

# CHAPTER ONE

## INTRODUCTION

### 1.1. General

Natural range supports and provides feed for large number of livestock, which plays a vital role in national economy through provision of animal product for local consumption and foreign exchange.

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).

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 a 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 Childs, 1994) and it managed, typically, for livestock production (Holechek *et al.*, 2004). In the developing countries, there are at least 40 million pastoralists who depend on natural grazing for their livelihood, most are subsistence herders (Elnour, 2007).

The Greater Darfur region occupies approximately an area of 500,000 km<sup>2</sup>. It lies in the north western part of the Sudan and mainly consists of four main climatic zones. Firstly, the rich savannah in the south with an average rainfall between 400 to 800 mm per year. Secondly, the poor savannah in the middle of the region with an average annual rainfall that ranges between 200 to 400 mm. thirdly, is the arid zone which occupies the middle of northern parts of the region, the rainfall ranges from 100 to 300 mm. The fourth zone is the desert zone and it is characterized by lack of rainfall and high temperatures during the summer (Fadul, 2009).

Pastoral and agro-pastoral systems are the mainstay of the economy of North Darfur State. Livestock and its products are the primary source of income for over 60% of the population. Traditional systems of cropping and animal husbandry predominate in the State. The major food crops grown are millet and sorghum. Animals raised are mainly sheep, goats and camels in the northern part of the State, sheep, goats and some cattle in the southern parts. North Darfur State is unique in its natural rangelands; being homeland for many nomadic tribes, capable of sustaining all kinds of livestock; and many livestock routes crossing the area. Rangelands in North Darfur State face many problems; these include seasonal fluctuation in feed quantity and quality, land degradation and desert encroachment, erratic rainfall and expansion of both traditional and mechanized rainfed cultivation. In addition to cutting of browse trees and fodder plants for fuel

and houses construction, water shortage and diseases prevalence resulted in range deterioration and movement of animals. The balance between animals and feed does not exist in North Darfur State for the time being, and the number of animals is by far exceeding what the land is offering. Therefore, with the prevailing systems of production, the negative impact on the land and the environment would be expected to continue. These constraints may be reflected in severe deterioration in both quality and quantity of rangelands and consequently reduce livestock productivity. Therefore, detailed assessment of vegetation affected by grazing is necessary to describe the current status of rangelands in Alfashir locality, comparing these measurements over time to detect the change that has happened to rangeland, using ground measurements. Such monitoring would enable setting up strategies and measures aiming at alleviating constraints and improving productivity.

## **1.2. Problem Statement**

As part of the semi-arid zone in Sudan, Alfashir locality is severely affected by drought; the major environmental issue is deterioration of rangelands. Specific causes include:

(i) a relentless series of droughts which reduce the ecological capacity for production as well as regeneration, (ii) expansion of cultivation into rangelands decreased land for grazing, blocking livestock access routes and took over the higher quality rangelands, (iii) the population increase, (iv) traditional land tenure system and social control over the use of land has broken.

As mentioned above, a complete study of the range condition, trend, range components and range attributes will be carried out.

### **1.3. Objectives**

The main objective of this study is to assess rangelands and the effect of grazing on natural rangelands in Alfashir locality (North Darfur State).

Specific objectives are

1- To assess the following parameters:

Range Components

Plant density

Vegetation cover

Range productivity

Species composition

Plant Frequencies

Carrying capacity

Trend of range condition

2- To assess the effect of grazing level on range attributes (vegetation cover, density and biomass production).

## **CHAPTER TWO**

### **LITERATURE REVIEW**

Rangeland covers nearly half the earth's land surface, 47% in all. Nearly half of this total area lies in the tropic and subtropics. The tropical rangelands support vast herds of domestic animals. About one-third of the world's people live on the same rangelands both in cities and as producers in the land. Many tropical people could not live without meat, milk and skins produced by range animals. People continue to increase in numbers, but no more land can be created. Range resources have great potential for production of food and other resources if they are carefully managed (Tahir, 2003).

#### **2.1. 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 covers 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). In the Sudan, the arid and semi-arid lands cover an area of 1.78 million km<sup>2</sup> (Sudan National Action Programme, SNAP, 2006).

Rangelands are wild forage-producing areas under native and/or annual grasses used, among other things, for livestock, wildlife and watershed

maintenance. Areas often classified as rangeland are too wet, too dry, too rocky, too steep, or too cold to farm or practice forestry. 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 highly erratic climates. Seasonal fluctuations influence the concentration and mix of herbivores, and multi-year droughts reduce the number of animals (Sidahmed, 1996. and Nasra, 2008).

## **2.2. Rangelands in Arid and Semi-arid Areas of the Sudan**

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, river 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 sparse thorn scrubs provide a period of good grazing for sheep, goats, cattle and camels besides the ephemeral grasses and herbs (Ayoub, 1998).

The semi-arid vegetation was mainly scrub and grassland. Dominant trees and shrubs include *Acacia tortilis*(Seyal), *Capparis decidua* (Tundob) , *Leptadenia pyrotechnica* (Marakh), *Maerua crassifolia* (Sereh) and *Salvadora persica* (Arak) with *Acacia mellifera* (Kitter),

*Balanites aegyptiaca* (Heglig), *Capparis decidua* and *Ziziphus spina-christi* (Sidr) on clay soils and water courses.

Herbaceous species include *Aristida spp.*(Gaw), *Blepharis spp* (Baghail), *Cenchrus spp.*(Haskaneet), *Cymbopogon nervatus* (Nal), *Panicum turgidum* (Tumam) and *Schoenefeldia gracilis* (Um Fredo) (Harrison and Jackson, 1958 and Wickens, 1991).

## **2.3. Types of Rangelands**

### **2.3.1. Grasslands**

Grasslands are the most productive rangelands in the world when forage production, wild and domestic animals are the major consideration. Grassland is typically free of woody plants (shrubs and trees) and is dominated by plants in the family Gramminae (grasses) (Adam, 2013).

### **2.3.2. Desert Shrub lands**

Desert shrub lands are the desert of the world's rangelands and cover the largest areas. Woody plants less than 3 meters in height with sparse herbaceous understory characterize vegetation of this type. Desert shrub lands have received the greatest degradation by heavy grazing of the rangeland biomass and as a result, show the slowest recovery. In some cases, desert shrub lands have been created through degradation of arid grasslands by heavy livestock grazing (Adam, 2013).

Desert shrub lands generally receive less than 250 mm of annual precipitation. In hot desert shrub lands areas, precipitation occurs as infrequent, high intensity rains during a short period (less than 90 days) of the year. This results in long periods where the water content of the soil surface is below the permanent wilting point. This provides highly unfavorable conditions for short, fibrous rooted plants (grasses). Shrubs can collect moisture from a much greater portion of the soil profile than

can those with short, fibrous roots near the soil surface. Desert shrub roots extend considerable distances laterally as well as downward. The sparse spacing of desert shrubs permits individual plants to collect moisture over a large area. This explains why they can survive long, dry periods much better than grasses in temperate areas with high winter snow fall and dry summer growing season, considerable moisture is available deep in the soil profile during the summer growing season. Shrubs can use this moisture much better than grasses because of their longer roots. Sandy – to loamy textured soils of variable depth are typical of desert shrub lands. Coarse-textured soils permit deep water infiltration and retain little moisture near the soil surface unless there is a restrictive layer. Heavy clay soils and sandy soils with shallow restrictive layer in desert typically show a much higher grass component than do surrounding areas (Stoddart *et al.*, 1975).

### **2.3.3. Savannah woodland**

Savannah woodlands are dominated by scattered, low growing trees (less than 12 m tall). They have productive herbaceous understory if not excessively grazed. Heavy grazing usually results in loss of the understory grasses and an increase in the density of the trees and shrubs. Typically savannah woodland occurs as a transition zone between grassland and forest. Shifts toward grassland or forest take place continually in this biome, depending on grazing intensity, fire control, logging, and drought. Shrub and tree densities on much savannah woodland have increased substantially due to fire suppression and heavy grazing of the understory, (Harrison and Jackson, 1958). Considerable potential exists for conversion of savannah woodland to grasslands when they occur on flat, non-rocky soils over 1 m in depth. Rocky thin soils favor woodlands in grassland climatic zones because the long, coarse roots of woody plants can grow down into cracks in the rocky layer where moisture is collected further,



many woody species have long lateral roots that can absorb moisture over a large area of very thin rocky soil. Without periodic fire, most of the wetter portion of the tall grass type with loamy to sandy soils is quickly invaded by trees and shrubs, because considerable moisture reaches that portion of the soil profile below 2 m (Stoddart *et al.*, 1975).

#### **2.3.4. Forest**

Forest is distinguished from savannah woodlands by having trees over 12 m in height that are closely spaced (less than 10 m apart). In many areas, forests are managed primarily for timber production and are too dense to have any grazing value. However, they can produce considerable forage for both livestock and wildlife when thinned by logging or fire or when in open stands. Forest generally occurs in high-rainfall areas (over 500 mm). Under high rainfall, that portion of the soil profile below 3 m has high water content during most of the year. Much larger quantities of moisture are needed to support the higher biomass of trees compared to grasses and shrubs (Adam, 2013).

#### **2.4. Importance of Rangelands**

Rangelands is defined by the Society of Range Management (SRM, 1974) as the land on which the native vegetation is predominantly grasses, forbs or shrubs suitable for grazing or browsing use. Includes lands revegetated naturally or artificially or provide forage cover that is managed like native vegetation. Another definition for rangeland (Stoddart *et al.*, 1975) is that are of land which is not suitable for cultivation due to physical or natural barriers as limited rainfall, rough topography, salinity, bad drainage or cold temperature.

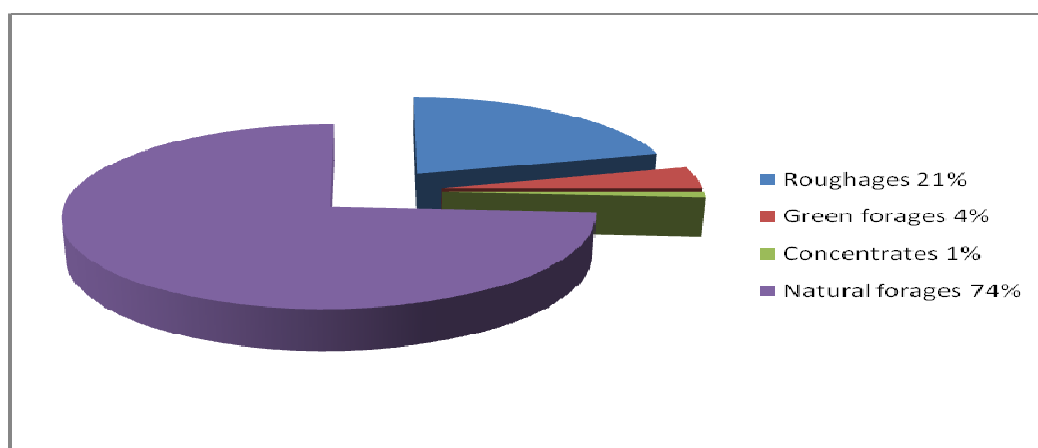
Rangelands ranks number one as a major land type whether measured by size, support for animal based industries, or sources of stream flow.

Sustainable portions of all major continents are rangelands. Williams *et al*, (1968) estimated that 47% of the earth land surface is rangeland. Sample (1951) stated that worldwide, 30% of the world's lands area is grassland, and 27% is classified as forest, 10% as cropland. This does not, however, fully indicate the extent of the range resources as considerable acreages of forests are grazed and many of the more arid portions of the world, normally considered desert, contribute significantly to forage production in favorable years (Abusuwar, 2007). A more useful measure of the importance of rangeland is the contribution they make to animal production. In the Sudan natural rangelands contribute to about 77% of the feed available to livestock (Abusuwar and Darrag, 2002).

As indicated by Figure (1) rangelands in the Sudan are the main source of feed for domestic and wild animals. Most of the meat consumed locally and for export is produced from range animals.

Besides, rangeland in the Sudan host an important economical tree which is hashab (*Acacia senegal*) is the main producer of gum Arabic, in addition to other important medical plants. Furthermore, rangelands contribute to fuel wood and building materials provision.

**Figure (1):** Different sources of forage in the Sudan and their contribution on matter basis, (Abusuwar and Darrag, 2002).



## **2.5. Range Improvements**

In order to limit further rangeland degradation, range improvement could be one of the effective tools to be used. However, Vallentine (1980) stated that range improvements are special treatments, developments, and structures used to improve range forage resources or to facilitate their use by grazing animals. Considerable research efforts is being expended worldwide to develop techniques which will improve forage production in deteriorated areas; aiming at the restoration of depleted ranges to higher levels of productivity and replacement of undesirable plants with desirable, productive forage species (Yousif, 2005). Rafiq, (1995) stated that range improvement activities not only improve socio-economic conditions of the grazers through the increase in forage production, but also play its role in sustainability of watershed.

### **2.5.1. Methods of range improvements**

Various options are available for pasture improvement. They include control of undesirable range plants, prescribed burning, range reseeding, fertilization, mechanical control, chemical control, biological control, application of soil moisture conservation techniques, and periodic protection of the ranges.

These methods may be applied individually or in various combinations to get efficient results (Herbal, 1983). Subsequent maintenance of treated rangelands by use of fire, mechanical methods, and individual plant treatment effectiveness and improve economic returns.

Implementation of some improvement strategies, depend on climatic peculiarities of the particular area. Socioeconomic factors also greatly influence the manner in which rangeland improvement is implemented (Silcock, 1986).

## **2.6. Range Management**

Range management is defined as the science and art of planning and directing range resources as to obtain the maximum sustained livestock production without deteriorating the range or the natural resources. SRM (1974) defines range management as a distinct discipline founded on ecological principles and dealing with the husbandry of rangelands and range resources.

Rangelands represent an important resource in many countries around the world. About 30 to 40 million people in arid and semi-arid regions have animal based economics, over 50% of these people live on the continent of Africa, and they are commonly referred to as pastoralists (Sandford, 1983). They derive most of their income and sustenance from livestock grazing in arid and semi-arid areas. In developing countries, pastoralists are more dependent on rangelands than in other countries because other employment opportunities, such as in industry, are seldom available. Rangelands in many developing countries are being stressed as animal numbers expand to meet the needs of a growing human population dependent on a shrinking resource base (Adam, 2013). Developing countries face multifaceted problems in range resource management some of these problems are somewhat unique to developing countries, whereas others are more general and apply to rangelands everywhere (Aldridge and Fraser, 2000).

## **2.7. Vegetation Attributes**

### **2.7.1. Plant cover**

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). Cover measurements are commonly used to evaluate soil protection, watershed, health, rangeland ecological condition, and range

trend (Holechek *et al.*, 2004). Aerial 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).

### **2.7.2. Density**

Plant density measurement is commonly used to determine plant survival in responses to grazing and drought, plant establishment, and range trend (Holechek *et al.*, 2004). Density is defined as the number of individual plants in a given area (Cooper, 1975). It is often used as a baseline inventory of the structure of rangeland or forest vegetation (Cooper, 1975). In situation where identification of individuals is ambiguous, density measurements may be based on some other count units such as culms (Bonham, 1989). Two general approaches can be adopted to determine density. With the first approach, density is directly determined by counting plants within a defined sample unit, whereas the second approach is a plot-less method based on measuring the distance or spacing between plants (Bonham, 1989).

### 2.7.3. Forage production

Forage production is the weight of forage that is produced within a designated period of time on a given area. This forage is essential for the determination of range carrying capacity (Darag and Suliman 1988). According to Vallentine (1990) forage is the part of vegetation that is available and acceptable for animal consumption, whether grazed by animals or harvested.

### 2.8. Range Condition

Range condition is a generic term relating to present status of a unit of range in terms of specific values or potentials. Some agencies define range condition as, the present state of vegetation of a range site in relation to the climax (natural potential) plant community for that site. It is an expression of the relative degree to which the kinds, proportions, and amounts of plants in a plant community resemble that of the climax plant community for the site (Altome, 2011). Range Condition Class: Confusion has existed regarding both definition and use of range condition class. One of a series of arbitrary categories used to either classify ecological status of a specific range site in relation to its potential (Early, mid, late serial or PNC - Potential Natural Plant Community-) or classify management-oriented value categories for specific potential, e.g., good condition, fair....etc.

Some agencies consider range condition class in the context of Range Condition as follows (FAO, 1991).

<b>Range Condition Class</b>	<b>% of climax for the range site</b>
Excellent	76 - 100
Good	51 - 75
Fair	26 - 50
Poor	0 - 25

## **2.9. Range Trend Classes and Ecological Status Ratings**

Trend in range condition or ecological status should be described as up, down or not apparent (Holechek *et al.*, 2004). Up represents a change toward climax or potential natural community; down represents a change away from climax or potential natural community; and not apparent indicates there is no recognizable change. This category is often recorded as static or stable. There is no necessary correlation between trends in resource value ratings, vegetation management status, and trend in range condition or ecological status (Altome, 2011).

## **2.10. Influence of Pasture Management on Soil Biological Quality**

The grazing of pasture and rangelands by livestock is a common practice in Canada and elsewhere. Grazing management systems have been shown to influence the soil-plant ecosystem (Warren *et al.*, 1986). The duration and intensity of grazing may affect conservation of soil, water and biological organisms. It has been suggested that the inclusion of a livestock component might play a significant role in increasing the long-term sustainability of agricultural ecosystems (Magdoff, 1995). Grazing livestock was found to exert Four primary effects on pasture (Hart and Hoveland, 1989):

- A- Defoliation of herbage reduces photosynthetic capacity and may reduce root development, carbohydrate storage, and N<sub>2</sub> fixation.
- B- Selectivity for plant parts and plant species in a mixed stand may affect relative productivity and persistence of the species present and invasion of undesirable species.
- C- Trampling damages plant tissue, increases soil bulk density, and slows water infiltration.

D- Excretion concentrates urine and dung in small areas and affects plant palatability and nutrient cycling.

Grazing systems may contribute to maintaining high forage nutritional value on pastures (Howarth and Goplen, 1983). The quality of forage sustained in rotationally stocked pastures has been reported to be greater than that in pasture stocked continuously (Walton et al., 1981), but in both rotational and continuous systems, seasonal fluctuations in forage quality have been noted (Jung *et al.* 1985). Sharrow (1983) demonstrated that better nutrition is provided to animals in rotationally than continuously stocked paddocks, because amounts of plant biomass are greater. Grazing system and stocking intensity experiments in pasture research have focused on livestock weight gains, and forage quality and quantity (Langlands and Bennett 1973. Walton *et al.*, 1981. and Jung *et al.*, 1985). However, the nutritional quality and quantity of forages in pasture also depend on the quality of the soil in which they grow. The maintenance and improvement of soil quality is fundamental to sustaining soil fertility and productivity (Doran and Parkin, 1994).

### **2.11. Influence of Human on Rangeland**

Primary productivity and cycling of nutrient in every rangeland ecosystem are affected by human population. Harlod *et al.* (1982) stated that people build their houses and even cities on range land. They like the animals, walk upon the soil, compacted it and trampling plants. They claimed that, in part of Africa and in Southeast Asia people clear field for cultivation by burning the trees and bush. They plant crops in the ash fertilized soil and then, when the fertility declines or when weeds infestation becomes serious, they abandon these fields to move to other locations. After the fields are deserted, forbs quickly colonizes the area and gradually give way



to woody shrubs and trees as the forest or bush returns. Shifting cultivation can make use of the land for while but the ecosystem is soon re-established once the human influence ceases. Man's activities contribute in many ways to rangelands ecosystem, when too many animals graze for too long a period ecosystem may be permanently damaged (Harlod *et al.*, 1982). They said that in Saudi Arabia and the drier parts of east Africa, Sudan, Ethiopia, the Sahel region of Africa, part of Asia and other areas, pastoral nomadism is one of the normal ways of life. Families follow their flocks from one grazing area to another. Often a route or trail is used in successive seasons, causing the vegetation along the route to be seriously trampled and over grazed. A pattern of transhumance may be followed, a combination of seasonal herds migration with subsistence cropping, usually of cereals at a central or home locations where the herds return for a part of the year.

## **2.12. Influence of Environmental Factors on Vegetation Patterns**

The environmental factors of an area interact and affect the vegetation pattern of that area. According to State Forest of New South Wales (SFNSW, 2003), there are five types of environmental factors each consisting of a number of individual factors, which can be of particular importance in different areas.

These factors are:

1. Climate:
  - a. Temperature – extremes, minimum and maximum.
  - b. Precipitation – In the form of rain, including quantity, distribution throughout the year, reliability, extremes and humidity.
  - c. Light – including day length variation, shadow and shading.

d. Wind –prevailing wind direction and strength, destructive storms and diseases carried by air.

2. Soil:

a. Physical characteristics –depth, drainage, moisture retention, aeration, texture and structure.

b. Chemical characteristics –nutrient contents, availability and additional of nutrients.

3. Topography:

Topography modifies the effect of climate and soil by increasing or reducing more or less favorable moisture factors.

4. Past history:

a. long term climatic changes

b. Past destruction, such as fire and clearing

c. Introduction of new organisms, animals, plants, insects or diseases.

5. Living organisms:

a. Local flora growing in the area.

b. Local fauna –seed distribution and loss (through consumption), loss of plant (through consumption and damage).

c. Microorganisms –decay organisms, pathogens.

d. Humans –Logging, clearing, burning, and grazing.

e. Fires –Destructive effects, beneficial effects.

## **2.13. Rangelands Problems**

### **2.13.1. Change in rangeland areas**

Because economic and social values change constantly, the area of rangeland in the world varies from year to year. For example large areas of land in the central Great Plains region of the United States have been shifted between rangeland and crop land several times during the past 100

years (Holechek *et al.*, 1989). According to Peter (2000), the nomads have probably have justified complains of declining forage resources. Most of their argument is directly related to the reduction of grazing lands because of the expansion of mechanized and traditional cropping. However, it could not be inferred that the 75% decrease in forest and grazing land in the Rawashda Wad Kabo area of eastern Sudan over recent decades led to a similar reduction in forage supply.

The area of rangeland in the world is expected to decline substantially in the next 30 years. Large amount of the rangelands in Africa and South America are presently being converted to farmlands. This trend is expected to continue until most of the potentially farmable land is put under cultivation. Rapid increase in the human population will necessitate the farming of all available lands on these continents. The expected rangeland-to-farmland conversion could decrease the amount of rangeland by 20% to 30% in Africa and as much as 40% in South America in the next 50 years. In some instances this conversion will be temporary and will cause degradation of the land resources (Holechek *et al.*, 1989).

### **2.13.2. Increase in human population**

Trend in human population growth and economic development will have considerable influence on how rangeland will be used in the coming years although the emphasis may shift among rangeland products, the rapid increase in the human population will undoubtedly make rangelands more important to humankind than ever before (Holechek *et al.*, 1989).

A rapidly growing human population and its associated stresses have placed communal or open access natural resources under increasing strain. The human population of the sub-Saharan Africa is growing at an unprecedented rate. The 49 countries in the region currently have a population of 500 million. According to the World Bank the population is

expected to reach 676 million in the year 2002 and 1,294 million by 2025 (Winrock International, 1992). Degradation, even to desert like condition, is reported well away from the desert front in areas that have high human population concentrations, leading to excessive wood cutting and crop cultivation in areas where it is not suitable (Sharpe, 1991). He stated that a rapidly expanding human population escalating degradation of natural resources and increasing socioeconomic pressure have all increased the complexity associated with the management of grazing system.

In recent years human population increase has accelerated the spiral in which the people are involved. Population increases are among the highest in developing countries. Darfur Joint Assessment Mission (DJAM, 2006) reported that the population of Darfur has increased substantially during the last 50 years. In the past three decades Darfur region has witnessed a significant population movement within the region and to other regions or even to neighboring countries. Simultaneously; it has received an influx of migrants from neighboring countries mainly Chad. The spatial distribution is largely affected by resources endowment, cultural and historical factors. However, recently political upheavals have enormously affected the population distribution. Darfur Population density has increased from 3 persons/km<sup>2</sup> in 1956, to 4 persons/km<sup>2</sup> in 1973, to 10 persons/km<sup>2</sup> in 1983, to 15 persons/km<sup>2</sup> in 1993, to 18 persons/km<sup>2</sup> in 2003 (DJAM, 2006) almost six folds. No doubt this situation will bring an increasing potential demand on a degraded natural resources, the over/ or growing population represents the most important reason that presses the resources of a very fragile environment. Furthermore, droughts and desertification exerted even more pressure on the natural resources (Bashir, 2001). Hubert (1991) mentioned that population growth and urbanization usually augment the

pressure on prime rangelands and forests, which are then converted to cropping or urban land.

### **2.13.3. Increase in livestock number**

Between 1974 and 1982 cattle population in the world increased 3% while sheep population increased 9%. Developing countries with rapidly increasing human populations, such as Sudan, Kenya, and Mexico have experienced large increases in cattle and sheep populations (Holechek *et al.*, 1989). They stated that in developing countries, range livestock number in the next 25 years are expected to increase at even faster rate than for the last 8 years as more and more herders share a declining land base due to conversion of rangeland to crop land. This will place tremendous pressure on rangelands in these countries.

Worldwide, there are at least 40 million pastoralists who depend on natural grazing for their livestock, most are subsistence herders and more than half are in Africa. Rapid increase in human and livestock populations in this century have contributed to increased grazing pressure, particularly in arid and semiarid environment (Wiggin, 1991). Etienne *et al.*, (2002) postulated that livestock increase can contribute negatively towards management of natural resources. Heavy grazing removes the vegetation cover, thereby exposing soil surface to erosion, and continued long term heavy grazing would result in deterioration of plants communities. Grazing intensity generally affects vegetation cover which increase bare soil percentage, (Lazim, 2009).

### **2.13.4. Burning**

Fire, which was a natural force that shape and maintain the grassland, is a management tool that may aid in restoring and maintaining grass cover. However, fire also aggravates the risk of increasing erosion and further soil

degradation because protection afforded by vegetation is reduced immediately after the fire (White and Loftin, 2000). The removal of vegetation cover by fire is an important driver of surface run off and erosion processes, as it reduce the frequency and size of vegetated areas over the landscape. Consequently the removal of vegetation exposes the soil surface to the energy of rain drop impact affecting surface aggregate stability and the permeability of surface soil layer to water infiltration (Baker, 1988; Simanton and Renard, 1981).

## **2.14. Rangeland Utilization in Sudan**

The rangeland utilization refers to the percentage of the annual production of forage that has been removed by animals throughout grazing season (Stoddart *et al.*, 1975). SRM (1974) defined range utilization as the percentage of the current year herbage production, consumed or destroyed by herbivores.

The area affected by range degradation and desertification in Sudan includes the semi-desert zone and the low rainfall savannah (Shaban, 1990). These ecological zones cover most of northern and western Kordofan and Darfur regions and some parts of central and eastern regions. Sudan's Soil Conservation Committee (SSCC, 1944) concluded that, soil deterioration and desertification that have occurred in 1944 was attributed to the general misuse of land rather to the periodic climatic changes.

Currently some environmental factors and human activities which led to degradation were believed to be desert encroachment and desertification, overgrazing, expansion of traditional rain fed farming and seasonal fire outbreaks. The degree of overstocking of the rangeland was demonstrated by Darag (1983) who estimated the national growth rate in animals as being 3.7, 4.3, 5.7, and 2.25 % for cattle, sheep, goats and camels

respectively leading to continuous livestock population increase on the same rangeland area resulting in overgrazing.

Animal census (Ministry of Animal Wealth and Fisheries, 1997) has indicated that 90% of livestock population was owned by nomads, there was always an imbalance between the available biomass produced from the rangeland and their carrying capacity.

The expansion of areas under cultivation at the expense of areas classified as rangeland was also considered a major constraint to rangeland utilization in Sudan. With increasing human population, the areas allocated for crop cultivation increased at the expense of rangeland. The area of traditional rain fed farming in western Sudan (Kordofan, Darfur, and western White Nile) increased from one million feddans in 1960 to 6.8 million feddans in the years 1979-1980 (Ministry of agriculture and forestry, 1983). RPA (1994) reported that fires destroyed more than 35% of the total forage produced from Sudan rangelands adding to causes that were responsible for changes in the vegetation cover. Water provision also constrained utilization of range resources in some areas and led to overstocking in other areas (Hana, 2007).

### **2.15. Quality of Range and Pasture**

The availability of pasture, the structure of the sward and the nutritive value of its components reflect the characteristics of the species present, the environment which determine their growth senescence (Humphery, 1991). The quality of harvested forage depends largely upon its protein content and total digestible nutrients. These, in turn, depend upon the age of the forage when it's harvested (Roy, 1979). Butler and Bailey (1973) reported that, at early growth stage of forage plants the leaves contain high moisture, protein, minerals, and low fiber and lignin. The cell constituents,

as protein, lipids, soluble carbohydrates and soluble minerals decreased with increased age. The cell wall fiber increased and become more lignified (Meirion *et al.*, 1973). Poor quality hay remains in the stomach of the animal about twice as long as does high quality forage. As the level of the roughages is increased in the ration, the digestibility of energy, dry matter, organic matter, and nitrogen free extract will decreased, and crude fiber digestibility will increase (Roy, 1979).

#### **2.15.1. Factors affecting forage quality**

Plant maturity, lignifications and cell wall content are the main preharvest factors affecting forage quality. Leaf losses, microbial processes, and heating are largely responsible for post harvest deterioration. Reduction in protein availability through heating is perhaps the most significant factor in damp hays and wilted silage (Yn and Thomas, 1976). Environmental factors that affect plant growth have a profound effect upon forage quality. Knowledge of these is vital for proper management and manipulation of plant selection, fertilization, and maturity (Wilison, 1983).

##### **2.15.1.1. Drought**

Severe drought causes loss of pasture quality, since leaf growth is arrested and senescent material is less digestible and less acceptable to stock. Mild water stress increase pastures quality (Wilison, 1983).

##### **2.15.1.2. Age of rangeland**

Young pasture growth lead to higher organic matter digestibility and intake than pasture reserved from grazing. The decrease in nutritive value with age is phenomenon observed through tropical countries (Soneji *et al.*, 1971).



#### **2.15.1.3. Palatability and preference**

Palatability which contribute to range quality is defined as "plant characteristic or condition which stimulate a selective response by animal" (Heady, 1964) or " The relish with which a particular species or plant is consumed by an animal " Range Term Glossary Committee, (RTGC, 1974). Preference, on the other hand, refers to selection by the animal and is largely a behavioral response (Heady, 1964).

#### **2.15.1.4. Grazing management practices**

The most difficult part of pasture livestock program is proper utilization by grazing or harvesting the forage. Cheap and efficient livestock gains come from grazing the forage when it's tender, palatable, with high protein and highly digestible (Roy, 1979).

### **2.16. Grazing Systems**

Range forage is one of the most important resources for meeting the red meat requirement of the world's human population. In the past, it has been exploited through heavy, uncontrolled grazing. Today there are principles of scientific management that can be applied to improve the range resources and ensure a sustainable yield of goods and services from rangelands. In order to apply these principles, grazing use must be planned and plan executed. Several planned grazing systems are available to improve range productivity. The first consideration in planning range use is to insure that the basic plant and soil resources are used in such a way that they continue to be productive under the grazing system employed. The selection of particular system will depend upon the kind of vegetation, the physiology of the range, the kind of animals, and the management objectives of the operation (Abusuwar, 2007).

### **2.16.1 Continuous grazing**

Livestock are kept on one area of land, on which they are allowed to freely move and graze “controlled” through the placement of salt blocks and mineral licks and opening and closing of stock tanks, boreholes and other water supplies. Continuous grazing in the absence of proper planning frequently leads to problem of overgrazing (Ffolliott *et al.*, 1995).

### **2.16.2 Seasonal grazing**

Livestock are confined to one area in the dry season and to another area in the wet season. A feature of this system is that one area of land is grazed at the same time each year. Rangelands that typically suffer misuse are those which are grazed regularly in the wet season. Therefore, seasonal grazing system is acceptable only during the wet-season. Grazing area is large in relation to the size of the dry –season grazing area and number of livestock (Ffolliott *et al.*, 1995).

### **2.16.3. Deferred grazing**

Deferred grazing implies delaying grazing until the most important forage species have set seeds. The longer the beginning of grazing of a range unit can be delayed, the better opportunity exists for new plants to become established and for old plants to gain vigor. Deferred grazing has certain theoretical advantages. If grazing can be deferred every few years, then forage plants have better opportunity to reproduce (Abusuwar, 2007).

### **2.16.4. Rotational grazing**

Rotation grazing, or alternate grazing, involves subdividing the range into units and grazing one range unit, then another, in regular succession. The rotation system of grazing is based on the assumption that animal in large numbers make a more uniform use of the forage, and that a rest from grazing is beneficial to the plant, even though it must support a greater

number of animals during the shorter time during which it is grazed. Certainly proper rotation grazing result in more uniform utilization and less selective grazing, which is harmful, is expected to take place. The disadvantages of the rotation system are embodied in the extra cost of fencing and moving of animals from unit to the other. In addition, the concentration of animals in small area may result in health problems, especially when there is an epidemic disease which can spread quickly to the herd (Abusuwar, 2007).

#### **2.16.5. Deferred rotation grazing**

In balanced rotational grazing system a period of deferment is applied to each block, with successive grazing periods in a block at different times of the year. Each block is grazed for equal period during the growing season, which normally 12 months on grazing lands region. Selection of a grazing cycle among the blocks is determined largely by the condition of the grazing land, species and type of livestock, and rangeland management objectives. The main reasons of deferment are to allow a buildup of food reserves in forage species and to allow plants to set seeds. The number of blocks in balanced rotational grazing systems is determined by the condition of the rangeland and availability of water. The blocks should have similar carrying capacity. Grazing systems of 4 or 5 blocks characterize situations with one rainy season in the year.

Some forms of compromise, taking into account the availability of water, condition of grazing land and species or type of livestock, is necessary in determining the number of blocks (Ffolliott *et al.*, 1995).

#### **2.16.6. Rest rotation grazing**

Rest rotation grazing is a system wherein the deferred part of the range is given complete rest for an entire year. It is similar to deferred rotation

grazing, deferred mainly in longer rest period and heavier use of the grazed portion, since, unlike deferred grazing; the rest portion is not grazed at all (Abusuwar, 2007).

### **2.17. Effect of Grazing on Herbaceous Production**

Grazing reduced leaf areas of plants at least temporarily, but the overall impact of grazing on plants depends largely upon the extent to which carbohydrate reserves are affected. The timing of grazing is important, with two periods being crucial – the period of active plant reproduction and the initial period of carbohydrate storage. Little is known about the critical levels of carbohydrate reserves that are necessary for most forage plants, although it is known that plant species vary greatly in their response to grazing. Response to grazing is related to phenology and morphology of plants, environmental conditions and level of grazing.

Grasses respond differently to grazing than woody plants do, largely because of differently in the location of meristematic tissue.

Meristematic tissue in grass is located at the base of stems, often close to the soil surface. In contrast woody plants have epistemic tissue, or buds, at the end of branches and therefore, elevated above the soil surface, making them more susceptible to grazing. Appropriate level of grazing on woody plants can stimulate lateral growth and increase forage production at the same time (Ffolliott *et al.*, 1995).

Method of reproduction also affects responses to grazing plants that reproduced by seeds, including most of grasses and forbs, can recover from grazing, drought, and other disturbances if allowed to produce seeds. Annual plants reproduce vegetatively by rhizomes are more resistant to grazing mechanical injury and, furthermore able to store more carbohydrate than can be stored in seeds.

Defoliation of plants by grazing early in the growing season is less injurious to plant than grazing late in the season. In all situations, the greatest effects on the physiology of plants occur when the plants are under stress, for example, during drought (Holechek *et al.*, 1989, Patt and Gwynne, 1977). If grazing is allowed too early in the growing season or too frequently throughout the grazing period, it lowers the production of dry matter by reducing the leaf areas and light interception, resulting in lower plant growth rate (Ffolliott *et al.*, 1995). When a forage plant shift from vegetation to reproductive development, intense grazing can prevent formation of flowering shoots. Promoting further growth of leaves and production of secondary branches, however, there is a limited rate to which any plant can be grazed and still survive (Ffolliott *et al.*, 1995).

## **2.18. Effect of Pastoralism on Rangelands**

Most observers of the nomadic grazing system agreed that forage resources are declining, as any equilibrium which may have existed between nomadic herds and forage resources in the past have been destroyed (Walker, 1980). In Botswana defined the major problem of the pastoral regions as over-stocking leading to certain ecological disaster, too little lands, the local rangeland could not carry an increased cattle population and that beside localized problems, the quality of the environment is deteriorating. At times of drought, pressure on grazing land and water resources, is leading to marked deterioration in range productivity. In Mali, the vegetation is devastated in radius of 20-30 km around the permanent water owing to increased human and animal population concentrating in the dry season. Pastoralist and agro-pastoralism can help mitigate the effect of land degradation, but certainly cannot solve the problem in

isolation. They could contribute to slow down the degradation processes, but they alone cannot eradicate them (Lehouerou, 1980).

## **2.19. Degradation of Vegetation Cover**

Degradation of vegetation is the quantitative and/or qualitative reduction of the vegetation cover resulting from various factors including human induced activities and severe prolonged drought under poor land resource management. Under natural condition, and in the ecosystems prone to desertification, plant cover varies from sparse or non-existent in the desert and the arid zones to relatively dense in the water parts of the semi-arid regions. Plants are more vulnerable to degradation in the drier parts of the arid region than the wetter parts. Degradation of the vegetation cover exposes the surface of the land and makes it vulnerable to soil erosion (Mustafa, 2007).

### **2.19.1. factors affecting vegetation degradation**

#### **2.19.1.1. Demography**

The accelerating growth rate of the population, in general, and pastoralists, in particular, and their herds of cattle, sheep, goats and camels in developing countries increased animal and human pressure around watering points and settlements producing spotty degraded areas. Under such conditions overgrazing is enhanced resulting in increase of these degraded spots, which over time join to form a large desertified area.

#### **2.19.1.2. Laws and legislations**

The presence of laws and legislations for protecting natural resources and a good strategy for their enforcement is essential for conserving the natural vegetation. In many countries like Sudan there are sufficient laws and legislations but with many loopholes coupled with a weak enforcement system (Mustafa, 2007).

#### **2.19.1.3. Poverty**

Poor communities in rural dry areas depend on their fragile ecosystem for sustenance. They rely on the natural vegetation for making homes, animal enclosures and for provision of energy. Because of poverty they are deprived from the use of modern technology and pushed into the following vicious circle of poverty: poverty – overuse of fragile ecosystem – land degradation – desertification – reduction of productivity – increased poverty (Mustafa, 2007).

#### **2.19.1.4. Horizontal expansion in mechanized rain-fed agriculture**

Dregne (1985) stated that mechanized rain-fed agriculture, by its very nature, poses series problems for soil conservation and management. These problems include:

- Stripping of natural vegetation from large tracts of land for cropping.
- The soil remains bare and therefore subject to soil erosion over several months each year.
- Drought-tolerant crops are selected for planting, and mono-cropping is practiced.
- Fertilizers are not applied in Sudan.

All these problems exacerbate further land degradation by soil erosion.

#### **2.19.1.5. Improvement of animal health services**

The development of veterinary services and water points in rangelands coupled with poor range management and lack of nearby markets results in high growth rate of animal population, overgrazing and land degradation.

#### **2.19.1.6. Government policy for nomad movement**

Restriction of the movement of nomads, forces them to graze their animals in a restricted area with on rest period for regeneration of vegetation.

Nomadism should be considered elaborating a range management strategy (Mustafa, 2007).

## **2.20. Desertification**

Desertification is the formation of desert like conditions, largely through human actions, in areas that don't have desert climates, biological productivity declines while the prevailing climate condition are thought to remain constant. Human activities implicated as causes of desertification include uncontrolled livestock grazing, burning, wood cutting, temporary cultivation, and abandonment of semiarid to arid land. Africa has been the focal point of concern over desertification during the past 20 years because of continued drought in the Sahel region. These droughts have caused tremendous losses of livestock and human hardship. A world conference was held on desertification in Nairobi Kenya in 1977. Comprehensive reviews on the subject desertification are provided by UN (1977) and Glantz (1998). Past climatologically data showed that drought has been a recurring phenomenon in the Sahele (Winstanley, 1983). However, the effects of drought on the vegetation have been magnified in recent years because of rapidly increasing human and livestock population. He also stated that there is some evidence that recent droughts have been more severe than those in the past (Elnour, 2007). Overgrazing is often blamed for worldwide desertification, which is partly true and partly false depending on the situation. It depends certainly on overgrazing intensity and also overgrazing duration, which can be measured in months, years, decades or even centuries. Apart from prolonged droughts, acceptable and fixed stocking rates will cause temporary overgrazing in some years because of grazing capacity fluctuations. Damage to the vegetation is usually repaired by natural processes. Stocking rates and managerial



systems that result in continual destructive grazing are a major cause of desertification on rangelands (Rahma, 2015).

### **2.20.1. Desertification processes and land use systems**

Desertification processes vary with the prevalent land use system. The three major land systems in the ecosystem prone to desertification include: rangelands, rain-fed croplands and irrigated lands (Mustafa, 2007).

#### **2.20.1.1. Rangelands**

The most common degradation process in these lands is the degradation of vegetation cover via overgrazing of desirable perennials that causes invasion of less palatable grasses, forbs, shrubs and poisonous plants. Furthermore, woody plant species on grazing lands are cut for fuel wood, building, implements, bush fencing and other purposes. Removal of grasses and wood expose the soil to accelerated erosion by wind and water. Trampling by livestock causes soil compaction and enhances soil erosion (Mustafa, 2007). Fire in semi-arid and sub-humid region can control the spread of undesirable shrubs and trees and encourage the growth of unpalatable grasses. The beating action of rain drops on bare soil and the pressure exerted by the hoofs of the livestock are the major causes of surface crusting. Crusts reduce infiltration rates and increase surface runoff and thereby enhance water erosion.

#### **2.20.1.2. Rain-fed croplands**

The preparation of a cropland begins with the removal of native vegetation cover, woodcutting and cultivation or burning of grasses thus exposing the soil to accelerated wind and water erosion. Under annual cropping, the soil is unprotected during the period from harvest to seeding of the next crop and during the clean fallow period, if practiced, to conserve soil moisture or mineralize organic nitrogen in the soil. During these periods, the soil

will be exposed to erosion. The use of tractors and heavy tillage machinery increases subsoil compacting and the raindrop impact may result in surface crust formation; both effects accelerate soil erosion.

#### **2.20.1.3. Irrigated lands**

The main desertification processes in these lands are salinization and sodication. The irrigation of salt affected soil in the arid and semi-arid regions may cause the accumulation of excessive amount of salts in the root zone. However, if the land is left unprotected during the fallow period, it will be vulnerable to wind erosion (Mustafa, 2007).

# CHAPTER THREE

## MATERIALS AND METHODS

### 3.1. The Study Area

The study was carried out at North Darfur State, Sudan (Figure 2). The State lies between latitudes  $12^{\circ} 30'$  and  $21^{\circ} 55' N$  and longitudes  $24^{\circ} 00'$  and  $27^{\circ} 30' E$  within the arid and semi-arid zones. Based on average annual rainfall amounts and soil types the state can be divided into two main geographical zones: Desert and semi-desert, and area amounts to about 296,400 km<sup>2</sup>; about 60% of it is rangelands. The state includes 13 localities; Alfashir, Kutum, Milliet, Dar elslam, Tawella, Elsirief beni husien, Umkaddada, Eltiwasha, Elaiyd, Kabkabia, Sarf oumra, Karnoy and Eltinna. The total population of North Darfur State is estimated at 2.1 million. The rural, urban and nomadic populations constitute 64%, 16.8% and 19.2% respectively (Adam, 2013). The majority of the rural populations are small farmers who cultivate crops and raise a small number of livestock.

Animal production is the mainstay of the economy of the State and the state is considered among the leading regions of Sudan in terms of animal resources estimated as 6916641 heads of sheep, 4953979 goats, 1331486 camels and 400594 cattle (Animal Statistic and Planning, Admin, 2009).

The study site is located at Alfashir locality. The study is conducted at three sites, the first site is Ummarahik 25km north of Alfashir, the second site is eastern part of Alfashir about 5km and the third site is Berka 30km west of Alfashir.

There are three distinct seasons at the area, the hot rainy season or autumn from June to September, the cold season or winter from November to

February and the hot dry season or summer from March to May. Table (2) shows the average annual rainfall for last ten seasons was 218.09 mm.

The mean, minimum and maximum temperatures are 17.7C° and 34.7C° respectively (Table 3), (Alfashir Meteorological Station, 2013).

Generally the major geology formations in Darfur (Table 2) according to Hunting technical Services (HTS, 1976) are:

(a) Basement complex rocks covering more than 45% of the area. These don't bear ground water aquifers and water availability is confined to some localized fractures.

(b) Naga formations which are rarely found as outcrop on the surface. These are composed of fine grain and are poor in terms of carrying groundwater.

(c) Nubian sandstone covers more than 30% of Darfur. This formation bears rich water aquifers.

(d) Tertiary volcanic which is formed after volcanic eruptions and is mainly found in Jabal Marra area.

(e) Um Ruawaba formation lies over the Nubian Sandstone.

Vegetation type is closely associated with rainfall. As the amount of rainfall increases, so do the height and density of vegetation. The vegetation composition will contain more preferable and palatable types as the rainfall increases. Ibrahim (1984) using Jackson and Harrison zonation of the Sudan vegetation (1958), classified the area into semi-desert vegetation.

This zone is characterized by sparse and patchy vegetation cover, mainly formed of thorny scrub trees. The dominant tree species are *Acacia senegal* (Hashab) *Acacia mellifera* (Kitter), *Boscia senegalensis* (Mukhait), *Acacia tortilis* (Seyal), *Acacia nubica* (Laot), *Faidherbia albida* (Haraz), *Maerua crassifolia* (Sereh), and *Balanites aegyptiaca* (Heglig). Annual grass cover

composed mainly of *Cenchrus sp* (Haskanit), *Aristida sp* (Gaw), *Echinocloa colonum* (Difra), *Eragrostis sp* (Banu), and *Dactyloctenium aegyptium* (Abuasabi).

**Figure (2):** Map of the Sudan, Location of North Darfur State and study area



Source: Adam, 2013

**Table (1):** Average maximum and minimum temperature and relative humidity at Alfashir town

<b>Month</b>	<b>Maximum Temp</b>	<b>Minimum Temp</b>	<b>% Relative Humidity</b>
<b>January</b>	29.4	9.9	25
<b>February</b>	31.8	11.9	21
<b>March</b>	35.2	15.9	17
<b>April</b>	37.9	19	18
<b>May</b>	38.9	22.1	25
<b>June</b>	38.5	23.3	32
<b>July</b>	35.8	22.9	51
<b>August</b>	34.6	22.3	58
<b>September</b>	35.8	21.8	45
<b>October</b>	36	19.5	31
<b>November</b>	32.7	13.7	26
<b>December</b>	29.8	10.5	25
<b>Average</b>	<b>34.7°</b>	<b>17.7°</b>	<b>31%</b>

Source: Alfashir Metrological Station, 2013.

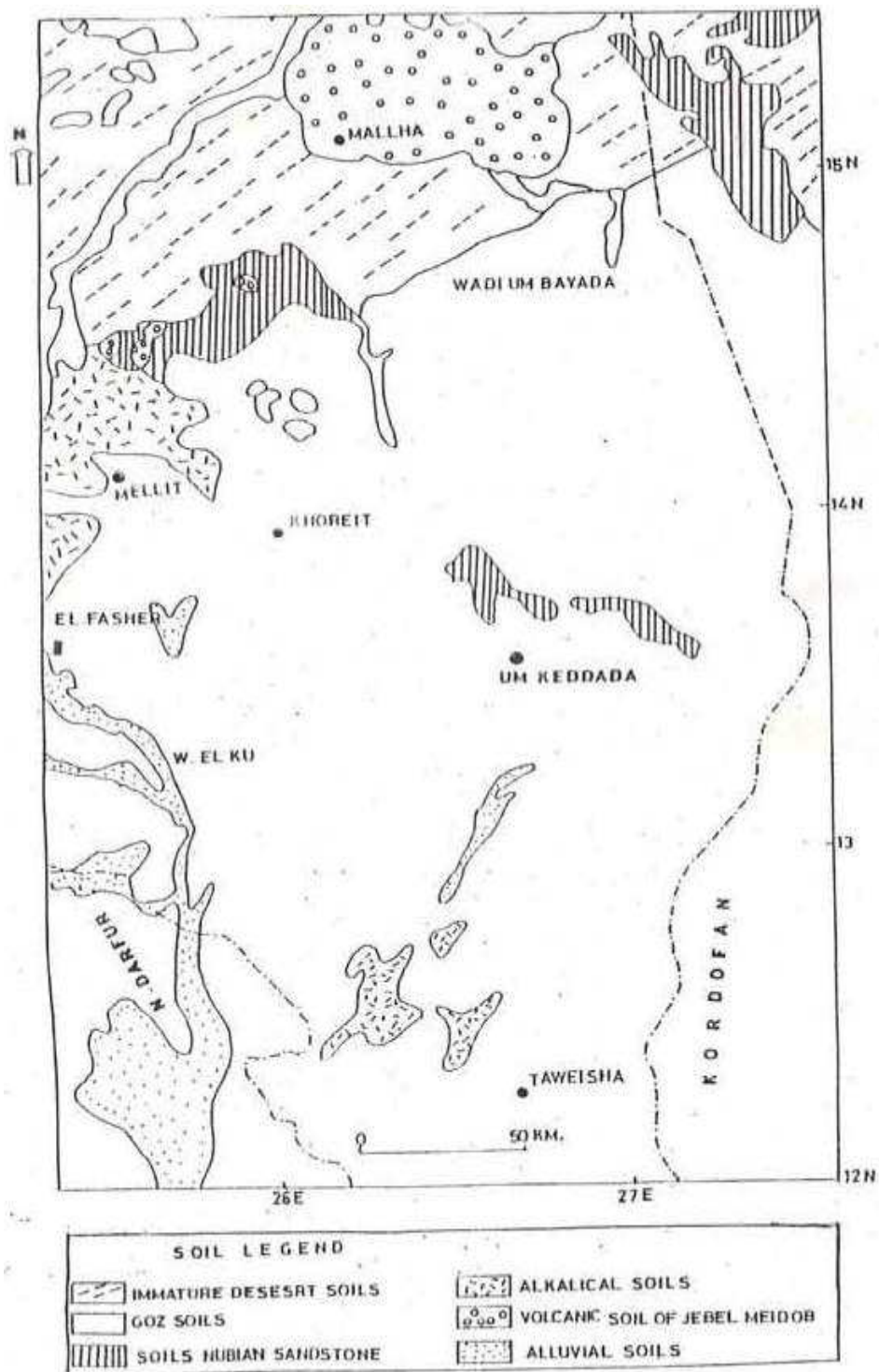
**Table (2):** Annual rainfall at Alfashir locality from 2000 to 2013.

<b>Season</b>	<b>Apr</b>	<b>May</b>	<b>June</b>	<b>July</b>	<b>Aug</b>	<b>Sep</b>	<b>Oct</b>	<b>Total</b>
<b>2000</b>	NR	21.7	21.1	100.4	76.2	27	21.6	<b>268</b>
<b>2001</b>	NR	1.4	43.6	68	33.3	18.9	NR	<b>165.2</b>
<b>2002</b>	NR	3.3	21.1	58	55.6	27.4	1.3	<b>166.7</b>
<b>2003</b>	NR	3.8	16.3	69.5	97.8	4.8	2.1	<b>194.3</b>
<b>2004</b>	NR	0.6	28.4	42.2	36.6	8.7	NR	<b>116.5</b>
<b>2005</b>	NR	23.3	4.5	58.9	188.5	42	NR	<b>317.2</b>
<b>2006</b>	NR	1.2	8.7	78.3	107.9	52.1	NR	<b>248.2</b>
<b>2007</b>	NR	8.7	3.9	42.9	205.3	20.2	NR	<b>281</b>
<b>2008</b>	6.1	1.5	5.4	37.9	83.4	24.8	NR	<b>159.1</b>
<b>2009</b>	NR	NR	NR	70.7	37.9	9.5	13.4	<b>131.5</b>
<b>2010</b>	NR	NR	8.9	108.4	69.4	37.4	15.9	<b>240</b>
<b>2011</b>	NR	42.1	7.9	18.6	50.6	28	NR	<b>147.2</b>
<b>2012</b>	NR	19.2	18.7	59.5	166.9	23.4	NR	<b>287.7</b>
<b>2013</b>	NR	0.9	20	139	67.5	25.1	NR	<b>252.5</b>

NR = No Rain

Source: Alfashir Metrological Station, 2013.

**Figure (3):** Soils of North Darfur State



Source: Ibrahim, 1984



### **3.2. Sampling Procedure**

This study was conducted at Alfashir locality, North Darfur State, at late rainy season in September 2012 and September 2013. The study was done at three sites:

- 1- Site one is Ummarahik which is located in the northern part of Alfashir town about 25 km.
- 2- Site two is Fashar located in the eastern part of Alfashir about 5km.
- 3- Site three is located in the western part of Alfashir about 20 km and east of Berka village about 7 km, given name of Berka site.

Three transect lines of 2 km length were selected randomly in each site, the total number of transects at the study area were 9 (3x3). In each transect three points were taken with 500 m apart, so the number of points in each site were 9 (3x3), and this made 27 (9x3) points in the total area. At each point 2 quadrates ( $1\text{m}^2$ ) were taken with 50 m apart, so the number of quadrates taken in each site were 18 (6x3), and the total number of quadrates in the area were 54 (18x3).

Plant composition, litter, bare soil, rock or gravels and droplets data was collected at one meter intervals along the 100 m tape using a loop of 3/4 " diameter. For quadrates size, the maximum number of plot size range ( $0.4\text{m}^2 - 1\text{m}^2$ ) for forbs and grasses ( $1\text{m}^2$ ) was used as reported by Lee and Hanus, (1999).

### **3.3. Botanical Composition**

The loop method (Parker and Harris, 1959) was used to measure plant species; litter, rock/feces and bare soil at every meter along a 100 m tape placed at the point of each transect by using 0.75" loop. Data were recorded in specified sheets (photo 1 and 2).

**Photo (1):** Part of rangeland around study area



Hits on plant, litter, bare ground, rock were recorded. The total numbers of hits along each point equal 100 hits. The following equation was used to calculate the percentage of plant composition, bare soil, litter, and rock/feces.

$$\text{Factor* \%} = \frac{\text{total of hits of factor}}{\text{Total number of hits}} \times 100$$

Factor\* = It represent the plant composition or bare soil or litter or rock or droplets.

**Photo (2):** Use of loop to measure plant composition in the study area



### **3.4. Vegetation Covers**

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).

To determine the ground cover percent, 1x1m quadrates were placed along the 100m tape at 50m intervals. Ground cover percent was estimated for each quadrate and recorded. The ground cover percent estimated was summed up and divided by the number of all quadrates to get the average ground cover of the area.



### 3.5. Plant Density

Density is defined as the number of individuals in a given unit of area. It was determined by counting of plants rooted within each quadrat ( Photo 3), (Bonham, 1989) as follow:

Density = No. of individuals in each quadrat

Average plant density = 
$$\frac{\text{the total number of a species in all quadrates}}{\text{the number of quadrates taken}}$$

**Photo (3):** Use of quadrat to determine density, cover and productivity



### 3.6. Plant Frequency

The frequency is the percentage of the quadrat that contains at least one individual of certain species (Barbour *et al.*, 1987). Species frequency is the probability of occurrence of species in randomly or systematically placed quadrates (Slingsby and Cook, 1986). Plant frequency helps in

determining plants distribution and their order of dominance (Darrag, 1996).

The species frequency was obtained by dividing the number of quadrates in which the species was present by the total number of quadrates taken.

$$\% \text{ Species frequency} = \frac{\text{the no. of quadrates contain the species}}{\text{The total number of quadrates taken}} \times 100$$

### **3.7. Biomass Production**

This term means the amount of dry matter in tones (ton) that range site can produce annually. It was determined by quadrat methods of sampling. To determine the dry matter production 1x1m quadrates was placed along 100 m tape at each point at 50 meter intervals. The double- sampling procedure (Wilm *et al.*, 1944) was used to measure biomass production. Within the study area, the number of quadrates were 54. The plant species inside each quadrat were clipped at 2.5-3cm above ground level (grazing level). The harvested forage species were then placed in paper bags and oven dried at 70°C for 48 hours (AOAC, 1990). Then the oven-dried materials were weighed using an electric sensitive digital balance. The dry matter per quadrat was obtained by dividing the total weight of all quadrates by their number. Then the dry matter per hectare was estimated in tones.

### **3.8. The Carrying Capacity**

According to Mustafa *et al.*, (2000), the proper use factor is 50% that means half of the forage production was used for determining the carrying capacity. According to Holecheck *et al.*, (1989) livestock units consumed dry forage equivalent to 2.5- 3% of their body weight per day. The carrying capacity was calculated according to the daily requirement of a Tropical Livestock Unit which is equivalent to 7.5 kg as reported by

Mustafa *et al.*, (2000). Carrying capacity can be determined as hectare/TLU/year (ha/TLU/Y) according to (FAO, 1980). Carrying capacity was calculated as follows:-

Carrying capacity = consumption / production

Ha/AU/day =  $\frac{\text{Animal requirement per day}}{\text{Forage production/ ha}}$

Ha/AU/month =  $\frac{\text{Ha/AU/day}}{30}$

Ha/AU/ year =  $\frac{\text{Ha/AU/month}}{12}$

### 3.9. Degree of Grazing Intensity

The degree of grazing intensity was determined using method similar to what was used by Saltaz *et al.*, (1999). In each quadrat the intensity of grazing was assessed as level I if it estimated <50%, level II if it is >50% and <75%, level III if >75% and <100% and level IV if it reached 100% grazing.

### 3.10. Tree Density

To determine the tree density in each site, three transect lines of two kilometers length and ten meter width were selected, the area of each transect were two hectares, each tree was identified, all trees in the transect area were calculated and divided by two to obtain the density per hectare in each transect, then the average density for all trees in each site were determined (Khatir, 2006).

### **3.11. Data Analysis**

SPSS software program was used to tabulate and analyses the collected data, descriptive statistics were used to present the results. Grazing intensity assessed based on Saltaz *et al.*, (1999).

## **CHAPTER FOUR**

### **RESULTS AND DISCUSSION**

The study investigated the effect of grazing on rangelands vegetation through assessing the range attributes, range compositions, species composition, species frequency, carrying capacity, range condition and trend at three sites (Ummarahik, Berka and Fashar) for two consecutive seasons.

#### **4.1. Range Components**

The unwise utilization coupled with the frequent cyclic drought that hits different parts of the world, severely affected the plant composition, and there is a serious change in vegetation composition and structure due to range deterioration, animal stress and human activities. These factors have all contributed to range degradation and change in species composition (Elnour, 2007).

Results in Table (3) showed the percentage of range components in different sites for two seasons; average plant composition was higher in the second season when compared with the first season. The low plant composition in these sites in the first season may be caused by heavy grazing, while good vegetation components may be attributed to the stability of the rain fall to some extent in the area, Skerman (1962) stated that the botanical measurement carried out during the Kordofan special fund project, indicated that the trend in the vegetation composition is towards the development and survival of the short-lived annual rather than perennial species. Litter is any dead plant material that is in contact with the soil surface. Litter provides a major source of the soil organic material and the raw materials for onsite nutrient cycling (Nasra, 2008). Results in



Table (3) and figure (4) illustrate that litter percentages was low in the different sites, the low litter percentage may be due to low rainfall characterizing the semi arid areas, which resulted in low vegetation cover. Coleman (1992) reported that litter in a pasture is a function of forage growth, senescence, harvest and decomposition. It may be also due to both the continuous grazing of the available sparse vegetation and the redistribution of litter by wind and water. Naeth *et al.*, (1991) and Jensen and Gutekunst, (2003) reported that the standing and fallen litter mass generally decrease with increased grazing intensity. The results of this study are in close agreement with the findings of Lazim (2009) and Altome (2011) who observed that standing and falling litter mass generally decreased while amount of bare soil increased with increasing grazing intensity. Bare ground is exposed mineral or organic soil that is susceptible to raindrop splash erosion (Morgan, 1986).

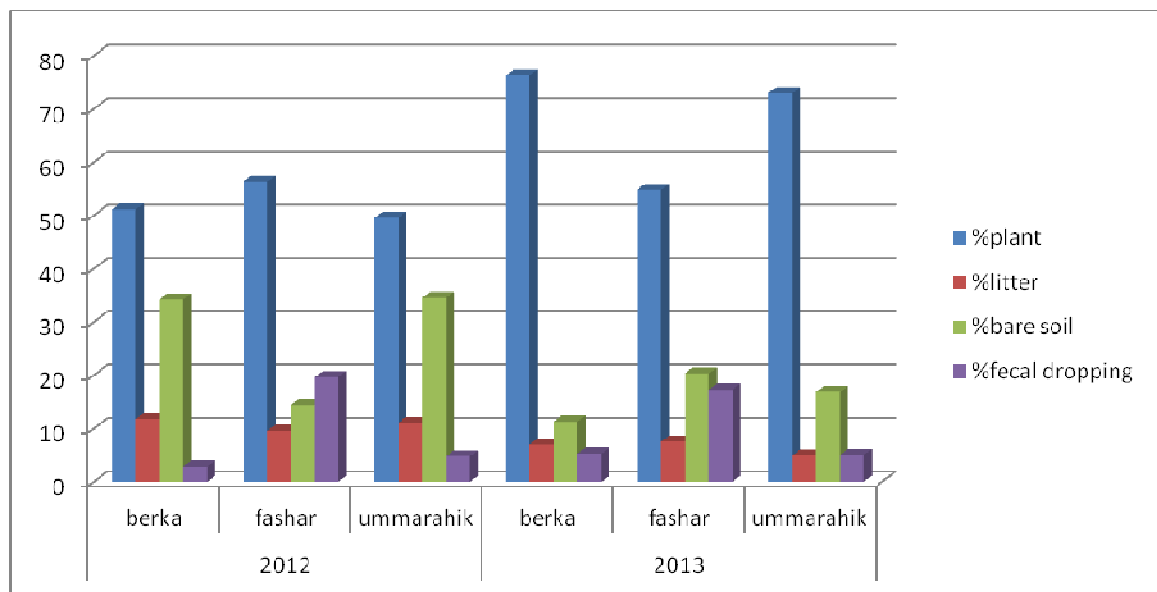
Table (3) and figure (4) show the bare soil percentage, the second season had higher bare soil than the first season. The high bare soil percentage may be caused by low rainfall, overgrazing and agricultural practices. Heavy grazing can also cause soil erosion, loss of soil structure, and deterioration of soil environment (Scholl and Kinucan, 1996).

The results of Zhaoa *et al.*, (2005) showed that the contribution of grazing and trampling to bare ground formation was 47.4% and that of wind erosion was 52.6%, Wind impact was more severe than that of heavy grazing. The variations between sites may be caused by variable rainfall and sites potentialities. This variation was aggravated by grazing and agricultural practices. 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.

**Table (3):** Mean vegetation measurements in all sites at seasons 2012 and 2013

Parameter measured %	2012				2013			
	Berka	Fashar	Ummarahik	Average	Berka	Fashar	Ummarahik	Agerage
<b>Plant %</b>	51.11	56.33	49.55	52.33	76.34	54.78	73.00	68.04
<b>Litter %</b>	11.78	09.56	11.11	10.82	07.00	07.56	05.00	06.52
<b>Bare soil %</b>	34.22	14.44	34.56	27.74	11.33	20.33	16.89	16.18
<b>Feces %</b>	02.89	19.67	04.78	9.11	05.33	17.33	05.11	09.26
<b>Total</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>

**Figure (4):** Average range composition at different sites.



**Table (4):** Average species composition percentage at the study area at seasons 2012 and 2013

Species Name	2012 Aver compo%	2013 Aver compo%
<i>Alysicarpus ovalifolius</i>	4.67	5.07
<i>Aristida sp</i>	26.75	26.56
<i>Cenchrus sp.</i>	26.25	24.55
<i>Dactyloctenium aegyptium</i>	10.48	10.83
<i>Eragrostis sp.</i>	20.46	22.87
<i>Sesamum alatum</i>	3.40	3.21
<i>Zalya pentandra</i>	7.99	6.91
<b>Total</b>	<b>100</b>	<b>100</b>

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 also 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. Better availability of soil resources generally allows establishment of larger species, increasing competition for light and leading to competitive displacement of smaller, less competitive species (Grubb, 1985; Tilman, 1988; Grime, 2001). Thus, within the range of productivity (resource availability) in which each species occurs, its abundance increases with increasing availability of limiting soil resources, but decreases when higher levels of resources allow the establishment of larger and more competitive species. Soil seed bank and grazing also affects species composition. Herlocker, (1999) declared that the degree of grazing strongly affects the structure, composition,

quality and productivity of rangeland vegetation. Continuous intense grazing leads to vegetation changes such as the replacement of palatable grasses by less palatable plant species, replacement of perennial grasses by annuals, bush encroachment, lower standing biomass and reduced basal cover (Kelly and Walker, 1976; Todd and Hoffman, 1999).

## 4.2. Species Frequency

Table (5), below shows the frequencies of the plant species in the area. The dominant species frequency was *Aristida sp* 83.34% while the lowest frequency was *Alysicarpus ovalifolius* 41.67%. The results of vegetation measurement indicated that palatable range plants species are very few within the plant community in term of frequency compared to low palatable species. The reduction of the palatable species may be attributed to the fact that the palatable species were subjected to intensive selective grazing by the animals.

There is clear difference between the frequencies during two years (Table 5). This variation may be due to the amount of rainfall. Harrison and Jackson (1958) stated that density and frequency of species are influenced by amount of annual rainfall.

**Table (5):** Plant species frequency for seasons 2012 and 2013.

<b>Species Name</b>	<b>2012</b>	<b>2013</b>	<b>Average%</b>
<i>Alysicarpus ovalifolius</i>	44.44	38.89	41.67
<i>Aristida sp</i>	75.93	90.74	83.34
<i>Cenchrus sp.</i>	72.22	83.33	77.78
<i>Dactyloctenium aegyptium</i>	51.85	57.41	54.63
<i>Eragrostis sp.</i>	66.67	94.44	80.56
<i>Sesamum alatum</i>	61.11	61.11	61.11
<i>Zalya pentandra</i>	55.56	74.07	64.82

### **4.3. Range Attributes**

#### **4.3.1 Ground cover**

During the last few decades, the range land resources in general were influenced by many different factors. One of the most important factors that influenced the range land particularly the vegetation cover is overgrazing. Results of ground cover percentages of the different sites were demonstrated in Table (6). The ground cover was generally low at all sites. At Berka site, cover was higher in the second season when compared with the other sites 51.94% (Fig 4). This reflects the temporal variation in the vegetation cover between the two seasons as the result of variable rainfall. Quite similar values were scored at the first season in Berka, Fashar and Ummarahik (33.06%, 35.50% and 35.56% respectively). The low vegetation ground cover in all sites at small and large scales was caused by low and fluctuated precipitation characterizing the semi-arid areas. The vegetation in these locations suffers from an increase in livestock numbers that exceeds the carrying capacity of the area. Overgrazing became widespread and acute. This led to rapid striping of the vegetation cover and increased wind erosion and movement of sand. Thus most of the study area suffered from decreased fertility. According to Ayoub (1998) overgrazing caused about 46% of the soil degradation.

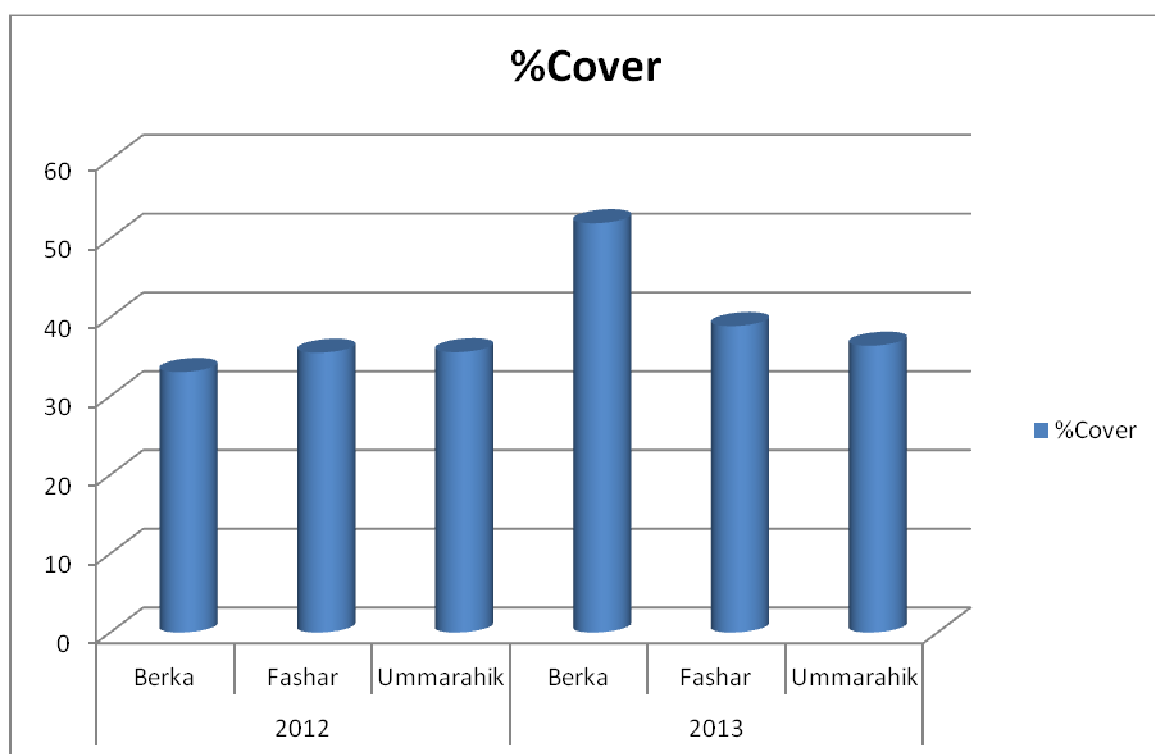
The accelerating growth rate of the population in general and pastoralists, and their herds of cattle, sheep, goats and camels at the study area, increased human and animal pressure around watering points and settlements producing spotty degraded areas.

Under such condition overgrazing is enhanced resulting in increase of these degradation spots, which over time join to form large degraded area. The continued over exploitation and over grazing over a long time have led to the depletion and exhaustion of rangeland.

**Table (6):** The ground cover percentage at the study area at seasons 2012 and 2013

	2012				2013			
	Berka	Fashar	Ummarahik	Average	Berka	Fashar	Ummarahik	Average
<b>%Cover</b>	33.06	35.50	35.56	34.71	51.94	38.89	36.39	42.41

**Figure (5):** The ground cover percentage at the study area.



Many of the palatable plants have disappeared and only few sparsely scattered annuals, thorny and perennial species mostly unpalatable remained. The degradation of rangeland had deprived the livestock sector of inexpensive, important and valuable animal fodder, and has led to soil erosion and consequently land degradation.

The main causes of rangeland degradation that persisted at the study area were overgrazing and marginal agriculture (Nasra, 2008). Generally grazing

at the study area was carried out without regard to the carrying capacity of the land or any consideration to its future regeneration.

Overgrazing reduced vegetation cover, increased bare ground, decreased productivity and increased soil erosion (Grainger, 1990 and Gobha, 1991)

The spatial variation in vegetation cover between sites may be attributed to many factors such as the pre-existing variations in soil properties topography and that affect soil moisture and mineral content. Cayrol *et al.*, (2000) and Loeser *et al.*, (2007) reported that both natural (floods, fires, droughts, volcanoes, etc.) and human (deforestation, overgrazing, urbanization and pollution) influences are known to cause massive changes in vegetation cover and dynamics. Over-grazing was considered as the main biotic factor responsible for the low vegetation cover. Beside over grazing 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 compaction (Branson *et al.*, 1981 and Oztas *et al.*, 2003). Doumbia, (2006) reported that the grazed area had less herbaceous cover compared to enclosure site.

Rangeland management plan should include grazing management with the purpose of increasing the vegetation cover and decreasing the grazing pressure on the natural vegetation, controlling kinds and numbers of animals (Proper stocking), when they utilize the rangeland is absolutely essential in regulating the effects of grazing on vegetation cover (Photo 4).

Connolly *et al.*, (1997) reported that when the percent of vegetation cover is less than 30–40%, runoff and soil loss dramatically increase. In vegetation cover improvement practices we need to maintain more than 40% vegetation cover to decrease runoff and soil loss.

**Photo (4):** Impact of over grazing on vegetation cover



#### **4.3.2. Plant density**

Results of the total plant density of the different sites were demonstrated in Table (7). The average plant density at different sites was 27.1 and 29.4 plants/m<sup>2</sup> for season 2012 and 2013 respectively. The reduction of the vegetation density may be attributed to various factors including human induced activities and severe prolonged drought, under poor land resources management. Peter (2000) mentioned that overuse and misuse activities such as heavy grazing and over cutting of trees in addition to drought and overpopulation of both human and animal have reduced the densities of plant species. The palatable species has been subjected to selective grazing by the huge number of animals in addition to erratic rainfall reduces the number and densities of the palatable species.

Difference among sites in plant density were markedly noticed, that might be due to site characteristics and environmental conditions prevailing. Yousif (2005) stated that the clay soil have reduced water penetration, held



moisture at the surface, where it readily evaporates and then often crust over the surface. While the sandy nature on the other hand favor good germination and establishment.

Results of density of the different species were demonstrated in Table (8), *Aristida sp* scored the highest density in Berka at two seasons while *Alysicarpus ovalifolius* and *Sesamum alatum* scored the lowest density at Fashar for the second season. The variation in species relative density between sites may be attributed to the spatial variation in rainfall. Noy-Meir (1973); Gutiérrez and Whitford, (1987) considered that water availability through rainfall as the main driving force for germination, growth and productivity of herbaceous plants and shrubs in arid ecosystems. Grazing can also decrease plant density. Qi (2002) reported that human activities are accelerating functional changes on fragile rangeland ecosystems.

**Table (7):** The plant density (plant/m<sup>2</sup>) at the study area.

	2012				2013			
	Berka	Fashar	Ummarahik	Average	Berka	Fashar	Ummarahik	Agerage
<b>Plant density</b>	30.06	22.67	28.61	27.1	36.17	26.11	25.78	29.4

**Table (8):** The species density (plant/m<sup>2</sup>) at the study area at seasons 2012 and 2013

Species name	2012			2013		
	Berka	Fashar	Ummarahik	Berka	Fashar	Ummarahik
<i>Aristida sp</i>	8.0	4.7	5.0	8.9	6.4	4.3
<i>Eragrostis sp.</i>	6.7	5.7	4.3	7.9	6.9	7.3
<i>Dactyloctenium aegyptium</i>	2.8	1.8	2.6	3.8	3.7	1.1
<i>Cenchrus sp.</i>	4.3	4.4	6.3	6.2	5.4	5.3
<i>Sesamum alatum</i>	2.1	3.2	4.6	3.4	0.7	3.3
<i>Alysicarpus ovalifolius</i>	2.9	1.2	2.2	2.2	0.8	1.3
<i>Zalya pentandra</i>	3.2	1.7	3.7	3.8	2.0	3.2

### **4.2.3 Biomass productivity**

The forage biomass production showed in Table (9) that Berka had the highest production for the second season while Fashar had the lowest biomass production for both seasons. The decline in forage production negatively affects the family income and health of both sedentary and nomadic people, this condition may subject the affected population to another internal displacement (Adam, 2013). The variation in biomass productivity between sites and seasons may be due to the variable and fluctuating rainfall. Bunderson (1984) stated that the amount and distribution of rainfall received in any given year has a profound impact on biomass, cover and composition of vegetation, particularly among the annual species. Whittaker, (1975) reported that biomass production will change with communities or ecological sites, biological diversity (Tilman and Downing, 1994), and with latitude (Cooper, 1975). If we compare the results of productivity in this study with those found by Harrison and Jackson, Range and pasture department and Suliman in (1985) (Table 5). It is clear that the biomass productivity has declined substantially. This reduction may be attributed to many different factors such as increase in livestock numbers above the carrying capacity of the range. As a result of the armed conflict that took place in Darfur since 2003, people were forced to leave their villages and gathered around certain locations in form of camps with all their properties including animals. The grazing intensity is another factor that affects the distribution of biomass production at the study area. Human activities mainly overgrazing and agricultural practices are responsible for decreasing biomass production in arid and semi-arid. Results of De Leeuw and Tothill, (1990) indicated that with adequate protection and controlled grazing the forage yield on the rangeland practically doubled in about 3 to 5 years. So management plan can include grazing management (proper stocking rate), protection of some areas, application of fertilizer, reseeding

with the adapted and palatable grasses and legumes can be applied to the protected areas, utilization of the appropriate rainwater harvesting technique and utilization of supplementary feeds to decrease the pressure on the over grazed areas.

In order to reduce the chance of range resources deterioration and to carry out correct range management system only 50% of the annual biomass produced by the rangelands is considered available for grazing and accessible to animal consumption. The other 50% will be left as reserve, for wild animals and other unseen utilizations, Vallentine(1990) said that forage is the part of vegetation that is available and acceptable for animal consumption, whether grazed, destroyed by animals or harvested by the local community.

**Table (9):** Biomass production (kg/ha) at the study area at seasons 2012 and 2013

	2012				2013			
	Berka	Fashar	Ummarahik	Average	Berka	Fashar	Ummarahik	Average
Biomass production	49.96	44.69	57.39	50.68	72.08	50.48	55.06	59.21

**Table (10):** Some changes at the herbage biomass productivity

Ecological Zone	Productivity ( Ton Dm/ha)		
	1958	1974/1975	1985/1987
	Harrison	Range and pasture	M. suliman
1) semi desert	0.2	0.1	0.05
2)Low rainfall Savanna	***	***	***
2.1 Northern part	0.24	0.1	0.14
2.2 Central part	0.33	0.1	0.14
2.3 southern part	0.66	1.5	0.2
2.4 eastern part	0.66	-	0.33
2.5 Baggara	0.99	2.5	0.8

Source: Suliman 1985

### 4.3. The Carrying Capacity

It is not easy to control the carrying capacity in the open range land but its determination is essential for correct utilization of the range resources to avoid overgrazing and range deterioration. Table (11) below shows the average carrying capacity for seasons 2012 and 2013.

The carrying capacity was determined according to Darag, (1996) who reported that the carrying capacity is usually determined using the proper use factor (PUF) of 50% in which only one half of forage biomass produced is considered as available for grazing.

This factor of proper use is rather low, this condition is caused by internal displacement people who depend mainly on green or dry plants to support the needs of their animals and improve their income. Ayuob (1998) stated that 6% of degradation was caused by human activities. The carrying capacity may vary from year to year in the same area as a result of damage by man and animals or forage production may fluctuate according to the rainy seasons. This indicates that the carrying capacity of the study area is very low if we compare it with the total numbers of the animal units utilizing the area. This can be attributed to the low forage production of the area since the determination of the carrying capacity is related to quantity of the forage that the area produces during the season

**Table (11):** Carrying Capacity (Ha/ AU/ Period) 2012 and 2013

<b>Carrying capacity</b>	<b>2012</b>	<b>2013</b>
Ha/AU/Month	8.88	7.6
Ha/AU/Year	106.56	91.2

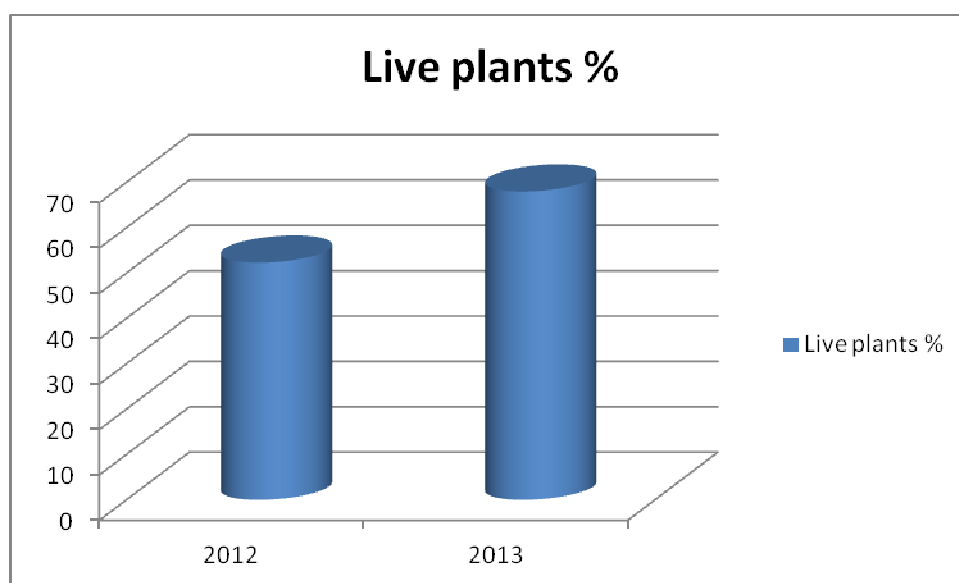
#### 4.4. Range Condition

Figure (6) below shows that the average percentage of plants in the first season was 52.3%, while in the second season was 68%.

This reduction of the range condition may be attributed to the pattern of grazing carried in the area and the intensity of range management system. According to Abusuwar (2007) the range condition is divided into four classes, Excellent in which the desirable forage species represent 76% and above of the overall plant species composition, good range, in which the composition of the desirable plants species range between 51% to 75% of the overall plant species composition, fair range in which the composition of the desirable species plants is between 26% to 50% from the overall plant species composition while in the poor range the composition of the desirable plants species is less than 25% of the overall plant composition.

Ecological factors and human activities combined with highly variable soil conditions produce extreme spatial and temporal variation in rangelands vegetation (Photo 5), the erratic rain in both quantity and distribution may influence the vegetation species composition (Elnour 2007).

**Figure (6):** Average live plants at the study area in 2012 and 2013.



**Photo (5):** Effect of human activities on range condition.



#### **4.5. Tree and Shrub Density**

Table (12) showed the average density of trees and shrubs at the study area. Results of density of species at different sites were shown in tables (13) and (14). Berka had highest trees density which scored 32 and 23 tree/ha at season 2012 and 2013 respectively. This may be due to the long distance of this area from IDPs who is settled at Alfashir town, this agreed with Adam (2013). Fashar scored lowest density 7 and 5 tree/ha. This may be attributed to the displacement activities; Rahma (2015) stated that the range and farms around Alfashir town is less in trees or low, and that due to influence of displacement activities.

Tables (13) and (14) indicate that *Balanite aegyptiaca* was the dominant tree species in the study area, while other species were less. This was because some of these tree species are preferred by animals at the study area which produces leaves during the dry season and was subjected to intensive browsing. Some species were influenced by intensive cutting for building purposes, shaking off from some trees for animals and fire wood (Photo 6 and 7). Human activities involving clearing or destruction of the area of natural vegetation also have the potential to influence the distribution of tree cover. Reynolds and Smith, (2007) mentioned that the human activities and the natural variability of rainfall and climate change as the main causes of degradation. The removal of economically important trees and shrubs by people, usually for wood fuel and construction of houses is regarded as the first type of vegetation degradation and as the main factors responsible for the decrease and /or the disappearance of woody (Macharia<sup>1</sup> and Ekaya, 2005). Heavy browsing can also affect woody species density. It affects populations of trees and shrubs negatively through increased mortality and decreased reproduction and recruitment (Young and Augustine, 2007).

**Table (12):** Average density (tree or shrub /ha) at the study area for season 2012 and 2013.

<b>Site</b>	<b>2012</b>	<b>2013</b>
<b>Berka</b>	<b>32</b>	<b>23</b>
<b>Fashar</b>	<b>7</b>	<b>5</b>
<b>Ummarahik</b>	<b>15</b>	<b>10</b>

**Table (13):** The species density (tree or shrub/ha) at the study area at season 2012.

<b>Species</b>	<b>Berka</b>	<b>Fashar</b>	<b>Ummarahik</b>
<i>Balanites aegyptiaca</i>	9	1	6
<i>Acacia tortilis</i>	6	1	3
<i>Calotropis procera</i>	7	3	0
<i>Capparis decidua</i>	3	2	0
<i>Boscia senegalensis</i>	4	0	0
<i>Fedherbia albida</i>	3	0	0
<i>Leptadenia pyrotechnica</i>	0	0	3
<i>Ziziphus spina-cristi</i>	0	0	2
<i>Maerua crassifolia</i>	0	0	1
<b>Total</b>	<b>32</b>	<b>7</b>	<b>15</b>

**Table (14):** The species density (tree or shrub/ha) at the study area at season 2013.

<b>Species</b>	<b>Berka</b>	<b>Fashar</b>	<b>Ummarahik</b>
<i>Balanites aegyptiaca</i>	6	0	4
<i>Acacia tortilis</i>	3	0	1
<i>Calotropis procera</i>	7	3	0
<i>Capparis decidua</i>	3	2	0
<i>Boscia senegalensis</i>	4	0	0
<i>Leptadenia pyrotechnica</i>	0	0	3
<i>Ziziphus spina-cristi</i>	0	0	1
<i>Maerua crassifolia</i>	0	0	1
<b>Total</b>	<b>23</b>	<b>5</b>	<b>10</b>



**Photo (6):** Effect of human activities on trees in the study area.



**Photo (7):** Cutting trees for charcoal as source of income generation.



#### **4.6. Grazing Intensity**

Table (15) show the higher number of quadrates subjected to grazing were at level (II) with the percentage of 55.56% for Ummarahik, and percent of 44.44% and 38.89% at level (I) grazing for Berka and Fashar in the season (2012). In Berka there was 5.56% for no grazing, and 16.67% in Fashar, this may due to low nutritive value of plants.

Also Table (15) showed that there was 16.67% at level IV in Berka and Ummarahik and 11.11% in Fashar; this may be attributed to more desirable plants at the study area, these plants were selected by animals or removed by human activities, another reason most of the livestock owners preferred to stay near to the security areas which is found around Alfashir town, this situation would result in excessive grazing which can lead to negative impact on rangelands. Rahma (2015) stated that livestock grazing and displaced people activities can be considered as first factors affecting the study area.

The result in Table (16) showed that the percent of no grazing were 22.22% and 16.76% in Berka and Fashar respectively. Also the result showed there was no grazing at level (IV) in Berka and Ummarahik, this result may be due to decrease in number of animals or the system of animal grazing selection in diet. The structure of plant communities is often changed by grazing since 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. This agreed with Huntly (1991). The forces and influences discussed above make grazing a valuable vegetation management tool, while the misuse of domestic livestock grazing can increase populations of invasive plants. Proper grazing management can promote desirable vegetation and reduce invasive plant populations.

**Table (15):** Grazing levels at different sites of the study in season 2012.

	Number of quadrates									
	No grazing		Level I		Level II		Level III		Level IV	
<b>Berka</b>	1	5.56%	7	38.89%	2	11.11%	5	27.77%	3	16.67%
<b>Fashshar</b>	3	16.67%	8	44.44%	4	22.22%	1	5.56%	2	11.11%
<b>Ummarahik</b>	0	0%	5	27.77%	10	55.56%	0	0%	3	16.67%

Level I (<50% grazed), Level II (>50 %< 75% grazed), Level III (>75 %< 100 grazed), Level IV (100% grazed).

**Table (16):** Grazing levels at different sites of the study in season 2013

	Number of quadrates									
	No grazing		Level I		Level II		Level III		Level IV	
<b>Berka</b>	4	22.22%	7	38.89%	5	27.78%	2	11.11%	0	0%
<b>Fashshar</b>	3	16.67%	4	22.22%	8	44.44%	1	5.56%	2	11.11%
<b>Ummarahik</b>	0	0%	5	27.77%	10	55.56%	3	16.67%	0	0%

Level I (<50% grazed), Level II (>50 %< 75% grazed), Level III (>75 %< 100 grazed), Level IV (100% grazed)

Decreased animal production under heavy grazing is related directly to reduce of quality and reduced nutritive quality of forage. Pasture studies have shown that on dense stands of forage 1,120 kg/ha dry matter, cattle ate 14.5 kg of dry matter per day, with continued grazing and decrease in forage (560 kg/ha), consumption decreased to 9.5 kg/day, with further grazing (280 kg/ha), consumption reached only 4.9 kg/day (Johnstone- Wallace and Kennedy, 1944). Continued heavy grazing may so reduce forage production that grazing periods must be shortened. Experiments with sheep on salt-desert range, some studies showed that as grazing continued through the non-growing season, there was a progressive decline in nutritive value of forage consumed. In contrast to this, some studies founds that western wheatgrass was more digestible on heavily grazed than lightly grazed pastures. This was possible due to the increase in vigor and stem production by the more vigorous, lightly grazed plants. Trampling may result in losses of forage; Bryant *et al* (1972) found that maximum reduction in yield of over 60% in June, seasonal reductions varied from none to 65% depending upon the month, height of vegetation and the travel performed per cow. Distance animals travel varies with grazing intensity 2.4 km/day at light intensity and 3.3 km/day at higher intensities. Forage losses were from 2 to 19% depending upon grazing intensity and the season (Abusuwar, 2007).

# **CHAPTER FIVE**

## **CONCLUSIONS AND RECOMMENDATIONS**

### **5.1. Conclusion**

Based on the results obtained, it can be concluded that:

The rangelands at the study area are subjected to overuse and depletion of vegetation cover, especially around Alfashir town, due to increase in human population, animal numbers and change in environmental conditions. Unwise utilization and exploitation of the range lands particularly by man causes range deterioration and serious reduction in range production in both quantity and quality, which fail to accommodate the increased numbers of animals and encourage the storage of dry grasses (hay) by sheep owners for the peak period. This activity increased the deterioration of rangeland and decreased the productivity, which caused land degradation. Continuous removing of trees and overgrazing expose the rangeland to wind erosion, disappearance of the palatable species give chance to unpalatable species to establish themselves and occupy the area.

Plant composition was generally moderate. Average percentage was 52.33% and 68.04% in season 2012 and 2013 respectively. Grazing management can improve the species composition by decreasing the pressure on the species that are disappearing with heavy grazing.

Vegetation cover was generally low at all sites due to continued excessive defoliation. Results indicated that there was severe erosion. Grazing management is the first consideration in management plan to regulate the effects of grazing on vegetation cover and to minimize the severe erosion hazards.

Biomass productivity ranges between 50 to 60 kg/ha, grazing management can be beneficial through: Balance livestock requirements with the available

forage for biomass production. One of the most important techniques in rangeland management is proper time of grazing. Avoidance of early grazing when plants are most vulnerable at germination stage and before seeds setting stage is urgent because the different species in the different sites have different responsibility to grazing intensities.

## **5.2. Recommendations**

It could, therefore, be recommended that:

- The deteriorated rangelands should be rehabilitated and improved by introducing new species with good grazing benefits, resistance to intensive grazing pressure and drought tolerance.
- Distribution of improved seeds of the highly productive crops to local farmers in order to expand the farms vertically instead of horizontally; this positively reduces conversion of rangelands into farm lands and may decrease chances of desertification.
- National government should give special attention to the Forest National Corporation to put into practice its activities such as nursery establishment, seed distribution, forest reservation, protection, seedling production and distribution all over the deteriorated areas especially at the study area in order to recover the areas which were depleted and eroded by intensive misuse.
- Further research work should be carried out to assess rangelands across different ecological zones in North Darfur State.

## REFERENCES

- AOAC. (1990).** Official methods of analysis (13th ED). Association of Official Analytical Chemists (AOAC). Washington, D.C.
- Abusuwar, A. and A. Darrag (2002).** Pan Arab Integration in Forage Production and Processing. Case study- Sudan - AOAD- Khartoum.
- Abusuwar, A. O. (2007).** Range management. UNESCO Chair of Desertification, Khartoum University printing press- Sudan.
- Adam, A. I. (2013).** Study on Impact of Darfur Armed Conflict on Vegetation cover, Case study: Umkaddada Locality, North Darfur State – Sudan, PhD thesis, Sudan University of Science & Technology, College of Graduate Studies.
- Aldridge, J. M., and Fraser, B. J. (2000).** A cross-cultural study of class room learning environments in Australia and Taiwan. Learning Environments Research, 3, 101-134.
- Alfashir Meteorological Station, (2013).** Daily and Monthly Reports for Rainfall, Temperature and relative Humidity at Alfashir Airport.
- Altome, A. I. A. (2011).** The Influence of Plant Growth Conditions on Rangeland Management in Kordofan Region, MSc thesis, Sudan Academy of Sciences (SAS), 26 pp.
- Animal Statistic and Planning, Admin (2009).** Ministry of Animal Resources and Fishers, North Darfur State, Elfasher, Annual Report.
- Ayoub, A. T. (1998).** Extent severity and causative factors of land degradation in the Sudan. Journal of Arid Environments 38:397-409.

**Baker, M .B. (1988).** Hydrogenic and water quality effect of fire, PP. 31-41. In: Effect of fire on management of Southern Natural Resources. Proc, Symposium. Nov. 15-17 USDA. Rocky Mountain forest and range Exp.Sta.Gen.Tech.Rep.RM.191.

**Barbour, M. D. Burk, J. H. and putts, W. D. (1987).** Terrestrial plant Ecology, the Brnjamin/Cummings publishing company. Inc California.

**Bashir, M. (2001).** Biodiversity in Forestry Resources in Sudan. The national biodiversity strategy and action plan (NBSAP), project no. SUD/97/G 31.

**Bennett, L.T., and Adams, M.A. (1999).** Indices for characterizing spatial variability of soil nitrogen in semi-arid grasslands of northwestern Australia. *Soil Biology and Biochemistry* 31: 735–746

**Bonham, C. D. (1989).** Measurements for terrestrial vegetation. John Wiley and Sons, New York.

**Branson, F.A., Gifford, G.F., Renard, K.G., and Hadley, R.F., (1981).** In: E.H. Reid (Ed.), Rangeland Hydrology, 2nd Edition. Society of Range Management. Kendall/Hund Publ. Com., Iowa.

**Broun, D. (1954).** Methods of Measuring Vegetation. Commonwealth Agricultural Bureau, Franham Royal, Bucks, England.

**Bryant, H.T., R. E. Blaser and J. R. Peterson (1972).** Effect of trampling by cattle on blue grass yield and soil compaction of a meaville loam. *Agronmy J.* 64: 331 – 334.

**Bunderson, W.T., Cook, R.H. and Fadlala,B. (1984).** Range and livestock research activities. Western Sudan Agricultural Research Project (WSARP). Publication No. 29.



**Butler, G. W, and Bailey, R. W. (1973).** Range of protein in leaf cells. Chem and Bioch of herbage .Vol.1, 67.

**Butler, L. D., Cropper, J. R. H., Peacock, G. L., Shaver, P. L., Spaeth, K. E., Pierson. F. P., and Weltz, M. A. (2003).** National Range and Pastures Handbook. Johnson, R. H. and T Butler, L. D. (eds). National Cartography and Geo spatial Center's Technical Publishing Team , Fort Worth, Texas.

**Cayrol , P., Chehbouni, A. , Kergoat, L. , Dedieu, G. , Mordelet, P. and Nouvellon, Y. (2000).** Grassland modeling and monitoring with SPOT-4 VEGETATION instrument during the 1997–1999 SALSA experiment. *Agricultural and Forest Meteorology* 105 :91–115.

**Coleman, S.W. (1992).** Plant-animal interface. *J. Prod. Agr.* 5:7-13.

**Connolly, R.D., Ciesiolka, C.A.A., Silburn, D.M., and Carroll, C. (1997).** Distributed parameter hydrology model (Answers) applied to a range of catchment scales using rainfall simulator data. IV Evaluating pasture catchment hydrology. *Journal of Hydrology* 201: 311–328.

**Cooper, J. P. (1975).** Photosynthesis and productivity in different environments. Cambridge University Press, Cambridge.

**Darag, A. and Sulliman .M (1988).** Course training in Range Management and Range improvement. Range and pasture Administration (Sudan).pp47.

**Darag, H. E. (1983).** Desertification of arid lands *Advances in Desert and Arid land Technology and Development. Volume 3.* Hard Wood, Academic Publishers. New York - 242 pp.

**DJAM. (2006).** Status of Natural Resources and the Environment, Darfur Joint Assessment Mission (DJAM), (Unpublished paper)

**Darrag, A.A. (1996).** Senior staff training lectures. Community Based Rehabilitation Project. Gerigekh Rural Council. Bara province North.

**De Leeuw , P. N. and Tothill, J. C. (1990).** The concept of rangeland carrying capacity in sub-saharan Africa- myth or reality. Pasroral Deelopment Network (PDN) paper 29b, overseas Development Institute (ODI), London.

**Doran, J. W. and T. B. Parkin. (1994).** Defining and assessing soil quality. pp. 3-21. In:J.W. Doran, D.C. Coleman, D.F. Bezdicek, and B.A. Stewart (eds.) Defining Soil Quality for a Sustainable Environment. Soil Sci. Soc. Amer. Special Publ. No. 35, Soil Sci. Soc. Of America Inc., Madison, Wisc.

**Doumbia, D. (2006).** An integrated herder knowledge and ecological methods for assessing of rangeland in Nara, North- West Mali. M.Sc. Thesis. Norwegian University of Life Sciences.

**Dregne, H. E. (1985).** Desertification of Arid Lands. Advances in Desert Arid Land Technology and Development No. 13. Hardwood academic Puplisher, London, 2<sup>nd</sup> ed. 242.

**Elnour, I. A, (2007).** Competition on Range Resources and its Impact on social situation in Darfur. Case study (Eddaein locality), South Darfur State, Ph.D thesis, College of Forestry and Range Science. Sudan University of Science and Technology- Sudan.

**Etienne, T. P., Rex, D. and Pieper. (2002).** Introduction to Range management in free and open access Environment of Sub-Saharan Africa. SITEMX and Express-Service –Cameroon.

**Fadul, A. A. (2009).** Environmental and Resource Issues as factors in African conflict. [www.africa.upeace.org/documents/environment\\_files.pdf](http://www.africa.upeace.org/documents/environment_files.pdf)

**FAO, (1980).** Food and Agriculture Organization. An introduction to African pasture land production. In: Strange. L.R.N (Ed). Rome.

**FAO. (1987).** Committee on Agriculture (Ninth session). Improving Productivity of Dryland Areas. FAO, Rome.

**FAO. (1991) b.** Guidelines for the Design of Agricultural Investment Projects, FAO Investment Centre Technical Paper, No. 7. p168.

**Ffolliott, P. F., Brooks, K. N., Gregersen, H. M. and Lundgren, A. L. (1995).** Dry Land Foresrry Planning and Management. John.Wiley & sons, Inc. New York.

**Fuhlendorf, S. D. and Engle, D. M. (2001).** Restoring Heterogeneity on Rangelands: Ecosystem Management Based on Evolutionary Grazing Patterns. *BioScience* 51 (8): 625.

**Glantz, M. H. (ED.), (1998).** Desertification: Environmental Degradation in and around Arid Lands. Westview press, Inc., Boulder, Colo.

**Gobha, A. M., (1991).** Water courses utilization as measure to reduce desertification hazard: case study Khor Abu Habil (Umm Rawaba District, North Kordofan). MSc Thesis, University of Khartoum.

**Grainger, A. (1990).** The threatening desert: controlling desertification, Earth scan Publications, London.

**Grice, A. C., Campbell, S., Breaden, R., Bebawi, F. and Vogler, W. (2008).** Habitat management guide—Rangelands: Ecological principles for the strategic management of weeds in rangeland habitats. CRC for Australian Weed Management, Adelaide.

**Grime, J. P. (2001).** Plant Strategies, Vegetation Processes and Ecosystem Properties, 2nd edn. John Wiley & Sons, Chichester.

**Grubb, P. J. (1985).** Plant populations and vegetation in relation to habitat, disturbance and competition: problems and generalizations. The Population Structure of Vegetation (ed. J. White), pp. 595–621. Junk, Dordrecht.

**Gutiérrez, J.R. and Whitford, W.G. (1987).** Chihuahuan Desert annuals: importance of water and nitrogen. *Ecology* 68: 2032-2045.

**Hana, A. (2007).** Effects of Grazing Intensity around Some Water Points on Range Management in El Nuhud Locality, Sudan.

**Harlod, F., Heady, H. and Eleanor, B. (1982).** Range and Wildlife Management in the tropics. Longman House. Burnt mill, Harlow, Essex.Uk.

**Harrison, M. N. and Jackson, J. K. (1958).** Ecological classification of the vegetation of the Sudan. Forests Bulletin No.2 (New Series). Forests Department, Khartoum.

**Hart, R. H. and C. S. Hoveland. (1989).** Objectives of grazing trials. pp. 1–5 in: G.C. Marten (ed.) Grazing Research: Design, Methodology, and Analysis. CSSA Special Publication No. 16, Madison, Wisc.

**Heady, H. F. and Child, D. (1994).** Rangeland Ecology and Management. West view Press, San Francisco, CA.

**Heady, H. G. (1964).** Palatability of herbage and animal preference .J. Range manages. 17:76.

**herbal, C. H. (1983).** Principles of Intensive Range Improvements. J. Of Range. Mgt. 36 (2): pp. 140 – 43.

**Herlocker, D. (Ed.) (1999)** Rangeland Resources in Eastern Africa: Their Ecology and Development. GTZ, Nairobi (1999).

**Holecheck, J. L., Piper R. D., Carleton and Harbal, C. H. (1989).** Range Management Principles and Practices, Prentice. Hall,inc,New Jersey U.S.A. 501pp.

**Holechek, J. (2001).** A Growing Population, Rangelands and the Future. *Rangelands*, 23(6): 39-43.

**Holechek, J. L., R. D. Pieper and C. H. Herbal. (2004).** Range management principles and practices. (5<sup>th</sup> ed). Pearson Education. Inc. upper Saddle River, New Jersey.

**Howarth, R. E. and B. P. Golpen. (1983).** Improvement of forage quality through production management and plant breeding. Can. J. Plant Sci., 63, 895–902.

**Hubert, B. (1991).** Changing Land Use in Province (France). Multiple uses as a management tool option Mediterranean's No. 15 pp.31-52.

**Humphery, L. R. (1991).** Tropical pasture utilization. Cambridge University, Press.p73.

**HTC. (1976).** Limited land water resources consultant. Borcham wood England. Savanna development phase (2) Hunting Technical Services (HTS).

**Huntly N. (1991).** Herbivores and the dynamics of communities and ecosystems. *Annual Review of Ecology and Systematics* 22:477-503.

**Ibrahim, F. N. (1984).** Ecological Imbalance in the Republic of the Sudan – with Reference to Desertification in Darfur. Vol. 6 . Bayreuth.

**Jensen, K. and Gutekunst, K. (2003).** Effects of litter on establishment of grassland plant species: the role of seed size and successional status. *Basic and Applied Ecology*, 4: 579–587.

**Johnstone- wallance, D. B. and K- Kennedy (1944).** Grazing management practices and their relationship to the behavior and grazing habits of cattle. *J Agric. Sci* 34: 190 – 197.

**Jung, H. G., R. W. Rice, and L. J. Koong. (1985).** Comparison of heifer weight gains and forage quality for continuous and short duration grazing systems. *J. Range Manage.* 38: 144–148.

**Kelly, R.D. and Walker B.H. (1976).** The effects of different forms of land use on the ecology of a semi-arid region in South-Eastern Zimbabwe. *Journal of Ecology* 64: 553- 576.

**Kent, M., and P. Coker. (1992).** *Vegetation Description and Analysis. A practical approach.* Belhaven Press. London. 363p.

**Khatir, A. A. (2006).** Guidelines in vegetation measurements and assessment of rangelands, unpublished.

**Kutiel, P. and Noy-Meir, Y. (1986).** The effects of soil depth on annual grasses in the Judean Hills. I. The effect of soil depth on individual plant species. *Israel Journal of Botany*, 35, 233–239.

**Langlands, J. P. and I. L. Bennett. (1973).** Stocking intensity and pastoral production I. Changes in the soil and vegetation of a sown pasture grazed by sheep at different stocking rates. *J. Agr. Sci., Camb.* 81:193–204.

**Lazim, A. M. M., (2009).** Response of natural range vegetation to four management practices at Tallow area (South Kordofan State), PhD thesis, Sudan Academy of Sciences, Sudan.

**Lee, P. and Hanus, S. (1999).** Monitoring of Terrestrial Vascular Plants and Structure in the Forested Regions of Alberta: Background, Indicators, and Protocols. Chapter 13. Alberta Research Council. 83 pp. [phil@arc.ab.ca](mailto:phil@arc.ab.ca)  
[hanus@arc.ab.ca](mailto:hanus@arc.ab.ca).

**Lehouerou, H. N. (1980).** The role of browse in Sahelian Sardinian Zones. pp 83 – 100. In: Lehouerous, H. N. (ed). Browse in Africa. The current state of knowledge,. ILCA. Addis Ababa.

**Loeser, M. R. R., Sisk, T. D. and Crews, T. E. (2007).** Impact of Grazing Intensity during Drought in an Arizona Grassland. *Conservation Biology*. 121(1): 87 -97.

**Macharia<sup>1</sup>, P.N. and Ekaya, W.N. (2005).** The Impact of Rangeland Condition and Trend to the Grazing Resources of a Semi-arid Environment in Kenya. *J. Hum. Ecol.*, 17(2): 143-147.

**Magdoff, F. (1995).** Soil quality and management. pp. 349–364. In: M.A. Altieri (ed.) *Agroecology: The Science of Sustainable Agriculture*, 2nd Edition. West view Press, Boulder, Colo.

**Meirion, Thomas, Ranson, S. L., and Richardson, J. A. (1973).** The rate of increase in dry matter. *Plant physiology* 5<sup>th</sup> edit., 733.

**Miller, D. (1997).** Rangelands and range management. Newsletter, ICIMOD, no 27.

**Ministry of agriculture and forestry. (1983).** Department of Agricultural Statistics, 1982-1983, Annual Report, Khartoum, Sudan

**Ministry of Animal Wealth and Fisheriess, (1997).** Department of Economics and Planning, Animal population Report, Khartoum, Sudan.

**Morgan, R. P. C. (1986).** Soil erosion and conservation. D.A. Davidson (ed.). Longman Scientific & Technical, Wiley, New York.

**Müller, B. (2005).** Sustainable grazing management in semi-arid rangelands: An ecological-economic modelling approach. Dissertation zur Erlangung des Doktorgrades der Naturwissenschaften (Dr. rer. nat.) am Fachbereich Mathematik/Informatik der Universität Osnabrück Osnabrück.

**Mustafa, H., Elgoni, O. and Mohammed, A. (2000).** Manual for range improvement and management, DHP publication. Feb2000.

**Mustafa, M. A. (2007).** Desertification Processes, 1<sup>ed</sup>, UNESCO Chair of Desertification, University of Khartoum, Sudan. 230P.

**Naeth, M. A., A. W. Bailey, D. J. Pluth, D.S. (1991).** Communities in an experiment. *Journal of Ecology* 85: 71–82.

**Nasra, (2008).** Spatial Heterogeneity and Range Management in Semi-arid Areas. PhD thesis, Sudan Academy of Sciences (SAS).

**Noy-Meir, I. (1973)** Desert ecosystems: environment and producers. *Annual Review of Ecology and Systematics*, 4: 25–52.



**O'Connor, T. G. (1991).** Influence of rainfall and grazing on the compositional change of the herbaceous layer of a sandveld savanna. *J. Grassl. Soc. South Africa* 8:103–109.

**Oztas, T., Kocb, A., and Comakli, B. (2003).** Changes in vegetation and soil properties along a slope on overgrazed and eroded rangelands *Journal of Arid Environments* 55 : 93–100

**Parker, K. W. and Harris, R. W. (1959).** The 3-step method for measuring condition and trend of forest ranges: a resume of its history, development and use. In: Techniques and methods of measuring understory vegetation. Proc. of a symposium at Tifton, Georgia.

**Patt, D. J. and M. D. Gwynne (1977).** Range land management and ecology in east Africa. Robert. E. Krieger publishing Company. Huntigon. New York.

**Peter, S. H. (2000).** Grassland Resources Assessment for Pastoral System. (FAO Plant production and Protection Paper), ISBN92-5-104537-2.

**Qi, J. (2002).** Improved Rangeland Information Products from Satellites. Center for Global Change and Earth Observations (CGCEO). Michigan State University, East Lansing, Michigan.

**Rafiq, S. M. (1995).** Appropriate Range Improvement Activities Prerequisite for Sustainability of Range Watershed Resources. Regional Workshop on Sustainable Agriculture Research Council, Islamabad.

**Rahma, A. A. E. (2015).** The Impact of Displacement on Vegetation Cover Around IDP Camps in Alfashir Locality- North Darfur State- Sudan. M.Sc Thesis, Alfashir University, College of Graduate Studies, Sudan.

**Range Term glossary committee. (1974).** A glossary of term used in range management .Soc.Range manages. Denver, Colorado.

**Reynolds, J. F., and Smith, D. M. S. (2007).** "Global Desertification: Building a Science for Dryland Development." *Science* 316(5826): 847-851

**Roy. A. Chessmore. (1979).** Profitable pasture management. The interstate printers and publishers, U.S.A.pp 230.

**RPA, (1994).** Range and Pasture Administration. Report in surveying the Rangeland of west Kordofan.

**Saltaz, D., H. Schmidt, M. Brown, A. Karneili, D. Ward, and I. Schmidt (1999).** Assessing grazing impacts by remote sensing in hyper-arid environments. *J. Range management* 52: 500-507 September 1999

**Sample, A. T. (1951).** Improving the World Grasslands. FAO, Agric, Studies, No 16, Rome.

**Sandford, S. (1983).** Management of Pastoral Development in the Third World. Jhon Wiley & Sons, Inc. New York.

**Scholl, E. L., and Kinucan, R., (1996).** Grazing effects on reproductive characteristics of common curly mesquite (*Hilaria belangeri*). *Southwest Naturalist* 41 (3): 251–256.

**SFNSW (2003).** State Forest of New South Wales, Autralia. 2003. Forest facts: Types and Vegetation patterns in New South Wales.

**Shaban, H. A. (1990).** Sustainable improvements of Range Condition in Elodaya. Master of Science Degree. Agricultural, University of Norway.

**Sharpe, C. (1991).** Impact of grazing in Savanna ecosystem, *AMBIO* 20(8): 351-356.

**Sharrow, S. H. (1983).** Forage standing crop and animal diets under rotational vs. continuous grazing. *J. Range Manage.* 36:447–449.

**Sidahmed, A. E. (1996).** The rangelands of the arid/semi-arid areas: Challenges and hopes for the 2000s. Key-note address to Symposium D: Range Management. The International Conference on Desert Development in the Arab Gulf Countries. KISR, Kuwait 23-26 March 1996.

**Silcock, G. R. (1986).** Strategies for Plant Introduction and Reseeding of Semi-arid Pastoral Lands. In Joss: J. P., Lynch, W. P. and Williams, B. O., (Eds). *Rangelands: A resource under siege* pp. 475 – 477.

**Simaton, J. R. and K. G. Renard. (1981).** Seasonal change in infiltration and erosion from USLE plots, South Arizona .Hydrology and water resources in Arizona and Southwest. Office of Arid land studies. Univ. Arizona.Tuesen.Ariz. 12.37-46.

**Skerman, F. I., (1962).** Ecological Observation Studies in Kordofan Special Fund Project. FAO (1962-65). ; In the Sudan, Work Shop Report DPH-sudan1996. DHP publication Series No. 1, November 1996

**Slingsby, D. and Cook, C. I. (1986).** *Partial Ecology* Macmillan Education LTD London 1-213.

**Society of Range Management-SRM, (1974).** *A Glossary of Terms used in Range Management.* Published by the Society of Range Management. Denver, Colorado, USA.

**Soneji, S. V., Musangi, R. S. and Olsen, F. J. (1971).** Digestibility and feed intake investigations at different stage of growth of *Bracharia ruziziensis*, *Chloris gayana* and voluntary intake .*East Africa Agricultural and forestry Journal*, 37, 125.

**Stoddart, L. A., Smith, A. D. and Box, T. W. (1975).** Range Management 3<sup>rd</sup> edition, Mc. Graw-Hill Book Company, New York, USA.

**Sudan National Action Programme (SNAP) (2006):** Sudan National Action Programme. A frame work for combating Desertification in Sudan in the context of the United Nation Convention to Combat Desertification. Ministry of agriculture and Forestry, National Drought and Desertification Control Unit (NDDCU). Khartoum, Sudan.

**Sudan's Soil Conservation Committee (1944).** Soil Conservation Committee Report, Sudan Government.

**Suliman. M. M. (1985).** Base line survey for Kordofan and Darfur

**Sullivan, S. and Rohde, R. (2002).**On non-equilibrium in arid and semi-arid grazing systems. *Journal of Biogeography*, 29, 1595–1618

**Tahir, A. M. (2003).** Rangeland Improvement and Water Conservation in the semi-arid zone of the Sudan: Nyala Area (South Darfur), Ph.D, thesis, Faculty of Agriculture, University of Khartoum – Sudan.

**Thomas, L. Thurow, T. I. Abdullahi, J. (1988).** Observation of vegetation response to improve grazing system in Somalia. *J. of rang mgt.*, 42(1) January 1989

**Tilman, D. (1988).** Plant Strategies and the Dynamics and Structure of Plant Communities. Princeton University Press, Princeton, New Jersey.

**Tilman, D. and Downing, J.A. (1994).** Biodiversity and stability in grasslands. *Nature* 367:363-367.

**Todd S. W. and Hoffman, M. T. (1999).** A fence-line contrast reveals effects of heavy grazing on plant diversity and community composition in Namaqualand, South Africa, *Plant Ecology* 142 (1999):169–178.

**UNCCD (2004).** Ten years on: UN marks World Day to Combat Desertification. <http://www.unccd.int>.

**United Nation (UN), (1977).** Desertification: It's Causes and Consequences, Pergamon press Ltd., Oxford.

**Vallentine, J. F. (1980).** Range Development an Improvements. Brigham Young University Press, Provo, Utah 84602. P516.

**Vallentine, J. F. (1990).** Grazing Management. Academic press U.S. pp.297. Science Guideline to information source, Gale Res.Co. Detroit. Michigan.

**Walker, B. H. (1980).** A review of the browse and its role on livestock production in Southern Africa. PP. 6 – 29. In: Lehouerou, H. N. (ed) Browse in Africa. The current state of knowledge. ILCA. Adis ababa – Ethiopia.

**Walton, P. D., R. Martinez, and A. W. Bailey. (1981).** A comparison of continuous and rotational grazing. *J. Range Manage.* 34:19–21.

**Warren, S. D., S. D. Nevill, W. H. Balckburn, and N. E. Garza. (1986).** Soil response to trampling under intensive rotational grazing. *J. Range Manage.* 50:1336–1340.

**White, C. S and Loftin, S. R. (2000).** Response of semi arid grasslands to cool season prescribed fire. *J. Range mange* .53 (1) p.52.

**Whitford, W. G. (1987).** Decomposition and nutrient cycling in disturbed arid ecosystems. Pages 136-161, IN: Allen, E.B. (ed). The reconstruction of disturbed arid lands. American Association for the Advancement of Science, Westview Press, Boulder, CO.

**Whittaker, R. H. (1975).** Communities and ecosystems, 2nd edition. Macmillan, New York.

**Wickens, G. E. (1991).** Natural vegetation. In: Craig G.M. (ed), The Agriculture of the Sudan. Oxford University Press, London. pp. 54–67.

**Wiggin, J. (1991).** Pastoralism in Crises Appropriate Technology (1): 1-4.

**Wilson, J. R. (1983).** In nutrition limits to animal production from pasture Farnham Royal, UK: commonwealth Agriculture Bureau.

**Williams, R. E., B. W. Allred, R. M. De Nio, and H. E. Paulsen (1968).** Conservation, Development and use of the rangelands. J. Range Management. 21:355-360

**Wilm, H. G., Costello, D. F. and Kipple, G .E. (1944).** Estimating forage by double-sampling method. J. Amer. Soc. Agron.36: 194 – 203.

**Winrok International, (1992).** Assessment of Animal agriculture in Sub-Saharan Africa, Morrilton.Arkansass- Winrock international pp-125.

**Winstanley, D. (1983).** Desertification climatologically perspective. P. 185-213. in: S. G. wells and D. R. Nargan(Eds.). Origin and evaluation of desert. University of Mexico press. Albuquerque. N. Mex.

**Yn, Y. and J. W. Thomas (1976).** Factors affecting forage quality.J.Animal Sci42;766.

**Young, T. P. and Augustine, D. J. (2007).** Interspecific Variation in the Reproductive Response of Acacia Species to Protection from Large Mammalian Herbivores. *Biotropica* 39(4):559–561.

**Yousif, Z. A. (2005).** Monitoring and Assessment of the impact of land degradation on grazing Resources using remotely sensed data, Um Kaddada province, North Darfur State, Sudan. PhD thesis, College of Natural Resources and Environmental Studies, University of Juba, Sudan

**Zaroug, M. G. (2000).** Country Pasture / Forage resource profiles, Sudan. FAO Crop and Grassland Service (CGPC).

**Zhaoa, H.L., Zhaoa. X. Y., Zhoua, R.L., Zhanga, T.-H. and Drakeb, S. (2005).** Desertification processes due to heavy grazing in sandy rangeland, Inner Mongolia. *Journal of Arid Environments* 62: 309–319.

# APPENDIX

## Plant Composition Form

Name of the researcher ..... Location.....

Transect no ..... Date..... Soil type .....

	1	2	3	4	5	6	7	8	9	10
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

Total plant species .....%

Liter (L) ..... %

Bare Soil (BS) ..... %

Rocks/Feces (R/F) ..... %