Susan and Mitchel, 1997).

Species composition refers to the contribution of each species to vegetation. Botanical composition is another term used to describe species composition (Bonham, 1989). It is generally expressed as a percent, so that all species components add up to 100% (Barbour *e tal*., 1987). Species composition can be expressed as on either an individual species basis, or by species groups that are defined according to the objectives of inventory or monitoring program (BLM, 1996). Species composition is a commonly determined attribute in rangelands inventory and monitoring. It is regarded as an important indicator of ecological and management processes at a site.

Ecological indicators - species composition provides the essential description of the character of the vegetation at a site. Certain images are readily understood when major species are mentioned. These distinctions form the basis of rangelands mapping and the delineation of range site boundaries. The relative contribution of a species also signifies its dominance in the vegetation and its ability to capture resources. Management indicators - most objectives in rangeland management are directly concerned with the assessment or manipulation of species composition. For example, carrying capacity is influenced by the relative abundance of desirable forage species at a site. Wildlife habitat is also influenced by the relative contribution of various species that provide sources of shelter and food. Species composition is used to determine range condition and range trend, which are valuable tools to judge the impact of previous management and guide future decisions (Bonham, 1989).

3.12.1 Plant cover percentage

Plant cover is defined as the area of ground that is occupied by the above-ground parts of each species when viewed from above (Kent and Coker, 1992). All methods of plant cover estimation depend on the interception of the plant by a quadrat of a known area (Bonham, 1989). Cover measurements are commonly used to evaluated soil protection, watershed, health, rangeland ecological condition, and range trend (Holechek *et al.*, 2004). Arial or canopy cover refers to the area covered by vertical projection of the crown of plant onto the soil surface (Broun, 1954).

Cover provides a variety of interpretations of direct concern to rangeland management, including erosion potential, the value of wildlife habitat, availability of forage, and trends in range condition. Ground cover is considered the best indicator of protection of the landscape against erosion, whereas canopy cover is commonly used to describe wildlife habitat or related to forage availability. Basal cover provides the most reliable measure for monitoring range trend (particularly when focusing on herbaceous components), because it is less sensitive to fluctuations caused by current seasonal conditions or immediate grazing history (Bonham, 1989).

Three methods that appear to meet time requirement for inventory and monitoring purposes are estimation (Daubenmire, 1958), the step point method (Evans and Love, 1957) and line intercept procedures (Canfield, 1941). Estimation procedures usually involve estimation cover by species in relatively small plots. The point step method was developed as a rapid, objective method of determining the cover and species composition of large range area (Evans and Love, 1957). The method involves cutting a notch or marking spot on the observers boot. The observer paces across the range area, recording whatever is directly beneath the notch or mark of his or her boot. Individual species, Litter, bare ground, rocks and so on can be recorded. Other devices, such as a fine rod or tripod, can be used to make placement of the point more objective (Owensby, 1973).

3.12.2 Frequency

Frequency is the quantization expression of the presence or absence of individual of species in population (SRM, 1989).Frequency is typically used to evaluate plant species distribution over an area and/or change in abundance of species over time due to management.

It has been used as measure of range trend. Frequency sampling is fast and easy to conduct in the field. If one determines density from quadrat, frequency can be calculated from the same data since frequency represents the percentage of quadrats in which the species occurs.

3.12.3 Biomass production and carrying capacity

Barbour *et al* (1987) reported that biomass is the weight of vegetation per unit area and productivity is the rate of change in biomass per area, over the course of growing season or year. Vallentine (1990) suggested that forage is the part of vegetation that is available and acceptable for animal's consumption.

Brody (1945) calculated the food requirements for animal unit. He recorded that weights have frequently been used as a guide to establish food requirements of animals and a good deal of research has gone into relationship of body size to nutrient needs. Although size does affect the need for maintenance of body tissue and heat losses, energy requirements are more directly related to body surface, which varies with the two – third power of the body weight.

Suliman (1986) reported that in El Rawshda forest (low rainfall on clay) forage production was 0.05 ton per hectare. Forage production values obtained from ungrazed spots was 2.05 ton per hectare. Darag and Suliman (1988) suggested that carrying capacity of the rangeland could be determined as animal unit per hectare per day, and that it can be calculated by using the total biomass productivity and then applying the proper use factor (0.5) i.e. half of the production was considered to be available for grazing. They also suggested that the daily animal unit requirement was 10.5 Kilogram per day. Darag (1986) suggested that carrying capacity was a term used to determine land use in term of livestock grazing and defined it as the number of livestock that can graze on a defined size of rangeland for a limited time. It was determined on the basis of range biomass production and the amount of feed requirement per animal unit. Kumar and Asija (2000) reported that carrying capacity of ecosystem, varies from region to region depending upon population pressure, dependence on food, water, energy, raw material requirement, waste production and important export. Mustafa *et al* (2000) defined carrying capacity as the maximum number of animal units that a certain range site can accommodate for specific period of time on sustainable basis.

3.13 Soil's characteristics

Soil is an important aspect of rangelands' communities and ecological sites have characteristic soils that have developed over time. Factors that affect soil development are: climate, living organisms, topographic relief or landscape position, parent material and time (Roselle *et al.*, 2011).

The soils of arid and semi - arid regions are characterized by frequent water stress, low organic matter content and low nutrient content, particularly nitrogen (N) (Skujins, 1991). Soils are the basic resource of dry lands as they provide the medium in which plants grow, and their properties, such as texture and water holding capacity, determine the proportion of rainfall available for plant growth.

The vegetation supported by these soils ranges from barren or sparsely vegetated desert to grasslands, shrub lands and savannahs, croplands and dry woodlands. Removal or loss of vegetation cover results in an increased risk of soil erosion and degradation because Plants protect the soil surface from wind and water erosion and livestock is the major user of primary production in the semi - arid and arid regions, so degradation has always been attributed to this sub-sector (Sidahmed and Yazman, 1994). This agrees with Chaichi *et al* (2005) who concluded that the soil of the heavily grazed and moderately grazed areas is high vulnerable to wind and water erosion.

Soil is likely to be an important indicator of the condition of the resource. A major limitation to including soil in assessments has been the absence, until recently, of process-based methods for rating soil and landscape function (Tongway, 1995).

Gholinejad *et al* (2012) showed that soil texture including clay, sand, nitrogen, slope and altitude are the most effective influencing factors on plant communities' distribution in semi-arid rangelands.

3.13.1 Soil organic matter

Soil is defined as the dynamic, natural body of the surface of the earth in which plants grow (Brady and Weil, 2002).Soil organic matter represents an accumulation of partially decayed and partially synthesized plant and animals residues. It makes up relatively small part of the soil (<1% - 6%) (Holechek *et al*., 2004).

Organic matter is a reservoir of nutrients that can be released to the soil. Each percent of organic matter in the soil releases 20 to 30 pounds of nitrogen, 4.5 to 6.6 pounds of P_2O_5, and 2 to 3 pounds of sulfur per year. The nutrient release occurs predominantly in the spring and summer, so summer crops benefit more from organic-matter mineralization than winter crops**.**

Organic matter behaves somewhat like a sponge, with the ability to absorb and hold up to 90 percent of its weight in water. A great advantage of the water-holding capacity of organic matter is that the matter will release most of the water that it absorbs to plants. In contrast, clay holds great quantities of water, but much of it is unavailable to plants.

Organic matter causes soil to clump and form soil aggregates, which improves soil structure. With better soil structure, permeability (infiltration of water through the soil) improves, in turn improving the soil's ability to take up and hold water.

This property of organic matter is not widely known. Data used in the universal soil loss equation indicate that increasing soil organic matter from 1 to 3 percent can reduce erosion 20 to 33 percent, because of increased water infiltration and stable soil aggregate formation caused by organic matter (Barber; 1984, Brady; 1974, Plaster, 1996; Tisdale and Nelson, 1975).

3.13.2 Soil seed bank

The earlier studies of the soil seed banks started in 1859 with Darwin, when he observed the emergence of seedling, using soil samples from the bottom of a lake. However, Roberts (1981) studied the occurrence of seeds at different soil depths and reported that weed seeds have been studied with more intensity than others because of their economic importance. Fay and Olson (1978) reported that the depth from which samples should be taken would depend on the type of vegetation and purpose of study.

According to Roberts (1981) the term soil seed bank has been used to designate the viable seed reservoir present in the soil. The best way to determine the presence and amount of seeds in the soil is to observe the seedling emergence at the site. However, the most frequently used technique involves the determination of number of seeds placed in soil samples for germination in appropriate places, or using physical separation of seeds from the soil particles, based on differences in size and density.

A simple technique was determined for rapid determination of weed seeds, rhizome, corm, or bulb populations in the soil. Soil samples were placed in nylon mesh bags. The soil was washed from bags by a machine leaving only small residues including the desired prop gules. These were hand separated and the seed population of a given plant species is calculated. The total manipulation time per sample was approximately ten minutes (Fay, and Olson, 1978).

In studying the vertical distribution of the soil seed bank and number of species at all sites. Teketay (1996) reported that the highest densities were observed in the upper three centimeters of soil followed by gradual decrease in density with increasing depth. In general, herbs, grasses and sedges were more deeply distributed in the soil than trees, shrubs and climbers, suggesting differences in seed longevity and movement of seeds in the soil. Herbs and grassland sedges have small and long- lived seeds compared with many woody species, which have relatively large, and short- lived seeds, and that species with small seeds have better chances of becoming buried in deeper layers of the soil.

Roberts and Richettes (1979) studied the seed bank by subsequent floatation in water and saturated $CaCl_2$ solution. Hayashi, *et al.*, (1978) determined that the seeds that sank in water, but floated in $CaCl_2$ were viable if they buried in deeper layers of the soil. Peter (1996) reported that in many plant species the soil seed bank is of great importance for survival of populations such as seeds of many species which may remain dormant in the soil for many years. The size of the weed seed bank varies to a great extent. (Jensen (1969) found the average seed bank size of Danish fields, within the upper 20-cm., is 50258 living seeds/m^2, varying between 600 and 496200 seeds/m^2**.**

The weed species have survived throughout time, because of their ability to resist to several adverse climatic conditions, tolerating high and low temperatures, dry and humid environments and variations in oxygen supply. The fundamental point in the success of weed survival is their persistence capacity in certain areas. This capacity is a consequence of a great number of seeds produced, long term viability, continuous germination, phenotypic and genetic plasticity (Freitas, 1990). The composition of seed banks is variable, and is classified as temporary or persistent, when modifying the regeneration of the vegetation during different time of the year. Temporary banks are composed of seeds of short life, which do not present dormancy and are dispersed in time for short periods during the year. Persistent seed banks are composed of seeds that have more than one year of age and reserves of seeds remain in the soil (Garwood, 1989). According to (Carvalho *et al* (1995), the success of a seed bank depends on the seed density ready to germinate, when replacement of a plant is necessary and when the environmental conditions for establishment are favorable. The longevity of seeds represents a major mechanism of survival of certain weed species, and this leads to a continuous source of emergency. The seed longevity in the soil varies among species, characteristics of the seeds, burial depth, and climatic conditions (Carmona, 1992).

The seed dormancy is another characteristic that affects the seed bank reservoir. The seed populations of several vegetable species behave in different ways with respect to germination; the weeds produce polymorphic seeds, with a certain proportion that is dormant and another not (Carvalho *et al* 1995).

Several internal and external factors prevent seeds of germination. Among the internal factors are: the presence of a seed coat, which is a barrier to the penetration of water and oxygen; presence of a biochemical inhibitor in the seed; and immature embryo. Among the external factors, the most common are soil water content and temperature (Fernández-Quintanilla *et al.*, 1991).

Carmona, (1992) used the term innate dormancy (primary) and induced dormancy (secondary) to characterize the development of the dormancy in the mother plant and after the dissemination in space, respectively. The term enforced dormancy, has been used for the inability of the seeds to germinate due to an environmental restriction, like water deficit, low temperature and poor aeration. However, some seed physiologists do not consider the induced dormancy as an actual dormancy since the seed does not germinate because of the absence of environmental conditions and characteristics of the seed, since the seed does not need break dormancy but responds only favorable conditions for germination. This situation is more conveniently refereed as a case of quiescent seeds.

The dormancy represents a main mechanism of species preservation in the seed bank, distributing the germination through the year. It can guarantee the species survival in the form of seeds, under adverse conditions, even when the population of plants is completely eliminated (Carmona, 1992).

In agro eco-systems, where the soil is disturbed frequently, the soil seed bank acts to stabilize and ensure species survival (Roberts, 1981). The input is determined by the seed "rain". This way of dispersion includes passive forms, mechanical ejection of seeds, fire, wind, water and animals. The result from physiological answer of plants to environmental factors, that induces the germination, seed burial or re- dispersion of the seeds, and predation of the seeds by insects, pathogens, and other animals (Carvalho *et al.*,1995). Land preparation and crop rotation are the two primary agricultural practices that generate impacts on weed seed banks (Ball, 1992). The land preparation practices are used in order to control weeds, break soil surface hardness, and increase aeration; the seed germination is stimulated because of the seed dormancy break by light, alternated temperature, water and nitrate ions (Cavers and Benoit, 1989).The type of land preparation influences the seed dispersion in the soil profile; the management at same depth, favor an uniform distribution of the seeds in the soil profile, finding lower seed populations deeper in the soil (Dessaint *et al*.,1990).

Ball, (1992) comparing land preparation systems, disc plow versus disc harrow, observed the predominance of weed seeds closer to the surface after disc harrowing. (Clements *et al*., 1996) studied the influence of land preparation types over the seed bank and found that more than 70% of the seeds were present in the layer of 0-5 cm in plots where no mechanical method was used, and 30% for plots mechanically managed.

Some weed species may present higher intensity of emergence in the no till planting than in the conventional till. Carmona, (1992) stated that no till and superficial tillage tends to reduce the amount of seeds at the soil surface shed by plants, since there is induction in the germination or loss of viability. The presence of seeds at the superficial layer of the soil and frequent cultivation, are factors that reduce the seed bank rapidly. This situation can facilitate seed predation by exposure of seeds to variations in temperature and humidity, and breaking their dormancy. However, the speed of soil seed bank depletion depends on the seed production of the species (Yenish *et al*., 1992; Fernández-Quintanilla, 1988).

For the seeds that are buried in the soil profile, where the conditions are more uniform, the action of external factors is less intense. The maintenance of viability will depend basically on the seed characteristics (Martins and Silva, 1994).

The use of herbicides can also influence the species composition of the seed bank, and may increase or decrease it, depending on the chemicals used (Ball, 1992). In general, it can be said that interaction among herbicides, land preparation and cultural practice have altered the size and nature of seed banks (Roberts, 1981).

3.14 Importance of trees and shrubs

Woody plants are common component of the rangeland ecosystem of the world. The principal role of woody plants is providing forage to livestock and wildlife which is very important, especially in semi- arid and arid ecological zone (Le Houerou, 1980). Fodder trees and shrubs constitute a vital component in livestock productivity in the arid and semi – arid zones, where about 52% of the cattle, 57% of the sheep, 65% of the goats and 100% of the camels in the tropical Africa are found (Von Kaufmann, 1986).

In addition they serve several other purposes such as improvement of soil fertility, control desert encroachment, wind breaking, land escaping, recreation, providing habitat for wildlife and production of firewood and construction materials and industrial products (Michell, 1980). The sparse thorn scrubs provide a period of good grazing for sheep, goats, cattle and camels besides the ephemeral grasses and herbs (Ayoub, 1998).

Woody component either shrubs or trees form are usually associated with herbaceous species and should be accommodated in any description of vegetation dynamics assessment of land use (Le Houerou, 1980).

3.15 Conflicts on natural resources

Most of the rural areas of the Sudan are dominated by a population of the nomads and agro-the nomads whom are totally dependent on land and its natural resources for support of their livelihoods. The traditional natural resource tenure system used to be effective for meeting the demands of herders and farmers without harming the overall environment. However, the increase in human and animal population, horizontal expansion in mechanized farming, and the series of droughts inflicting fragile ecosystem, e.g. those of the northern parts of northern states of Sudan, are leading to the breakdown of the tenure system (UNDP, 2006: Ahmed and Abu Sabah, 1993). This worsening situation has disrupted transhumance routes and forced the nomads to move further south. This compulsory movement subject nomads to conflicts with existing agricultural and pastoral land users. Moreover, the current legislations on pastoral livelihood system is fragmented and not reconciled with existing customary local rules. The formal land allocation system also marginalized customary rights and procedures. (Elhassan, 2007).

Though customary low states that agriculture land after harvest is subjected to public grazing land, during the crop – growing period, from mid- July to mid-January, no animals are allowed to enter the field. This period coincides with the passing of the herds of the pastoralist, and the time of greatest pressure on pastoral resources in region. Conflicts between the nomads and resident farmers over crop damage are increasing due to the increase number of animals in area, as well as the expansion of productive field into areas which were used for grazing and livestock corridor (Egeimi *et al*, 2003: Ahmed and Abu Sabah, 1993).

According to (Elhassan, 2007and UNDP, 2006) the legislation issue, the search for water, fodder, and safe stock routes are not limited to the northern states but are also manifested to some degree in many areas of southern Kordofan. Moreover, the civil war, inter-tribal frictions and militia fighting in the South have resulted in a state of insecurity which in turn has created new pressures on livestock movement between seasonal pastures. Of particular importance are the stock routes (*Morhal*) which are recognized corridors for animal movements through farmed areas between seasonal pastures. Conflicts along these routes have become common in El Dilling locality and they are generally triggered by increasing demand for cropland, expansion of mechanized agriculture, shortage of water points and land degradation. Rules, agreements, acts and resolution committees have been initiated for governing transhumance routes but they remained ineffective due to lack of satisfactory involvement of farmers and herders (UNDP, 2006).

3.16 Remote Sensing (RS)

Remote Sensing is defined as the science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area or phenomenon under investigation (Frimpong, 2011). Recently, remote sensing with multi-temporal high resolution satellite data has become a strong tool for monitoring aspects such as vegetation cover, soil degradation, and urban expansion and more generally for most types of land-cover/land-use changes (Frimpong, 2011).

Eva *et al* (2006) stated that the ongoing process of land cover change in sub-Saharan Africa can be monitored and quantified using Earth observing satellites. This dynamic has been shown to be largely a conversion of natural vegetation to agricultural lands, with less and less land available for future exploitation, and shorter fallow periods. This trend has implications on the available natural resources (land, water, fuel-wood, pastures) for the poorest.

The technical capacity to put in place a permanent land-cover monitoring system at different levels, from national to continental, exists.

Remote sensing data has been expected to provide quantitative information about land degradation. This technique has now become the single most effective method for land-cover and land-use data acquisition (Lillesand and Kiefer, 1994). In addition it provided useful spatial and spectral information at relatively reasonable costs for mapping Land Use/Cover. Using remote sensing techniques to develop land use classification mapping is a useful and detailed way to improve the selection of areas designed to agricultural, urban and/or industrial areas of a region (Selcuk *et al*., 2003).Using the spectral signature of different vegetation states, remote sensing enables us to describe spatial and temporal patterns of vegetation in a spatially continuous way (Jensen, 2007).

Remote sensing systems provide an option for collecting information for rangeland management and it has been used worldwide in vegetation change studies (Kheiry, 2003, Suliman, 2003). Research proves that remote sensing can be considered as a useful tool for studying arid and semi-arid ecosystems.

Spectral vegetation index measurement derived from remotely sensed observations shows great promise as a means to improve knowledge of vegetation pattern. Different band ratios are possible given the number of spectral bands of the satellite image. Various mathematical combinations of satellite bands have been found to be sensitive indicators of the presence and condition of green vegetation. These band combinations are thus referred to as vegetation indices. The dominant method for vegetation area identification and change detection using remotely sensed data is through vegetation indices (Deering and Hass, 1980). Vegetation indices are algorithms aimed at simplifying data from multiple reflectance bands to a single value correlating to physical vegetation parameters (such as biomass, productivity, leaf area index, or percent vegetation ground cover) (Tucker, 1979). These vegetation indices are based on the well-documented unique spectral characteristics of healthy green vegetation over the visible to infrared wavelengths.

NDVI is a simple numerical indicator that can be used to analyze remote sensing measurements, typically but not necessarily from a space platform, and assess whether the target being observed contains live green vegetation or not. It was natural to exploit the strong differences in plant reflectance to determine their spatial distribution in these satellite images. Based on the reflectance pattern of vegetation, different models of vegetation indices were developed to explain the healthiness, vegetation cover and biomass condition of vegetations. Various mathematical combinations of the Landsat channel Red band (R) and channel near infrared band (NIR) data were found to be sensitive indicators of the presence and condition of green vegetation (Mideksa, 2009). Among these, NDVI is the most common used index for forest vegetation biomass monitoring. The absolute value of NDVI for vegetation change analysis is between 0 and 1. The NDVI empirical analysis is computed using the following equation:

$$\text{NDVI} = \frac{\text{NIR}-\text{R}}{\text{NIR}+\text{R}} \quad \ldots\ldots\ldots\ldots\ldots \qquad \text{Wesis } et\ al \text{ (2004)}$$

Where: NIR = Near Infrared band R = Red band

CHAPTER FOUR

MATERIALS AND METHODS

4.1 General

This study was carried out in South Kordofan State to study the impact of site's characteristics on vegetation and implications on management process in Eldebeibat area. The vegetation measurements were done for the two rainy seasons respectively (2013/2014).

4.2 Sampling Procedures

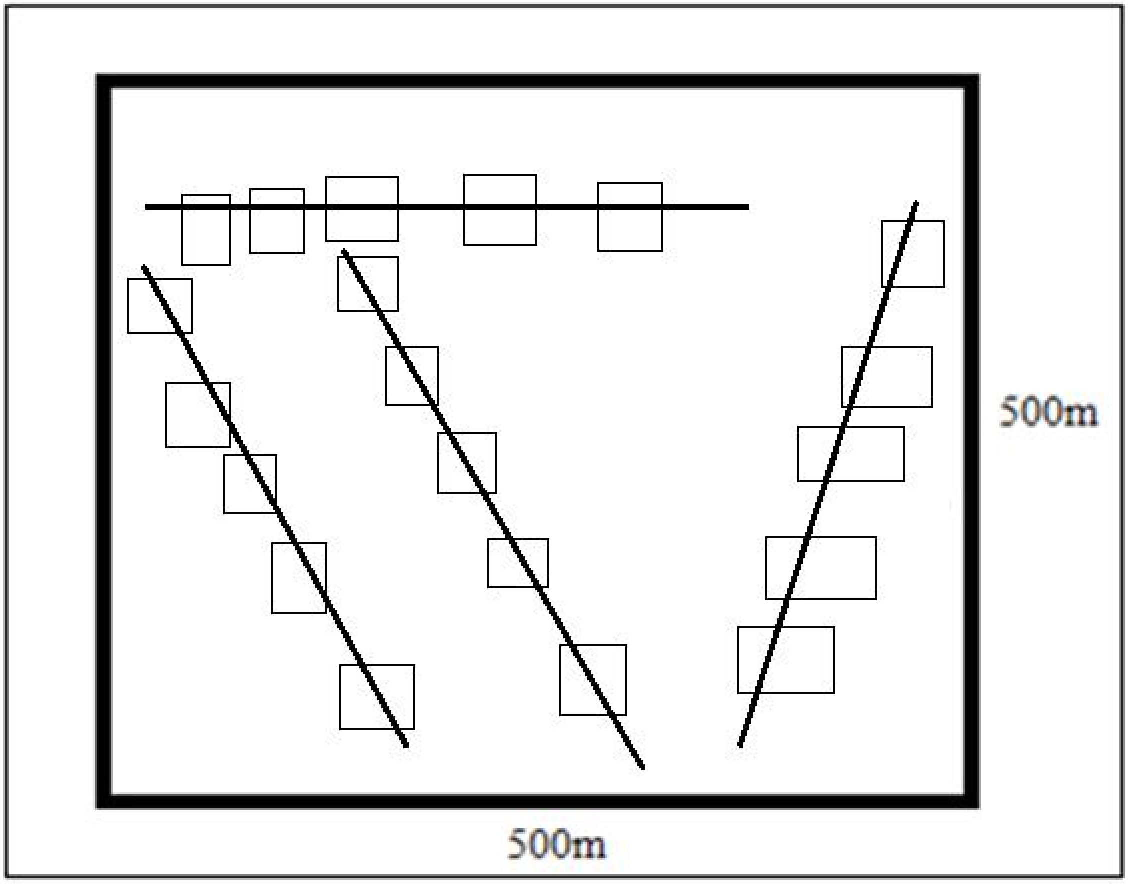
Three rangelands sites were identified in the study area based on soil physical characteristics identified during a visit conducted in October 2012; the area included sandy, clay and gardud (Plates 4.1, 4.2 and 4.3) respectively. The three sites represented the main types of rangelands in the study area based on the minimal area theory (Mueller Dombios and Ellenberg, 1974). The each site was divided in two blocks, area of each block 500m^2. Four transects were laid randomly within each block, the length of each transect was100m to come up with eight transects in each site and ten quadrats were distributed along each transect (interval 10m) to come up with 40 quadrats in each block (Fig. 4.1).

Plate (4.1) Sandy site

Plate (4.2) Clay site

Plate (4.3) Gardud site

Fig (4.1) Layout of transects and quadrats distribution in the each block



Abdelrahim, (The author), 2017

4.3 Measurements of vegetation attributes

A. Plant composition

Plant composition refers to the total plants observed from total number of hits; while the relative plants composition refer to the contribution of each individual plant species in the total plants percent (Parker, 1951). Parker loop method (Parker and Harris, 1959) was used. A total of 100 hits per transect were taken, then distribution of the species, litters, bare soil and rocks along each transect were identified. The total hits of each parameter were calculated. The following equations were used to calculate percent of certain parameters such as (Plants composition%, relative plants species composition%, litter%, bare soil% and rocks %) Parker, (1951).

$$\text{Plant composition\%} = \frac{\text{Total hits on plants}}{\text{Total hits/transect}} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (1)$$

$$\text{Relative plant composition} = \frac{\text{Total hits on each species}}{\text{Total hits on all plants species}} \times 100\ldots\ldots\ldots (2)$$

$$\text{Percentage of each parameter} = \frac{\text{Total hits on each parameter}}{100} \times 100. (3)$$

Parameter = If it is present refer to litters or bare soil or rocks.

B. Frequency

Frequency is the quantization expression of the presence or absence of individual of species in population (SRM, 1989). Frequency is typically used to evaluate plant species distribution over an area and/or change in abundance of species over time due to management.

Ten quadrats per transect at interval of 10 m that give (40) quadrat per block and (80) quadrat per site to estimate plant distribution at the study area.

Plant frequency was calculated by counting species, which occur within each quadrat and recorded their names only not their number in form of frequency. The following equation was used to calculate frequency: (Daubenmire, 1968).

$$\text{Frequancy} = \frac{\text{Number of quadrats with plants species occurrence}}{\text{Total number of all quadrats}} \times 100 \ldots\ldots\ldots\ldots (4)$$

C. Plant cover percentages

Plant cover is defined as the area of ground that is occupied by the above-ground parts of each species when viewed from above (Kent and Coker, 1992). It was estimated as a visual percentage of the quadrat covered by plant material (Bonham, 1989). Plants rooted outside the quadrat are included in cover measurements to the extent that their canopy projects into the quadrat space (Barbour *et al*., 1987).

Plant cover percentage usually estimated by looking at the quadrat from the above and estimate approximately the part covered by plants. Plant cover percent was estimated for each quadrat and recorded in form of plant cover%. The total cover for all quadrats determined total cover for each block, which is divided by the number of quadrats taken in each block to obtain one average. The following equation was used to calculate plants cover%.

$$\text{Plants cover percentage} = \frac{\text{Total estimations}}{\text{Total number of quadrats}} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots . (5)$$

D. Biomass production

Biomass is the weight of vegetation at a point in time (Holecheck *et al.*, 1989). It was determined by direct harvesting of vegetation from the square meter quadrat (Bonham, 1989).

Equipments were included Quadrat (1m x1m), Scissors, Paper bags, Sensitive balance and Form for biomass.

The plant species in each quadrat were clipped at 3cm above the ground level, as this represent grazing level using scissors .The harvested plant materials were placed in paper bags, dried partially under the sun light to reduce the moisture contents of plants and to protect them from decaying. The plant materials were oven dried at 105°C for 17 hours. The oven dried materials were weighed. The dry matter per quadrats was obtained by dividing the total weight of all quadrats by their number to obtain one average of weight (gram/m^2). Then the dry matter (ton per hectare) was used following formulas.

$$\text{Biomass production gm/m}^2 = \frac{\text{Total weight of dry matter of plants}}{\text{Total number of Quadrats}} \ldots\ldots\ldots\ldots\ldots.. (6)$$

$$\text{Biomass production ton/ha} = \frac{\text{Biomass gm/m}^2 \times 10000}{1000 \times 1000\text{gm}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots... (7)$$

(Gaiballa, 2014)

Available forage production = Biomass production ton/ha × 0.5

0.5 = Proper Use Factor

E. Carrying Capacity

The carrying capacity was calculated on basis of total biomass production and amount of the feed requirements per animal unit. Carrying capacity is usually determined using proper use factor (PUF), of 50% in which only half biomass produced is considered available for grazing, livestock requires daily dry matter (DM) intake equivalent to 2.5 – 3% of their body weight.

Thus Tropical Livestock Unit (TLU) of 250 Kg body weight consumes 2.5 – 3% of their body weight the daily Animal Unit (AU) requirements is equivalent to 6.25 – 7.5Kg dry matter per day (Darag and Suliman 1988). The following equations were used to calculate Carrying Capacity.

Requirements of AU/day = 3× 250 ÷ 100 = 7.5 kg

Requirements of AU/month = 7.5 × 30 = 225 kg

Requirements of AU/year = 7.5 × 30 ×12 = 2700 kg

$$Carrying\ Capacity = \frac{Available\ forage\ production}{Total\ animal\ unit\ consumption\ (AU/Year)} \ldots\ldots\ldots\ldots\ldots\ldots.. (8)$$

(Gaiballa, 2014).

Where: Available forage production is the biomass production at the study area in ton/hectare.

AU: Animal Unit.

4.4 Seed bank assessment

The soil seed bank is the natural storage of seeds within the soil and refers to the reserve of persistent seeds in the soil and is usually assessed as the number of seed in a given volume of soil for a given ground area. The viable seeds were separated by using the flotation method reported by Johnston *et al.,* (1978).

A. Seed bank sampling:

To assess seed bank, five soil samples were taken randomly in each block (10 samples at each site) in 10x10 cm at 10 cm depth, and put in paper bags. The samples were mixed thoroughly, and sub-sample of 250g from each sample was prepared for seeds extraction.

B. Seeds extraction

Preliminary washing of the soil samples were done using sieves of 1.0, 0.5, and 0.25mm pore size. The technique comprised initial washing of the soil, floatation, and then separation of live seeds based on their density using Ca Cl_2 solution.

Each soil sample (250g) was placed and filtered through three sieves of mesh sizes 1.0, 0.5, and 0.25mm and washed for 20min. The residuals in the three sieves were washed by about 250ml of water, then transferred into 500ml beaker and stirred. The floating organic matter including dead seeds was filtered using a funnel with filter paper inside it; the funnel is placed into one litter side arm flask to aid filtration. The filtered residue on the filter paper, was transferred to 9cm. Petri – dish and the organic matter retrieved included mainly dead seeds.

About 250ml of $CaCl_2$ (1.5g/ml of water) was added to the same sample residues, and let each sample residues for 40 min into a beaker. The floated material after stirring included mainly live seeds (Ramadan, 2001). The washing of samples was done at chemistry laboratory of SUST, College of Forestry and Range Science.

C. Seeds identification

Extracted seeds were identified through comparison with reference samples of seeds collected from plants growing in the study area, using a microscope and lenses. The identified seeds in each sample where recorded and counted (Ramadan, 2001).

$$\text{Percentage of live seeds} = \frac{\text{Total live seeds}}{\text{Total of all seeds (live } \textit{and dead}\text{)}} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots . (9)$$

$$\text{Pecent of dead seeds} = \frac{\text{Total dead seeds}}{\text{Total of all seeds(live and dead)}} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots... (10)$$

$$\text{Number of seeds/m}^2 = \frac{\text{Number of seeds/depthx100x100}}{\text{quadrat area(m}^2\text{)xnumber of quadrats/depth}} \ldots\ldots\ldots\ldots\ldots (11)$$

4.5 Trees and shrubs density

Density in vegetation measurement refers to the number of individuals per unit area. Density for trees and shrubs was determined by using the Nearest Individual Method (Barbour *e t al.*, 1987) in which 60 points were taken at each block (120 point at each site), at each point the distance to the nearest individual tree of any species (shrub or tree) was measured; the species were identified and recorded. Only one measurement from each point was taken. All distances for all species were summed and divided by their numbers to yield one average distance to calculate density per hectare (10000m^2) for all trees. The following equations were used to calculate trees density and relative trees density.

$$\text{Trees density} = \frac{10000}{2(\text{Average distances in meter})^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (12)$$

$$\text{Relative trees density} = \frac{\text{Number of species encountred}}{\text{Number of all trees}} \times \text{trees density} \ldots\ldots\ldots \quad (13)$$

(Barbour *e t al*., 1987).

4.6 Soil organic matter determination

The organic matter is the plant and animal residues incorporated into the soil, such as parts of leafs, manure, or plant parts.

Equipments were included Muffle furnace, Balance, Porcelain dish, Spatula and Tongs

The furnace method was used to determine organic matter percentage in the soil; five soil samples were taken from each block (ten samples for each site) by using augur to take samples at depth 20cm and then mixed thoroughly to take sub sample of 50g was taken from each sample which was taken in the field and dried in oven and weighed. Also the sub samples were burned at furnace. The following procedures were done at laboratory:

(1) Determined and recorded the mass of an empty, clean, and dry porcelain dish (MP).

(2) Placed a part of or the entire oven-dried test sample of soil from the moisture content experiment (Expt.1) in the porcelain dish and determined and recorded the mass of the dish and soil sample (MPDS).

(3) The dish placed in a muffle furnace gradually increased the temperature in the furnace to 440^{o}C. Leave the soil sample in the furnace overnight.

(4) The porcelain dish removed carefully using the tongs (the dishes very hot), and allowed it to cool to room temperature.

5- The mass of the dish containing the ash (burned soil) (MPA) was determined and recorded.

Analysis of organic matter (OM) data

(1) Determined the mass of the dry soil MD=MPDS-MP

(2) Determined the mass of the ashed (burned) soil MA=MPA-MP

(3) Determined the mass of organic matter MO = MD - MA

(4) Determined the organic matter percentage (content). (Reddy, 2002)

$$MO\% = \frac{MO}{MD} \times 100 \qquad (14)$$

4.7 The Socio - economic aspect in the area

The data of the socio – economic depend on distribution of questionnaires 243 and 129 people were selected and that equivalent 10% of families for both respondents. The information which collected from them included the information about the land uses, rangelands utilization and management methods (indigenous knowledge), the conflicts between them, rangelands status, and livestock and rangelands improvement methods.

4.8 Remote Sensing Technique

Characterization of rangelands' sites using RS technique:

Satellite images MODIS product MOD13Q1for the years 2010, 2011, 2012, 2013, and 2015 covering the months of June, July, August, September, October, and November for each of the years, were used to trace the pattern of change in NDVI values time series across the three rangelands sites. Images for the months of each year stacked and displayed. A region of interest (ROI) represented the three sites were made, then exported as class image and then class image statistics for each month within each site, then plotted in a graph for each year to illustrate the pattern of change of NDVI monthly values for each site, after that differences of the pattern were compared between the three sites, which express contribution of the three sites characteristics on the pattern of the plants growth.

The image processing and analysis have been carried out using ENVI imagine software version 4.7. The ENVI imagine image processing package was used to obtain the values of NDVI then the mean of NDVI was obtained by statistics for each site within each month to assess differences between the three sites. Excel Microsoft program was used to make the graphs of NDVI values for each of the three sites.

4.8.1 Images acquisition and Pre-processing:

The images downloaded from the website http://glovis.usge.gov/. MODIS satellite imagery of study area taken within months of rainy season, starting from June up to November of each year.

The selected images taken some process, before NDVI values calculation such as change projection to WGS 1984, Lon/Lat, and resize all MODIS images to facilitate and increase speed of images' processing. The following process done to obtain the values of NDVI such as overlay shape file of each three sites on resized images for each year within each month and then exported images to image class and class image statistics was obtained, and lastly NDVI values were set as a graph for each year within selected months at each the three sites. Wesis *et al* (2004) concluded that NDVI is a good tool for characterizing vegetation variability in arid and semi-arid regions and allows long time-scale analyses of vegetation behavior in response to climate variability. The NDVI is a normalized difference measure comparing the near infrared (NIR) and visible red bands using the formula:

$$NDVI = \frac{NIR - R}{NIR + R}$$ (Wesis *et al.*, 2004) ………………………………….. (15)

Where NIR (841-876 nm) and red (620-670 nm) are the surface reflectance for the respective MODIS bands. NDVI values usually range from -1 to +1. Because of high reflectance in the NIR portion of the electromagnetic spectrum, healthy vegetation is represented by high NDVI values between 0.05 and 1. Conversely, non vegetated surfaces such as water bodies yield negative values of NDVI. Bare soil areas represent NDVI values which are closest to 0 due to high reflectance in both the visible and NIR portions of the electromagnetic spectrum (Lillesand and Kiefer, 1994).

4.9 Data analysis

The quantitative and qualitative rangelands measurements were conducted based on standard rangelands measurements techniques as stated in the materials and methods. While Chi - square analysis using Statistical Package for Social Science (**SPSS**) program was performed for the socio-economic data.

CHAPTER FIVE

RESULTS AND DISCUSSION

5.1 Sites' preference

In the study area, 73% of the nomads preferred sandy site to practice grazing particularly in the rainy season compared to 64% of sedentary (table 5.1). In contrary, both the nomads and sedentary preferred clay site (8% and 11%) and gardud site (19% and 25%) respectively and there were highly significant differences at $P<0.0001$when Chi – square test was used appendences (20 and 21).

According to the reasons of selecting certain sites for grazing 43% of the nomads stated the reason was due to availability of plants, 37% due to livestock's movement was easy in rainy season, followed by 20% free from insects (Table 5.2) there were highly significant differences at $P<0.0001$ when Chi – square test was used.

Table (5.1) Sites types and preference for grazing in the rainy season by both respondents at the study area

Site	Frequency		%	
	Sedentary	Mobile pastoralists	Sedentary	Mobile pastoralists
Sandy	178	82	73	64
Clay	20	14	8	11
Gardud	45	33	19	25

Table (5.2) Reasons for the sites' preference for grazing in the rainy season by the nomads at the study area

Reasons	Frequency	%
Availability of palatable plants	56	43
Easy animals movement	47	37
Free from insects	26	20

During rainy season more than half of the nomads enter the sandy site in early June. 58% of the nomads starting entering the sandy site compared to 24% and 18% for clay and gardud site respectively. By the end of the rainy season (October) 44% of the nomads exist in gardud compared to 39% and 17%from sandy and clay site respectively (Table 5.3) with high significant differences at $P<0.0001$ when Chi – square test was used. The early entering could be attributed to the characteristics of sandy site which lead to facilitate and accelerate germination process of plants species seeds and create vegetation cover earlier than other sites (clay and gardud) and livestock movement is easy. For all of these factors, sandy site encourage herders to graze it early before other sites. On the other hand, the early existing could be due to the drying of grasses and shortage of water in gardud site. Grasses remain green until the end of rainy season in the clay site that encourages the nomads to stay longer in this site, which leads to intensive grazing which could affect vegetation cover, biomass production and seed bank.

Table (5.3) Time of entering and exiting to the three sites by the nomads at the study area

Sites	Frequency		%	
	June (+)	October(-)	June (+)	October(-)
Sandy	75	50	58	39
Clay	31	22	24	17
Gardud	23	57	18	44

(+) starting date and (-) starting existing date

5.2 Land Cover

5.2.1 Herbaceous cover at the study area

5.2.1.1 Plants composition

Plant composition at the three rangelands' sites for the two rainy seasons (2013/2014) showed no systematic trend. Sandy site scored the highest plant composition compared to the other sites that was 95% and 87% for year 2013 and 2014 respectively, with small difference within the two rainy seasons. Gardud site had high plant composition (76%) compared to (66%) for clay site in the rainy season of 2013. In the rainy season of 2014 the trend was reversed, gardud had low plant composition relative to clay that was 44% and 67% respectively (Fig.5.1-5.3) and (Appendix no.2). However, the plant composition highly decreased at gardud site in the rainy season of 2014 which was 32% compared to 8% and 1% for sandy and clay respectively. The plant palatability of the dominant species at the sandy site explains this result (table 5.5) which is in line with Herlocker, (1999).

5.2.1.2 Plant litters

The amount of litters in this study is used as an indicator for both degree of grazing and, plant palatability where high litter indicate intensive grazing and high palatability of species. Both sandy and clay sites showed no differences in the amount of litters and bare soil during the rainy season of 2013 and 2014 (Fig. 5.1 and 5.2). Gardud site had different picture, the decreasing of plant composition was reflected in increasing of bare soil indicating degradation of the vegetation cover. The high amount of litter in 2014 compared to 2013 showed the intensive grazing at this site (Fig 5.2), this agreed with Naeth *et al*., (1991) and Jensen and Gutekunst, (2003) stated that Intensive and early grazing of rangelands leads to deceasing in amount of plant litters. Generally, the clay site recorded the highest plant litters in the two rainy seasons (6% and 7%) followed by gardud (2% and 5%) while sandy site scored the lowest plant litters (1% and 3%) figs (5.1 – 5.3). The plant cover at the three sites and the starting entering date of livestock for different rangelands' sites (table 5.3 and 5.4) can explain the status of the different sites.

5.2.1.3 Bare soil

Figs (5.1 - 5.3) shows percentages of bare soil at the three sites for the two rainy seasons (2013/2014). Sandy site scored the lowest bare soil for the two rainy seasons (6% and 6%), followed by clay (30% and 29%) and gardud site recorded the highest percentage of bare soil with (23% and 52%). Highest percentage of bare soil at gardud site may be attribute to high ratio of run-off, type of topography, continuous intensive grazing, low ground cover and compacting of soil surface layer by repetition of livestock's' movement. Add to that spatial variation in bare soil; caused by variability in features of soil topography (FAO, 1987). Contribution of grazing and trampling to bare ground formation was 47% and that of wind erosion was 53% as stated by Zhaoa *et al.*, (2005). Heavy grazing can also cause soil erosion, loss of soil structure, and deterioration of soil environment (Scholl and Kinucan, 1996). Once heavy grazing created bare spots, wind would impose further severe erosive impacts on the soil, which causes small bare spots to merge together. The result is enlargement of continuous bare patches however wind impact was more severe than that of heavy grazing (Zhaoa *et al.*, 2005).

The sandy and clay sites had no variation in plant composition percent, plant litters and bare soil for (2013/2014) rainy seasons but gardud site had a big variation of vegetation parameters are mentioned above in fig (5.3) for the two rainy seasons (2013/2014).

Figure (5.1) Plant composition%, litters% and plant cover% at the two sites (sandy and clay) for season 2013 at the study area…………………Equations (1 and 3)

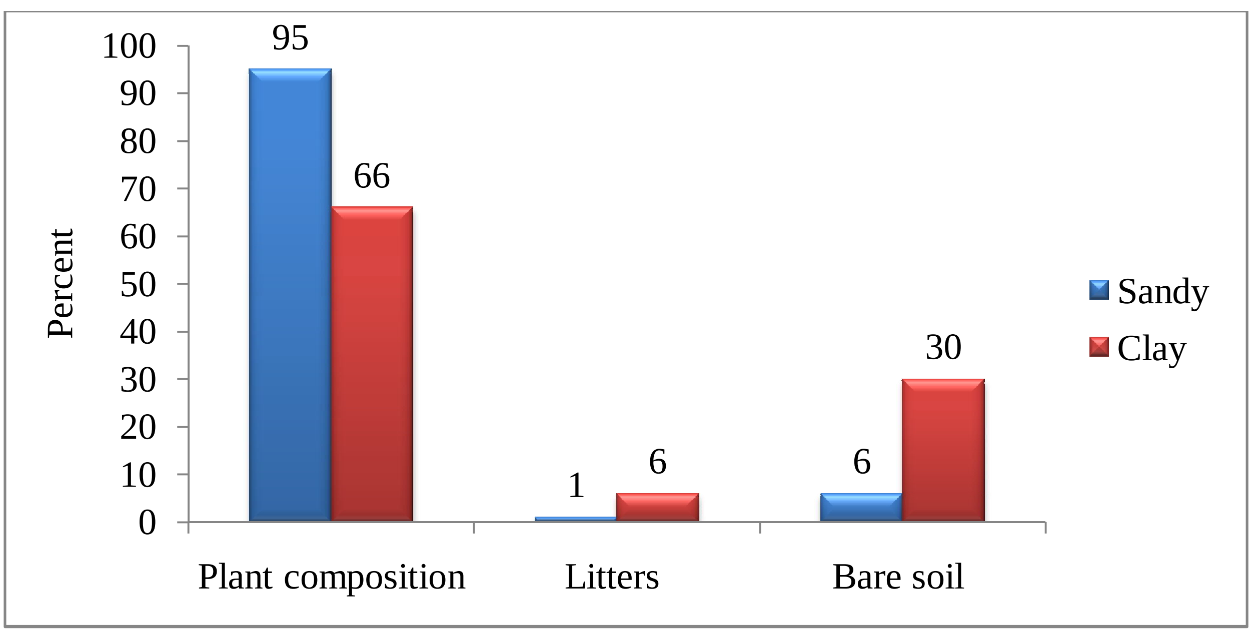


Figure (5.2) Plant composition%, litters% and bare soil% at the two sites (sandy and clay) for season 2014 at the study area …………………Equations (1 and 3)

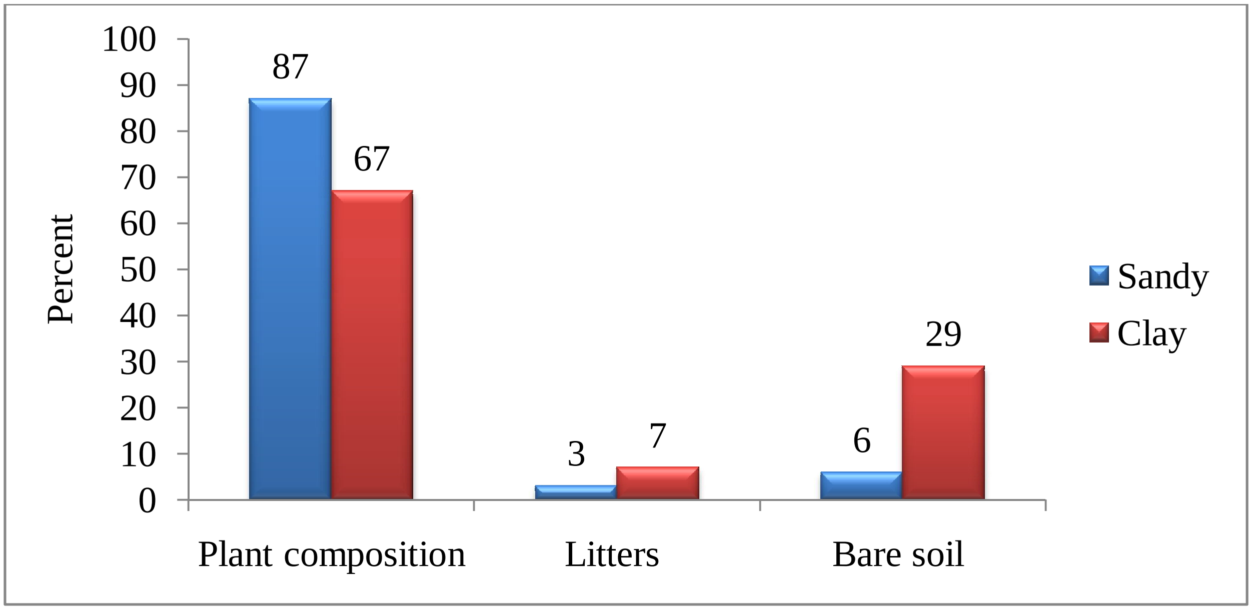
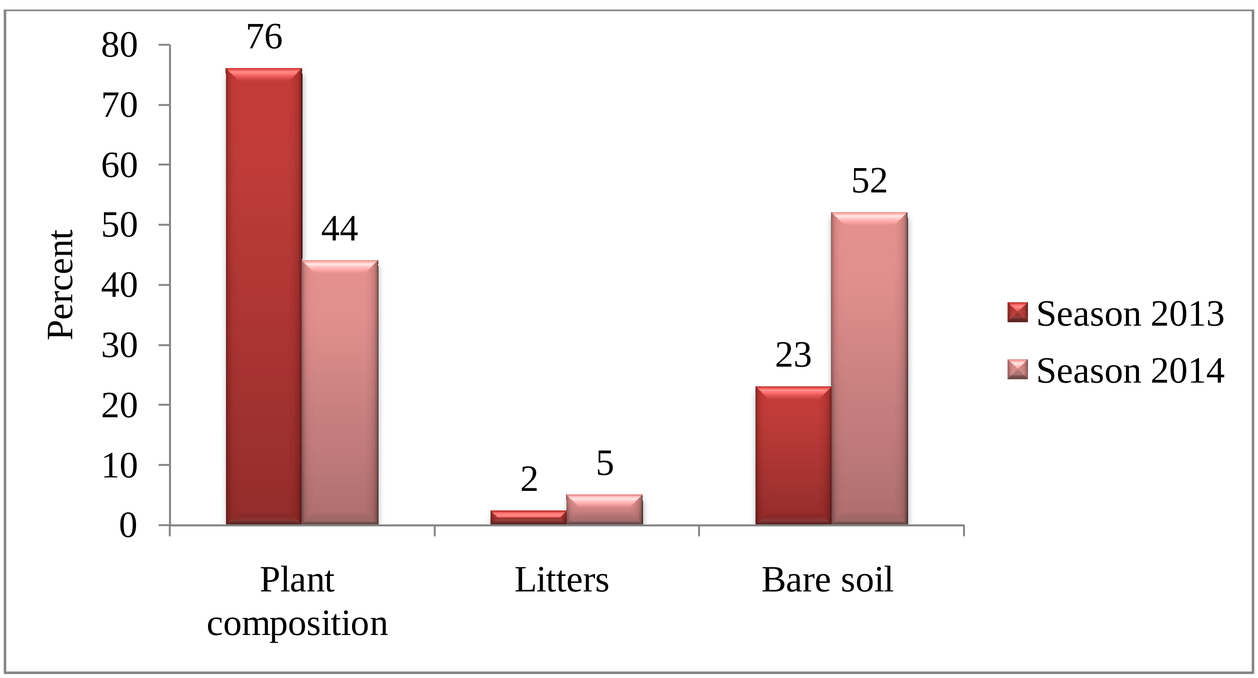


Figure (5.3) Plant composition%, litters% and bare soil% in the gardud site for the two rainy seasons (2013/2014) at the study area ………………Equations (1 and 3)



5.2.1.4 Plant cover

The three sites at the study area scored low plant cover percentage, sandy had (16% and 27%), and the clay (11% and 16%) and the gardud (11% and 16%) for the (2013/2014) respectively (Table 5.4). This could be due to intensive and early grazing, expansion of agriculture, deforestation and compaction soil surface causes by repetition of livestock's movement. All these lead to loss of the vegetation cover for both (overstory and understory) in the area. Cayrol *et al.*, (2000) and Loeser *et al.*, (2007) reported that both natural (floods, fires, droughts, volcanoes, etc.) and human activities such as (deforestation, overgrazing, urbanization and pollution) influences are known to cause massive changes in vegetation cover and dynamics. Overgrazing was considered as the main biotic factor responsible for the low vegetation cover besides overgrazing or un-controlled grazing, trampling by domestic livestock in semi-arid regions always reduces plant cover that protects the soil and generally results in soil erosion and soil compaction (Branson *et al*., 1981 and Oztas *et al*., 2003).

All sites did not reach the standard percentage of plant cover needed to protect soil and reduce the erosion in the area, the percentage of plant cover in the study area ranging from 11% – 27%. Connolly *et al*., (1997) reported that when the percent of vegetation cover is less than 30% – 40%, run-off and soil loss dramatically increase.

Table (5.4) Plant cover/m^2 at the three sites for the rainy seasons (2013/2014) at the study area ……………………………Equation No (2)

Parameter	Sites					
	Sandy		Clay		Gardud	
	2013	2014	2013	2014	2013	2014
Plant cover%	16	27	11	16	11	16
Changes%	11 ↑		5↑		5↑	

Note;↑shows the increasing

5.2.1.5 Relative plants species composition

The estimation of this parameter is important to investigate the increment distribution of the species in the rangeland and to study the changes in the structure of the plant community. Appendix (no. 1) shows average relative plants species composition at the three sites for the two rainy seasons (2013/2014). The plants species which measured by Loop method in the sandy site included *Zornia glochidiata* (27% and 75%), *Eragrostis spp* (22% and 9%), *Echinochloa colona* (25% and 5%), *Aristida spp* (7% and 4%), *Oldenlandia senegalensis* (5% and 3%), the species in the clay included *Schoenfeldia gracilis scored* (53% and 53%), *(Chloris gayana* (2% and 15%), *Eragrostis spp* (4% and 13%), *Dactyloctenium aegyptium*(10% and 2%), *Chloris preiurii* (11% and 1%) and gardud site integrated the following species *Vossia cuspidata* (44% and 46%), *Schoenfeldia gracilis* (38% and 15%), *Zornia glochidiata* (0.0% and 16%), *Dactyloctenium aegyptium* (4% and 5%), *Echinochloa colona* (5% and 3%). The spatial variation of plants species in the three sites could be due to variation of rainfall and soil topography, the three sites dominated by different species in both rainy seasons such as sandy site dominated by *Zornia glochidiata* (27% and 75%) respectively, clay site dominated by *Schoenfeldia gracilis* (53% and 53%) in both two seasons respectively and gardud site *Vossia cuspidata* considered dominant species for two rainy seasons (44% and 46%) respectively. Bennett and Adams, (1999) reported that spatial and temporal variability of rainfall in dry lands results in a complex association between vegetation and soils, notably organic matter, nutrients and microbial activity. O'Connor, (1991) found that rainfall variability over 1 or 2 years could induce substantial changes in composition. In addition to rainfall, spatial variation between sites potentialities which was affected by topographic variation can influence species composition. Kutiel and Noy-Meir, (1986) reported that the availability of soil resources may act as an environmental filter, selectively determining the establishment of annual species according to their growth requirements."

5.2.1.6 Plant frequency

The effective rangelands management at the study area should considered site's characteristics to provide better protection and improvement to achieve sustainable management of rangelands in the area. The sandy site dominated by *Zornia glochidiata* (91% and 88%)for the two rainy seasons, but this species not preferred by most animals in the area, this site needs to replace the less palatable species with other more palatable to avoid gathering animals at one site which could lead to overgrazing and causes rangelands deterioration.

Table (5.5) showed the dominant species at the three sites for the two rainy seasons (2013/2014), sandy site dominated by *Zornia glochidiata*(91% and 88), in the clay site *the* species *Schoenfeldia gracilis* (62% and 59%) considered dominant species and gardud site dominant by *Vossia cuspidata* (71% and 46%) for the two rainy seasons. Frequency of each species reduced in the second season, the species in sandy and clay sites their frequency reduced in the same percent 3% but the dominant species in the gardud site the frequency of it declined more than other species in the different sites, recorded 25%, that due to degree of preference of each species for livestock in the study area. Sandy and clay sites had 3% reduction compared to 25% at gardud. This due to the fact that species *Vossia cuspidata* is more palatable compared to species *Zornia glochidiata* and *Schoenfeldia gracilis* in the sandy and clay respectively.

Table (5.5) Dominant species (in %) at the three sites for the two rainy seasons (2013/2014) at the study area ……………………….Equation No (4)

Sites	Species	Frequency%		Reducing
		2013	2014	
Sandy	*Zornia glochidiata*	91%	88%	3%
Clay	*Schoenfeldia gracilis*	62%	59%	3%
Gardud	*Vossia cuspidata*	71%	46%	25%

5.2.3.7 Biomass production

Table (5.6) shows average biomass production (in ton/ha) at the three sites for the two rainy seasons. The results showed low biomass production in all sites. Sandy recorded (1.88 ton/ha, 1.22ton/ha), clay (0.90 ton/ha, 1.17

ton/ha) for (2013/2014) respectively while gardud site scored the lowest value (0.74 ton/ha and 0.63 ton/ha). The low biomass could be due to intensive grazing, early grazing, fluctuating of rainfall amount and distribution, climate change and low vegetation cover at the three sites. This is line with results of starting date of entering rangelands (table 5.3) and the vegetation cover standard which ranging (30% – 40%) while in the study area ranging between (11-27) that confirmed in (Table 5.5). Le Houerou and Hoste (1977) reported that biomass production depends upon various factors such as climate, nature of soil, botanical composition, vegetation cover, intensity of management such as grazing source, stocking rates, time of use and fire. Ellis (1995) declared that the amount and temporal distribution of precipitation, more than any other factor, determines plant growth in semi-arid regions.

5.2.1.8 The Carrying Capacity

The available forage production was used to estimate the carrying capacity at the three sites. Available forage production was calculated using the biomass production. Table (5.7) shows available forage production at the three sites for the two rainy seasons. The sandy site had 0.94 ton/ha and 0.61ton/ha; clay site scored 0.45 ton/ha and 0.59ton/ha and gardud site scored the lowest biomass production for the two seasons (0.37 ton/ha and 0.32 ton/ha) respectively. The high decreases in available forage production at the sandy site (0.33) compared to gardud (0.5) and small increases at clay site (0.14) (Table 5.6) as reflections on carrying capacity at the three sites The Carrying Capacity at the three sites for the two rainy seasons displayed that sandy site were (142 - 225 ha/AU/year, the clay site were (270 - 225 ha/AU/year) and the gardud site were (338 - 386 ha/AU/ha) respectively (table 5.8). However the carrying capacity influenced by biomass production which could be due to the intensive and early grazing and this is in line with (Ellis, 1995; Scoones, 1995).

Table (5.6) Biomass production (in ton/ha) at the three sites for the two rainy seasons (2013/2014) at the study area …………………Equation No (7)

Parameter	Sites					
	Sandy		Clay		Gardud	
	2013	2014	2013	2014	2013	2014
Biomass ton/ha	1.88	1.22	0.90	1.17	0.74	0.63
Changes ton/ha	0.66 ↓		0.27↑		0.11 ↓	

Note; ↑ increasing ↓ decreasing

Table (5.7) Available forage production (in ton/ha) at the three sites for the two rainy seasons (2013/2014) at the study area

Parameter	Sites					
	Sandy		Clay		Gardud	
	2013	2014	2013	2014	2013	2014
Biomass ton/ha	0.94	0.61	0.45	0.59	0.37	0.32
Changes ton/ha	0.33↓		0.14↑		0.5 ↓	

Note; ↑ increasing ↓decreasing

Table (5.8) Carrying Capacity at the three sites for the two rainy seasons (2013/2014) at the study area ……………………. Equation No (8)

Parameter	Sites					
	Sandy		Clay		Gardud	
	2013	2014	2013	2014	2013	2014
Carrying Capacity*	142	225	270	225	338	386
Changes	83↑		45↓		48 ↑	

* in: ha/ AU/Year ; **AU:** Animal Unit - Note; ↑ increasing ↓decreasing

5.2.2 Trees and shrubs cover at the study area

Table (5.9) showed the trees and the shrubs densities at the three sites for (2013/2014) seasons. In the sandy trees density were (425 tree/ha and 960 tree/ha) and in clay were (423 tree/ha and 728 tree/ha) both sites had high density compared to gardud (229 tree/ha and 382 tree/ha). The variation of trees and shrubs density could be related with level of utilization, distance of sites from villages or camps of the nomads in the study area, topography, palatability of species which occurs in each site for the animals and human activities such as deforestation, expansion of mechanized agriculture and cutting of trees for local utilization. In general spatial distribution of the different woody species depends on precipitation, where very low precipitation or drought provoked an overall mortality of 30 to 50% of shrubs and trees (Le Houèrou, 1980).

Appendences (3 and 4) illustrated relative trees density at the three sites for the two rainy seasons (2013/2014) the results indicated that the three sites dominated by different woody species in the two seasons. Sandy dominated with *Guiera senegalensis* (315 shrub/ha and 89 shrub/ha) while the clay site was dominated by *Acacia oerfota* (131 shrub/ha and 446 shrub/ha) and the gardud dominated by *Acacia mellifera* (134 shrub/ha and 91 shrub/ha) for the two rainy seasons respectively (Table 5.10). This variation of trees and shrubs at the three sites for the two rainy seasons may be due to topography, soil types and rainfall characterization. The species *Acacia oerfota* consider dominant species in the clay but does not prefer by most animals particularly when it is green that due to its unpleasant smell for this reason animals avoid to eat it. (It is worth measuring that all dominant species in sandy and gardud in their relative density decreased whereas the dominant species in the clay increasing in relative densities. This confirmed in table (5.10).

Table (5.9) Average total trees density (in tree/ha) at the three sites for the two rainy seasons (2013/2014) at the study area ………… Equation No (12)

Parameter	Sites					
	Sandy		Clay		Gardud	
	2013	2014	2013	2014	2013	2014
Trees density/ha	425	960	423	728	229	382
Changes trees/ha	535 ↑		305 ↑		153↑	

Not; ↑ shows increasing

Table (5.10) Relative trees and shrubs density for dominant species at the three sites for the two rainy seasons at the study area`………… Equation No (13)

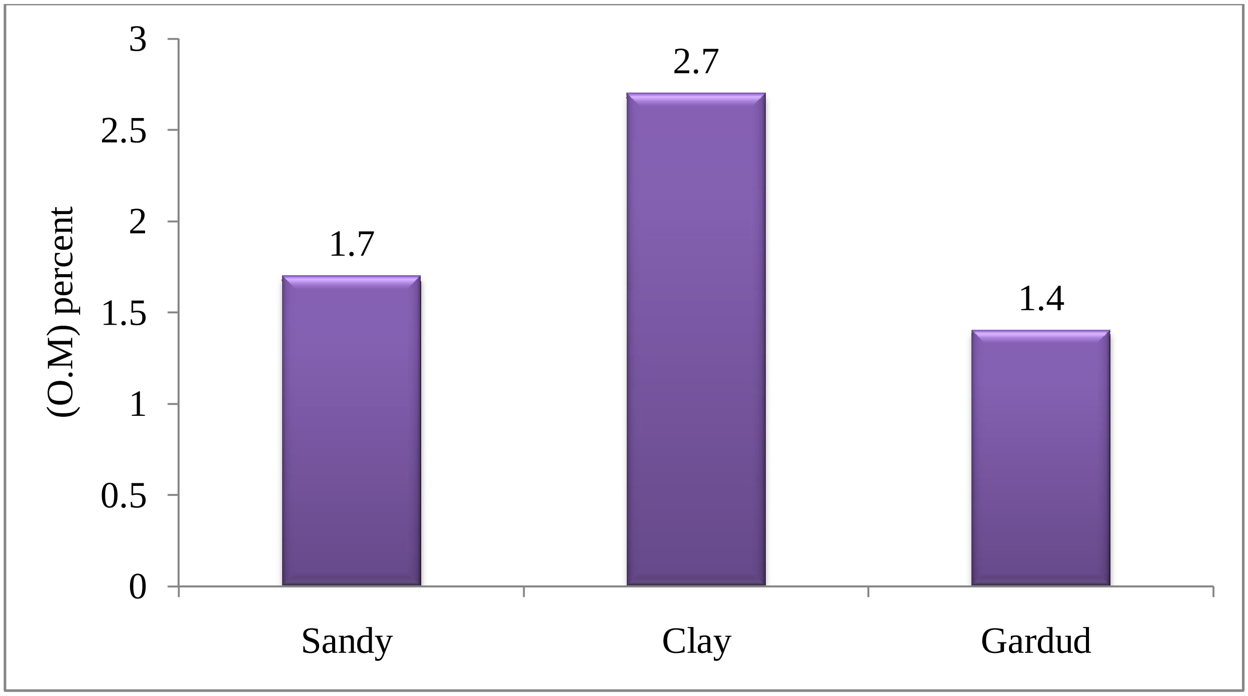
Sites	Species	Relative density/ha	
		2013	2014
Sandy	*Guiera senegalensis*	315shrub/ha	89shrubha ↓
Clay	*Acacia eorfota*	131shrub/ha	446shrub/ha↑
Gardud	*Acacia mellifera*	134/shrub/ha	91shrub/ha↓

Not; ↑ shows increasing and ↓decreasing

5.3 Soil organic matter content

The values were 1.7%, 2.7% and 1.4% for sandy, clay and gardud site respectively (Fig. 4). The three sites had low organic matter; this could be due to the changes in the plant cover and plant litters at the three sites (Table 5.4), where the three sites had low plant litters percent for the two rainy seasons (figures5.2 - 5.4). (Whitford, 1988 and 1996) stated that plant litters provides a major source of soil organic content and the raw materials for nutrient cycling. It is known that a soil with low organic matter content and no aggregate structure is vulnerable to wind erosion (Faraggitaki, 1985). Nevertheless the vegetation cover in the sandy site not influenced by early grazing because the site dominated by *Zornia glochidiata* that species was not preferred by most livestock in the area on the other hand increasing of vegetation cover in the clay site that lead to increase plant litters on surface of land and reflect positively on increasing soil organic matter content.

Figure (5.4) Average percentage of Soil Organic Matter at the three sites in the study area ………… Equation No (14)



5.4 The soil seed bank

Table (5.11) displays the live and dead seeds, live were 55%, 54% and 43 % while dead were 57% and 46% and 57% for sandy, gardud and clay respectively. The sandy and gardud sites scored comparable seeds density that were (3980 seed/m^2, 3320 seed/m^2 and 3540 seed/m^2, 3040 seed/m^2) live and dead respectively (appendix no. 9). Both sites had high density compared to clay site and this could be due to the morphology of seeds and its palatability. The dominant seed in gardud were *Vossia cuspidata*, it has hair and heavy weight resists its movement (visual observation) while *Zornia glochidiata* is a dominant in sandy site, the dominant species is not preferred by most livestock in the study area (table 5.20). In comparison clay recorded the lowest seeds density (1460 seed/m^2 and 1920 seed/m^2) for live and dead respectively; the dominant seeds were *Schoenfeldia gracilis,* this due to seeds morphology and soil erosion could be the reasons (Appendix no.9). However, the widely seed bank diversity may be attributed to grazing, that can decrease flower and seed production directly by consuming reproductive structures or indirectly by stressing the plant and reducing energy available to develop seeds (Solomon and Snymal, 2005).

Table (5.11) Live and dead seeds percent of dominant species at the three sites at the study area ………… Equations No (10 an 11)

Sites	Species	Live%	Dead%
Sandy	*Zornia glochidiata*	55	45
Clay	*Schoenfeldia gracilis*	43	57
Gardud	*Vossia cuspidata*	54	46

5.5 The Socio -economic aspects of respondents at the study area

* Remind the reader in Analysis was done using Chi – square.

5.5.1 Age groups of both respondents

Table (5.12) shows that there were highly significant differences at P<0.0001according to age among the nomads in the study area. About 32% their age within the range (20 – 30year), the available young boys may be due to role of them for look after livestock, 25% (40 – 50year), 19% (30 – 40year), 13% (less than 20) and 11% (above 50year) about 89% of the nomads in age able to practice grazing activity in the best way. Sedentary groups also showed highly significant differences at P<0.0001 (Table 5.12) according to their age 41% of them above (50), 28% (30 – 40year), 25% (20 – 30year) and

6% (less than 20year) most people among the sedentary group their age above 50year, this due to migration of young people from rural area to urban areas look for other source of income, and learn higher education at universities or higher institutes, young people among the nomads ending their education early. Sedentary group migrate in summer season to towns, particularly when their cultivation failed and agriculture production does not cover their livelihood requirements.

According to education levels among the nomads in table (5.13) about 43% of them were illiterate, 22% were educated at basic , 11% khalwah, 22% at secondary followed by 2% at university level there were high significant differences at $P<0.0001$(Table 5.13). While sedentary group also showed highly significant differences at $P<0.0001$ in education levels (Table5.13) 31% of them at basic educated, 22% at secondary level, 19% illiterate, 16% at university educated followed by 12% khalwah. The high illiteracy among the nomads (43%) can be attributed to the lack of the schools in places where they are living or the school timing contradicts with their life pattern, but illiteracy among sedentary families does not high. This may be due to stability of them in one place and availability of schools surrounding their villages. Nevertheless most of sedentary had basic education, early marriage among them and migration of most young boys to cities looking for another source of income and practice marginal works, particularly at capital of Sudan are the reasons.

Table (5.12) Age of both respondents

Ages groups	Frequency		%	
	Pastoralists	Sedentary	Pastoralists	Sedentary
Less than 20yaer	17	15	13	6
20 -30 year	41	60	32	25
30- 40 year	25	69	19	28
40 – 50 year	32	0.0	25	0.0
Above 50 year	14	99	11	41

Table (5.13) Education levels for both respondents

Education levels	Frequency		%	
	Pastoralists	Sedentary	Pastoralists	Sedentary
Illiterate	55	47	43	19
Khalwa	14	29	11	12
Primary	29	74	22	31
Secondary	29	54	22	22
University	2	39	2	16

The results in table (5.14) showed the source of income for respondents, the sedentary were mainly depend of different types of sources of income 61%, 32%, 2% and 5% depend on cultivation, animals raising, combination of animals raising and cultivation and trade respectively. Traditional cultivation (without rotation and shifting) compassed 96% and mechanized was only 4%.

In the nomads community combination of animals raising and cultivation was dominant. For sedentary were 61%, 25% for animals raising and 14% for trade.

According to the results of sedentary groups in table (5.15). About 55% of them using both millet and durra, 25% utilize millet for feeding and 20% depend on durra with highly significant differences at $P<0.0001$. The people in the area depend on millet as main food, but fluctuation of rainfall lead them to change their feeding pattern toward durra beside millet to secure their food.

Table (5.14) Source of the income for respondents at the study area

Source of income	Frequency		%	
	Pastoralists	Sedentary	Pastoralists	Sedentary
Cultivation	0.0	149	0.0	61
Animals raising	32	5	25	2
Animals raising and cultivation	78	77	61	32
Trade	18	12	14	5
Types of cultivation practices by the respondents				
Traditional	0.0	232	0.0	96
Mechanized	0.0	11	0.0	4

Table (5.15) Types of crops used by sedentary groups at the study area

Types of crops	Frequency	%
Millet	61	25
Durra	48	20
millet and durra	134	55

Most of sedentary groups in table (5.16) 80% keep their animals in villages in the both dry and wet seasons while 20% of them do not keep their livestock in their villages there were highly significant differences P<0.0001. This attributed to the sedentary characteristics in the area have small herds, that does not need to move away to graze, practice farming besides grazing and collecting the crop residues to use them in summer season to compensate for cover shortage of the forage in the dry season.

Most of sedentary groups 96% collected crop residues after harvesting their crops (Table 5.17). This may be due to shortage of forage in the dry season that encourages the sedentary to collect crop residues to use in many purposes. This agreed with (Brandstrom, *et al*., 1975) who stated some reserves were set aside to save fodder for dry season.”

Table (5.16) Staying period of livestock in the villages at the study area

Category	Frequency	%
Staying	195	80
Moved	48	20

Table (5.17) Collection of crop residues by sedentary at the study area

Answered	Frequency	%
Collected	234	96
Do not collected	9	4
Purposes of collection crop residues		
To feed animals in the dry season	87	36
To build houses and feed animals	144	59
To trade	12	5

5.5.2 Livestock Resources

Both sedentary and nomads prefer mixed herds (68% and 48%) respectively mainly to adapt to the range condition. This is in line with Morton (1989) indicating the adaptation of the nomads to rangelands condition. Nevertheless the in cases of pure herd sedentary had 28%, 12% and12%for goats, sheep cattle respectively compared to 6% camel compared to 11% goats, 5%sheep and 10% cattle in nomad community (Table 5.18). Generally, milk production was the reason for raising animals in communities, 83% and 71 % for sedentary and the nomads respectively (Table 5.18). This is the line with (Coppock, 1994).Traditionally, herders consume most of the milk produced; any surplus is usually shared with neighbors, exchanged in barter or sold in urban areas. In Somalia, a commercial milk chain through a cooperative has been established among the nomads for marketing, camel milk in Mogadishu as source of income to buy sugar, clothes and medicines (Herren, 1990).

Table (5.18) Herds structure and purpose of animals' raising for both respondents at the study area

Kinds of animals	Frequency		%	
	Pastoralists	Sedentary	Pastoralists	Sedentary
Cattle	13	28	10	12
Sheep	6	30	5	12
Goats	14	69	11	28
Camels	8	0.0	6	0.0
Mixed of animals	88	116	68	48
Purpose of keeping livestock				
Purpose	Pastoralists	Sedentary	Pastoralists%	Sedentary%
Milk	92	201	71	83
Meat	0.0	10	0.0	4
Trade	35	32	27	13
For boaster	2	0.0	2	0.0

5.5.3 Disappearance and invader plants species at the study area

Both respondents considered the following species were disappeared from grazing areas *Blepharis linariifolia* (35% and 35%), *Echinochloa colona* (14% and18%), *Cymbopogon nervatus* (3%, 1%), *Dactyloctenium aegyptium* (2%, 4) (Table 5.19). Most of them are palatable for the livestock in the area. Disappearance of more palatable species could be due to intensive grazing and absence of rangelands improvement programs in the area. The invader species included *Sida cordofolia* (50% and 65%) *Xanthium brasilicum* (4%

and 3%), *Zornia glochidiata* (2%, 1%), *Datura stramanium* (0.0% and 3%), *Cynodon dactylon* (0.0% and 2%) (Table5.20). Most of the nomads 97% stated that the invader species were not preferred by livestock in the study area (Table 5.21) there were highly significant differences at P<0.0001.

Table (5.19) Disappeared of plants species at the study area

Species	Investigated respondents %		Frequency% measured	Status
	Pastoralists	Sedentary		palatable
Blepharis linariifolia	35	35	0.0	Palatable
Echinochloa colona	14	18	30	Palatable
Ipomea spp	5	0.0	13	Palatable
Cymbopogon nervatus	3	1	0.0	Palatable
Dactyloctenium aegyptium	2	4	35	Palatable
Oldenlandia senegalensis	1	3	27	Palatable
Aristida spp	1	0.0	0.0	Palatable
Zornia glochidiata	0	5	50	Unpalatable
Brachiaria obtusiflora	0.0	3	0.0	Palatable
Senna obtusifolia	0.0	1	0.0	Unpalatable
Andropogon gayanus	0.0	1	0.0	Palatable
Cenchrus spp	0.0	1	2	palatable
Gegaria alata	0.0	1	0.0	Unpalatable
Sorghum spp	0.0	1	0.0	Palatable

Note; (80%) of disappeared species considered palatable for livestock in the area

Table (5.20) Invader plants species at the study area

Species	Investigated respondents %		Frequency% measured	Status
	Pastoralists	Sedentary		
Sida cordofolia	50	65	12	Unpalatable
Xanthium brasilicum	4	3	0.0	Unpalatable
Aristida spp	3	0.0	3	Palatable
Zornia glochidiata	2	1	50	Unpalatable
Chloris spp	1	0.0	0.0	Palatable
Eragrostis spp	1	0.0	51	Palatable
Senna occidentalis	0.0	1	0.0	Unpalatable
Amaranthus viridus	0.0	1	0.0	Unpalatable
Datura stramanium	0.0	3	0.0	Toxic
Cynodon dactylon	0.0	2	0.0	Palatable

0.0; not measured or investigated and (60%) of invaded plants considered unpalatable for livestock

Table (5.21) Preferring of plants species appeared at the study area

Category	Frequency	%
Preferred	4	3
Not preferred	125	97

Most of the nomads97% facing the shortage of the forage in the area for that they buy crops residues from sedentary to cover the shortage of forage and 3% decrease their livestock number by selling in the market (table 5.22).

There were highly significant differences at P<0.0001. That due to the nomads do not moves away from rainy season domain due to security situation. A total of 97% investigated the respondents of the nomads about livelihood pattern stated was changed and just 3% do not change their livelihood pattern (Table 5.23) there were highly significant differences at P<0.0001. Most of the nomads 98% stated that expansion of agriculture considered the main causes of livelihood changing (Table 5.23) there were highly significant differences at P<0.0001. According to Garcia (1981) the main problem of Africa rangelands is the expansion of agriculture into grazing areas.

Table (5.22) Methods used to face shortage of forage at the study area

Methods used	Frequency	%
Buying crop residues from sedentary groups	125	97
Selling unhealthy and thin livestock	4	3

Table (5.23) Livelihood pattern of the nomads and causes of changing at the study area

Status	Frequency	%	Causes	Frequency	%
Changed	125	97	Expansion of agriculture	126	98
			Security situation in the State	3	2
Constant	4	3	0.0	0.0	0.0

5.5.4 Rangelands Condition

According to range condition in the study area most of the nomads88% stated that the rangelands was deteriorated and 12% had not changes (Table 5.24) there were highly significant differences at $P<0.0001$. 51% of them said that the deterioration of rangelands may be due to shortage of grass, 24%, appearance of unpalatable species, 20% disappeared of more palatable plants species, 2% soil erosion, and 2% conflicts in the area and 1% increasing of the livestock number.

Table (5.24) Rangelands condition and causes of deterioration at the study area

Condition	Frequency	%	Causes of deterioration	Freq	%
Deteriorated	114	88	Disappeared of palatable species	26	20
			Appeared of unpalatable species	31	24
			Soil erosion	3	2
			Shortage of grasses	52	51
			Increasing of No. of livestock	1	1
			Conflicts	2	2
Do not deteriorate	15	12	0.0	0.0	0.0

5.5.5 General status of livestock

Most of the nomads feel that there was tendency for decreasing in the number of livestock 76% while 16% felt it was increasing and only 8% seemed to them is constant (Table 5.25). The most of the respondents 72% ascribed the decreasing to the shortage of forage and 22%, 9% and 7% for diseases, conflicts and selling respectively.

According to the results in table (5.25) the majority of the nomads 60% mentioned there was deterioration in livestock health and only 40% of them seemed not deteriorated. The reasons behind the deterioration of livestock health expressed by the nomads and 70% said due to shortage of forage followed by 25% there broken diseases and only 5% for security issue at the level of high significant at $P<0.0001$ (Table 5.25).

Table (5.25) the general status of livestock at the study area

Number of livestock			Reasons of decreasing			
Decreased	Increased	Constant	Shortage of forage	Diseases	Conflicts	Selling
76%	16%	8%	62%	22%	9%	7%

Health of livestock					Reasons of health deterioration		
Weak	Moderate	Good	V. good	Excellent	Shortage of forage	Diseases	Security situation
60%	7%	13%	15%	5%	70%	25%	5%

According to grazing pattern practices in the study area 71% of the nomads stated that they practice transhumant system, 23% semi transhumant, followed by 6% sedentary most of the nomads in the area moving either for a long or short distance most of them move in the different directions of State in both seasons (dry and wet) (Table 5.26) with highly significant differences at P<0.0001.

Most the nomads 72% were stayed with their livestock in their villages and only 28% moved with herds with highly significant differences at P<0.002 (Table 5.27).This could be due to the nomads depending on other activities to meet needs of life such as cultivation, trading, fuel wood collection and charcoal making.

According to activities practiced by members of the nomads stayed in summer season domain (permanent areas) 84% of them practice cultivation, 15% look after oldest livestock and 1% practice trade (Table 5.27) with highly significant differences at P<0.0001 .This may be due to fluctuated of animal's number production and decreasing of number.

Table (5.26) Grazing pattern practice by the nomads at the study area

Pattern	Frequency	%
Transhumant	91	71
Semi transhumant	30	23
Sedentary	8	6

Table (5.27) Moving of pastoralists' families with livestock at the study area

Status	Frequency	%
Moved	36	28
Do not moved	93	72
Role of families' members at permanent areas		
Practice cultivation	109	84
look after oldest animals	19	15
Practice trading activities	1	1

5.5.6 Using trees and shrubs for feeding livestock in dry season at the study area

The both respondents using trees and shrubs in summer season to cover the shortage of forage 64% of the nomads depend on trees and shrubs as source of feeding their livestock 36% do not using and 57% of sedentary using trees and shrubs to fill gap of forage shortage and 43% do not prefer using trees to feed their livestock (Table 5.28) there were highly significant differences at P<0.0001.

Figures (5.5 and 5.6) shows trees and shrubs species used to feed livestock in the dry season by the nomads64% used *Balanites aegyptiaca* and15% *Guiera senegalensis* and majority of sedentary 47% used *Combretum hartmannianum* and 25% *Balanites aegyptiaca*

Table (5.28) Using of trees and shrubs for feeding livestock during dry season at the study area

Category	Frequency		%	
	Pastoralists	Sedentary	Pastoralists	Sedentary
Used	83	138	64	57
Don not used	46	105	36	43

Figure (5.5) Percentage of trees and shrubs use for feeding livestock by the nomads during dry season at the study area

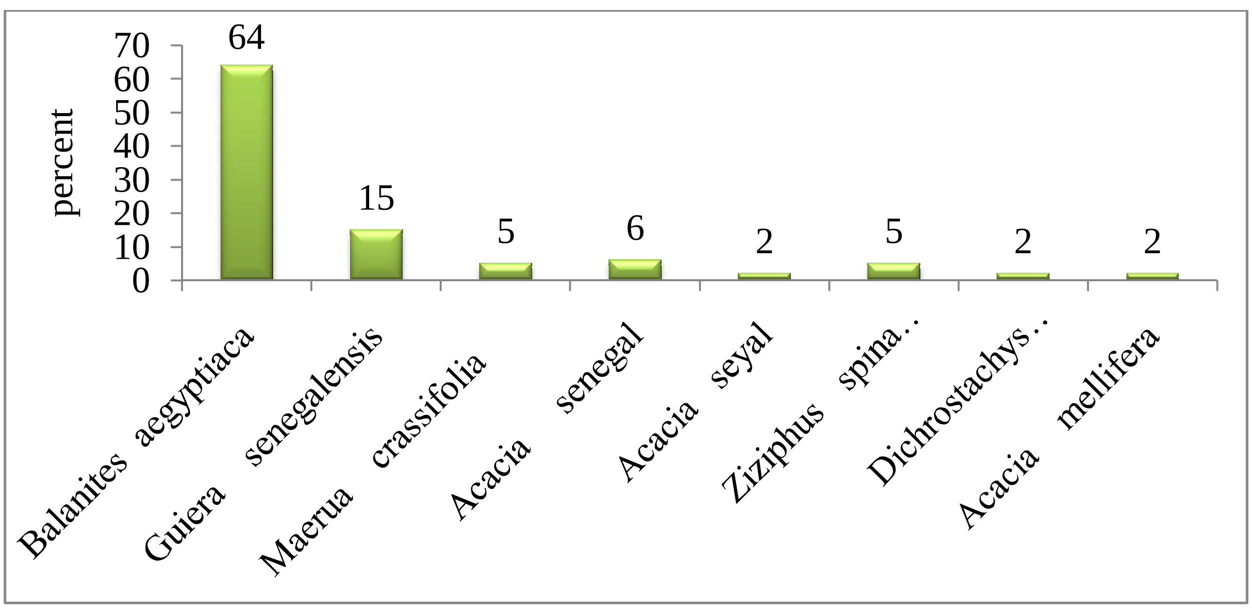
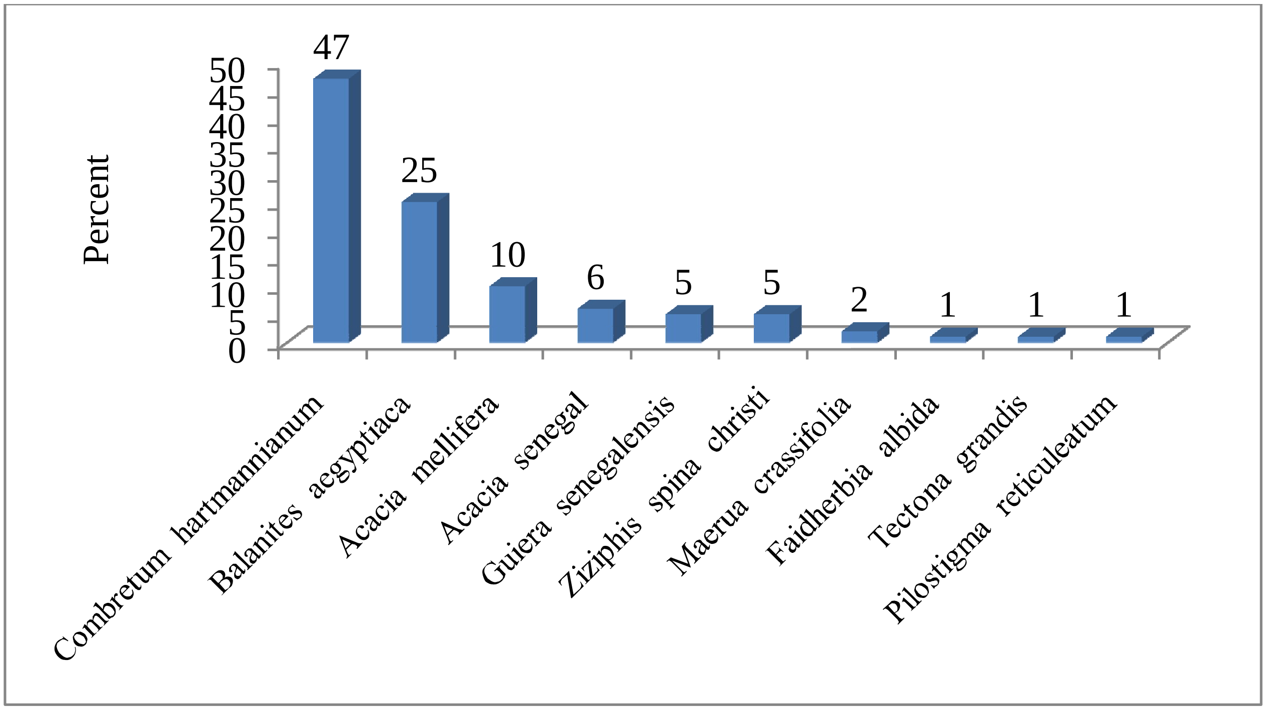


Figure (5.6) Percentage of trees and shrubs use for feeding animals by sedentary group during dry season at study area



5.5.7 Water sources at the study area

Respondents of the nomads investigated about water sources used for human and livestock at the study in the rainy season domain "*Makhraf*" 47% they depend on pools, 48% depend on "*hafires*", only 5% used wells (Table 5.29), with highly significant differences at P<0.0001. For sedentary 33% using pools, 25% as hand pumps, 22% using wells, 18% "*hafires*" and 2% depend on dams the differences between two groups are related to differences in the using style.

Table (5.29) Water sources for both respondents at the study area

Water sources	Frequency		%	
	Pastoralists	Sedentary	Pastoralists	Sedentary
Wells	6	53	5	22
Hafires	62	44	48	18
Pools	61	80	47	33
Hand pump	0.0	60	0.0	25
Dams	0.0	6	0.0	2

59% of the sedentary stated that water sources are considered common right, 37% belong to government and 4% belong to private sectors. Most of the nomads 66% have conflicts in water sources 34% does not have and 67% of them stated the conflicts due to shortage of water compared to 28% due to shortage of grasses and 5% increasing animals in the area (Table 5.30) with highly significant differences at $P<0.0001$. The occurrence of conflicts in water sources could be due to common ownership of water sources in the area.

Table (5.30) Ownership of water sources and conflicts at the study area

Ownership	%
Common	59
Governmental ownership	37
Private	4
Conflicts of water sources among mobile pastoralists	
	%
Occurrence	66
Do not occurrence	34
Causes of conflicts at water sources	
Causes	%
Shortage of water	67
Shortage of grasses	28
Increasing of animals	5

5.5.8 Provision of services for the nomads at the study area

Table (5.31) stated that 54% of the nomads received services and 46% do not get services. About 72% of respondents said they have received veterinary services compared to 16% water supply, 10% get education and 2% extension programs. 85% of services provided by international organizations and 15% by government and other bodies (Table 5.31) with highly significant differences at $P<0.0001$. This could be due to civil war in most parts of state restricts the government accessibility pastoralists' community in their locations.

Table (5.31) Provision of services for the nomads at the study area

Answers	%
Provided	54
Not provided	46
Types of services	
Veterinary services	72
Water supply	16
Education	10
Extension programs	2
The institutes provide services	
International organizations	85
Government	13
National governmental organization	2

5.5.9 Participation of the nomads in local organization at the study area

According to the participation of the nomads in rangelands activities at the area. About 90% both were not participate with highly significant differences P<0.0001.This could be due to lack of extension services provided to measure awareness among the nomads to participate in rangelands activities and low education levels among them. These results confirmed that table 5.13. Most of respondents (95%) participated in livestock diseases control program (Table 5.32) with highly significant differences P<0.0001.This showed the awareness of community about their herd and how is it important.

Table (5.32) participation of the nomads in rangelands' activities in the study area

Category	%
Participate	10
Do not participate	90
Activities that respondents participated of them	
Activities	%
Control diseases	95
Extension programs	3
Seeds broadcasting	2

5.5.10 Conflicts among both respondents at study area

Conflicts are common between the nomads and sedentary groups in the study area. 85% of the nomads have conflicts compared to 15% do not have conflicts. 77% of sedentary have conflicts, 23% do not have conflicts (Table 5.33) with highly significant differences at $P<0.0001$.

According to the reasons of conflicts as stated by the nomads that 67% due to narrow routes, resulting from expansion of agriculture into grazing areas, 20% shortage of forage, while 13% due to shortage of water. As for sedentary 75 % of conflicts resulting from damaging farms by animals compared to 17% competition on grazing while 8% due to competition of water sources (Table 5.33) with highly significant differences at $P<0.0001$. From these results the expansion of agriculture considered the main causes of conflicts in the area. Garcia (1981) stated that main problem of Africa rangeland is expansion of agriculture into the nomads grazing areas. Salih (2001) stated that most of the nomads do not use the traditional routes, which had been determined by government, so they search about the pure grazing areas anywhere and this lead to damage the settler's farms and finally causes the conflicts between them.

Table (5.33) Conflicts among both respondents at the study area

Occurrence		Do not occurrence	
Pastoralists	Sedentary	Pastoralists	Sedentary
85%	77%	15%	23%
Causes of conflicts			
Causes		%	%
Closing routes of livestock by cultivation		67	0.0
Shortage of water		13	0.0
Shortage of forage		20	0.0
Damage farms by animals		0.0	75
Competition on grazing		0.0	17
Competition on water sources		0.0	8

According the sedentary groups 91% of them stated, the conflicts exist around farms, while 5% around water sources followed by 4% around to the villages (Table 5.34).

Conflict existing between sedentary and pastoralists during grazing time as reflected by 61% pastoralists and 42% sedentary (Table 5.34) More frequently in rainy domain. Both pastoralists and sedentary (24% and 30%) conflict erupted between the two communities during rainy season when pastoralists entered the domain (Table 5.34).

Table (5.34) Period of conflicts increasing and places of happening sat the study area

Frequency			%	
Places	Pastoralists	Sedentary	Pastoralists	Sedentary
Around farms	0.0	223	0.0	91
Around sources of water	0.0	11	0.0	5
Around villages	0.0	9	0.0	4
Period of conflicts increasing				
Period	Pastoralists	Sedentary	Pastoralists%	Sedentary%
When the nomads entrance to rainy domain	30	73	24	30
When the nomads return to summer domain	0.0	67	0.0	28
Through grazing time	79	103	61	42
Through drinking of livestock	3	0.0	2	0.0
When the nomads exist from rainy season domain	17	0.0	13	0.0

Majority of respondents (82% and 40%) the nomads and sedentary respectively settled their conflicts by leaders of tribes (Table 5.35) there were highly significant differences at P<0.0001   This may be due to short period which the nomads spend in rainy season domain, and close relationship between both groups.

Table (5.35) Ways of conflict's transformation among both respondents at the study area

Frequency			%	
Ways	Pastoralists	Sedentary	Pastoralists	Sedentary
Pay fine	0.0	76	0.0	31
Prison	0.0	3	0.0	1
Settlement	0.0	55	0.0	23
Pay fine and prison	0.0	13	0.0	5
Local administrative "*gowdyah*"	106	96	82	40
Court	23	0.0	18	0.0

5.6 Characterization of rangelands

Remote Sensing (RS) and Geographic Information Systems (GIS) techniques were used to estimate NDVI values at the three sites in the rainy season. Vegetative production in the rangeland sites was affected by some factors such as site characteristics and response to water all these affected the type of plants species which grow, since fast rate of grow and hence biomass production. It's clear that the sandy site reflected the highest NDVI value during the rainy season in five years through months from June to November, the peak of NDVI values was not in the same NDVI. This is reason why the nomads prefer to enter first the sandy sites in the rainy season and delay other sites.

According to these results of remote sensing can be used to map different range sites' characteristics and hence inputs of means of management. The sharp decrease in NDVI values for the sandy site compared with other sites resulting from the early use by nomads as confirmed by them will need to be considering in management process to avoid erosion of seed bank and deterioration of sandy areas (Fig 5.30).

Gardud site in all cases is either the lowest NDVI value although showed early NDVI value in rainy season during the years 2010, 2011, 2013 and 2014 (Fig 5.7 – 5.11 except 5.9) that due to exist of *Acacia mellifera* in this site, which tend to be come green early with early showers unlike grasses and herbs in most cases grow bigger in August and September. It's noticed that this was not the case in season 2012 though not remarkable difference indicating that this year was characterizes by late rain compare with other years.

Figure (5.7) Mean of NDVI for the six months in (2010) at the three sites at the study area

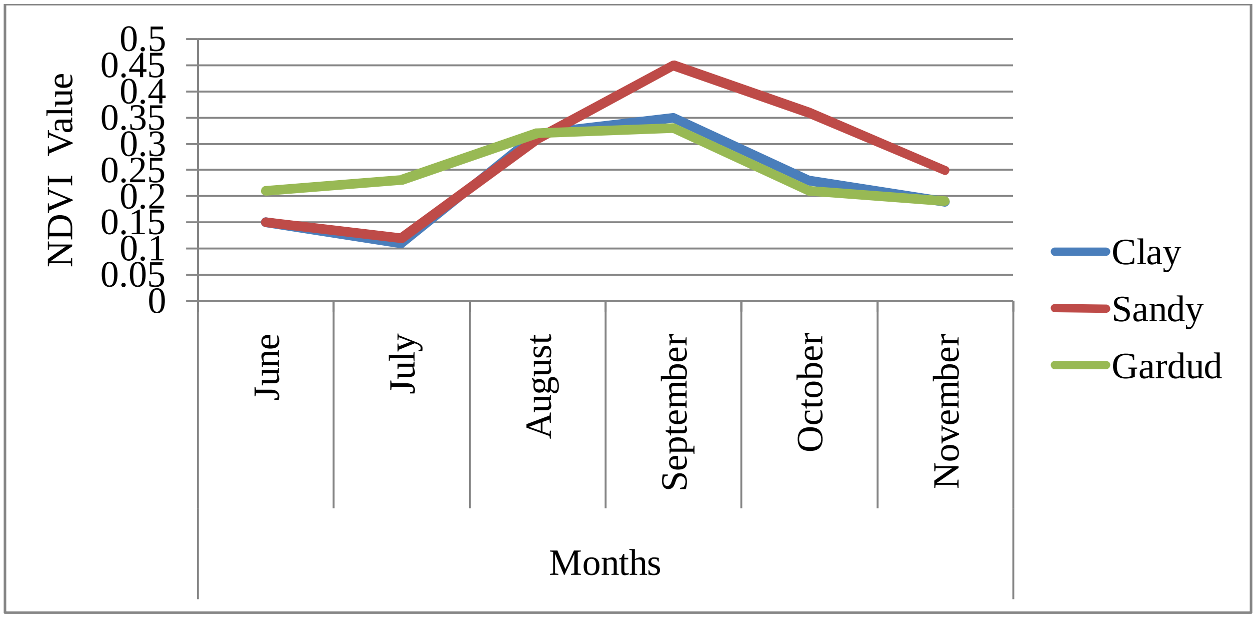


Figure (5.8) Mean of NDVI for the six months in (2011) of the three sites at the study area

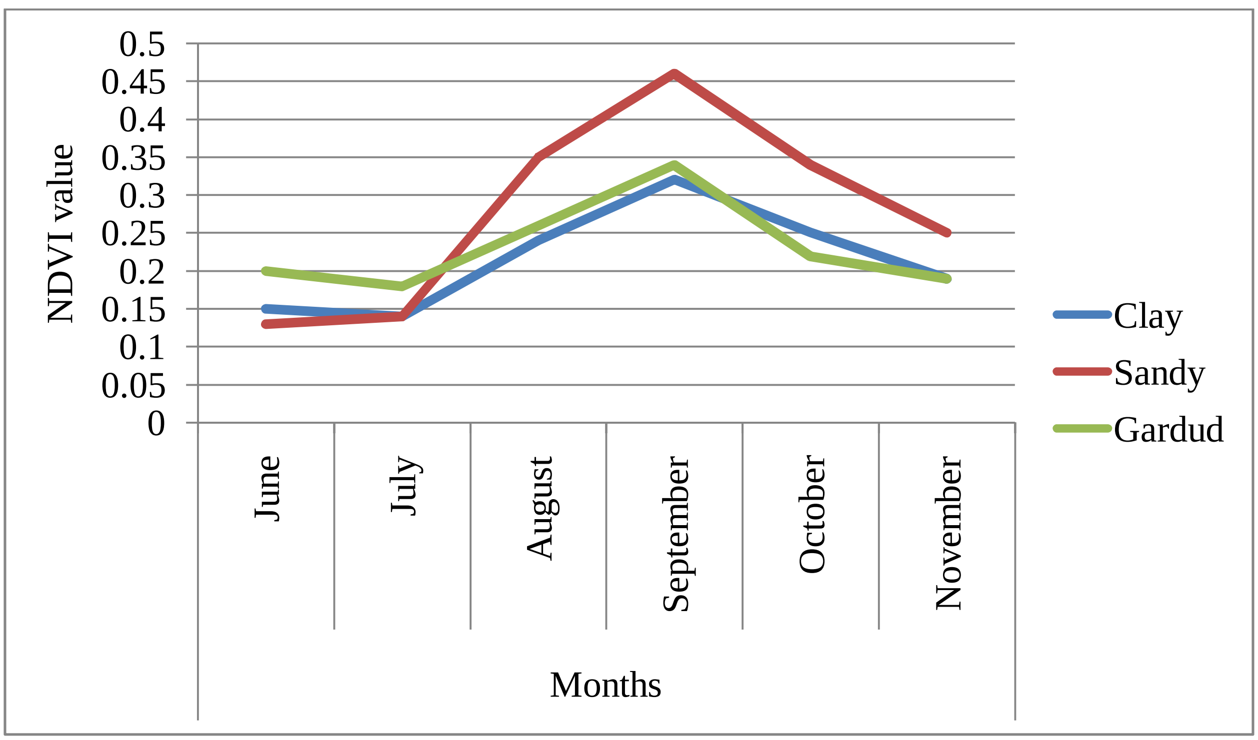


Figure (5.9) Mean of NDVI for the six months in (2012) of the three sites at the study area

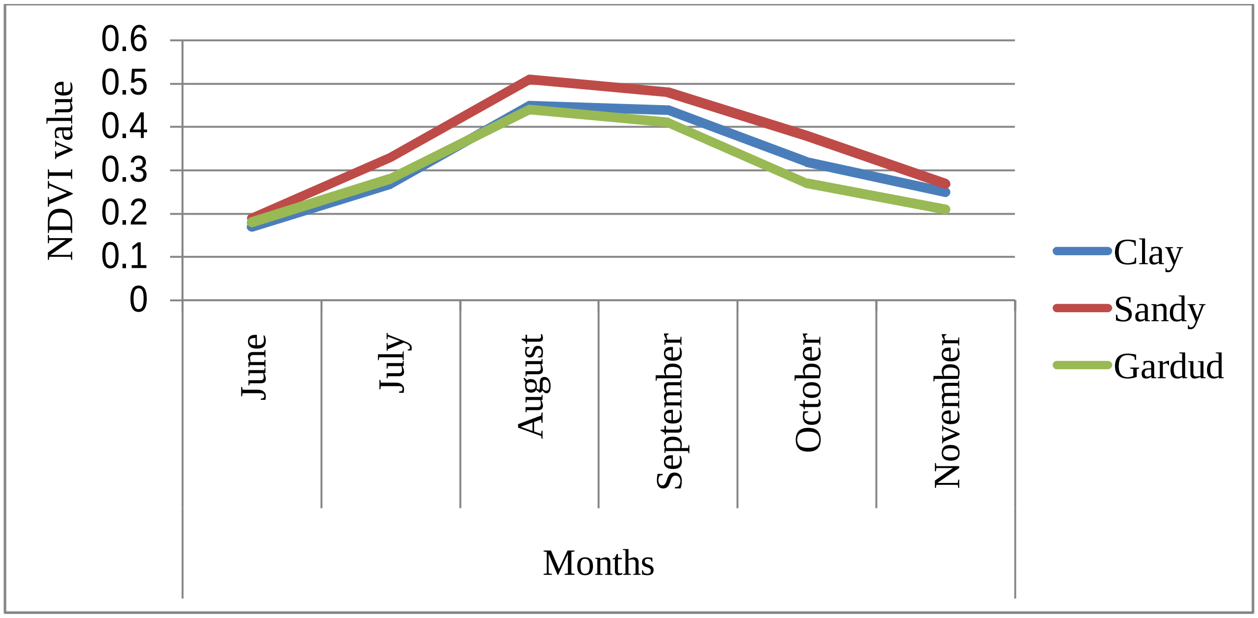


Figure (5.10) Mean of NDVI for the six months in (2013) of the three sites at the study area

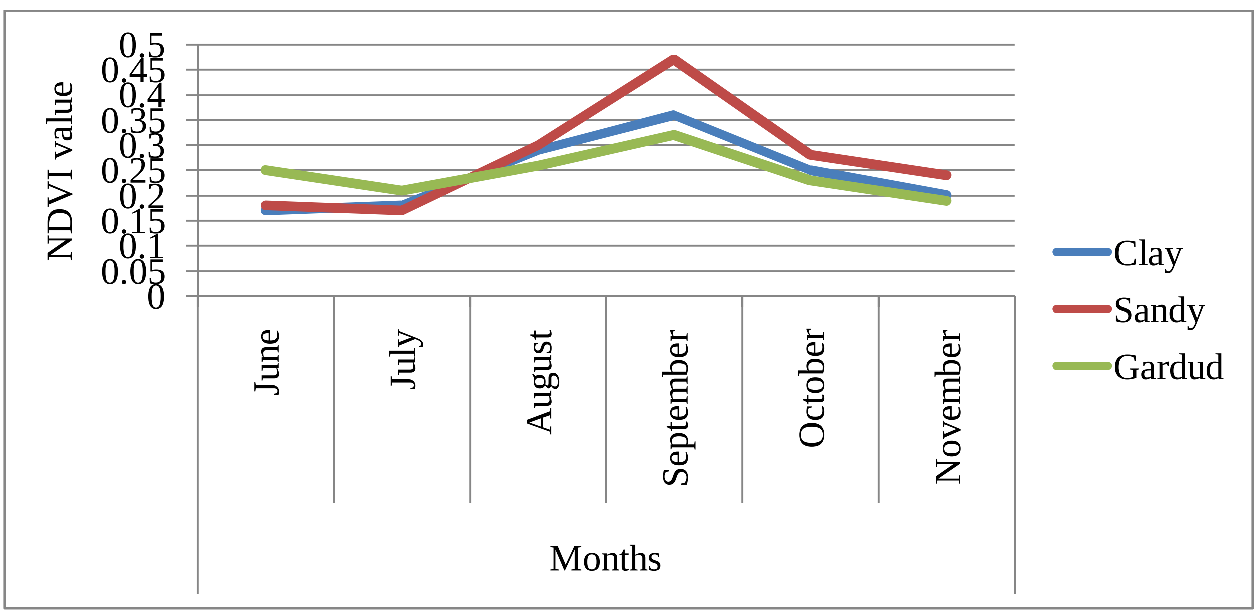
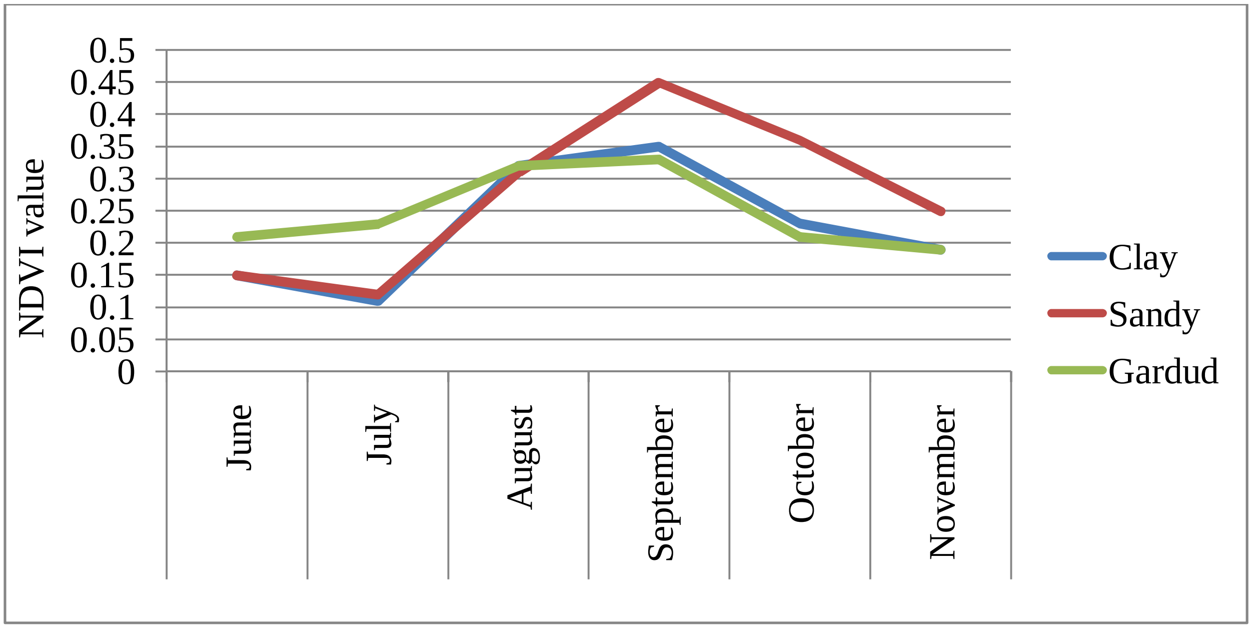


Figure (5.11) Mean of NDVI for the six months in (2014) of the three sites at the study area



CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

The study showed variations between the three sites as reflected in vegetation attributes measurements for both herbaceous and trees cover and socio economic survey for the nomads and sedentary. Herbaceous measurements using plant composition, biomass and letter showed that the sandy site had the highest plant composition, lowest bare soil and lowest plant litters compared to the clay and gardud sites. However, the three sites recorded low plant cover, low biomass production and dominated by different plant species. Sandy site was dominated by unpalatable species: *Zornia glochidiata* and *Guiera senegalensis,* clay site was dominated by *Schoenfeldia gracilis* and *Acacia oerfota* and gardud site was dominated by *Vossia cuspidata* and *Acacia mellifera.* In addition the nomads and sedentary respondents confirmed invasion of unpalatable species and disappearance of more palatable species such as *Blepharis linariifolia* and *Andropogon gayanus*. The dominant species indicating that the sandy site is deteriorating compared to clay and gardud sites.

Most the nomads entering to sandy site early in June and majority of them exiting from gardud site in early in October and both respondents preferred sandy for practice grazing. The status of the rangelands, as indicated by NDVI, seems to be the factor affecting the nomads entering and existing date. NDVI results for the six months studied along five years (2010 to 2014) showed that the peak of the NDVI value obtained earlier and sharply decrease in value in the sandy site compared to clay and gardud sites.

The assessment used to monitor the condition and the status of the rangelands in the study area could help to design and implement proper rangelands management. Site's characteristics impact the status of the rangelands and the traditional practices has to be improved to accommodate changes. The resilience of the different sites seems better in clay site followed by gardud and sandy site indicated less resilience in condition vulnerable to conflict. The majority of both respondents confirmed existence of conflicts among them in rainy season domain "Makhraf" and most of them mentioned reasons of conflicts in separately ways such as blocking routes of livestock by farms on livestock's routes and damaging of farms by livestock belong to mobile pastoralists. The conflicts were taking place around farms and increase when the nomadsenter the rainy season and through practice grazing. Both respondents settled the conflicts by leaders of their tribes.

Therefore the rangelands should consider site's characteristics and conditions when applying different rangelands management approaches. Nevertheless seed broadcasting of more palatable species, should be done in the sandy site with proper measure to control the unpalatable species invasion. The plant cover in the clay site should be increased and gardud site needs soil erosion measure particularly water erosion.

According to results the study recommended the following:

® The rangeland areas should be dealt based on their characteristics in order to adopt management prescription as appropriates for each site.

® The rangelands improvement practices such as seeds broadcasting, control of unpalatable species should be focus on in the sandy site to ensure stability and sustainability of rangelands at the study area.

® The rangelands managers to be aware about period of plants species flourish and drying, that facilitate to select suitable period to entrance the rangelands and existence from it by livestock and determine time of seeds collection.

® The sharp decrease in NDVI values for the sandy site compared with other sites resulting from the early and intensive use by nomads as confirmed by them will need to be considered in the rangelands management process to avoid erosion of seed bank and deterioration of sandy areas.

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APPENDECES

Appendix NO (1) Average relative plants species (herbaceous) composition at the three sites for the two rainy seasons (2013/2014) at study area

Scientific name	Habit	Plants species composition%					
		Sandy		Clay		Gardud	
		Season 2013	Season 2014	Season 2013	Season 2014	Season 2013	Season 2014
Schoenfeldia gracilis	Grass	1	0.0	53	53	38	15
Dactyloctenium aegyptium	Grass	9	0.0	10	2	4	5
Zornia glochidiata	Forbs	27	75	2	7	0.0	16
Solanum dubium	Forbs	0.0	0.0	0.0	3	0.0	0.0
Echinochloa colona	Grass	25	5	8	3	5	3
Chloris gayana	Grass	0.0	0.0	2	15	1	7
Ipomea spp	Forbs	1	0	0.0	0.0	0.0	0.0
Eragrostis spp	Grass	22	9	16	14	2	5
Sida cordofolia	Forbs	1	2	0.0	0.0	0.0	0.0
Pennisetum pedicellatum	Grass	0.0	1	0.0	0.0	0.0	0.0
Oldenlandia senegalensis	Forbs	5	3	0.0	1	0.0	0.0
Waltheria indica	Forbs	0.0	0.0	00	1	0.0	0.0
Aristida spp	Grass	7	4	4	2	4	0.0
Cenchrus biflorus	Grass	0.0	1	0.0	0.0	0.0	0.0
Alycicarpus vaginalis	Forbs	0.0	0.0	0.0	0.0	0.0	0.0
Fimbristylis dicotomo	Grass -Like	0.0	1	0.0	0.0	0.0	0.0
Vossia cuspidata	Grass	0.0	0.0	0.0	0.0	44	46
Digitaria gayana	Grass	0.0	0.0	0.0	0.0	0.0	0.0
Acanthospermum hispidum	Forbs	0.0	0.0	0.0	0.0	0.0	0.0
Senna obtusifolia	Forbs	0.0	0.0	4	1	2	4
Cenchrus ciliaris	Grass	0.0	0.0	0.0	0.0	0.0	4

Appendix No (2) Average plant frequency at the three sites for the two rainy seasons (2013/2014) at the study area

Scientific name	Habit	Frequency %					
		Sandy		Clay		Gardud	
		Season 2013	Season 2014	Season 2013	Season 2014	Season 2013	Season 2014
Schoenfeldia gracilis	Grass	1	0.0	63	59	48	24
Dactyloctenium aegyptium	Grass	45	38	46	46	18	15
Senna obtusifolia	Forbs	0.0	0.0	29	11	10	20
Zornia glochidiata	Forbs	91	88	20	61	6	30
Solanum dubium	Forbs	0.0	0.0	3	13	0.0	0.0
Echinochloa colona	Grass	65	51	21	16	8	15
Chloris gayana	Grass	3	0.0	13	44	8	18
Tribulus trestris	Forbs	0.0	0.0	1	0.0	0.0	0.0
Ipomea spp	Forbs	29	18	1	0.0	0.0	0.0
Eragrostis spp	Grass	69	78	66	44	20	30
Sida cordofolia	Forbs	24	41	3	0.0	0.0	0.0
Pennisetum pedicellatum	Grass	0.0	15	1	0.0	0.0	0.0
Oldenlandia senegalensis	Forbs	55	79	5	19	0.0	1
Waltheria indica	Forbs	5	8	1	6	0.0	0.0
Aristida spp	Grass	31	15	0.0	11	4	3
Cenchrus biflorus	Grass	18	14	0.0	3	0.0	0.0
Alycicarpus vaginalis	Forbs	10	19	0.0	5	0.0	0.0
Fimbristylis dicotomo	Forbs	4	25	0.0	0.0	0.0	0.0
Commelinia subulata	Forbs	1	3	0.0	0.0	0.0	0.0
Vossia cuspidata	Grass	0.0	0.0	0.0	0.0	71	46
Sesamum alatum	Forbs	0.0	1	0.0	1	0.0	0.0
Digitaria gayana	Grass	18	0.0	0.0	11	0.0	0.0

Corchorus olitorius	Forbs	0.0	0.0	0.0	4	0.0	1
Abutilon angulatum	Forbs	0.0	0.0	0.0	1	0.0	0.0
Cyperus rotundus	Grass-Like	0.0	1	0.0	1	0.0	3
Ipomea cordofana	Forbs	0.0	0.0	0.0	1	0.0	0.0
Acanthospermum hispidium	Grass	0.0	1	0.0	1	0.0	0.0
Commelinia subulata	Forbs	1	0.0	0.0	0.0	0.0	0.0
Striga hermonthica	Forbs	0.0	0.0	0.0	0.0	0.0	3
Setaria sphecelata	Grass	0.0	0.0	0.0	0.0	0.0	3

Appendix NO (3) Average trees and shrubs density/ha of the three sites in the rainy season (2013) at the study area

Scientific name	Habit	Sites		
		Sandy	Clay	Gardud
Balanites aegyptiaca	Tree	26	94	0.0
Ziziphus - spina christi	Tree	0.0	56	0.0
Acacia oerfota	Shrub	0.0	131	61
Acacia mellifera	Shrub	0.0	35	133
Acacia nilotica	Tree	14	42	6
Acacia senegal	Tree	10	0.0	6
Combretum aculeatum	Shrub	0.0	5	2
Guiera senegalensis	Shrub	315	0.0	0.0
Piliostigma reticulatum	Shrub	24	0.0	0.0
Leptadonia pyrotechnica	Shrub	4	0.0	0.0
Albizzia amara	Tree	6	0.0	0.0
Acacia seyal	Tree	0.0	30	0.0

Appendix NO (4) Average trees and shrubs density/ha at the three sites in the rainy season (2014) at the study area

Scientific name	Habit	Sites		
		Sandy	Clay	Gardud
Balanites aegyptiaca	Tree	11	100	10
Ziziphus spina christi	Tree	0.0	19	0.0
Acacia oerfota	Shrub	0.0	476	31
Acacia mellifera	Shrub	0.0	19	91
Acacia nilotica	Tree	11	34	21
Acacia senegal	Tree	11	8	25
Comretum aculeatum	Shrub	0.0	66	3
Guiera senegalensis	Shrub	889	0.0	0.0
Piliostigma reticulatum	Shrub	28	0.0	0.0
Leptadonia pyrotechnica	Shrub	14	0.0	0.0
Albizzia amara	Tree		0.0	10

Appendix NO (5) Existing of plants species of the sandy site through vegetation measurements and investigation of the nomads at the study area

Species	Frequency % measured	% of species investigated by the nomads
Schoenfeldia gracilis	1	0.0
Dactyloctenium aegyptium	42	9
Zornia glochidiata	90	33
Echinochloa colona	58	2
Chloris gayana	2	0.0
Ipomea spp	38	1
Eragrostis spp	74	19
Sida cordofolia	33	8
Pennisetum pedicellatum	8	0.0
Oldenlandia senegalensis	67	5
Waltheria indica	7	0.0
Aristida spp	23	0.0
Cenchrus biflorus	1	28
Alycicarpus vaginalis	15	0.0
Fimbristylis dicotomo	15	0.0
Commelinia subulata	2	0.0
Sesamum alatum	1	0.0
Digitaria gayana	9	0.0
Cyperus rotundus	1	1
Blepharis linariifolia	0.0	1
Andropogon gayanus	0.0	1
Ipomea cordofana	0.0	1

0.0; not measured or mentioned by investigated respondents

Appendix NO (6) Plants species at the clay site through vegetation measurements and investigation of the nomads at the study area

Species	Frequency % measured	% of species investigated by the nomads
Schoenfeldia gracilis	61	33
Dactyloctenium aegyptium	46	15
Senna obtusifolia	20	0.0
Zornia glochidiata	41	0.0
Solanum dubium	8	0.0
Echinochloa colona	19	19
Chloris gayana	29	28
Tribulus trestris	1	0.0
Ipomea spp	1	1
Eragrostis spp	55	6
Sida cordofolia	2	0.0
Pennisetum pedicellatum	1	0.0
Oldenlandia senegalensis	12	2
Waltheria indica	4	0.0
Aristida spp	6	2
Cenchrus biflorus	2	0.0
Alycicarpus vaginalis	3	0.0
Sesamum alatum	1	0.0
Digitaria gayana	6	0.0
Corchorus olitorius	2	0.0
Abutilon angulatum	1	0.0
Cyperus rotundus	1	0.0
Ipomea cordofana	1	4
Acanthospermum hispidium	1	0.0
Andropogon gayanus	0.0	2
Blepharis linariifolia	0.0	3
Cympopogon nervatus	0.0	1
Hyperrhenia confinis	0.0	1

0.0; not measured or mentioned by investigated respondents

Appendix NO (7) Plants species of the gardud site through vegetation measurements and investigation of the nomads the study area

Species	Frequency % measured	% of species investigated by the nomads
Schoenfeldia gracilis	36	0.0
Dactyloctenium aegyptium	17	12
Senna obtusifolia	15	1
Zornia glochidiata	18	1
Echinochloa colona	12	7
Chloris gayana	13	1
Eragrostis spp	25	48
Oldenlandia senegalensis	1	0.0
Aristida spp	4	6
Vossia cuspidata	59	4
Corchorus olitorius	1	0.0
Cyperus rotundus	2	0.0
Striga hermonthica	2	0.0
Setaria sphecelata	2	0.0
Ipomea spp	0.0	9
Senna occidentalis	0.0	1
Cenchrus spp	0.0	7
Hyperrhenia confinis	0.0	1

0.0; not measured or mentioned by investigated respondents

Appendix NO (8) Plants species around villages through vegetation measurements and investigation of sedentary groups at the study area

Species	Frequency% measured	% of species investigated
Eragrostis spp	51	47
Zornia glochidiata	50	17
Cenchrus spp	2	15
Sida cordofolia	12	6
Echinochloa colona	30	5
Dactyloctenium aegyptium	35	4
Aristida spp	3	2
Oldenlandia senegalensis	27	1
Senna occidentalis	0.0	1
Brachiaria obtusiflora	0.0	1
Ipomea spp	13	0.0

0.0; not measured or mentioned by sedentary group

Appendix NO (9) Average live and dead seeds densities of species in depth (0 -10) in the three sites at the study area

Scientific name	Habit	Sites					
		Sandy		Clay		Gardud	
		Live	Dead	Live	Dead	Live	Dead
Schoenfeldia gracilis	Grass	0.0	0.0	29	0.0	1	0.0
Chloris gayana	Grass	0.0	0.0	20	32	4	0.0
Zornia glochidiata	Forbs	155	64	13	4	0.0	6
Echinochloa colona	Grass	19	90	10	30	76	0.0
Dactyloctenium aegyptium	Grass	13	6	0.0	7	0.0	0.0
Eragrostis spp	Grass	0.0	0.0	0.0	18	3	14
Vossia cuspidata	Grass	0.0	0.0	0.0	5	91	128
Alycicarpus vaginalis	Forbs	7	1	1	0.0	1	2
Cenchrus biflorus	Grass	0.0	1	0.0	0.0	0.0	0.0
Oldenlandia senegalensis	Forbs	0.0	1	0.0	0.0	0.0	0.0
Acanthospermum hispidum	Forbs	5	1	0.0	0.0	0.0	0.0
Cassia senna	Forbs	0.0	0.0	0.0	0.0	0.0	1
Senna obtusifolia	Forbs	0.0	0.0	0.0	0.0	1	1
Total		199	166	73	96	177	152
Total seeds/m^2		**3980**	**3320**	**1460**	**1920**	**3540**	**3040**

Appendix No (12) shows scientific and local name of herbaceous in the study area in the two rainy seasons (2013/2014)

Scientific name	**Habit**	**Local name**
Schoenfeldia gracilis	Grass	ضنب الناقة
Dactyloctenium aegyptium	Grass	أبو أصابع
Zornia glochidiata	Forbs	شليني
Echinochloa colona	Grass	الدفرة
Chloris gayana	Grass	عفن الخديم
Ipomea spp	Forbs	الحنتوت
Eragrostis spp	Grass	البنو
Sida cordofolia	Forbs	النيادا
Pennisetum pedicellatum	Grass	الدز
Oldenlandia senegalensis	Forbs	تمر الفأر
Waltheria indica	Forbs	عرق النار
Aristida spp	Grass	القو
Cenchrus biflorus	Grass	حسكنيت خشن
Alycicarpus vaginalis	Forbs	أم نقيقيرة – الفريشة
Fimbristylis dicotomo	Grass – like	أم فسيسيات
Commelinia subulata	Forbs	أبريق الفكي – البييض
Sesamum alatum	Forbs	سمسم الجمال
Digitaria gayana	Grass	أم عاج
Cyperus rotundus	Grass – like	السعدة
Andropogon gayanus	Grass	أبو الرخيص
Ipomea cordofana	Forbs	التبر
Senna obtusifolia	Forbs	الكول
Solanum dubium	Forbs	الجبين
Tribulus trestris	Forbs	الضريسة
Corchorus olitorius	Forbs	ملوخية الخلاء
Abutilon angulatum	Forbs	مكشاشة الرجال

Acanthospermum hispidium		حراب هوسا
Vossia cuspidata	Grass	فرت الأرنب
Striga hermonthica	Forbs	البودا
Setaria sphecelata	Grass	ضنب الفلو
Senna occidentalis	Forbs	السوريب
Brachiaria obtusiflora	Grass	أم جر
Cassia senna	Forbs	سنمكة
Cenchrus ciliaris	Grass	حسكنيت ناعم

Appendix No (13) shows scientific and local name of trees and shrubs in the study area in the two rainy seasons (2013/2014)

Scientific name	**Habit**	**Local name**
Balanites aegyptiaca	Tree	الهجليج
Ziziphus - spina christi	Tree	السدر
Acacia oerfota	Shrub	اللعوت
Acacia mellifera	Shrub	الكتر
Acacia nilotica	Tree	السنط
Acacia senegal	Shrub	الهشاب
Combretum aculeatum	Shrub	الهبيل
Guiera senegalensis	Shrub	الغبيش
Piliostigma reticulatum	Shrub	الخروب – خف الجمل
Leptadonia pyrotechnica	Shrub	المرخ
Albizzia amara	Tree	العرد
Acacia seyal	Tree	الطلح

Appendix NO (14) Recording sheet (Loop reading Form)

Sudan University of Science &Technology

College of Graduate Studies

College of Forestry &Range Sciences, Range Science Department

Transect Number (   ) Quadrat No (Location)……Date..........................

Collector's Name……………………………………………

1	L									
2		Bs								
3				Bs						
4										
5			L							P
6						R				
7		P								Bs
8										
9					P			Bs		
10										L

Where: **-** L =litters, R = Rocks, P = Plant (recorded name of plant) and Bs = Bare soil (source, Candidate, 2014)

Appendix NO (15) Frequency Form

Sudan University of Science &Technology

College of Graduate Studies

College of Forestry &Range Sciences, Range Science Department

Transect Number (   ) Quadrat No ( )

Location………………Date........................... Collector's Name……………

Species	Number Quadrats										Total
	1	2	3	4	5	6	7	8	9	10	
Dactyloctenium aegyptium	X	Ω	X	X	Ω	Ω	Ω	Ω	Ω	Ω	7
Chloris gayana	Ω	Ω	Ω	X	X	X	X	Ω	Ω	Ω	6
Walhteria indica	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	10

Where Ω Presence of species and X absent of species (source, Candidate, 2014)

Appendix NO (16) Plants cover Form

Sudan University of Science &Technology

College of Graduate Studies

College of Forestry &Range Sciences, Range Science Department

Transect Number ( ) Quadrat No ( )

Location…………………………Date..

Collector's Name………………………………………………………..

Quadrat number	Plats cover%
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
Total	
Average	

Appendix NO (17) Biomass production Form

Sudan University of Science &Technology

College of Graduate Studies

College of Forestry &Range Sciences, Range Science Department

Location (Site)……….Date..... …………Collector's Name………………….

Transect NO	Quadrat NO										Total biomass production	
	1	2	3	4	5	6	7	8	9	10	Gram/m^2	Ton/ha
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												

بسم الله الرحمن الرحيم

Appendix NO (18) Questionnaire of sedentary at Eldebeibat area (South Kordofan State)

Sudan University of Science and Technology

College of Graduate studies – Faculty of Forestry and Range Science

(The information in top secrete use for research only)

Social and economic information

*Tribe:

………………………………………………………………………………………

* Six

Male (   )   female   ( ).

*age

Less than 20 year (   ),   20   - 30 (   ), 30 - 40 (   ), 40 - 50 (   )

and more than 50

*Education level

Illiterate ( ) Khalwah   ( ) primary (   ) Secondary (   ) University (   ).

*Main source of income

Agriculture (   ) breeding animals (   ) agriculture& animals breeding (   ) other ().

*Crop use for feeding human?

Millet (   ) durra (   ) millet and durra (   ).

*Type of agriculture?

Traditional (   )   mechanized (   ).

*Is there use agricultural rotation?

Yes   (   )   No ( ).

*Is there leave piece of land without cultivation?

Yes   (   )   No   (   ).

*Is there breed animals?

Yes ( ) No ( ).

*If yes what species of animals you breed?

Cows ( ) sheep ( ) goats ( ) camels ( ) mixed of animals ( ).

*Purpose of animals breeding?

Milk ( ) meat ( ) trade ( ).

*Is there stay with your animals in village for both seasons rainy and summer?

Yes ( ) No ( ).

*Is there prefer some type of sites to animal's grazing in rainy season?

Yes ( ) No ( ).

*If yes what the types of site?

……………………………………………………………………………………

Sources of water:

*Is there use limited sources of water in rainy season?

Yes ( ) No ( ).

*If use what those sources?

……………………………………………………………………………………

*Distance of water sources from village?

One kilo ( ) two kilo ( ) three kilo ( ) above three kilo ( ).

*Possession of water sources?

Governmental ( ) private ( ) common ( ).

*Is there collect crops residues?

Yes ( ) No ( ).

*If yes what purpose of crops residues collection?

To feed animals (   ) to building houses and feed animals ( ) to trade ( ).

*Is there the quantity of crops residues enough for feed animal till rainfall down?

Yes (   )   No   (   ).

*If not enough what the reasons?

……………………………………………………………………………………

*Is there use trees for feed animals in the summer season?

Yes   (   )   No (   ).

*If yes what those species use?

……………………………………………………………………………………

*****Is the species mentioned are desirable for animals?

Yes   (   )   No   (   ).

*What plants species found around your village?

……………………………………………………………………………………

*Is there plants species found around village desirable for animals?

Yes   ( )   No   (   ).

*****Is there have plants species disappeared from your area?

Yes (   )   No   ( ).

*If yes what those species?

....

*Is there appeared new species in the area?

Yes (   )   No (   ).

*If yes what the new species?

……………………………………………………………………………
……
*Is there new species desirable for animals?
Yes ( ) No ( ).
Conflicts with nomads
*Is there have conflicts with nomads?
Yes ( ) No ( ).
*If yes what the reasons of conflicts?
Damage of farms by nomads ( ) compotation on range ( ) compotation on water ( ).
*Places of conflict occurrence?
Around farms ( ) around villages ( ) in water sources ( ).
*Period of conflicts increasing?
When entrance to rainy season domain ( ) when return to summer season domain ( ) though grazing ( ).
*Methods of conflicts settlement?
Pay fine ( ) prison ( ) settlement ( ) pay fine and prison ( ) godyah ( ).

بسم الله الرحمن الرحيم

Appendix NO (19) Questionnaire of the nomads at Eldebeibat area (South Kordofan State)

Sudan University of Science and Technology

College of Graduate studies – Faculty of Forestry and Range Science

(The information in top secrete use for research only)

Section one: Social and economic information

*Tribe:

…………………………………………………………………………………

* Six

Male ( ) female ( ).

*age

Less than 20 year ( ), 20 - 30 ( ), 30 - 40 ( ), 40 - 50 ( ) and more than 50

*Education level

Illiterate ( ) Khalwa ( ) primary ( ) Secondary ( ) University ( ).

*Main source of income

Grazing ( ) cultivation ( ) grazing and cultivation trading ( ).

Section two: activities linked with grazing by nomads

* Which types of animal area breeding?

Cows ( ) Sheep ( ) Camel ( ) Goats ( ) mixed of animals

*What the purpose of animals breeding?

Milk ( ) Meat ( ) trading ( ) social purposes ( ).

*What the health of your animals in the autumn?

Excellent ( ) very good ( ) good ( ) medium ( ) deteriorated ( ).

*If the health of animals deteriorated what the reasons?

Shortage of range (   ) diseases (   ) Limitation of movement due to insecurity in the area (   ).

*Number of your animals compare with in the past time?

Increasing (   ) Decreasing (   ) at stable   (   ).

*If the answer Decreasing what the reasons?

Shortage in the range ( ) Diseases ( )   paying to cover the needs ( ) Conflicts ().

*Is there change the methods of grazing?

Yes   (   )   No   (   ).

*If yes what the new methods of grazing?

………………………………………………………………………………………

*Why changed the methods of grazing?

………………………………………………………………………………………

Is there having decreasing in the milk production?

Yes (   )   No   (   ).

*If the answer yes what the reasons?

Shortage of range (   )   Diseases (   )   other give them (   ).

*Is there methods and means to treat the shortage of grasses in the area (Indigenous Knowleadge?

Yes (   )   No   (   ).

*If the answer yes what the means

………………………………………………………………………………………

………………………………………………………………………………………

Section two: type of grazing

*How to practice the grazing?

Transhumant (   ) semi transhumant (   ) settlead (   ).

*Place of start movement?

Inside state   (   ) out of state (   ).

*Is there all family members move with livestock?

Yes ( ) No ( ).

*If the answer no what their role?

Cultivation ( ) graze the oldest animal ( ) trade

*Is there use limited routes to entrance the autumn and get out

Yes ( ) No ( ).

Factors lead to reduce productivity in the area

* Is there reduced range area in the rainy season domain?

Yes ( ) No ( ).

* If yes what the reasons of range area reduce?

Expansion of agriculture ( ) Establishment of towns ( ) other ( ).

* Types of soil prefer for grazing in the rainy season domain?

Sandy ( ) Clay ( ) Gardud ( ).

*Factors use to selection type of soil to grazing?

Available of palatable plants () Easy of animals movement ( ) free from insects ().

*Types of soil prefer by herders in summer season domain?

Sandy ( ) Clay ( ) Gardud ( ).

*Plants species occur on sandy soil?

………………………………………………………………………………………

………………………………………………………………………………………

*Plants species occur on clay soil?

....

....

*Plants species occur on gardud soil?

....

....

*Is there entrance the sandy, gardud or clay soil firstly in the rainy season domain? Why

....

....

*Is there exist from sandy, gardud or clay? Why

....

....

*Is there use trees for feeding animals at dry season?

Yes ( ) No ( ).

* If yes what the trees species?

....

…………………………………………………………………………………

*****Is there occurrence change in range condition?

Yes ( ) No ( ) .

*If yes the changes included the flowing?

Disappeared of palatable species ( ) appearance of undesirable species ( ) soil erosion ( ).Shortage of grasses () diseases through the animals ( ) deteriorated of animals health ( ).

*Is use one area for grazing through rainy season?

Yes ( ) No ( ).

*Is there have plants species disappeared from range?

Yes ( ) No ().

*If yes what the species?

....

....

*What the new species appeared in the range?

....

....

*Is there new species desirable for animals?

Yes ( ) No ( ).

Section three: water sources for human and animals

*What water sources for human and animals?

Wells ( ) Water yards ( ) ruhud ( ) water yards ( ).

*Places of water sources?

Within grazing areas ( ) out of grazing areas ( ) close to farms ( ).

*Distance of water sources from range?

One kilo ( ) two kilo ( ) three kilo ( ) above three kilo ( ).

*Is there quantity of water enough for both human and animals?

Yes ( ) No ( ).

* Is there have conflicts at water sources?

Yes ( ) No ( ).

*If yes what the reasons of conflicts?

Shortage of water ( ) reduce of range ( ) overstocking ( ).

Section four: services and range administrative

*Is there have services from other body or institute?

Yes ( ) No ( ).

*If yes what the institutes give the services?

Government ( ) International organization ( ) National non government organization ( ).

*Types of services?

Veterinary ( ) education ( ) water ( ) extension services ( ).

*Is there have services from range administrative?

Yes ( ) No ( ).

*If yes what those services?

Routs opening ( ) seeds broadcasting ( ) control of undesirable plant ( ) fire lines opening ( ).

*Is there having herders union in the area?

Yes (   )   No   (   ).

*If yes are you member of it?

Yes ( )   No   (   ).

*Is there participate in any activity of range?

Yes   ( )   No   (   ).

*If yes what the activity participate of it?

....

Section five: Problems and difficult face nomads with sedentary

*Is there have conflicts with sedentary?

Yes (   )   No   (   ).

*If yes what the reasons of conflicts?

Close the routs by agriculture expansion ( ) water shortage ( ) grasses shortage   ().

*Period of conflicts occurrence?

When entrance to rainy season domain (   ) through grazing (   ) through watering animals (   ) when exist from rainy season domain (   ).

*How settlement the conflicts?

Court   (   )   by leaders of tribes (   )   other (   ).

Appendix NO (20) Shows One-Sample Test for Sedentary in the study area

	t	Df	Sig. (2-tailed)
Age	33.406	242	.000
education level	23.915	242	.000
source of income	11.965	242	.000
basic crop use in feeding	23.853	241	.000
type of agriculture	3.387	242	.001
is there use agriculture rotation	19.085	242	.000
is there leave piece of land without agriculture	10.494	242	.000
is there raise animals	5.727	242	.000
if anwser yes what the kind of animals are raise	24.911	218	.000
purpose of animals raising	6.610	218	.000
is there stay rainy season and dry in village with animals	7.799	223	.000
is there are prefer grazing on some soil in the rainy season	11.333	224	.000
if answer yes what type of soil	29.600	142	.000
is there are some source of water in rainy season	13.773	238	.000
if answer yes what the source	12.022	139	.000
distance of water resources from village	11.365	241	.000
what the possission of water sources	20.025	242	.000
Is there collect residues of crops	3.051	242	.003
if you collected what the porpuse of collection	18.531	235	.000
if the residuise for animals feeding its enough until rainy	16.186	223	.000
if No what the reseason of reducing	16.943	121	.000
is there use trees for feed animals at summer season	13.477	232	.000
what the species found throunding your village	10.380	239	.000
there find disappearance of some plant species around your village	9.111	242	.000
if yes what those species	9.055	180	.000
is there appear new species in the area	8.245	236	.000
if yes what those species appeared in the area	4.888	185	.000
if those species appeared in the area prefer by animals	57.694	187	.000
Are there having conflicts with Nomads	8.226	240	.000
what reasons of conflicts	5.447	189	.000
• What are places of conflicts	4.467	188	.000
period of increasing conflicts	18.022	188	.000
method of conflicts solve	18.528	188	.000

Appendix NO (21) Shows One-Sample Test for the nomads in the study area

	t	Df	Sig. (2-tailed)
Age	17.323	128	.000
education level	11.568	128	.000
main source of income	16.026	128	.000
species of animals you are raised	27.295	128	.000
purpose of animals raising	7.115	128	.000
health of your animals at rainy and dry season	26.043	128	.000
number of animals now compare with past time	21.927	128	.000
if dereased what the reason	7.997	98	.000
is there change your methods in the grazing	63.246	128	.000
is there milk production decrease	3.787	128	.000
if yes what the reasons of decreasing milk	5.621	115	.000
is there have means to face the shortage grasses in the area	9.473	127	.000
how practice the grazing	6.786	128	.000
places of strat movement	2.025	122	.045
is there all members of family move with animals	17.171	122	.000
if No what their rule	3.200	91	.002
is there use limited routes to entrnce and extrance from rainy domin	5.573	123	.000
is there find derease in area use for grazing in rainy season	3.623	128	.000
type of soil prefer in rainy season	8.117	128	.000
factor for select the soil to grazing	11.385	128	.000
types of soil prefer in summer domins	8.712	128	.000
species of plants found at sandy soil	10.831	128	.000
species of plants found at clay soil	10.829	128	.000
Species of plants found at gardud soil	7.907	128	.000
is there entrance sandy , clay or gardud firstly	18.657	128	.000
is there extrance from sandy, gardud or clay	11.231	128	.000
is there use trees for feed animals during dry season	8.423	128	.000
is there occured change in the range condition	4.104	128	.000
if yes what changes	14.416	114	.000
is there use one place in the rainy season	9.297	128	.000
is there plants species disappeared from your range	8.897	126	.000
if yes what those that species	6.601	78	.000

what the speceies replaced the native species	10.232	77	.000
is there new species which replaced native plants are prefer by animals	37.743	77	.000
what the water sources for human and animals	25.532	127	.000
place of water sources	7.851	128	.000
distance of water sources from range	10.093	128	.000
is there quantity of water enough for human and animals	9.148	128	.000
is there face conflicts in the water sources	8.140	128	.000
is there have services	10.550	128	.000
is there have services from adiminstrative range in the locality	11.627	127	.000
is there have heerders union in the area	9.909	128	.000
if yes are you participate in any activity	33.796	128	.000
is there have conflicts with sedentary people	4.846	128	.000
if yes what the resesons of conflicts	5.281	109	.000
time of increasin conflicts	11.515	108	.000
method of conflicts solve	20.095	108	.000

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