

**Eco- taxonomic Study on the vegetation of Um Rimmitta Area,
White Nile State
(Central Sudan)**

By

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Dedication

To my family for their encouragement and patience.....

To my wife Maria.....

To my daughter Ruwa

and to my sons Khalid & Ahmed

I dedicate this work.

ACKNOWLEDGEMENT

I am particularly indebted to my main supervisor Dr. Abd El Gabar Nasir Guma'a, Faculty of Education, University of Khartoum and my co-supervisor Prof. Mohamed Mohamed Ahmed El Nour Faculty of Forestry, University of Khartoum, for their close supervision, patience and valuable comments through out this work.

My appreciation extends to Sudan University of Science and Technology (SUST) for the release and financing of this study. My thanks are also due to the staff of Medicinal and Aromatic Plants Research Institute (MAPRI) specially the staff of the Herbarium Mr. Wail, Haider and Yahia. I am also thankful to the general director of the FNC and the FNC director and his staff, the White Nile State, staff of Forestry Research Centre at Soba and the staff of the College of Forestry and Range Science, Sudan University of Science and Technology. Special thanks are to my colleague Dr. Mohamed Ahmed, University of Western Kordofan and my brothers Dr. Elhaj and Musa for their help and assistance.

Abstract

The study deals with the ecology and taxonomy of the vegetation of Um Rimmitta area, White Nile State.

Taxonomic studies included collection, preparation, identification and classification of plant species in the study area. In the present study (85) species were identified belonging to 30 families. Botanic names and synonyms have been updated. Brief descriptions of the collected specimens have been included. Medicinal and other uses have been given. Almost 49.4% of the species were found to have medicinal uses. Moreover, a check-list of endangered, extinct and famine food plants has been provided.

Seven ecological parameters have been studied. These were density, abundance, frequency, diversity, association between species, dominance of woody species and site similarity. The total density of woody species in the study area was found to be 19.3 stems/ha. It was also found that the density of trees and shrubs differed from one site to another according to topography. The density of *Acacia tortilis subsp. spirocarpa* was associated with high frequency and abundance. A positive association was observed between *Acacia tortilis subsp. spirocarpa* and *A. tortilis subsp. raddiana*.

The soil seed bank was analyzed for the number of live and dead seeds at each of the three depths within the study area. The analysis revealed the following: The seed bank density was higher in the upper soil depths as compared to the lower levels. It was found that the seed density decreases with increasing depth. The live seed density ranged from 1015 – 5371 seeds/m², whereas the density of the dead seeds ranged from 3215- 6957 seeds/m².

The dominant plant species to which the live seeds belong were *Schoenefeldia gracilis*, *Brachiaria spp.*, *Dactyloctenium aegyptium* and *Aristida spp.*, whereas the dominant species to which the dead seeds belong were *Panicum turgidum*, *Euphorbia aegyptiaca* and *Cyperus rotundus*.

The results of biomass and carrying capacity showed that there was a decline in the carrying capacity from 26 a.u. /km²/year to 3 a.u. /km²/yearly. The total biomass of the study area was found to be 33540.5 kg/km².

Natural regeneration of woody species at the study area was found to be 421 seedlings/ha. The dominant regenerating species was *Acacia tortilis subsp. spirocarpa*.

The average canopy cover/m² was determined for each of the three sites in the study area and it was found to be 1062 m² /ha. Accordingly, the study area was classified by FAO (2000) as other wooded land.

The present study revealed that the soil moisture content was relatively low at the study area. The chemical analysis of the soil revealed that there were no significant differences between the three sites in the study area, with respect to soil elements. However, there were significant differences between the three sites in their pH values.

30

(85)

49.4%

()

/ 19.3

Acacia tortilis subsp. *spirocrpa*

Acacia tortilis

Acacia tortilis subsp. *spirocrpa*

.subsp.*raddiana*

² / 5371 – 1015

² / 6957 – 3215

Schoenefeldia

Aristida spp.

Dactyloctenium aegyptium

gracilis

(*Panicum turgidum*)

.*Cyperus* spp.

Euphorbia spp.

26

3

/

.33540.5

/

/

/ 421

. *Acacia tortilis* subsp. *spirocrpa*

/² 1062

)

.(2000

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CHAPTER ONE INTRODUCTION

Sudan is the largest country in Africa and the ninth largest in the World with an area of about 2.5 million square kilometers. It exhibits a wide range of variation in its topography, climate, soil, and hydrology. These characteristic variables are reflected in Sudan's diversified ecological habitats, vegetation zones and consequently rich flora.

Studies on the flora of Sudan are few and represented in the work of Broun and Massey (1929), Andrews (1950, 52, 56), which may be regarded as the standard reference floras of the area. Recently, El Amin (1990) made valuable attempts to update the trees and shrubs of the Sudan.

The vegetation composition of a particular area is the result of interaction of species with varying ecological tolerances and requirements. The change in the physical and / or biotic environment leads to the disturbances of interaction which cause changes in vegetation over-time. Other factors which also cause vegetation change include: Intensity of grazing and climatic variations.

Higher Council for Environment and Natural Resources (HCENR) reported that there was no concrete evidence to prove that climatic conditions have changed in the Sudan during the past Century.

Sudan is one of the Sudano- Sahelian countries seriously affected by drought spells and desertification since the late sixties up to the present time. The area affected by drought and desertification in the

Sudan lies between latitudes 12⁰ to 18⁰ north and traverses the country from Nile in the east to the Chadian border in the west (DECARP, 1976).

Studies on the ecology and flora of the Sudan were few and they include the work of Broun and Massey (1929), Smith (1949), Andrews (1950, 52, 56), Harrison and Jackson (1958), Ramsy (1958), Sahni (1968) and Noordijk (1984). Recently El Amin (1990) studied the trees and shrubs of the Sudan and this study is regarded as a standard reference for ecology and flora of Sudan.

The study area (Um Rimmitta) has been selected for the present study for a number of reasons: Firstly, there is a large collection of specimens from the study area in various herbaria that needs to be updated and incorporated in the main flora of Sudan. Secondly, there is no ecological study carried out in the study area.

The present study was designed to fulfill the following objectives:
1- To document the flora of the study area, and consequently to contribute to the updating of the Sudan flora. 2- To provide a literature survey on the medicinal folkloric uses of plants of the study area, in attempt to highlight their economic importance. 3- To investigate the ecology of the study area.

The present study consists of six chapters: after the introduction, chapter two includes a brief description of the study area (location, climatic factors (e.g. rainfall, temperature, relative humidity, evapotranspiration, winds, cloud and sunshine), topography, geology, geomorphology, soils, inhabitants, present land use and human activities, communication and water resources. Chapter three provides a literature review on the vegetation cover, biomass productivity, species composition, soil seed bank, tree cover assessment, crown measurement, natural regeneration and soil analysis. Chapter four describes the materials and methods employed in the present study. Chapter five

presents the results which include the vegetation of the study area, taxonomical results and brief descriptions of species with special reference to their medicinal uses, the synonyms, vernacular names, habits and habitats. Other ecological factors included biomass and carrying capacity, seed bank, canopy area, natural regeneration, endangered and threatened species and famine food plants. Chapter six deals with discussion of results, conclusions and recommendations.

It is hoped that more studies will be conducted in the study area in order to cover topics that have not been dealt with in the present study.

CHAPTER TWO

The Study Area

The study area lies between latitudes $14^{\circ} 36'$ and $14^{\circ} 49'$ N and longitude $32^{\circ} 05'$ and $32^{\circ} 11'$ E. It is bordered from the east by the White Nile and from the west by North kordofan state, and from the north by Guetaina province about seventy kilometers north of Ed Dueim town Fig.(1).

Climate:-

The climate is a typical tropical continental characterized by warm dry winters and hot rainy summers.

Temperature:-

The study area is generally characterized by high temperatures for most of the year, with means of 37°C and 21°C for maximum and minimum summer temperatures respectively. Fig. (2).

Rainfall:-

The rainy season extends from June to October and most of the rains fall during July- August. The average annual rainfall for Ed Duiem had declined from 330 mm (1920-1950) to 248 mm (1960-1995) (Duiem meteorological station, 2005) .The great variations in rainfall are characteristic of arid climates (Halwagy, 1961). Fig. (3)

Relative humidity: -

The mean relative humidity percentage is the lowest in April (10%) and the highest in August (67%). Fig. (4).

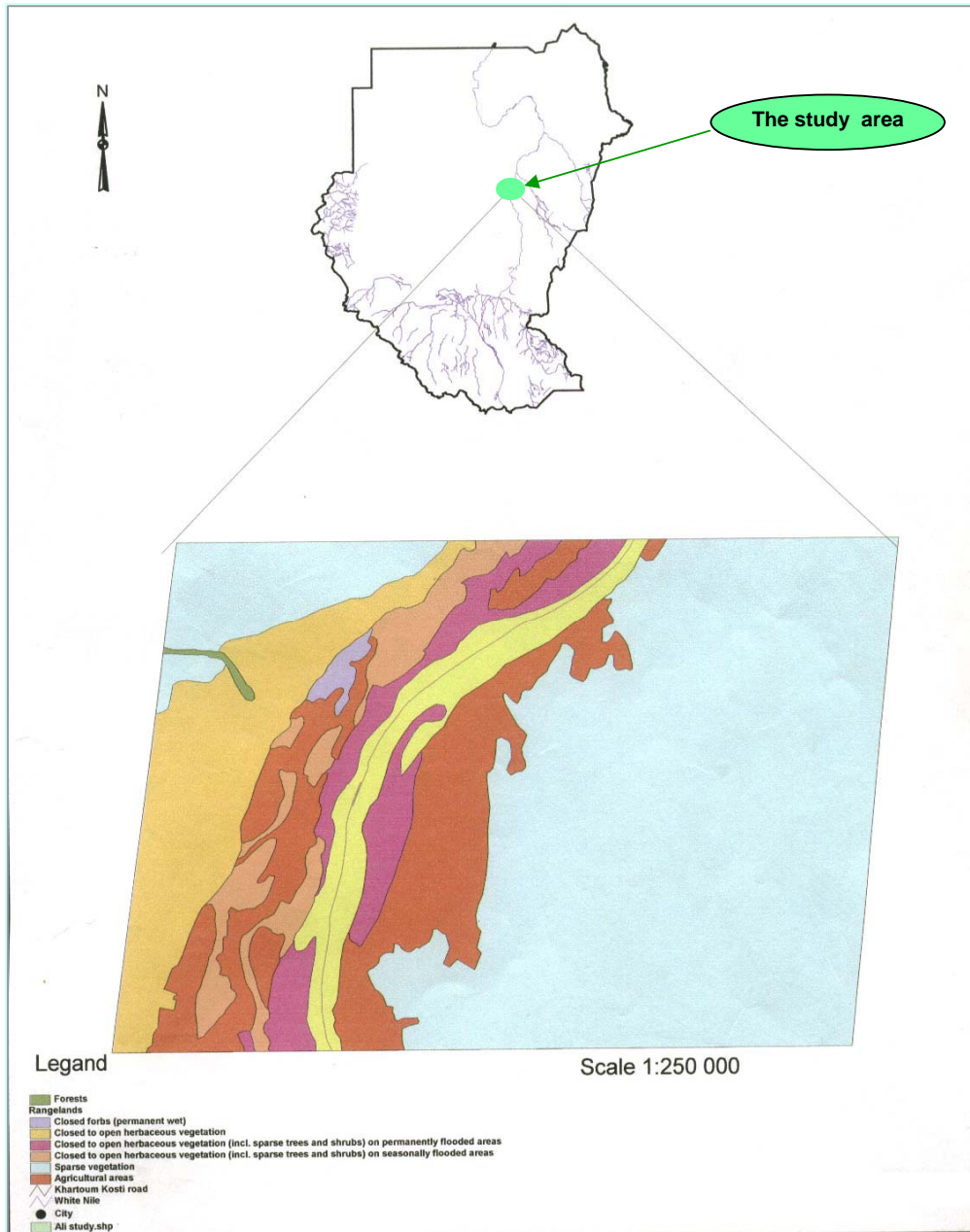


Fig. (1). Location of the study area.

Source : FNC. 2005

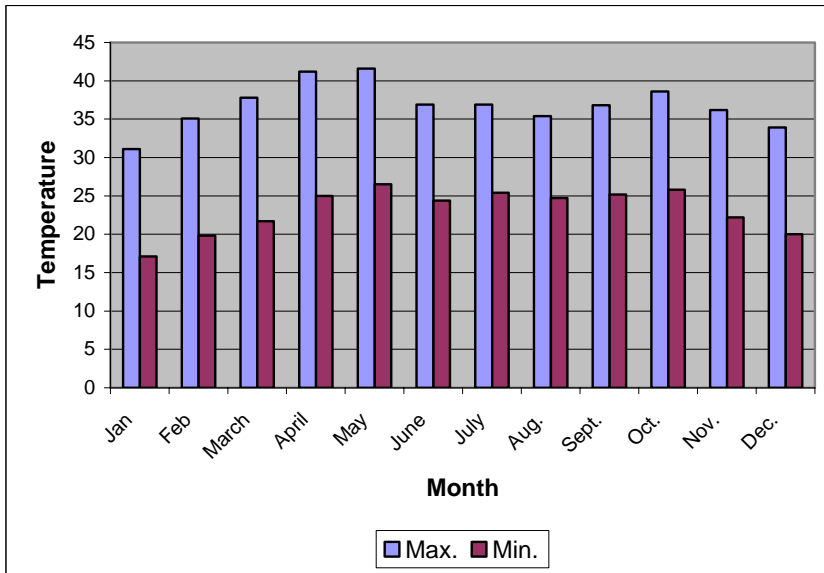


Fig. (2): Mean annual temperature, maximum and minimum C° (1970 – 2005)

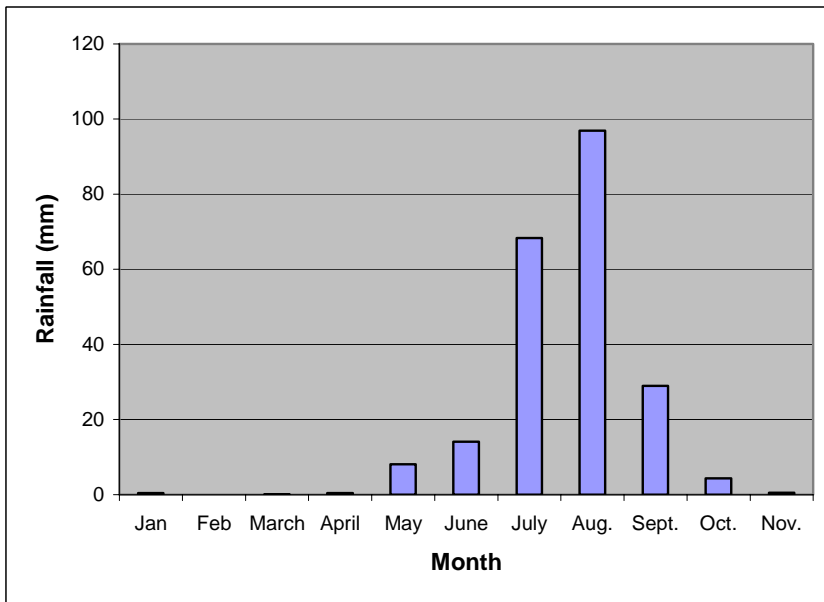


Fig. (3): Mean annual rainfall (mm) (1970 – 2005).

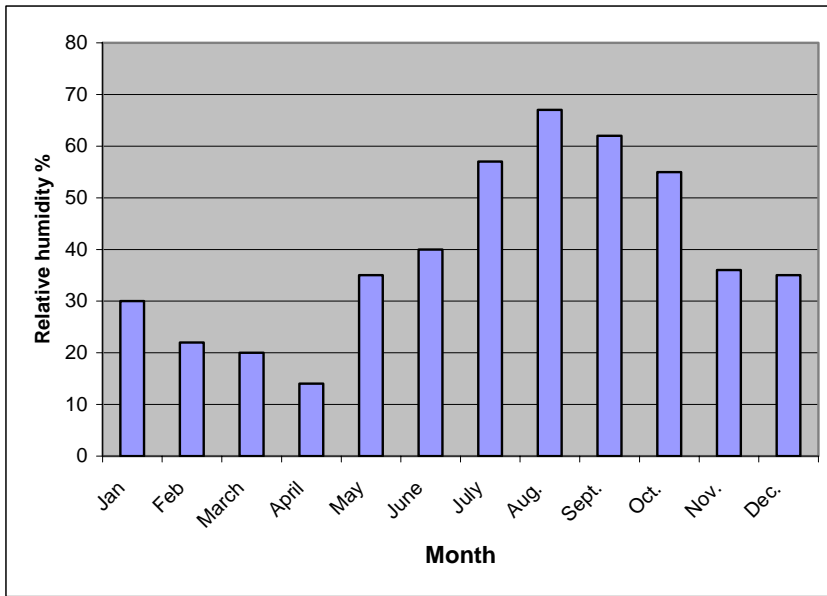


Fig. (4): Relative-humidity % (1970 – 2005)

Evaporation:

The mean daily evaporation is the highest in April (20.00mm) and the lowest in August (10.8mm). This is to be expected since high temperatures coincide with lower R.H. in April, while in August, cooler and more humid conditions reduce evaporation.

Winds :-

The winds at the study area prevail from different directions at different times of the year. The north-east or northerly trade winds prevail during the winter, whereas the south and south-east winds prevail during the autumn. The dust storms (haboobs) are common in the summer season.

Cloud and sunshine:

Clouds prevail almost 6 months in the year, whereas the mean sunshine is 3650 hours/year.

Topography:-

The study area is an open flat country. It is traversed by wadis (Wadi Afuo, Wadi Umm Sider and Umm Aoud) and Khors or seasonal water courses which run along the west – east direction towards the White Nile. There are also small scattered hills i.e. (Elbairth and Masalt).

Geology:-

The geology of central Sudan is simple; the whole area is underlain by the "African Basement Complex" (gneiss-group) of Precambrian origin. Inselbergs are of volcanic or metamorphic origin and they may be gneissic, granitic or serpentinitic. "Qoz" sand dunes are widely found in the west of the study area (quaternary) (Braun *et al*, 1991). The area is generally underlain by basement complex rocks (Whiteman, 1971). The country rock is formed of meta sediment of gneisses and schist. Sand

dunes of quaternary age extend as North- South oriented longitudinal dunes covering the western parts of the study area and characterized by interdunal hollows. A narrow strip of clay extends North- South of the study area on the east, parallel to White Nile and is used for agricultural activities.

Geomorphology:

The semi-desert part of the country to the west of the White Nile is covered by blanket of sand in which occasional localized clay-rich or gravel - rich patches may be encountered. These semi –desert soils were formed mostly in situ by weathering of the underlying Nubian formations (Andrews, 1948; Whiteman, 1971).The khors which traverse the semi-desert country are shallow lines of surface drainage in which rain water accumulates through run-off from the adjacent country during the heavy down pours that occur during the rainy season.. Water remains for a short time and then soaks through the loose alluvial unconsolidated material of the khor bed. This consists mainly of pale yellowish –white coarse sand and pebbles. The proportion of finer material in the khor bed generally increases from west to east, because, as the khor stream becomes progressively slower and therefore less capable of carrying its load of suspended material, it deposits first the coarser and then the finer particles. On the khor terraces, which are subjected to occasional inundation, especially during heavy thunderstorms, silting may take place. Thus the soil may become richer in clay than the adjacent country which is not reached by standing water. Sometimes a thin greyish surface crust could be seen overlying the loose sand underneath.

The underlying solid rock formations on the other hand consist of the Nubian Series of sandstones and mudstones, which rest on a platform of the basement complex system. The basement complex forms a peneplained platform on which the

Nubian Series rests (Andrews, 1948). Several out-crops of the rocks of the basement complex system occur in the form of small hills.

Qoz deposits of Kordofan and central Sudan:-

Probably the most extensive of the Pleistocene and recent deposits in the area west of the Nile are the qoz or kordofan sands. Originally the word (Qoz) was applied to the dune-like accumulations of sands in kordofan (Edmonds, 1942) but later this term has been used to include the sand sheets as well.

The Qoz is widespread in central Sudan, especially in kordofan, Darfur and northern provinces, where it forms extensive gently-rolling sheets, and fixed dunes. These are now stabilized by a special flora, a thin surface crust of iron oxide and fine silt and clay.

Towards the White Nile, the clay fraction increases, due to lower rate of flow of the distributory systems that deposit the clay.

Soils:

Braun *et al* (1991) classified the soils of the study area as follows:

- 1- White Nile clays: These contain 60-70% clay and are rather uniform in texture and profile features.
- 2- Nubian Sandstone soils: These consist of a reddish sandy layer overlying ferruginous gravel and calcareous material. Many of these soils are eroded by surface wash. These soils have been derived from weathering of the Nubian sandstones.
- 3- Qoz sands: - (Aridisols) these are extensive areas of stabilized sands found to the west of the White Nile.
- 4- Miscellaneous soils: (Entisols) these are conspicuous but rather minor areas of alluvial and colluvial soils of very mixed materials occurring adjacent to wadis and khors.

Present land use and Human activity:-

Part of the area is grown with sorghum and vegetables during the flood season and by cucumbers after recession of the flood. During the rainy season the main activity is cultivation of Sorghum and Millet. Grazing is practiced after recession of the flood, and during the rainy season. People work as farmers, herdsmen, merchants and labourers.

Communications and water sources:-

The area is connected by roads from Dueim to Jabel Aulia and Khartoum. It is also connected by roads to Kosti and then across the White Nile towards the Gezira. The White Nile is the main water source in the area.

People:

The main tribes living in the area are Hassania, Kawahalla, Hussunat, Kababish, Magalab, Sawarda, and Galieen. The population of the area is about 48600 (2004 census).

CHAPTER THREE

LITERATURE REVIEW

3.1 Natural Vegetation of the Study Area:

The first major attempt to produce a description and map of the vegetation of the Sudan was in 1948 by F.W.Andrews, and the same classification with slight modifications was followed by Smith (1949). A decade later, Harrison and Jackson (1958) produced somewhat similar classification of the vegetation. Wickens(1991) found that informal classification of Harrison and Jackson (1958) required reorganizing into a hierarchial system in order to meet the requirements of more mapping at a scale of 1:250000 (Hunting Technical Services ,1964). This modification was developed further for use in a number of FAO and UK Over-seas Development Administration (ODA) projects in the Sudan, including the United Nations Development Program (UNDP). These studies resulted in a revision of the vegetation map of the Sudan in 1977, which was revised again by Parry and Wickens (1981).

The vegetation of the study area was described as part of the regional vegetation zones of the Sudan by various authors (Andrews, 1948; Smith, 1949; Harrison & Jackson, 1958; Noordwijk, 1984; Bebawi *et al*, 1991 and Wickens, 1991).

Andrews (1948) classified the area as *Acacia* Desert Scrub Region, the chief floristic character being the dominance of *Acacia spp*. The vegetation, however, is in general scattered and, with no trees and it is mainly a scanty shrubby flora. Of these shrubs, *Acacia nubica* occupies the lighter soils of the southern boundary whereas *Acacia mellifera* dominates on heavier soils.

Other common trees and shrubs are *Ziziphus spina-christi*, *Boscia senegalensis*, *Balanites aegyptiaca*, *Cadaba farinosa*, *Salvadora persica*, *Calotropis procera* and *Ficus sycomorus*. In localities with clayey soils subject to inundation, the dominant tree is *Acacia nilotica* which is replaced by *Faidherbia albida* and *Acacia seyal* at higher ground. In the gravelly area the common species are *Cymbopogon nervatus*, *Schoenefeldia gracilis*, *Aristida spp.* and *Cenchrus biflorus* as associates. Among climbing plants, *Cissus quadrangularis* is the most conspicuous species.

The northern part of the study area is characterized by stretches of light clay, stone and gravels with rocky out-crops. The ground vegetation in this area consists essentially of tufts of annual grasses such as *Aristida funiculata*, *A. adscensionis*, *A. steudeliana*, *Cenchrus spp.* and *Blepharis spp.* The sides of the small seasonal water courses are often lined with herbaceous vegetation including *Cymbopogon proximus*, *Tephrosia nubica*, *Indigofera suaveolens*, *Lasiurus hirsutus*, *Sporobolus helveolus*, and *S. glaucifolius*. The sandy beds are occupied by *Chrozophora oblongifolia* and more abundantly *Panicum turgidum*. The hard open ground is occupied by scattered trees and shrubs mainly *Acacia mellifera*, *Cadaba farinosa*, *Capparis decidua*, *Acacia raddiana*, *Commiphora africana*, *Cadaba glandulosa* and *Maerua crassifolia*.

The western region is composed of stretches of rolling sand varying from gentle undulations to dunes 5m high. This is often dominated by scattered patches or often thickets of *Leptadenia pyrotechnica*. There is often a ground cover of the sedge *Pycreus mundtii*, the grass *Panicum sp.* and the undershrubs *Bouchea marrbiifolia*, *Melhania denhamii*, *Crotolaria thebaica*. Annuals such as *Cenchrus spp.*, *Tragus racemosus*, *Eragrostis spp.*, and *Blepharis spp.* are common. On the tops of high

dunes, where sand is looser, *Chrozophora oblongifoila* may be seen. Fig. (5).

According to Smith (1949), the area belongs to Acacia Desert Scrub. The commonest species are *Acacia raddiana*, *Maerua crassifolia*, *Capparis decidua*, *Acacia senegal* and *Boscia senegalensis*.

Harrison and Jackson (1958) classified the area as the semi- desert region. This has been divided into five sub-divisions on various desert soils a. Sub –division *Acacia tortilis*- *Maerua crassifolia* Desert scrub in the east. b..*Acacia mellifera*- *Commiphora* Desert scrub in the west. The *Acacia tortilis* is the only feature of the vegetation that is generally constant. It is usually distributed as an uneven scatter with greater concentration of bushes along drainage lines. *Maerua crassifolia* is usually present in considerable amount. *Acacia tortilis* , *Leptadenia pyrotechnica*, and *Salvadora persica* are locally abundant on sandy drainage lines, d. *Capparis deciuua* - *Ziziphus spina-christi* and *Balanites aegyptiaca* on clay drainage lines, and e. *Acacia nubica* and *Calotropis procera* .

The dominant annual grasses associated with the woody vegetation are *Aristida spp.*, but are replaced by *Schoenefeldia gracilis* on clay soils. On the sandy soils, *Cenchrus spp.*, *Cymbopogon proximus*, and *Blepharis linariifolia* are present.

In the west, away from water the three most abundant plants are *Aristida plumosa*, *Blepharis spp.* and *Monsonia sp.* Leguminous shrubs, including *Indigofera sp.* and *Chrysopogon aucheri* are often abundant.

Considerable areas have a surface layer of soft wind – blown sand recently fixed by perennial sand- binding grasses such as *Panicum turgidum* and *Lasiurus hirsutus*, which are also dominant on sandy drainage lines. In heavily over- grazed areas and also on clay soils, these were replaced by *Cymbopogon proximus*. Fig. (6).

Wickens (1976) classified the area as Semi-desert scrub and grass land, with average annual rainfall from 75- 250mm. Scrub vegetation includes *Acacia tortilis subsp. tortilis*, *Leptadenia pyrotechnica* and *Salvadora persica* . The dominant grasses were *Aristida spp.* and *Panicum turgidum* on the sandy soils.

According to Noordwijk (1984) the area under study belongs to the Semi- Desert or Semi-arid land with annual rainfall of 90- 300mm. Woody shrubs include *Acacia tortilis* and *Maerua crassifolia*. On the deeper soils or sites *Acacia mellifera* and *Commiphora africana* are found.

Braun *et al* (1991) reported that the study area is located in Central Sudan which belongs floristically to the Sudano- Zambesian region of the paleotropics. Main families are *Poaceae*, *Fabaceae*, *Asteraceae*, *Convolvulaceae*, *Asclepiadaceae*, *Capparidaceae*, *Brassicaceae* and *Zygophyllaceae*. Fig. (7).

Bebawi *et al* (1991) identified the study area as Semi-desert, with annual rainfall of 75 to 300mm. Although the Semi-desert becomes green during the short –rainy season, in the remaining part of the year most of the vegetation is confined to water courses, drainage channels, depressions, runnels and catchment areas.

According to Wickens (1991) the area is classified as Semi-desert scrub and grass- land. The woody species were *Acacia tortilis subsp tortilis*,

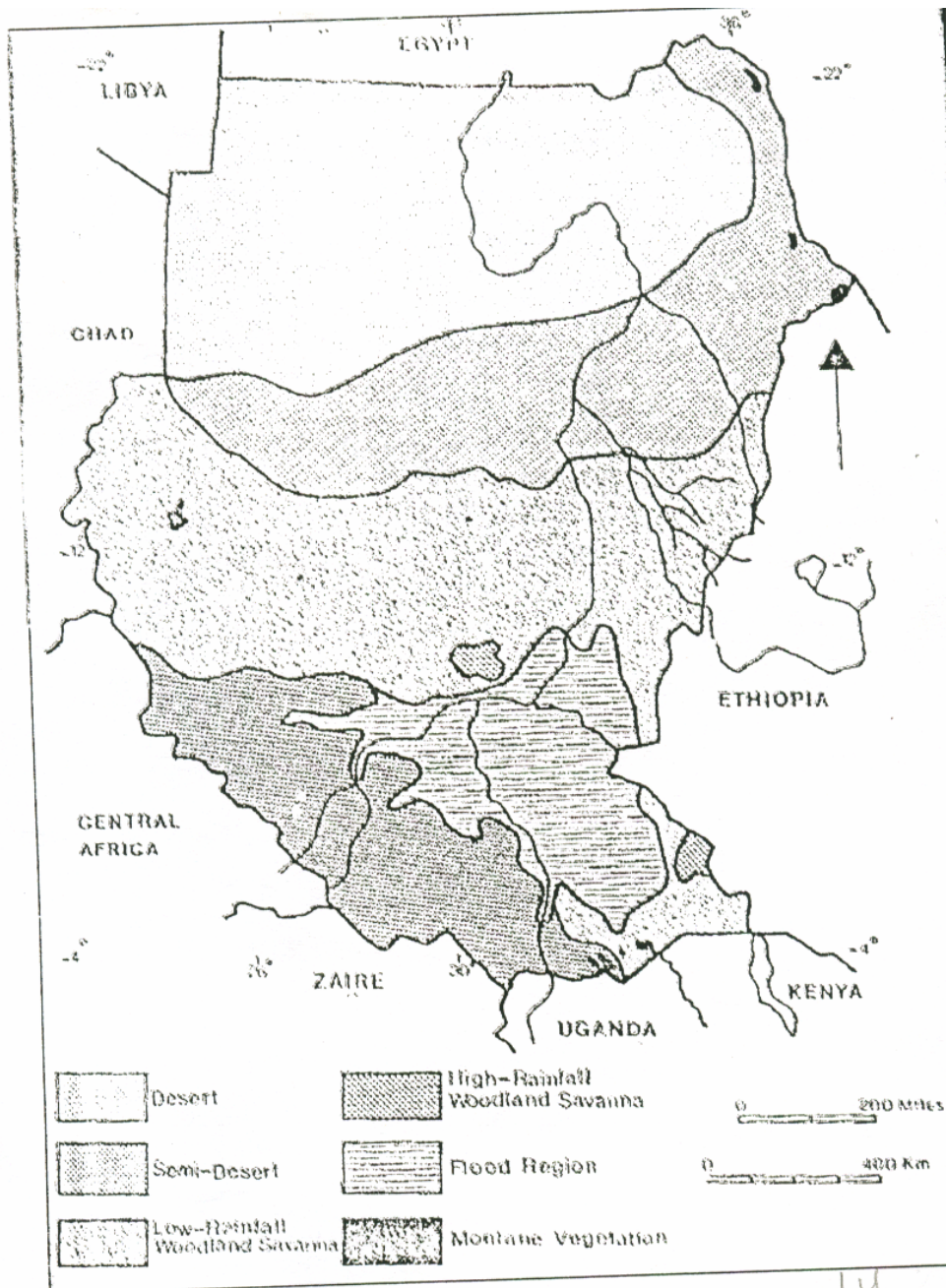
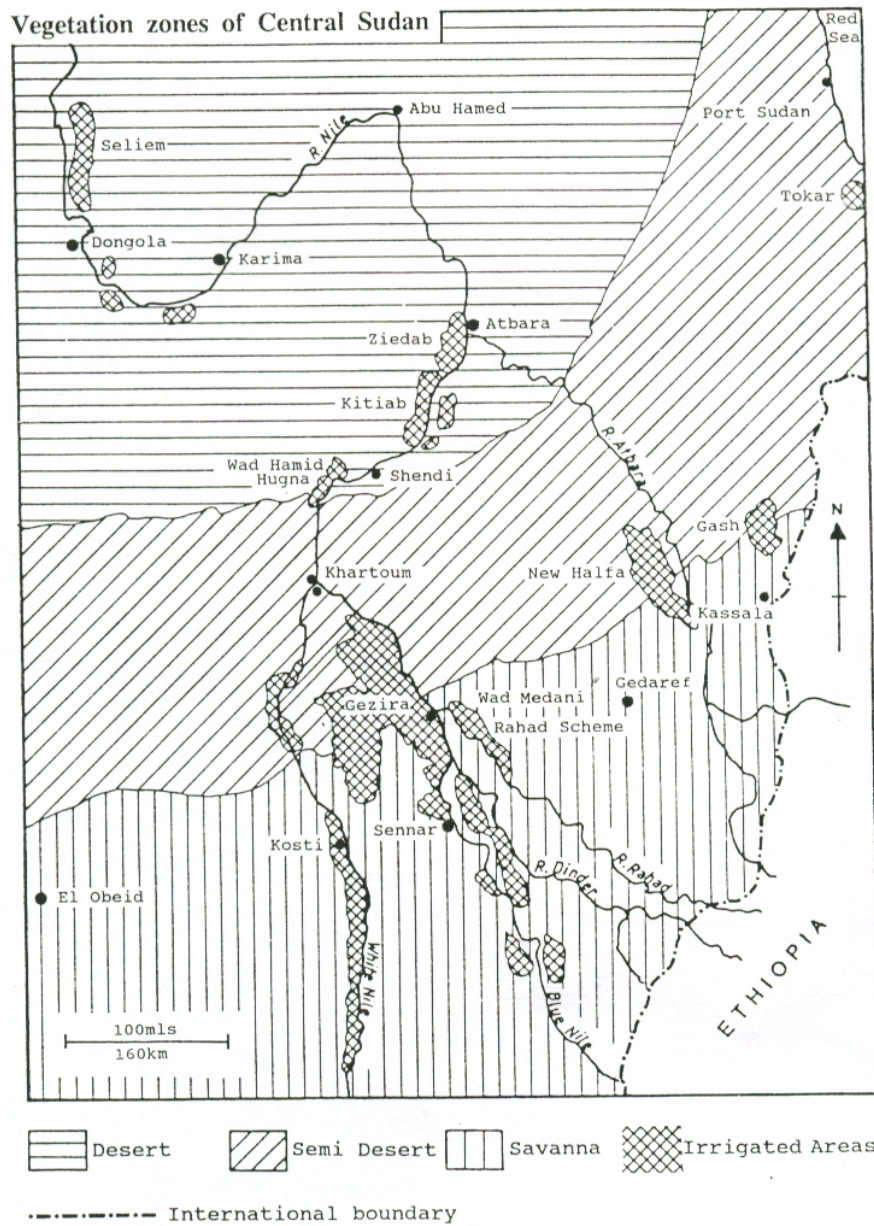


Fig. (6). Sudan Vegetation Map (Harrison & Jackson, 1958).



after Harrison and Jackson, 1958; Ekhlal 1977; Braun 1991

Fig. (7). Vegetation Zones of Central Sudan (Braun *et al.*, 1991).

Leptadenia pyrotechnica, *Salvadora persica*, *Maerua crassifolia* and *Capparis decidua*. The major grasses include *Aristida funiculata*, *A. mutabilis*, *Stipagrostis plumosa*, and *Cenchrus setigerus*. The perennial, sand-binding culms grass *Panicum turgidum* is often present on loose sand dunes. Fig. (8)

3.1.1. Endangered and Threatened species:

The Sudan is largely covered with forests and grassland, grossly estimated at 66 million ha. There are many factors threatening the biodiversity in the Sudan including the study area. These factors can be summarized as follows: Environmental changes, socio-economic factors, biotic factors, expansion of new constructions, increases of livestock population, lack of legislation and recent surveys of rangelands, the war, the increase of human population and settlement.

3.1.2. Famine Food Plants:

The Indigenous Wild Food Plants (IWFPs) are crucial to people's survival during times of crop shortage. They have particular economic importance to women, children and the poor in southern Sudan. In contrast to exotic food crops, IWFPs are adapted to their environment and do not require inputs. The IWFPs in southern Sudan include *Balanites aegyptiaca*, *Sclerocarya birrea*, *Amaranthus sp.*, *Gynandropis gynandra*, *Corchorus sp.* and *Leptadenia sp.*

The rural people in Ethiopia are still endowed with a deep knowledge concerning the use of wild plants. Some of the wild plants are consumed at times of droughts, war and other hardships. The most common wild plants in Ethiopia are *Ficus sp.*, *Carissa edulis*, *Sterculia africana*, *Dobera glabra*, *Maerua sp.*, *Balanites aegyptiaca*, *Opuntia sp.* and *Portulaca sp.*

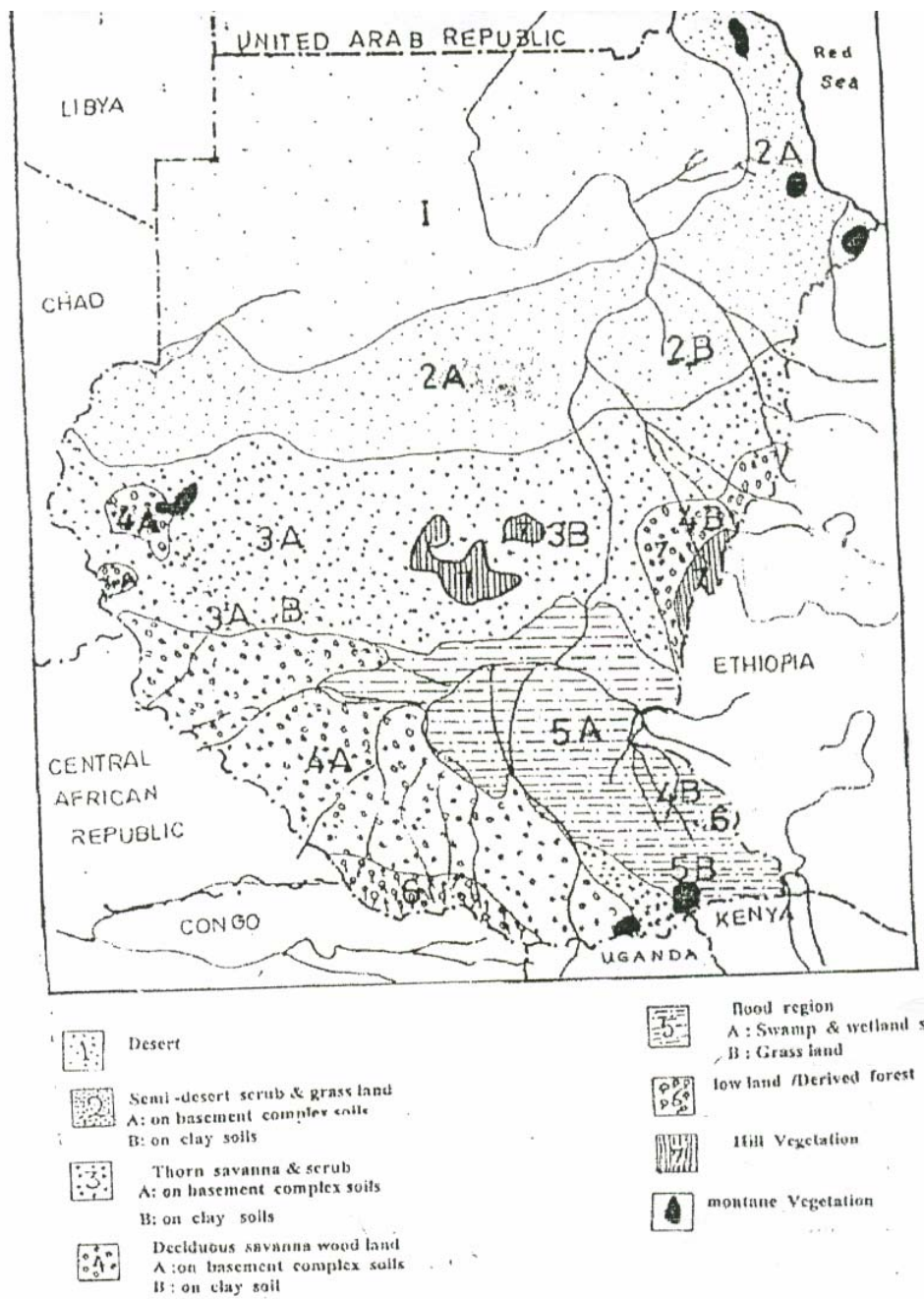


Fig. (8). Sudan Vegetation Map (Wickens, 1991).

The Food and Fruit-bearing Forest Species (FS) provide a supplement to largely starchy diets based on subsistence crops. When other means fail, local inhabitants can often rely for survival on the presence of these forest species (FAO, 1986).

3.2. Biomass productivity:-

Biomass is a common vegetation measure that refers to the weight of plant material within a given area. Other general terms, such as yield or production are sometimes used interchangeably with biomass (Bonham, 1989). Biomass is one of the most commonly measured attributes in range inventory or monitoring programmes, and the data may be collected on an individual species basis, as species groups, or as a total weight for the vegetation (Cook *et al*, 1986).

Biomass can be determined using either direct or indirect sampling methods. Direct methods involve techniques that weigh or estimate the actual biomass of plants in quadrats. Indirect methods are based on developing a relationship between plant weight and other attributes such as plant height, rainfall, or cover (Bonham, 1989).

The most suitable approach to determine biomass in an inventory or monitoring programme depends on the type of vegetation, skills of observers and sample size requirements (Cook *et al*, 1986).

Grazing capacity is defined as the maximum animal numbers which can graze each year on a given area of range, for a specific number of days without inducing a downward trend in forage production, forage quality or soil.

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

metabolism (when the animal was in a fasting and resting state) and that food requirements vary with the 0.73 power of body weight. This figure has been widely used, although other investigations have reported higher values. Graham (1972) suggested that the food requirement was 0.9 of the body weight for sheep and cattle and that 0.75 was commonly acceptable as a mean value for all species of animals.

Darag and Suliman (1988) suggested that the carrying capacity of the range land could be determined as animal unit per hectare per day, and that it can be calculated by using the total biomass productivity and then applying the proper use factor (0.5) i.e. half of the production was considered to be available for grazing. They also suggested that the daily animal unit requirement was 10.5 kilogram/ day.

Darag (1996) suggested that the carrying capacity was a term used to determine land use in terms of livestock grazing and defined it as the number of livestock that can graze on a defined size of rangeland for a limited period of time. It was determined on the bases of range biomass production and the amount of feed requirement per animal unit.

Kumar and Asija (2000) reported that the carrying capacity of a system varies from region to region depending upon population pressure, dependence on food, water, energy, raw material requirement, waste production and important export. In order to live within the carrying capacity, the society will have to change the life style and consumption pattern in such a manner that causes least damage to the ecosystem.

Mustafa *et al* (2000) defined carrying capacity as the maximum number of animal units that a certain range site can accommodate for a specific period on sustainable bases.

Harrison (1955) estimated the carrying capacity on the basement complex to be 26 livestock units per km² compared with 18 livestock units on the clay soils.

Vegetation dynamics is defined as the change in vegetation with time according to an appropriate scale of abundance (Austin, 1981).

3.2.1 Species Composition:-

Species composition is generally expressed as a percent, so that all the species components add up to 100% (Barbour *et al* 1987). Species composition can be expressed on either an individual species basis, or by species groups that are defined according to the objectives of the inventory. It is regarded as an important indicator of ecological and management process at a site.

3.3. Soil seed bank:-

Soil seed banks are important components of vegetation dynamics affecting both ecosystem resistance and resilience. In arid ecosystems seeds are characterized by high spatial and temporal variability and are particularly affected by spatial patterns of vegetation. Rainfall unpredictability is the underlying factor causing the huge soil seed banks found in arid environments.

According to Roberts (1981) the term soil seed bank has been used to designate the live seed reservoir present in a soil. For Baker (1989) this reservoir corresponds to seeds not germinated but, potentially capable of replacing the annual adult plants, which had disappeared by natural death or otherwise and perennial plants that are susceptible to plant diseases, disturbance and human or animal consumption. All the viable seeds present in the soil or mixed with soil debris constitute the soil seed bank (Simpson *et al*, 1989).

The persistence of seeds in the soil is a major component of plant succession and plays a substantial role in the evolution of plant communities (Robert, 1981). Seeds that remain incorporated in the soil form a reserve that can be depleted for potential regeneration over a period of time that may extend to a century.

The seasonal pattern of rainfall, as it influences the size and composition of the soil seed bank is the major factor affecting recruitment of species (Orr, 1991).

The techniques for estimating the population of the soil seed bank (live and dead seeds) can be grouped. These involve: sieving, flotation and subsequent viability determination on one side and those that rely on direct assessment of seedlings arising from soil samples on the other side (Kropac, 1966).

The physical extraction of seeds from the soil tended to overestimate the number of germinating seeds, since extraction counts may include dormant and dead seeds. The seed numbers are normally expressed as number of seeds/m² related to certain depth. The determination of the proportion of dead seeds present in the soil seed bank is important in studying population dynamics and methods of determining viabilities have been developed.

The germination technique, although undoubtedly useful, may be less efficient than the extraction method (Jensen, 1969). The time of sampling in relation to the vegetation cycle must also be taken into account, either by occasional samples at different sites or sampling at the same time in different years (Barralis, 1972).

To separate weed seed from soil, a simple technique was described for rapid determination of weed seed, rhizome, corm or bulb population in the soil. Soil samples were placed in nylon mesh bags. The soil was washed from the bags by machine, leaving only small residues including the desired propagules. These were hand-separated and the soil population of a given plant species was then calculated. The total manipulation time per sample was approximately 10 minutes (Fay and Olson, 1978).

Different soil sample sizes were used by different workers, depending on the condition under investigation. Malone (1976) worked on chemical extraction of seeds using aqueous sodium hexa-metaphosphate. He adopted individual soil samples of 500 gm., but he

mentioned that 100 gm. are more conveniently manipulated. In his study, individual soil samples of 250gm. were used for extraction by calcium chloride (CaCl_2).

The size of weed seed bank varies to a great extent. Jensen (1969) found that the average seed bank size within the upper 20cm was 50258 living seeds/ m^2 in 57 Danish fields. In a British investigation (Roberts & Stokes,1966), values between 1600 and 86000 live seeds/ m^2 were recorded in 58 fields within the upper 15cm. Von Hofsten (1947) reported an estimate of 1777 seeds/ m^2 for *Sinapis arvensis* in Sweden. Another way to estimate changes of the size of the seed bank is to register the number of emerged seedlings in the field. According to Ebregt *et al* (1988) weed surveys give a poor estimation of the seed bank due to large yearly fluctuations in emergence and growth conditions. Thus soil sampling is a more reliable method than field surveys to estimate the seed bank.

Demel & Granstrom (1995) reported that in dry Afromontane forests of Ethiopia at least 167 plants species were identified in the 0-9cm soil layer with total densities ranging between 12300 and 24000 seeds/ m^2 . In Sudan, Mustafa (1997) found about 20 seeds/ m^2 under the canopy of *Acacia seyal*. In Kenya, Schimidit in Tybrik *et al* (1994) found 1510 seeds/ m^2 and Kaarakka (1996) found under the canopy of *Acacia zanzibrica*, a species similar to *Acacia seyal*, a maximum of 6 seeds/ m^2 . Ibrahim (2005) recorded a total number of soil seed bank of about 19700 dead seeds/ m^2 and 7238 live seeds/ m^2 in the low rainfall savannah.

The weed species have survived through time, because of their ability to resist several adverse climatic conditions including tolerating high and low temperatures, dry and humid environments and variations in oxygen supply (Hafliges, 1990).

The composition of seed bank is variable and is classified as temporary or persistent, with respect to the regeneration of the vegetation during different times of the year. Temporary banks are composed of seeds of short life, which do not have dormancy (Garwood, 1989). Persistent seed banks are composed of seeds that have more than one year of age and reserves of seeds remain in the soil year after year, generally buried into the soil.

The seed longevity in the soil varies with species, characteristics of the seeds burial depth and climatic conditions. Freitas (1990) studied weed species, which were buried and placed to germinate at different times of the year. After 40 years, some species produced seedlings, among which was the species *Portulaca olercea*. Seeds in the soil last longer in the deeper layers than on the surface (Taylorson, 1970; Qi *et al*, 1996) and those with impermeable coats are mostly likely to last longer in the soil (Owen, 1950). Bekker *et al* (1997) found that change in soil moisture contents could have a large effect on seed longevity. Several internal and external factors prevent seed germination. Among the internal factors, the most important are the presence of the seed coat, a biochemical inhibitor in the seed, and immature embryo. Among the external factors the most common are soil water content and temperature (Fernandez-Quintanilla *et al*, 1991). The dormancy represents a main mechanism of species preservation in the seed bank, thus distributing germination through the year (Carmona,1992).

Different factors affect the viability of seed bank in the soil. Grazing and cutting intensity affect the seed bank, through effects on the seeds return. O'Connor *et al* (1992) studied the seed bank of *Aristida bipartia* and other spp. in savanna grassland and reported that the seed bank was dominated by less palatable species in areas subjected to heavy grazing.

The dynamics of a seed bank involves a series of events, in relation to time (Simpson et al, 1989). Land preparation influences the seed dispersion in the soil profile. Other events include management of soil depth, fair or uniform distribution of seeds in the soil profile and finding lower seed population deeper in the soil (Dessaint *et al*, 1991). Clements and Bendoit (1996) studied the influence of land preparation types on the seed bank. They found that more than 70% of the seeds were present in the layers of 0-5cm in plots where no mechanical method was used and 30% for plots mechanically managed.

3.4. Tree cover assessment:

According to Krebs (1989) numerous studies have evaluated quadrat size, and no consistent recommendation has been made about the sizes to use. The sizes most often used are 0.01-0.25sq.m. for bryophytes, lichens and algae. A quadrat size of 0.25-16sq.m. was used for grassland, tall herbs, short shrubs or aquatic macrophytes. A quadrat of 25-100sq.m. was used for tall shrub community, whereas a quadrat of 400-2500sq.m. was commonly used for trees.

3.4.1. Crown measurements:

Crown density is defined as the relation of crown (canopy) area to the land area involved. It is used for trees and shrubs, and for this type of vegetation it is synonymous with foliage density. FAO (1995) uses a minimum of 10% crown closure as the definition of forest in the developing countries. According to FRA (2000), the forest is defined as a land area of more than 0.5ha. with a tree canopy cover of more than 10%.

3.4.2 Natural regeneration:

Natural regeneration is the process by which old trees and shrubs replace themselves without intervention. It is by far the best form of regeneration. Natural regeneration arises from seeds which have fallen from existing plants or from vegetative recovery such as sprouting from shrubs or roots. Many bush species regenerate primarily from resprouting rather than seeds (Kirkpatrick *et al*, 2000).

Steward (2004) studied a community woodland and defined natural regeneration as: “is the nature doing its own thing without human intervention.” It usually refers to the process by which native species return to area of land that has been degraded (usually by human activities). Natural regeneration should occur as long as there is sufficient existing native biodiversity in the area and that it may take time. Certain pioneer species are most suited for a particular habitat and these will do best at any time. As time passes, the habitat will change and other species may replace the earlier pioneers. It was also reported that the advantages of natural regeneration include good root development by native seedlings, less disturbance to soil ecology and reduced risk of soil erosion, low cost establishment, less labour and equipments and no problem of geographical origin of seeds. The disadvantages are: less control over initial stocking and spacing, generally lower commercial yield, no genetic improvement or the introduction of disease resistant stock, possible delays in regeneration due to drought or inadequate seeds and the possible need for precommercial thinning to ensure good growth. Kirkpatrick *et al* (2000) counted the advantages of natural regeneration as: it occurs from plant material that is already present so it will be best suited to the environment and it will help to protect the genetic make-up of the bush on ones property. It is effective in re-establishing or rehabilitating the bush on your property, particularly on large areas. He also reported the causes of poor natural regeneration as: competition from grasses and other native species, too high stock levels which graze the young seedlings, lack of regenerating fire, soil compaction by the hooves of stock, seeds harvesting by ants and predation by other invertebrates. The seeds of most forest trees

germinate soon after reaching the ground and tree seedlings are abundant in the ground stratum.

Seydack *et al* (2000) defined the regeneration individuals as plants between 50cm and 1.5m. in height. Seedlings were identified as those individuals without any connection with an adult.

According to Mustafa (1997) rainfall plays a vital role in natural regeneration in the Sudan. The density and occurrence of the trees decreased northwards similar to pattern of rainfall. He also reported that the natural regeneration from seeds is successful on cleared forest sites and fallow land where the rainfall exceeds 600mm. It is difficult on sites that receive less than 600mm unless the seeds were ingested by animals or placed on on- flow sites. There are some activities, such as cultivation, that may promote the natural regeneration of *Acacia seyal* by mobilizing the dormant seeds in the top layers of the soil (Mustafa, 1997).

Soil characteristics:

The soil is undoubtedly the most valuable and dependable natural resource but it is not renewable and therefore it must be managed to maximize its conservation and productivity. Tropical soils have many peculiarities most of which are related basically to geology, climate and the way in which tropical soils have developed. These soils are also more susceptible to run-off and erosion losses. The ability of the soils to retain water and supply it to the plants becomes a critical factor in tropical agriculture. In contrast to soils in temperate regions, most tropical soils are characteristically coarse textured and low in organic matter, base exchange properties and natural fertility. They are also predominantly acidic and poorly buffered.

The traditional shifting cultivation or bush fallowing, which helps to restore fertility, is currently being replaced by continuous intensive cultivation because population and other socio-economic pressures have increased considerably the demand for land.

CHAPTER FOUR

MATERIALS AND METHODS

The study area falls within the semi- desert region. Different parameters were selected and measured. Direct observations and primary surveying were used to assess environmental conditions and plant community types. The global positioning system (GPS) was used to determine the images of the study area, sample plots and quadrats.

4.1. Collection, Identification and Preparation of Herbarium Specimens:

Fresh plant specimens were collected from different sites of the study area at different times of the years 2003 and 2004. Whole plants were collected for herbs and grasses, whereas twigs with leaves, flowers and/or fruits were clipped for trees and shrubs.

The collected specimens were spread to dry between newspapers and firmly pressed in a herbarium press. Newspapers were continuously changed during the days of collection to avoid rotting of the material. The air- dried specimens were deposited at the herbarium of Medicinal and Aromatic Plants Research Institute (MAPRI), National Centre for Research (NCR), Khartoum. Field observations were recorded which included habit, habitat, distribution and color of flowers during the collection trips.

In the herbarium further analysis and /or identification were done, initially by examining the various parts of the specimens collected by using a hand-lens. Fine floral characters were examined under Mbc-10 dissection microscope.

A preliminary species identification was carried out using a set of keys (Andrews, 1950,52, 56; Hutchinson and Dalziel, 1963; Braun *et al*, 1991). The identified species were compared with already identified herbarium specimens from the herbaria of Forestry Research Centre

(FRC) at Soba, Faculty of Science herbarium U. of K. and (MAPRI) herbarium, NCR, Khartoum.

The families, genera and species were all arranged in alphabetical order. The synonyms of identified species were extracted from many references such as (Hutchinson and Dalziel, 1963; Index Kewensis, 1895-1965; Wickens, 1976; Sahni, 1968; El Awad, 1995; El Ghazali *et al*, 1987,1991, 1994, 1998; Bebawi & Neugebohrn, 1991; El Amin, 1990).

The arabic vernacular names of species cited (Ar.= Arabic), were recorded from local inhabitants within the study area ,or extracted from Broun and Massey (1929), Braun *et al* (1991),Bebawi and Neugebohrn, (1991) and ElGhazali *et a l*(1991,1994,1998).

Brief species descriptions have been provided. These include growth habits, leaves, inflorescences and flowers, types of fruits, habitats and distribution.

Medicinal folkloric uses of the collected species have been provided.

These uses have been extracted from available literature on Sudanese plants or plants of neighboring countries (El Ghazali *et al*, 1991, 1994, 1998). In addition, some information was obtained from the inhabitants of the study area.

4.2. Determination of Biomass productivity:

The vegetation biomass of the study area was determined by 126 (1x1m) systematic quadrats with intervals of 16.5m between the quadrats. Plants at each quadrat were harvested at a level of 2-2.5 cm above ground level using scissors. They were then put in labeled paper bags and oven dried for 24 hours at 105 C⁰. Sample dry weight was obtained by using a sensitive digital balance. The dry weight (g/m² and kg/km²) was calculated. The formula used for determining the biomass was:-

$$\text{Biomass} = \frac{W_1 - W_2}{W_1}$$

Where: -

W_1 = Fresh weight of plant sample.

W_2 = Dry weight of plant sample.

4.3. Carrying capacity: The carrying capacity of the study area was determined according to Darag and Suliman (1988) as follows:

$$\text{C.C} = \frac{\text{Allowable matter production/ ha}}{\text{Daily animal unit requirement}}$$

Where:

Allowable matter production/ha = Present Biomass Product of the study area /ha.

Daily animal unit requirement = 10.5 Kg/day.

4.4. Soil Seed Bank:

Soil samples were taken from 42 sample plots along each transect, from a total depth of 15 cm (0-5, 5-10, 10-15), and put into plastic bags. The samples were mixed thoroughly and then sub-samples of 250gm were prepared for extraction.

The soil sub- samples were placed in a set of sieves with pores of 1, 0.5, 0.25, and 0.1mm, respectively. These were then washed for 10-15 min. under continuous flow of water. The soil was washed away leaving only the seeds. The seeds were transferred to a 500ml beaker and water was added. The dead seeds were observed to float. The water containing the floating dead seeds was immediately filtered in a Bunchner funnel. The residue (dead seeds) was air-dried.

The live seeds at the bottom of the beaker were extracted as follows:

A weight of 1.5g of CaCl₂ was accurately weighed and dissolved in 250 ml of distilled water. The solution was added to the live seeds in the beaker and left for 40 min.

The live seeds were observed to float in the CaCl₂ solution. These were then filtered in a Buchner funnel and the residue (live seeds) was air-dried.

The density of seeds was determined by the following formula:

$$\text{Density of seeds} = \frac{\text{Number of seeds/soil depth} \times 2 \times 10000}{\text{Quadrat area} \times \text{number of quadrats/soil depth}}$$

The extracted seeds were identified by comparison with a reference seed samples collection from plants growing in the study area. Magnifying lenses and Mbc-10 dissection microscope were used for seed identification.

4.5. Crown Measurements: -

Crown is defined as the expression of the relation of crown (canopy) area to land area involved. It is used for trees and shrubs, and for this type of vegetation it is synonymous with foliage density.

Forest includes natural forests and forest plantations. The term is used to refer to land with a tree canopy cover of more than 10% and area of more than 0.5 ha. The trees should be able to reach a minimum height of 5m. Young stands that have not reached, but are expected to reach, crown density of 10% and a tree height of 5m are included under forest, as are temporarily unstocked areas (FRA, 2000).

The crowns in each quadrat were measured, by taking two readings of diameter for each tree in a sample plot 50x 50m, along each transect. The crown area is calculated by the following equation:

$$\text{Crown area} = \pi \left\{ \frac{(d_1 + d_2)}{4} \right\}^2$$

Where:

$$\pi = 3.14$$

d_1 = First diameter.

d_2 = Second diameter.

4.6. Natural Regeneration:

In the present study, 42 (10 x 10 m) systematic quadrats along each transect were studied. The new seedlings of natural regeneration were counted for all the species /area. The regenerating species (R.S) were calculated as follows:

$$\text{R.S} = \frac{\text{Number of saplings} \times \text{ha}}{\text{Number of quadrats} \times \text{quadrat area (m}^2\text{)}}$$

4.7. Quantitative ecological parameters:-

The vegetation of the study area was sampled to determine ecological parameters such as Association, Diversity, Similarity and Dissimilarity, Density, Abundance and Frequency in the sample plots along each transect.

4.7.1 Woody vegetation: -

To assess the trees and shrubs, 42 (50x50m) systematic sample plots were surveyed. The results were recorded and analyzed for the following parameters:-

1. Association:-

The degree of association between any two species (X and Y) in a set of samples can be quantified. One of the most widely used methods of measuring association is that of Chi-square (χ^2) using contingency tables as follows:

		Species X		
		+	-	
Species Y	+	a	c	a+c
	-	b	d	b+d
		a+b	c+d	N

Where:

a = both species X and Y are reported.

b= species X is present but species Y is absent.

c = species Y is present but species x is absent.

d = both species x and Y are absent.

N = a+ b+ c+ d = total number of quadrats.

X² can be calculated by the following formula:

$$X^2 = \frac{(|ad - bc| - 0.5 N)^2 N}{(a+b) (c+d) (a+c) (b+d)}$$

Joint occurrence (J.O.) of the two species was calculated as follows:

$$J. O. = \frac{(a+b) \times (a+c)}{N}$$

2. Diversity Indices: -

When ecologists talk of high diversity, they often mean a community containing a large number of different species. However, Magurran (1988) states that most methods for measuring diversity actually consist of true components (species richness and relative abundance). The index used for measuring diversity is the index of Simpson's. It is calculated as follows:

$$SiD = \frac{N(N-1)}{\sum n(n-1)}$$

Where:

SiD = Simpson's Index of diversity.

N = Total number of individuals.

n = Number of individuals of each species.

Σ = Sum of.

3. Similarity and Dissimilarity:-

Similarity indices measure the degree to which the species compositions of quadrats or samples matches are alike. One of the most widely used Coefficient of measuring the similarity is that of Sorensen (1948). The similarity can be calculated as follows:

$$Ss = \frac{2a}{2a + b + c}$$

Where:

Ss = Sorensen coefficient of similarity.

a = number of species common to both quadrats and sample.

b = number of species in quadrat / sample (I).

c = number of species quadrats / sample (II).

The coefficient is multiplied by 100 to give a percentage similarity figure.

4. Density (D):

This is the number of individuals per unit area, and determined as follows:

$$D = \frac{\text{Total number of individuals}}{\text{Total number of quadrats}}$$

5. Abundance (A):

This was determined as follows:

$$A = \frac{\text{Total number of individuals}}{\text{Number of occupied sample plots}}$$

6. Frequency (F):

This is calculated as follows:

$$F = \frac{\text{Number of occupied quadrats}}{\text{Total number of quadrats}} \times 100$$

4.8. Soil analysis:-

36 random soil samples were taken from two depths (0-30cm) and (30 – 60 cm), from three sites of the study area.

4.8.1. Soil moisture:

There are many ways of measuring soil moisture, but the most commonly used method is Gravimetric method. The soil samples were weighed and oven- dried, for 24 hours at 105C°. The samples were then reweighed and their moisture content (M.C.) is expressed as a percentage of the dry weight as follows:

$$\text{M.C \%} = \frac{W_1 - W_2}{W_1} \times 100$$

Where:

W₁ = Fresh weight of soil sample.

W_2 = Oven- dry weight of soil sample.

4.8.2. Soil chemical analysis:

The soil samples were chemically analyzed for PH, organic matter (O.M), Nitrogen (N), Phosphorus (P) and Potassium (K).

The pH was determined by using calorimetric methods.

The organic matter was determined by using the combustion method while the nitrogen was determined by Kjeldahl method.

The phosphorus was determined by digestion and calorimetric methods.

The potassium was determined by the flame photometer method.

CHAPTER FIVE

RESULTS

The findings of this study covered the following parameters: The flora and the vegetation cover, endangered and famine food plant species, soil seed bank, biomass production and carrying capacity, natural regeneration and canopy cover and soil characteristics. Details of results pertaining to these parameters are as follows:

5-1 The Flora:

The Study reported 85 plant species at the study area, belonging to 30 families (28 dicots. and 2 monocots.). The species have been shortly described and the names have been updated. The results are as follows:

AIZOACEAE

(MOLLUGINACEAE & FICOIDACEAE)

Key to Genera:

A. Erect herbs; leaves rosette. ... *Mollugo*

AA. Prostrate herbs; leaves opposite. *Zaleya*.

Mollugo nudicaulis Lam., Encycl. 4:234(1797).

Syn.: *Phamaceum spathulatum* Sw., Fl.Ind.Oce.1: 568(17790);
P.bellidifolium Poir., Encysl. 5:262 (1804); *Mollugo bellidifolium* (Poir.)
Ser. in.DC., Prodr. 1:391(1824).

Vern.names: Shamar kazib (Ar.).

Glabrous erect annual herbs, up to 35cm. high. Leaves rosette, oblanceolate or ovate, 0.9-4x0.2-2.7cm. Flowers greenish, solitary. Fruits loculicidal capsules.

Habitat: Moist places.

Distribution: Widespread.

Zaleya pentandra(L.)Jeffrey,in.K.B.14:238(1960).

Syn.: *Trianthema pentandra*.L.,Mant.1:70 (1767); *Rocama prostrata* Forssk ., Fl.Aegypt-Arab.58(nomen) and 71 Descr.(1775); *Limeoum kensuesseng*, in Hitt. Bot.Stass.Miilnchen2: 46(1950); *Trianthema redimita* Mellville in K.B.7:268(1952).

Vern. names: Al-Rabaa (Ar.).

Diffuse prostrate annual herbs up to 15cm. high, with cylindrical fleshy and striate stems. Leaves opposite, oblong-ovate to lanceolate, 1.5-3x0.3-1cm. Flowers axillary clusters. Fruits capsules.

Habitat: Water catchment areas.

Distribution: Widespread.

Medicinal uses: The macerations of the whole plant are used against scorpion bites (El Ghazali, 1994, 1997)

AMARANTHACEAE

Keya to Genera:

A. Leaves alternate:

B. Ovary with several ovules. *Celosia*

BB. Ovary with one ovule:

C. Flowers glabrous; staminodes absent:

D. Fertile flowers supported by 2 sterile ones. *Digera*

DD. Fertile flowers not supported by sterile ones.

.....*Amaramthus*

CC. Flowers with fine hairs; staminodes present.*Aerva*

AA. Leaves opposite.*Alternanthera*

Aerva javanica (Burm.f.)Schultes, Syst.Vg. ed.15, 5:565(1819).

Syn.: *Iresine javanica* Burm.f., Ind: 212, 213, t.65 Fig. 1(1768);

Aerva tomentosa Forssk., F.L. Aegypt Arab.: 170(1775).

Vern. names: Ras Elshieb. (Ar.).

Woody erect or suberect perennial herbs or undershrubs up to 1m. high, with solid, cylindrical striate white stems. Leaves alternate, exstipulate, lanceolate or oblanceolate 2.5-5x 0.5-2cm.. Flowers white. Fruits circumscissile capsules.

Habitat: Arid and dry sites.

Distribution: Widespread.

Medicinal uses: The whole plant is used as a potent fumigant (ElGhazali *et al*,1994).

Alternanthera nodiflora Forssk., Fl. Aegypt-Arab: 28(1775); R.Br., Prod., Nov. Holl.1:417(1810).

Vern.names: Abuturma (Ar.).

Glabrous procumbent herbs up to 1m. high, with greenish-brown, hollow, striate stems. Leaves opposite, sessile, linear-lanceolate, 2-4x0.5-1cm. Flowers clustered axillary spikes, silvery white. Fruits very flat and winged.

Habitat: Weed of cultivation.

Distribution: Central and southern Sudan.

Medicinal uses: The whole plant is used for treatment of swellings and skin ulcers (ElGhazali, 1985).

Amaranthus graecizans L., Sp.Pl., 1:990(1753).

Syn.: *A. blitum* L., loc. Cit.; *A. polygamous* sensu P.O.A.C.: 172(1895).

Vern.names: Lissan el Tair Saghir (Ar.).

Decumbent or erect, branched annual herbs, up to 40 cm high, with hollow angled and striate stems. Leaves narrowly oblong to obovate, 1-5x 0.3-1.5 cm. Flowers in axillary clusters. Fruits capsules, sub-globose.

Habitat: Weed of cultivation.

Distribution: Central Sudan

Celosia argentea L., Sp. Pl.; 205 (1753).

Vern. names: Danab Elkalib. (Ar.).

Glabrous erect to ascending annual herbs, up to 1 m. high, with solid cylindrical striate stems. Leaves linear to linear- lanceolate, up to 10 cm long. Flowers silvery- white, terminal. Fruits capsules.

Habitat: Weed of cultivation, low land plains.

Distribution: Central and southern Sudan.

Medicinal uses: The leaves mixed with crushed bean and taken orally as an anthelmintic (ElGhazali *et al* 1987). The seeds are used as a remedy for diarrhoea (Bebawi *et al* 1991).

Digera muricata (L.) Mart., in Nov.Act. Acad. Caes. Leop-Carol., Nat Curios 13(1): 285 (1826).

Syn.: *Achyranthes muricata* L., Sp. Pl.2: 295 (1762); *A.alternifolia* L., Mant.Pl.: 50(1775); *Digera arvensis* Forssk.,Fl.Aegypt- Arab.: 65(1775); *D.alternifolia* (L.) Aschers., in Schweinf, Beiter. Fl. Aeth.:180(1887); *Desmocheata alternifolia* (L.) DC., Cat.Hort. Monep. : 103 (1813).

Vern.names: Lablab Ahmer (Ar.).

Branched annual herbs, up to 70cm high, with hollow and striate stems. Leaves alternate, lanceolate or ovate, 3-5x 0.3-2 cm. Flowers spikes axillary, red-pink, changing to almost white. Fruits capsules, sub- globose.

Habitat: Weed of cultivation.

Distribution: Widespread.

ARISTOLOCHIACEAE

Aristolochia bracteolata Lam., Encyl.1:258(1783).

Syn.: *A.bracteata* Rez., Ons.Bot. 5:29(1788); *A. kotschyia* A. Rich., Tent.Fl. Abyssinica klotzsch, Monatsb. Akab.Bero.1858: 59(1859).

Vern.names: Umm Galagil (Ar.).

Glabrous trailing or procumbent perennial stoloniferous herbs, up to 50cm. high, with solid cylindrical stems. Leaves alternate, ovate, 2-5x 1-4cm.. Flowers solitary, axillary, purple. Fruits capsules.

Habitat: Lowland plains.

Distribution: Widespread.

Medicinal uses: The whole plant has anthelmintic and purgative properties, antidote to snake poison and scorpion bites (Bebawi *et al*, 1991). Antitumor (Elgazali *et al*, 1994). The root extract is used against abdominal pains and scorpion bites (ElGazali *et al*, 1987).

ASCLEPIADACEAE

Key to species:

A. Flowers yellow- green.*L. pyrotechnica*

AA. Flowers whitish. *L. arborea*.

Leptadenia pyrotechnica (Forssk.) Decene in Andr.,F.P.Anglo-Aegyp. Sud. Vol.II: 410(1952).

Vern. names: Marekh (Ar.).

Leafless shrubs, 5-10 ft.high; branchlets pale green, whip-like, rarely with small leaves on the young shoots. Flowers small, in several flowered sub -axillary umbels. Follicles 3.5-4.5 in. long, 0.25 in. thick,terete, beaked.

Habitat: Low land plains.

Distribution: Northern and Central Sudan.

Leptadenia arborea (Forssk.) Schweinf., Arab.Pflazem:167(1912).

Syn.: *Cynanchum arboreum* Forssk.,Fl. Aegypt- Arab.:53(1775);
C.heterophyllum Del.,Cent. Pl. Afr. Voy.Merore 47: t,63; *Leptadenia heteropylla* (Del.) Decnce., F.T.A.4,1;432 (1904).

Glabrous twiners, with hollow and terete stems. Leaves variable, linear to linear- lanceolate, 4-10 x 1-4 cm. Flowers whitish, in lateral umbels. Fruits follicles, glabrous.

Habitat: Moist places and waste lands.

Distribution: Widespread.

Medicinal uses: The leaves and stems are used against bites (ElGhazali *et al*, 1994).

ASTERACEAE(COMPOSITAE)

Key to Genera:

A. Flowers not all ligulate; milky juice absent. *Xanthium*

AA. Flowers all ligulate, milky juice present. *Sonchus*

SONCHUS L.

Key to species:

A. Achens more or less compressed and narrowed at both ends, with a 4-
cornered basal pit. . . .*S. oleraceus*

AA. Achens more or less cylindrical, with a 4-5 cornered basal pit.
..... *S.cornutus*

Sonchus cornutus Hochst.ex Oliv. &Hiern., Andr.,F.P.S.Vol.III: 51(1956).

Erect perennial herbs, 2 or more ft.high. Leaves sessile , crowded near the base. Flower heads yellow. Achens transversely rugose.

Habitat: Weed of cultivation.

Distribution: Northern and Central Sudan.

Sonchus oleraceus L., Sensu. Oliver. & Hiern in. F.T.A.3: 457(1877).

Syn.: *Sonchus oleraceus* L. var. *asper* L.,Sp.Pl .:794(1753); *S. asper* L. Hit., Herb. Brit 1:47(1769).

Vern.names: Moleita (Ar.).

Erect annual herbs, up to 90cm high, with hollow and striate stems. Leaves pinnatifid,6-11x1-2.5cm. Flowers in terminal heads, yellow. Fruits achens, striate.

Habitat: Weed of cultivation.

Distribution: Northern and Central Sudan.

Medicinal uses: The leaves are used to reduce the blood sugar (Reported by locals Umm Rimtta, 2004), and also used with root as tonic and ferbrifuge (Broun and Massey ,1929). The whole plant is used to treat anaemia (Adjanohom *et al*, 1993).

Xanthium brasiliicum Wallr.,Pl.Flum. 10:329(1887).

Syn.: *X. stramonium* L.,Sp. Pl.: 987 (1753) ;*X. antiquorum* Wallr. ,Beitr. Bot. 1:229(1924).

Vern.names: Rantouk (Ar.).

Erect to ascending scabrous stout annual herbs up to 60cm high, with solid, striate and terete stems. Leaves 3-5-lobed, broadly ovate, 6-

14x1.5-5cm. Flowers axillary heads, greenish- yellow. Fruits achenes, globose, with hooked spines.

Habitat: Lowland plains.

Distribution: Central Sudan.

Medicinal uses: The fruits possess anti-allergic and anti-inflammatory properties, also used for treating tuberculosis, impetigo, ulcers, urticaria, scrofula, goiter, rheumatism, arthragia, cramp of extremities, headache, chronic catrrhal, rhinitis, sorethroat and dysentery. The decoction of the fruits is a gargle for tooth-ache and as unguent for linea capitis and dermatomycosis (WHO/IMM, 1990).

BALANITACEAE

Balanites aegyptiaca (L.) Del. In Descr. Aegypt. Hist. Nat. 2:221.t. 28, fig.1(1813).

Syn.: *Ximenia aegyptiaca* L., Sp. Pl. : 1194 (1753).

Vern names: Hegleeg, Desert date (Ar.).

Armed trees up to 9m high, with fluted and slightly enlarged stems, with rough and fissured barks. Leaves bifoliate; leaflets obovate to rhomboid, 2-5x0.8-2.5cm.. Flowers yellow- green, supra- axillary clusters. Fruits drupes, oblong- elliptic, yellow.

Habitat: Lowland plains.

Distribution: Widespread.

Medicinal uses: The embryo and fruits are eaten to cure diabetes, balharzia, and also as a purgative (Reported by locals, 2004). The aqueous extract of the bark is used for jaundice and the branches are used as a fumigant for rheumatism (ElGhazali 1985,1986). The leaves are used

for wound healing and mixed with sesame oil and used as anti-rheumatic (El Ghazali *et al*, 1987,1994). The decoction of the root is taken against malaria, while bark fumigant is used to heal circumcision wound and the fruits are mild laxative, antidote to arrow poisons (Boulos, 1983). Gum mixed with maize meal porridge and roots are used for abdominal pains, as a purgative and as anthelminthic (Kokwaro,!976,1993).

BORAGINACEAE

Heliotropium supinum L.,Sp.Pl.: 130 (1753).

Vern. names: Danb Elagrab (Ar.).

Pubescent decumbent or prostrate much branched annual herbs up to 50cm.high, with solid cylindrical stems. Leaves elliptic, 1-3x0.6-1.5cm. Flowres nutlets.

Habitat: Lowland plains.

Distribution: Central Sudan.

BRASSICACEAE (CRUCIFERAE)

Key to Genera:

A. Hairs stellate. *Matthiola*

AA. Hairs 2- armed, medifixed, compressed. *Farestia*

FARSETIA Jurra

Key to species:

A. Leaves vary, narrow linear; flowers white to pale- orange.
.....*F. longisiliqua*

AA. Leaves linear- lanceolate, flowers orange- yellow.
.....*F. hamiltonii*

Farsetia hamiltonii Royle., *Illust. Bot. Hinall.*:71(1834).

Syn.: *F. ramosissima* Hochst. ex. Forurn., *in flora*,24:42(1841).

Hoary erect to decumbent annual or perennial herbs, up to 80cm. high, with solid, cylindrical stems. Leaves linear, 1-5x0.2-0.5cm. Flowers orange- yellow. Fruits siliques, short appressed.

Habitat: Lowland plains.

Distribution: Northern and Central Sudan.

Farsetia longisiliqua Decne. *In Ann. Sci. Nat.* 11,4:69 (1835).

Vern. names: Um Adafir, Dakheyen (Ar.).

Hoary erect annual herbs up to 50 cm high., with hairy and terete stems. Leaves narrow, linear, 1-4x 0.5-1cm. Flowers in axillary or terminal spikes. Fruits siliques, linear, valved.

Habitat: Lowland plains.

Distribution: Northern and Central Sudan.

BURSERACEAE

Commiphora africana (A.Rich.) Engl. and C.DC., Mon. Phan.4:14(1883).

Syn.: *Balsamondrum afrianum* (A.Rich.) Arn., Ann. Nat. Hist.3:87 (1839); *Balsamea pilosa* Engl., Bot. Jahrb. 1:87 (1880); *Commiphora pilosa* Engl. in DC., Mon. Phan. 4:12 (1883); *C.sambesiaca* Engl., Bot.Jahrp. 44:146 (1909).

Vern names: Gafal (Ar.)

Shrubs or small trees, up to 7m high, with straight, short and cylindrical stems. Leaves trifoliate, ovate or lanceolate; leaflets sessile, 2-5x1.5-3cm. Flowers axillary and clustered. Fruits drupes, ellipsoid.

Habitat: Rocky hill slopes, lowland plains, Khor and Wadi banks.

Distribution: Widespread.

Medicinal uses: Roots are boiled in water and the decoction is drunk for treatment of swollen testides, and stomach troubles, and used with bark in steam baths for fever and colds. The bark is chewed with tabaco and applied on snake bite, while the resin is used for sealing up and disinfecting wounds. The fruits are used for treatment of typhoid (Kokwaro, 1993).

CAESALPINIACEAE

Senna alexandrina Mill. in Lock., Kew Bull:43(1989).

Syn.: *Cassia senna* L., Sp. Pl.: 377 (1753); *C. acutifolia* Del., Fl. Aegypt. 3:61,t.27(1813); *C. lanceolata* Forssk., Fl. Aegypt-Arab: 85(1775).

Vern names: Sana Meka (Ar.)

Glabrous erect perennial undershrubs, up to 1-2m.high, with solid and terete stems. Leaves pinnate; leaflets elliptic to lanceolate, 1.5-4x0.5-1 cm.. Flowers axillary and terminal, yellow. Fruits pods, flat.

Habitat: Water catchment areas.

Distribution: Widespread.

Medicinal uses: The leaves and fruit are laxative (Reported by locals. Um Rimmitta, 2004;Kokwaro, 1993; Boulos, 1983 and lGhazali, 1986).

CAPPARIDACEAE

Key to Genera:

A. Petals absent:

B. Fruit torulose, seeds numerous. *Maerua*

BB. Fruit globose, seeds few. *Boscia*

AA. Petals present, 1 or more.*Capparis*

Boscia senegalensis (Pers.) Lam. Ex. Poir. in DC., Prod. 1: 244(1824).

Syn.: *Podoria senegalensis* Pers., Syn. Pl.: 215 (1806); *Boscia octandra*

Hochst. Ex. Rodik. In Sitz.,Math. Phys. Acad. Muench. 15: 62(1884).

Vern. Names: Mokheit, Kursan (Ar.).

Shrubs or small trees up to 5m. high, with stout and greyish branches or stems. Leaves elliptic- oblong to obovate, 3.4- 9x 1.5-3.4cm. Flowers green scented. Fruit drupes, globose.

Habitat: Lowland plains.

Distribution: Widely distributed south of 16°N.

Medicinal uses: Aqueous extract of the roots is used against Bilharziasis, the leaves used as a poultice for muscular pains and the fruit water extract used against tuberculosis (El Ghazali, 1985), whereas powdered root mixed with milk and taken against gonorrhoea and urinary tract

infammatioins and the leaves mixed with sesame oil and used as anti-rheumatic (El Ghazali *et al*,1994).

Capparis decidua (Forssk.), Edgew. in J. Linn.Soc.Bot.6: 184(1862).

Syn.: *Sodada deciduas* Forssk., Fl.Aegypt-Arab.:81(1775); *Capparis aphylla* Hayne ex. Roth., Nov. Pl.Sp.:238(1821).

Vern. Names: Tundub (Ar.).

Armed much-branched shrubs or small trees up to 4 m. high, with terete, solid, prickled and dark green stems. Leaves small, deciduous.

Flowers lateral and terminal fascicles, pink. Fruits globose, edible.

Habitat: Lowland plains.

Distribution: Widely distributed except in extreme South.

Medicinal uses: The aqueous extract of the stems is used against jaundice, whereas the stems are used as a poultice for swellings and joint pains (ElGhazali, 1985). The poultices of the twigs are used against head-ache and the fumigant of the stem is used as anti-rheumatic (ElGhazali et al, 1994-97). Green branches are used for stringet, cardiac problems, boils, swelling, tooth-ache, as laxative, diaphoretic, anthelmintic, cough, athma, inflammation, fever(Boulos,1983).

Maerua crassifolia (Forssk.) Gilg &Bendict. in Engl., Bot. Jahrb.,53:250(1915).

Syn.; *M. uniflora* Vahl, Oliv. F.T.A.1: 86(1868); *M. meyeri* (Johannis) Gilg.in E.J.51: 225(1914); *M.uguenensis* Gilg. in E.J.53: 251(1915);*M. hirtella* Chiov.,Fl. Somlia 1:83(1929).

Vern. names: Sareh, Sarha or Sorakh and Kowoge (Ar.).

Pubescent small trees, up to 8m. high, with straight and cylindrical stems. Leaves obovate- elliptic, 1.7-3x0.6-1.6-cm. Flowers axillary solitary or 2-3 together. Fruits pods, torulose.

Habitat: Lowland plains.

Medicinal uses: The fumigant of the stems is used as anti-rheumatic (ElGazali *et al*, 1997).

CLEOMACEAE

Cleome gynandra L., Sp. Pl. :671(1753). Plate (1).

Syn.: *Gynandropsis gynandra* (L.) Briq. in Ann., Conserv. Jard. Bot. Genere 17:382(1914); *G. pentaphylla* (L.) DC., Prodr. 1:238(1824).

Vern. names: Tamalaika (Ar.).

Pubescent erect annual herbs, up to 60 cm.. high, with striate hollow and terete stems. Leaves 5-foliate, about 1-3x0.5-1cm.. Flowers spread out, white or purplish. Fruits capsules, linear.

Habitat: Weeds of cultivation.

Distribution: Widespread.

Medicinal uses: The young softer leaves are powdered and the liquid squeezed into the aching ears and also poured into nostrils, eyes, in cases of epileptic fits. Roots are boiled and the decoction, drunk to facilitate birth, or stomach-ache, and for treatment of conjunctivitis, and severe infection by tape worms (Kokwaro, 1993). Leaves are used to treat open wound and splenomegaly with pain (Adjanoahous *et al*, 1993).

CONVOLVULACEAE

IPOMOEA L.

Key to Species:

A. Leaves cordate. *I. cordofana*

AA. Leaves reniform. *I. aquatica.*



Plate (1). *Cleome gynandra* L.



Plate (2). *Ipomoea cordofana* Choisy

Ipomoea cordofana Choisy in. DC., Prodr. 9:350(1845). Plate (2).

Syn.: *Batas auriculata* Hochst., nomen. Nudam., Loc. Cit.; *Ipomoea auriculata* Holl. in. E.J., 18:130(1893).

Vern. names: Tebr or tibr (Ar.).

Annual or perennial herbs, trailing or creeping, laxly pilose. Leaves ovate – orbicular, broadly cordate, 1.5x6.3cm. Flowers white, funnel-shaped. Fruits capsules, globose.

Habitat: Weeds of cultivation.

Distribution: Central and Southern Sudan.

Ipomoea aquatica Forssk., Fl. Aegypt- Arab. 44(1775).

Syn.: *I. repens* Roth, Nov. Pl. Sp.: 110(1821).

Vern. names: Abu Halageem (Ar.).

Glabrous trailing or prostrate perennial herbs, with hollow woody cylindrical striate stems. Leaves reniform, 7-15 cm. in diameter. Flowers bright-red . Fruits glabrous capsules.

Habitat: Moist sites.

Distribution: Central and Southern Sudan.

CUCURBITACEAE

Key to the Genera:

A. Setose herbs; stem striated; leaves ovate; fruits oval. *Cucumis*

AA. Scarbid herbs; stem 5-angled; leaves orbicular-reniform; fruits sub-globose.
..... *Luffa*

Cucumis melo var. argestis Naud., .Ann.Sc.Nate.Ser.4,12:110(1859).

Syn.: *C. melo* L.var. *cullus* kuntz., in Journ. As. Sco. Berg. 46:103 (1877); *C. cognatus* in DC., Monoger. Phan. 3:437 (1881).

Vern. names: Seinat (Ar.).

Setose, prostrate or climbing annual herbs; with hollow and striated stems. Leaves lobed, broadly ovate, 2.5-7x2-5cm . Flowers axillary clusters. Fruits oval.

Habitat: Lowland plains.

Distribution: Central Sudan.

Medicinal uses: The fruits are used as expectorant, emetic, whereas the seeds are used as vermifuge, digestive refrigerant and anti-tussive (Boulos, 1983).

Luffa echinata Roxb., Hort. Beng. :104 (1814).

Syn.: *L. bendual* Roxb., Op. Cit; *L. longistyla* Edgew., in Journ.As. Soc. Beng !1852); *Momordica erinocarpa* Fenzl., ex. Naud., in Ann.Sc. Nat. Ser. 412:135(1859); *M. echioncarpa* Fenzl.ex. Hook.f. in Oliv.,Fl. Trop. Afr.2:531(1871).

Scarbid climbing annual herbs with solid 5- angled stems and branched tendrils. Leaves orbicular- reniform, 5-7-lobed, 5-10cm. broad. Flowers yellow to white. Fruits berry, sub-globose.

Habitat: Lowland plains.

Distribution: Widespread.

Medicinal uses: The fruits have purgative properties, also used as a remedy for dropsy and with milk is taken by barren women to stimulate pregnancy (Bebawi *et al*, 1991).

EUPHORBIACEAE

Key to Genera:

A. Male and female flowers not enclosed in common involucre.

....*Acalypha*

AA. Male and female flowers enclosed in common involucre.

..... *Euphorbia*

Acalypha indica L., Sp. Pl. : 1003 (1753).

Syn.: *A bailloniana* Muell. Arg. in Linn. Soc. Bot.,34:44(1865); *A. somalium* Muell. Arg., in Abh, Nat. Ver. Bremen 7:27(1880); *A. indica* L., var. *bailloniana* (Muell. Arg.) Hutch. in F.T.A. 6(1): 904(1912).

Vern. names: ElMatraba (Ar).

Small annual herbs or sub-shrubs up to 90cm.high, with tomentose to densely pubescent, sulcate and angular stems. Leaves ovate to ovate-lanceolate, 1-9x0.5-2cm. Flowers axillary, solitary . Fruits trilobate and pilose.

Habitat: Water catchment areas.

Distribution: Central and Southern Sudan.

Medicinal uses: The roots , leaves and tender shoots are used in India for various disorders. The juice of the plant is esteemed as an emetic for children(Broun and Massey, 1929).

Euphorbia aegyptiaca Bioss., Cent. Euph.13(1801).

Syn.: *E. forsskali* J. Gay in Webb. And Benth., Phyt. Canar.3(3):243(1847).

Vern. namesUm- Lebaina(Ar.).

Prostrate, spreading annual herbs up to 30cm, with pubescent and terete stems. Leaves oblong, 6x3cm. Flowers axillary, leafy clusters. Fruits globose capsules.

Habitat: Weed of cultivation.

Distribution: Northern and Central Sudan.

Medicinal uses: The whole plant is used as purgative (Broun and Massey, 1929) and against scorpion bites (ElGhazali *et al*, 1994).

FABACEAE(PAPILIONACEAE)

Key to Genera:

A. Pods not jointed:

B. Leaves simple or 1-foliolate:

C. Styles abruptly bent over near the base. *Crotalaria*

CC. Styles not as above. *Indigofera*

BB. Leaves compound or trifoliolate:

E. Leaves gland- dotted beneath. *Rhynchosia*

EE. Leaves not gland-dotted beneath:

F. Racemes terminal. *Tephrosia*

FF. Racemes axillary. *Sesbania*

AA. Pod jointed:

G. Articulations of pod not flat.... *Alysicarpus*

GG. Articulations of pod flat.... *Desmodium*

Alysicarpus vaginalis (L.) DC., Prodr. 2:353(1825).

Syn.: *Hedysarum vaginale* L., Sp.Pl.: 746(1753).

Vern. Names: Shillini (Ar.)

Diffuse annual herbs, up to 60cm. high, with pubescent and striate stems. Leaves ovate or oblong, 2.5-6x1.2-2.5cm. Flowers in axillary and terminal racemes. Fruits cylindrical pods.

Habitat: Lowland plains.

Distribution: Widespread.

Medicinal uses: An infusion of the leaves is used as a stimulating wash for babies (Kokwaro, 1993).

Crotalaria pycnostachya Benth. in Polhill. R.M, 1982. A.A. Balkema, Rotterdam 389 pp, *Crotalaria* in Africa & Madagascar.

Herbs up to 18 in. high; branches striate, finely silky. Leaflets 3, 0.75-2.75 in. long. Flowers yellow, sessile, in racemes. Fruits pods, subsessile, oblong.

Habitat: Lowland plains.

Distribution: Central Sudan.

Desmodium dichotomum (Klein) DC. Andr., F.P. Anglo-Aegypt. Sud. Vol. II: 195 (1956).

Vern. names: Abu Araida (Ar.).

Under shrubs, 1 or more feet high; branches robust, angular; stipules persistent. Leaflets 3, the central one ovate. Flowers reddish, in moderately lax racemes. Fruits pods.

Habitat: Lowland plains.

Distribution: Central Sudan.

INDIGOFERA L.

Key to species:

A .Diffused branched herbs. *I. hochstetteri*

AA. Stiff branched under- shrubs:

B. Flowers in heads..... *I. strobilifera*

BB. Flowers in dense axillary racemes. *I. oblongifolia*

Indigofera hochstetteri Bak.in F.T.A. 2:101(1871).

Syn.:*I anabaptista* Steud. ex.Bak. in Hook. F., Fl.Brit. Ind. 2:102(1876); *I ornithopodiodes* Joub. & Spach. 111. Pl.Or., t. 480(1856); *I. arenaria* A.Rich.,Tent. Fl. Abyss. 1:183(1847).

Vern.names: Sharaia. (Ar.)

Diffuse annual herbs, up to 30cm.high, with angular hairy and weak stems. Leaves odd- pinnate; leaflets oblong to ovate,1-2x 0.4-1cm. Flowers axillary racemes. Fruits linear pods.

Habitat: Lowland plains.

Distribution: Northern and Central Sudan.

Indigofera oblogifolia Forssk., Fl. Aegypt-Arab.: 173(1775).

Syn.: *I. paucifolia* Del., Fl.Egypt:251(1813).

Vern. names: Dahassir (Ar.).

Pubescent stiff branched perennial under-shrubs, up to 2m.high, with solid cylindrical stems. Leaves alternate; leaflets 3-7, glaucous. Flowers in dense axillary racemes. Fruits pods, slightly curved.

Habitat: Canal sites, moist sites.

Distribution: Widespread.

Indigofera strobilifera Hochst. Ex. Baker. in Oliver., Fl.Trop. Afr.ii: 75; (Hochst.)Hochst.ex.Bak.Andr.,F.P.Anglo-Aegyp. Sud., Vol.II:210(1952).

Low branched under shrubs, 1 or more feet high. Leaflets 5-7, oblong or lanceolate, 0.5- 0.75 in. long. Flowers deep- red, small, in heads. Fruits pods, oblong.

Habitat; Lowland plains.

Distribution: Central Sudan.

Rhynchosia minima var. ***memnonia*** (L.) DC., Prodr. 2:385(1825).

Syn.: *Dolichos minima* (Del.) DC., Prodr.2:386(1825).

Vern names: Adan elfar (Ar.).

Hoary silky twining annual herbs, with hollow cylindrical striate stems. Leaves trifoliate; leaflets orbicular, 2cm.in diameter. Flowers yellow, in short racemes. Fruits pods, curved, pubescent.

Habitat: Lowland plains.

Distribution: Widespread.

Sesbania sesban (L.) Merrill in Philipp.J.Sci.Bot.7:235(1912).

Syn.: *Aeschynomene sesban* L.,Sp.Pl.:714(1753); *Sesbania aegyptiaca* Poir. in lam.,Encyl.Bot.7:128(1806).

Vern names: Sesban (Ar.).

Tall shrubs, copiously branched. Leaves compound, bipinnate; leaflets small., oblong. Flowers yellow. Fruits pods.

Habitat: Lowland plains.

Distribution: Widespread.

Tephrosia uniflora Pers.,Syn.Pl.2:329(1807). Plate (3).

Syn.: *T. anythylloides* Webb. In Kew J.Bot.2:245(1850); *T. transjubensis* Chiov., Fl. somalia 2:161(1932).

Vern. Names: Um-Rigaygay, Um-Adafier, Kharata, and Amoyoga (Ar.)

Ascending or decumbent annual or perennial herbs up to 60cm high, with solid and pubescent stems. Leaves odd-pinnate; leaflets oblanceolate, 1.5-3x0.4-0.8cm. Flowers axillary in clusters. Fruits pod linear.

Habitat: Water catchment areas.

Distribution: Widespread.

Medicinal uses: The root water extract is used for tooth pains and as a tonic (ElGhazali, 1985).



Plate (3). *Tephrosia uniflora* Pers.

LAMIACEAE (LABIATEAE)

Key to Genera:

A. Flowers in verticillate-racemes. *Ocimum*

AA. Flowers in verticillate- dense- globose heads. *Leucas*

Leucas urticifolia (R.Br.) Sm. in Rees. Cyclop.xx.(1819).

Vern. names: Um-Meloud, Um-Galout (Ar.).

Erect annual herbs up to 60cm high, with pubescent and angled stems. Leaves opposite, ovate, 2.5-6x1-2cm. Flowers axillary and terminal. Fruits nutlets.

Habitat: Lowland plains.

Distribution: Central Sudan.

OCIMUM L.

Key to species:

A. Stems densely pubescent. *O. canum*

AA. stems glabrous. *O. basilicum*

Ocimum canum Smis, Bot. Mag.: 51 t.2452(1823).

Syn.: *O. americanum* L., Andr., F.P.S.VI. 3,218(1956).

Vern. Names: Raihan (Ar.).

Erect much- branched annual herbs; stems densely pubescent, 1-2ft. high. Leaves ovate or lanceolate, 1-2 in. long. Flowers white, in dense racemes. Filaments of upper stamens with a tooth near base.

Habitat: Lowland plains.

Distribution: Central and Southern Sudan.

Ocimum basilicum L., Andr. F.P.S.Vol. 3:218(1956).

Vern. names: Raihan El-khala (Ar.).

Erect much- branched annual herbs; stems glabrous, 1-2 ft.high. Leaves ovate, 1-2 in. long. Flowers white or tinged with purple, in dense racemes. Filaments of upper stamens with a tooth near base.

Habitat: Lowland plains.

Distribution: Northern and Central Sudan.

LORANTHACEAE

Loranthus acaciae Zucc. In Abd. Akad. Muench iii 1837(1837-43).249.t.-2.f.3.; Andr. F.P.S.2:292(1952).

Vern. names: Anaba (Ar.).

Glabrous branched brownish plants. Leaves opposite or sub-opposite rigidly coriaceous, linear. Flowers purple. Fruits yellow.

Habitat: Parasitic on Acacias.

Distribution: Widespread.

MALVACEAE

Key to Genera:

A. Epicalyx absent. *Abutilon*

AA. Epicalyx present. *Hibiscus*

Abutilon figarianum Webb.Fragm.Fl.Aethiop.52,11(1837).

Syn.: *A. graveolens* sensu. Broun and Massey, F.S.:12(1929).

Vern. names: Ambru. (Ar.)

Erect tomentose perennial herbs, up to 1.8m.high, with solid and cylindrical stems. Leaves broadly ovate, 2.5-9x2-6cm. Flowers axillary solitary or paired, yellow. Fruits capsules.

Habitat: Depressions of clay soils.

Distribution: Northern and Central Sudan.

Medicinal uses: The leaves are used as lactagoge and for throat infections (ElGhazali *et al*, 1997).

Hibiscus vitifolius L. subsp. *vulgaris* Brenan&Exell,Bot.Soc.32(2a) (19580.

Syn.: *H. vitifolius* var. *genuinus* Hocht., Ann. Conserv. Jard. Bot. Geneve 4:169(1900); *H. heterotrichus* Dc., Prod.10:450(1824); *H. lepidospermus* Miq.,Fl.Ind.Bot.1,2,159(1859).

Glandular erect annual herbs or undershrubs . Leaves alternate, 3-5 lobed, 2-12x1.2-7cm. Flowers solitary, axillary, yellow with dark-red centre. Fruits capsules.

Habitat: Lowland plains.

Distribution: Widespread.

MIMOSACEAE

Key to Genera:

A. Inflorescences cylindric spikes. *Faidherbia*

AA. Inflorescences capitate, globose. *Acacia*

ACACIA Mill.

Key to species:

A. Inflorescences spicate, more or less cylindrical. ... *A. mellifera*

AA. Inflorescences capitate, globose:

B. Pods spirally twisted or falcate:

C. Pods annular or spirally Twisted:

D. Pods and branchlets glabrous. *A. tortilis subsp.raddiana*

DD. Pods and branchlets pubescent. *A. tortilis subsp.spirocarpa*

CC. Pods falcate. *A. seyal var. seyal*

BB. Pods straight or slightly curved:

E. Pods markedly torulose. *A. nilotica subsp. nilotica*

EE. Pods not torulose. *A. oerfota*

Acacia mellifera (Vahl) Benth. In Hook.; Brenan. In Kew Bull.11:191(1956).

Syn.: *Mimosa mellifera* Vahl, Symb. Bot.3:103(1791); *A. detinens* Burch, Trav.:310(1822).

Vern. names: Kitir (Ar.).

Small trees, up to 7m.high, much branched from base. Leaves bipinnate, up to 5cm.long,;leaflets 1-2 pairs. Flowers axillary, spicate, white-cream. Fruits pods, papery, flattened, dehiscent.

Habitat: Lowland plains.

Distribution: Northern and Central Sudan.

Medicinal uses: The bark is boiled in water and the liquid used as a remedy for stomach trouble, cleaning primary infection of syphilis sterility, malaria, pneumonia (Kokwaro,1993).

Acacia nilotica (L.) Willd. ex. Del., *subsp. nilotica*; Brenan, Kew Bull.9;84(1957). Plate (4).

Syn.: *Mimosa nilotica* L., Sp. Pl.:52(1753); *Acacia arabica* (Lam.) Willd., Sp.Pl.4:1085(1086).; *var. nilotica* (L.) Benth in Hook., Lond. J.Bot.1:500(1842).

Vern. names: Garad, Sunt (Ar.).

Trees, up to 15m. high, with straight and cylindrical stems. Leaves bipinnate, alternate; leaflets 7-30 pairs, 1.5-4x0.5cm. Flowers capitate, yellow. Fruits pods, constricted between the seeds.

Habitat; Silty soils, khor and wadi banks.

Distribution: Northern and Central Sudan.

Medicinal uses: A decoction of the bark is taken for diarrhoea and dysentery, and the pods are used for cough and as a gargle for tonsillitis (ElGhazali,1985). The bark is peeled off and the phloem strands folded into a ball and chewed. The juice is used for treatment of sorethroat and coughs. The leaves may also be boiled in tea or coffee which is drunk without milk or sugar as a treatment for chest pains or pneumonia. Boiled roots used for indigestion or stomach trouble (Kokwaro,1993).



Plate (4). *Acacia nilotica* (L.) Wild. ex Del. subsp. *nilotica*



Plate (5). *Acacia oerfota* (Forssk.) Schweinf.

Acacia oerfota (Forssk.) Schweinf. in Bull. Herb. Bioss 4, App. II: 213 (1896). Plate (5).

Syn.: *Acacia nubica* Benth, in Hook., Lond. Journ. Bot. 1:498(1842).

A. virchowiana Vatke in Oes. Terr. Bot. Zeitschr. 30:275(1880);

A. merkeri Harms in E.J. 36:208(1905).

Vern. names: Laot (Ar.).

Shrubs up to 5m high, with basal branching. Leaves bipinnate, up to 6cm long; leaflets 6-12 pairs, linear. Flowers axillary heads. Fruits pods, yellow, pubescent.

Habitat: Lowland plains.

Distribution: Widespread.

Medicinal uses: The leaves are used as poultice for swelling. The roots are used for scorpion bite (ElGhazali, 1985). The smoke of stems and branches is used to cure rheumatism and back pains (ElGhazali *et al*, 1998). The ash from the burned plant is used as a protection against anthrax, while bark decoction is taken as emetic (Kokwaro, 1993).

Acacia seyal Del., *var. seyal* Brenan, Fl. Aegypt: 142, t, 52, Fig. 2 (1813). Plate (8).

Vern. names: Talh (Ar.).

Trees, up to 14m. high; with straight and cylindrical stems with red barks. Leaves bipinnate, alternate, up to 10cm. long; pinnae 3-9 pairs. Flowers in axillary heads, yellow. Fruits pods, linear, glabrous.

Habitat: Lowland plains.

Distribution: Widespread.

Medicinal uses: The stem is used as fumigant for women (ElGhazali, 1985), and also for rheumatic pains, to protect women against

cold and fever two weeks after birth, whereas the bark and the leaves are used in treating gastric ulcers. In addition, the gum is effective against rheumatism and inflammation of respiratory systems(Boulos,1983).

Acacia tortilis (Forssk.) Hayne, *subsp. spirocarpa* Arzeyk., Gebr. Gewachse.10:t,3191827). Plate (6).

Syn: *Mimosa tortilis* Forssk.,Fl.Aegypt-Arab.73,176(1775).

Vern. Names: Samur (Ar.).

Shrubs or small trees, up to 4m.high, with many stems from the base. Leaves 0.5-3cm long, pinnae 7-15 pairs. Flowers capitate, white. Fruits pods, twisted, constricted between seeds.

Habitat: Dry sites.

Distribution: Northern and Central Sudan.

Medicinal uses: The plant is used in witchcraft as follows:- Thorns are stuck in goat pancreas to blind a man who has evil eye(Kokwaro,1993).

Acacia tortilis (Forssk.) Hayne, *subsp. raddiana* (Sav.) Brenan in K.B.1957:87(1957). Plate (7).

Syn.: *A. raddiana* Sav. Alc.Acacie.Egiz;1(1830); *A. tortilis* Hayne var. *pubescens* A. Chev. In Bull.Soc.Bot.Fr.74:960(1927).

Vern. names: Sayal (Ar.).

Shrubs or small trees, up to 7m.high, with straight stems. Leaves 0.5-2cm long; pinnae 2-10 pairs. Flowers in axillary heads. Fruits pods, contorted, glabrous or compressed pubescent.

Habitat: Dry sites and Bank of wadis.

Distribution: Northern and Central Sudan.



Plate (6). *Acacia tortilis* (Forssk.) Hayne subsp. *spirocarpa*



Plate (6). *Acacia tortilis* (Forssk.) Hayne subsp. *raddiana*

Faidherbia albida (Del.)A.Chev.,in Rev.Bot.Appliq.14:86(1934).

Syn.: *Acacia albida* Del., in Ross.J.H.(1979).

Vern. names: Haraz (Ar.).

Large trees up to 20m.high. Leaves bipinnate; pinnae 4-6 pairs; leaflets 8-10 pairs, oblong. Flowers cream. Fruits pods, circularly coiled, flat, orange -yellow.

Habitat: Lowland plains.

Distribution: Widespread.

Medicinal uses: A decoction of bark is used orally against leprosy (Boulos,1983), for diarrhoea(ElGhazali et al,1987) and as a cure for cough(Kokwaro,1976).



Plate (8). *Acacia seyal* var. *seyal* Del.

NYCTAGINACEAE

Boerhaavia repens L. var. *diffusa*(L.) Hook. F., Pl. Brit. Ind. 4:709(1885).

Syn.: *B. adscendens* Willd., Sp.Pl. 1:19(1797); *B. coccina* Mill., Gard. Dict.No.4(1768).

Vern. Names: Rubaa, Shok alkhal. (Ar.)

Prostrate spreading annual herbs, with hollow, cylindrical stems. Leaves opposite, lanceolate-ovate, 1.5-3x0.5-1.5cm. Flowers axillary and terminal. Fruits indehiscent achenes.

Habitat: Moist sites.

Distribution: Widespread.

Medicinal uses: The entire plant is used as purgative, emetic and antisyphilitic(Boulos,1983). The whole plant burnt and ash rubbed on to the body to cure scabies. Dried leaves pounded and rubbed on paining chest(Kokwaro,1993).

PEDALIACEAE

Sesamum alatum Thonn. In Schum.& Thonn. Pisker. Guin.Pl.284., Andr. F.P.S.VI. 1,162(1950).

Vern. names: Simsim ElGumal (Ar.).

Erect herbs, 2-3 ft. high; stems sulcate. Lower leaves digitately divided almost to the base, the upper ones undivided; segments linear-lanceolate or oblanceolate, 1-3 in. long. Flowers pink, solitary, axillary. Fruits capsules, long- beaked.

Habitat: Lowland plains.

Distribution; Northern and Central Sudan.

PORTULACACEAE

PORTULACA L.

Key to species:

A. Leaves alternate, not woolly at nodes. *P. oleracea*

AA. Leaves opposite, woolly at nodes. *P. quadrifida*

Portulaca oleracea L., Sp. Pl. 445(1753).

Vern names: Rigla (Ar.).

Succulent glabrous prostrate or ascending annual herbs, up to 30cm.high, with cylindrical reddish brown stems. Leaves alternate, fleshy, flat, spatulate- oblanceolate, base round. Flowers yellow, sessile. Fruits capsules.

Habitat: Weed of cultivation.

Distribution: Widespread.

Medicinal uses: The entire plant is used as anti- bacterial, anti-inflammatory and anthementic to treat dysuria (WHO&IMM, 1990). The whole plant is also used antiphlogistic, diarrhoea, hemorrhoids, enterorrhagia, anti-diabetic, emollient, calmative, antiscorbutic, vermifuge (Boulos, 1983). The roots are used for snake bites (Kokwaro, 1976). The seeds are used as demulcent diuretic and slightly astringent (Bebawi *et al*, 1991).

Portulaca quadrifida L.,Mant. Pl.73 F(1767).

Vern. names: Um Mamleeha,Lagab Elhummar (Ar.).

Prostrate or decumbent, fatty annual herbs, mat forming, glabrous, up to 40 cm. across. Stems striate or angled and conspicuously woody at the nodes. Leaves opposite, fleshy, numerous very variable in size and shape, lanceolate or ovate lanceolate, woolly at the nodes. Flowers yellow. Fruits capsules, hirsute.

Habitat: Weeds of cultivation.

Distribution: Widespread.

Medicinal uses: The pounded and young stems are mixed with water and the strained off solution mixed with an extract of *Plectranthus cylindraceus* in treatment, for gastric ulcers. Leaves are used to cure scalded or swollen parts of the body. The leaves are pounded applied, to the affected area and then bandaged with a piece of cloth. Leaves are also chewed and the juice swallowed as a cure for toothache. Whole plant is pounded and applied on to wounds and burns(Kokwaro,1993).

RHAMNACEAE

Ziziphus spina-christi (L.) Desf., Fl. Atlant.20(1798).

Syn.: *Rhamnus spina-christi* L.,Sp. Pl.:195(1753); *Rhamnus nadeca* Forssk.,Fl. Aegypt- Arab.:204(1775); *Ziziphus nadeca* (Forssk.) Lam.,Engl.3;320(1789); *Z. spina-christi* Desf. var.*inermis* DC., Prodr.2:20(1825); *Z. spina-christi* (L.) Desf., var. *mitissima* Chiov., Fl. Somalia. 2139(1932).

Vern. Names: Sidder, Nabak (Ar.).

Armed trees or shrubs, up to 10m.high; stems short and branched, with grey fissured barks. Spines paired, one straight and the other downly hooked. Leaves alternate ovate to oblong- elliptic, 2-6x 1.5-3cm. Flowers greenish-yellow and very small. Fruits drupes, globose, edible.

Habitat: Lowland plains.

Distribution: Northern and Central Sudan.

Medicinal uses: The powdered leaves are used to heal the swellings, whereas the fruits are used to stop diarrhoea (Reported by locals, 2004). The water extract of the roots and barks are used for gonorrhoea and stomach plains (ElGhazali,1985), whereas the decocotions of the bark are used against intestinal spasms(ElGhazali et al, 1994). The maceration of the roots are used as anti-purgative (ElGhazali *et al*, 1997). The leaves are used against the losses of hair and dundroff, whereas the fruits are used for throat pains and the oil is applied for rheumatism (ElGhazali *et al*, 1998). The ash of the stems and branches mixed with vinegar are used for serpent bites (Boulos,1983). Leaves are used as a stringent, anthemintic, anti-charrhoeic, it is catapasm for abscesses, also put on swollen eyes before going to bed. Infusion of the fruits are used as febrifuges, emollient, laxative and reputed remedy for measles (Boulos,1983).

RUBIACEAE

Kohautica aspera (L.) Roxb. Andr.F.P.Anglo-egyp.Vol.II:451(1952)

Vern names: Um Hebiag (Ar.).

Erect much-branched herbs, up to 1ft.high; stems 4-angled. Leaves sessile linear to linear-lanceolate, 3x1.6 in. Flowers white, axillary and solitary. Fruits subglobose.

Habitat: Lowland plains.

Distribution: Central and Southern Sudan.

SALVADORACEAE

Key to genera:

A. Petals free..... *Dobera*

AA. Pods united into a short tube. *Salvadora*

Dobera glabra (Forssk.) Juss.ex Poir. in Lam., Encyl. Suppl.ii: 493(1812). Plate (9).

Syn.: *Salvadora glabra* (Forssk.)Bail. in Adansonia 9:290(1870); *Tomex glabra* Forssk.,Fl.Aegypt- Arab.:32(1775)

Vern. names: Maikah (Ar.).

Large trees; branchlets upwards. Leaves corciaceous, very variable in shape, ovate or obovate, 2-3 in. long. Flowers polygamous, in erect panicles. Fruits drupes, ellipsoid.

Habitat; Lowland plains.

Distribution: Widespread.



Plate (9). *Dobera glabra* (Forssk.) A. DC.

Salvadora persica L., F.W.T.A. ed. 2,1(2): 644(1858).

Vern. names: Arak. (Ar.).

Glabrous much branched evergreen shrubs or small trees, up to 4m. high, with greenish branches and solid, finely striate stems. Leaves simple, opposite, coriaceous, oblong. Flowers small, crowded in verticillate leafy sessile terminal and axillary heads. Fruits capsules.

Habitat: Moist sites.

Distribution: Central and Southern Sudan.

Medicinal uses: The plant is used for gonorrhoea, spleen, boils, sores, gum diseases, stomachache and anti-syphilitic. Powdered bark used for bites of poisonous animals. Oil diuretic. The fruits used for stomachache, carminative and febrifuge (Boulos, 1983).

SOLANACEAE

Key to Genera:

A. Anthers opening by longitudinal slits. *Physalis*

AA. Anthers opening by terminal pores. *Solanum*

Physalis angulata L., Sp. Pl. : 183(1753).

Vern names: Karam karam, Fruta (Ar.).

Pubescent erect to ascending annual herbs up to 50cm.high, with angular and fleshy stems. Leaves alternate, ovate, coarsely serrate, 2.5-7x1-5cm. Flowers uniformly yellow, axillary, solitary. Fruits berries.

Habitat: Moist sites.

Distribution: Central Sudan.

Medicinal uses: The leaves are used to treat abdominal pains (Adjanhoun et al,1993).

SOLANUM L.

Key to species:

A. Spinescent or prickly herbs; flowers violet; fruits yellow.. *S. coagulans*

AA. Glabrous herbs; flowers white; fruits black. *S. nigrum*

Solanum coagulans Forssk., Fl. Aegypt- Arab.: 107(1775).

Syn.: *S. dubium* Fresen., Mus. Senk., 1:66(1833).

Vern. names: Gubbain, Nuda, Tellet (Ar.).

Spinescent, erect to prostrate perennial herbs, up to 40cm.high, with armed and cylindrical stems. Leaves broadly ovate to ovate- lanceolate, 3-11x1-5cm. Flowers axillary, violet. Fruits berries, yellow, globose.

Habitat: Lowland plains

Distribution: Northern and Central Sudan.

Medicinal uses: Boiled roots used for threatened mis-carriage. The roots are chewed by expectant mother who may be experiencing an abdominal pain(Kokwaro,1993).

Solanum nigrum L., Sp. Pl.:186(1753).

Syn.: *S. nodiflorum* Jacq., Ican. 2.11.t,326(1852).

Vern. names: Einab ElDeeb (Ar.).

Glabrous ascending to erect leafy annual herbs up to 50cm.high, with hollow, cylindrical stems. Leaves alternate, ovate, 5-12x 2-6cm. Flowers white umbellate cymes, at or above the nodes. Fruits berries, black, globose.

Habitat: Moist sites.

Distribution: Widespread.

Medicinal uses: The cataplasm of the entire plant is used as camative, emollient for burn dermal affections, as article of diet for dropsical and other suffering from chronic inflammation of liver (Bebawi *et al*, 1991). The leaves are used to treat high blood pressure (Adjanooun *et al*,1993), and also to keep the fetus in the womb, in case of repeated abortion(Adjanooun et al,1994). The berries are used as mydriatic eye lotion, ear drops and narcotic analgesic, if used extrenaly, sedative (Bolous, 1983), and also as purgative (Bebawi *et al*, 1991). The seeds are a phrodistic (Bolous, 1983).

TILIACEAE

CORCHORUS L.

Key to species:

- A. Perennial herbs, leaves not tailed at the base:
 - B. Prostrate or decumbent herbs, leaves elliptic or obovate.....
 -*C.depressus*
 - BB.Erect herbs, leaves oblong or lanceolate.....
 -*C.fascularis*
- AA. Annual herbs, leaves tailed at the base....
 -*C.tricularis*

Corchorus depressus Stocks, in Proc.Linn.Soc.(1848).

Syn.: *C. antichorus* Raeush., Nom. Bot. ed 3:158(1979).

Vern. names: Sutab, Umshiteh (Ar.).

Prostrate or decument perennial herbs, with strong roots, and cylindrical stems. Leaves elliptic or obovate-elliptic,1-4x0.7-1cm. Flowers solitary or paired. Fruits capsules, sub-sessile.

Habitat: Moist sites.

Distribution: Northern and Central Sudan.

Corchorus fascularis Lam., Ency.Meth. Bot. 2:104(1786).

Vern. Names: Khudra, Mulukhia (Ar.).

Annual or perennial herbs up to 50cm.high, with hollow stems and lax branches. Leaves oblong or lanceolate,4-10x1-2cm. Flowers yellow. Fruits capsules, in clusters, sub-sessile, beaked.

Habitat: Weed of cultivation.

Distribution: Central and Southern Sudan.

Corchorus trilocularis L., Syst. Nat. Ed. 12,2:349(1767).

Vern. names: Molokhiat Elkhala (Ar.).

Herbaceous or half woody annual herbs up to 60cm. high, with hollow stems. Leaves elliptic or oblong- lanceolate, 5-17x1-3cm. Flowers yellow. Fruits capsules, slender, 3-valved.

Habitat: Weed of cultivation.

Distribution: Central Sudan.

ZYGOPHYLLACEAE

Key to Genera:

A. Leaves pinnate,; fruits tipped by 2 rigid divergent spines..

.*Tribulus*

AA. Leaves 1-3 foliate; fruits tipped by hard persistent style. ...

.*Fagonia*

Fagonia cretica L.,Sp.Pl.:386(1753).

Vern. names: Umm showeika, Sholib (Ar.).

Diffuse, spinescent woody annual herbs, up to 50cm.high. Leaves opposite; leaflets linear- lanceolate, 1-2x0.2cm. Flowers axillary solitary. Fruits capsules, ovate.

Distribution: Northern and Central Sudan.

Medicinal uses: The maceration of the whole plant is used for heat burn and anti-spasmodic(ElGhazali,1986; ElGhazali *et al*,1997). The fumigant of the whole plant is used against muscular pains(ElGhazali,1994).

Tribulus terrestris L.,Sp.Pl.:387(1753).

Syn.: *T. Lanuginosus* L.,Loc. Cit.; *T. hispidus* Pers., Bot. Bemerk.:29 (1845); *T. terresteris* L. var. *hispidissimus* Sond. in.Fl.Cap.1:353(1860).

Vern. names: Dereisa (Ar.).

Prostrate, spreading annual herbs, up to 30cm. high, with hollow cylindrical striate stems. Leaves opposite; leaflets ovate, 0.4-1x0.3cm. Flowers single, axillary and bright yellow.

Habitat: Waste lands.

Distribution: Widespread.

Medicinal uses: The fruits are used to improve sexual activity of males(Reported by locals,2005). The extracts of the plant are used as anti spasmodic. The fruits are used as a tonic in spermatorrhoea, nearashemia, astringent, oral inflammation deterrent, diuretic, also for dysentery and pain of bladder(Boulos,1983).

MONOCOTYLEDONS

CYPERACEAE

Key to Genera:

A. Spikes up to 0.5cm.long; glumes arranged in more than one plane; bracts prickly at the apex. *Fimbristylis*

AA. Spikes 1-2.5 cm. long; glumes arranged in one plane; bracts glabrous at the apex. *Cyperus*

Cyperus rotundus L., Sp.Pl.:67(1753).

Syn.: *C. friginus* Forssk., Fl.Aegypt-Arab.14: (1775).

Vern. names: (Ar.) Seida, Elseid.

Glabrous erect perennial herbs, up to 30cm.high, with triangular solid, culms and under-ground corms. Leaves linear, up to 18cm.long and 0.4cm.broad. Flowers umbels, simple or compound; spikes loose; spikelets red-brown. Fruits nuts, dark brown.

Habitat: Weed of cultivation and water catchment areas.

Distribution: Widespread.

Medicinal uses: The fresh roots are diaphoretic and astringent. They are used for indigestion in children and in fevers(Broun and Massey,1929).

Roots used medicinally for colic, indigestion, cough, and heart troubles. It is also worn as a protective charm against various ailments (Kokwaro, 1993). The rhizome is successfully used in the treatment of irregular mensuration, dymenorrhoea, gestralgia, dyspepsia, diarrhoea, and vomiting(WHO&IMM,1990).

Fimbristylis bis-umbellata (Forssk.) Bulb., Dodecanthea:30(1850).

Syn.: *Scripus bis-umbellatus* Forssk., Fl. Aegypt-Arab:15(1775);

Fimbristylis dicotoma Vahl, Enam.2:287(1805).

Vern. names: Dign Eltais (Ar.).

Pubescent erect tufted annual herbs, up to 20cm.high, with thin culms. Leaves setaceous or linear, 10x0.1cm. Flowers compound umbels, with numerous spikelets, rust- coloured. Fruits nutlet-like.

Habitat: Water catchment areas and Weeds of cultivation.

Distribution: North and Central Sudan.

POACEAE(GRAMINEAE)

Key to Genera:

- A. Spikelets 1- to many- flowered, more or less laterally compressed:
 - B. Spikelets borne in open or contracted or spike- like panicles
 - C. Spikelets usually with 2 or more fertile florets:
 - D. Spikelets sessile, lemmas awned:
 - E. Spikes or racemes arranged on an elongated axis. ..*Dinebra*
 - EE. spikes or racemes digitate:
 - F. Spikelets spreading at right angles; awns curved.....
..... *Dactyloctenium*
 - FF. Spikelets sub-imbricate; awns not curved.....
.....*Dicanthium*
 - DD. Spikelets pedicellate; lemmas awnless.....
.....*Eragrostis*
 - CC. Spikelets with 1-fertile floret; lemmas 3- awned.....

.....*Aristida*

BB. Spikelets sessile or shortly pedicellate along one side of the axis of solitary digitate or scattered spikes:

G. Spikelets with 1-fertile and/ or more imperfect florets above or below the fertile one. *Chloris*

GG. Spikelets with 1-fertile floret and no imperfect florets:

H. Spikelets awnless or very shortly awned.

.....*Cynodon*

HH. Spikelets with long flexuous awns.....

.....*Schoenefeldia*

AA. Spikelets 2-flowered, falling entirely at maturity:

I. Spikelets solitary or paired, more or less similar:

J. Spikelets falling entirely, and singly:

K. Spikelets arranged in open panicles, contracted and spike-like:

L. Spikelets not subtended by bristle-like branches.....*Panicum*

LL. Spikelets subtended by 1-to many bristle-like branches.....

.....*Setaria*.

KK. Spikelet arranged in one sided spikes or spike-like racemes...

.....*Brachiaria*

JJ. Spikelet falling in clusters with involucre of bristles:

M. Bristles connate at base or to beyond the middle, often rigid or spine like. *Cenchrus*.

MM. Bristles free to the base, fine to very fine.....*Pennisetum*

II. Spikelets often paired with one sessile and the other pedicellate...

.....*Sorghum*.

Aristida adscensionis L., Sp.Pl.: 82,1753.

Syn.: *A. submucronata* Schumach., Besker. Gll.in Pl.: 47(1827); *A. muritiana* A.Rich., Tent.Fl. Abyss.2: 392(1851).

Vern. names: Humra (Ar.).

Erect or spreading annual herbs, up to 40cm.high, with cylindrical solid culms. Leaves linear,11x0.2cm. Flowers spikes, upper glumes distinctly emarginated. Fruits caryopsis..

Habitat: Weed of cultivation.

Brachiaria L.

Key to species:

A. Ascending perennial herbs; leaves linear. *B. mutica*

AA. Prostrate annual herbs; leaves lanceolate. *B.reptans*

Brachiaria mutica Stapf. in Prain., Fl. Trop. Afr. Ix 526(1919).

Syn.: *Panicum muticum* Forssk., Fl. Aegypt-Arab: 20(1775).

Vern. names: Korraib (Ar.).

Ascending perennial herbs up to 2m.high, with cylindrical hollow culms and rooting at lower nodes. Laminas linear, 5-30x0.6-2cm. Flowers spike-like racemes. Fruits caryopsis.

Habitat: Flat moist areas.

Distribution: White Nile, Equatoria.

Brachiaria reptans (L.) Garden. & Hubbard. Andr.F.P.S.Vol.III: 404 (1956).

Vern. names: Um Kewaiat (Ar.).

Prostrate or creeping annual or subperennial herbs. Laminas lanceolate to ovate or linear- lanceolate, 1/2-2 x1/2 in .long. Flowers spikelets, more or less closely arranged. Fruits caryopsis.

Habitat; Weed of cultivation.

Distribution: Northern and Central Sudan.

Cenchrus biflorus Roxb., Fl. Ind.1:238(1920). Plate (10).

Syn.: *C. barbatus* Schum., Beskr. Guim. Pl. 43(18270); *C. catharticus* Del., Cat. Hort. Monsp. (1838).

Vern. names: Haskanit khashin (Ar.).

Erect or ascending herbs, up to 90cm.high, with cylindrical yellowish culms and rooting at the lower nodes. Leaf sheaths compressed and keeled; ligules with densely ciliate rims; laminas linear, 3-30x0.2-0.8cm. Flowers spikes- like racemes. Fruits caryopsis.

Habitat: Flat areas.

Distribution: Northern and Central Sudan.

Chloris virgata Swartz., Fl.Ind. Occ. 1:203(1797).

Syn.: *Rhabdochloea virgata* (Sw.) P.Beauv., Ess.Agrost.84:158,1812; *Chloris compressa* DC.,Cat.Hort. Monsp.: 94(1812); *C.elegan* S.H.B.K. Nor.,Gen. Sp. 1:166t.49, 1816.

Vern. Names: Karm Elshaib,Um Faru, Afen Elkhameem (Ar.).

Erect or ascending perennial & annual herbs, up to 90cm. high,with cylindrical, solid culms. Leaves linear,12x0.5cm. Flowers, spikes, whitish green, sessile. Fruits caryopsis.

Habitat: Weed of cultivation.

Distribution: Northern and Central Sudan.

Medicinal uses: Leaves pounded, soaked in water and applied on wounds to prevent bacterial infection(Kokwaro,1993).

Cynodon dactylon (L.) Pers., Syn. Pl.: 58(1805).

Syn.: *Panicum dactylon* L., Sp.Pl.: 58(1753);*Cynodon glabrous* Steud., Syn. Pl. Glum. 1:212(1854).

Vern. Names: Nagil or Nagila (Ar.).

Erect prostrate perennial herbs, up to 30cm.high, with cylindrical solid culms. Leaves usually conspicuously distichous; laminas linear, up to 15x0.3cm. Flowers spikes; spikelets light green. Fruits caryopsis.

Habitat; Weeds of cultivation.

Distribution: Widespread.

Medicinal uses: Decocotion of rhizomes are used for renal urinary troubles depurative emmenagogue, diuretic, refreshing agents, sudorific, emollient for cough, for suppression of urine and vesical caculus, for purifying the blood, disinfectant, vulneray (Boulos, 1983). The tops of this plant are used to treat scabies and for pain due to trauma or injury(Adjanhoun *et al*,1993). Leaf decoction mixed with banana beer drunk as a remedy for liver diseases (Kokwaro, 1993).

Dactyloctenium aegyptium (L.) Willd., Enum. Hort. Berol.: 129 (1809). Plate (11).

Syn.: *Cynosurus aegyptius* L., Sp. Pl. 1:72(1753); *Eleusine aegyptia* (L.) Desf., Fl. Atlant. 1:85(1798).

Vern names: Umm Asabiaa (Ar.).

Prostrate to decumbent annual herbs, up to 45cm.high, with solid striate compressed culms. Leaves linear, up to 13x0.4cm. Flowers in spikes, scabrous; spikelets spreading at right angles. Fruits caryopsis.

Habitat: Weed of cultivation.

Distribution: Widespread.

Dicanthium annulatum Stpf. in Prain, Fl.Trop. Afr. IX :178(1917).

Vern. names: Lukh(Ar.).

Densely tufted perennial herbs; culms up to 3 or more ft. high. Laminas linear, up to 12 in. long. Flowers in spikes, subdigitate; spikelets- subimbricate. Fruits caryopsis.

Habitat; Weeds of cultivation.

Distribution: Northern and Central Sudan.

Dinebera retroflexa (Vahl) Panz., Dank., Acad. Munch. 1813:270,t.12 (1814).

Syn.: *Cynosurus retroflexa* Vahl,Symb.Bot. 2: 20(1791); *Dinebera arabica* Jacq., Fragm.&7,t. 121/1(1809); *Leptochloa arabica* (Jacq.) Kunth., Rev. Gram. 1:91(1820).

Vern.names: Um Maliha (Ar.).

Pubescent erect or ascending annual herbs, up to 1m.high, with compressed, hollow culms. Laminas linear. Flowers in spikes; spikelets loosely imbricate. Fruits caryopsis.

Habitat: Weed of cultivation.

Distribution: Widespread.



Plate (10). *Cenchrus biflorus* Roxb.



Plate (11). *Dactyloctenium aegyptium* (L.) Beauv.

ERAGROSTIS Beauv.

Key to species:

- A. Panicles narrow, more or less spike-like, dense..... *E. cilianensis*
AA. Panicles ovoid or oblong, loose and open or contracted but not spike-like..... *E.tenella*

Eragrostis cilianensis (Au.) Lut., F.T. Hubb. in philip., J.Sc. C, Bot., 8:159(1913).

Syn.: *Briza eragrostis* L., Sp. Pl. 70(1753); *Poa cilianensis* Au., Fl. Pedom. 2:246,t.91/2(1785).

Vern. Names: Bannu, abu Meleh (Ar.).

Erect ascending annual herbs, up to 80cm.high,with hollow cylindrical culms.Laminas linear up to 12x0.5cm. Flowers in spikes; spikelets, narrowly ovate to narrowly oblong. Fruits caryopsis.

Habitat: Weed of cultivation.

Distribution: Widespread.

Eragrostis tenella (L.) Beauv. Ex Roem. &Schut., Andr .F .P .S .VI .3 , 452 (1956).

Vern. names: Banu (Ar.).

Loosely tufted annual herbs,2-20 in.high. Laminas flat or rolled, glabrous. Spikelets green-or purplish, loose, 3-9-flowered. Fruits caryopsis.

Habitat: Weed of cultivation.

Distribution: Central Sudan.

Panicum turgidum Forssk., Fl. Aegypt-Arab:18(1775). Plate (12).

Vern. names:Tumam(Ar.).

Glabrous erect perennial or annual herbs, up to 1.2m.high, culms woody, solid, glabrous, many-nodded. Laminas linear. Flowers in spikes; panicles very variable in size; spikelets swollen, ovoid. Fruits caryopsis.

Habitat: Lowland plains.

Distribution: Northern and Central Sudan.

Pennisetum pedicellatum Trin. In Mem.Acad. Sci. Peters.6,3:184(1934).

Syn.: *P.lanuginosum* Hochst.in Flora,27:252(1844); *P.implicatum* Steud., Sun.Pl. Glum.1:107(1854).

Erect annual herbs, up to 130cm.high, with cylindrical and much branched culms. Laminas linear to linear lanceolate, 20x1cm. Flowers spikes; spikelets lanceolate; bristles dense woolly. Fruits caryopsis.

Habitat: Weeds of cultivation.

Distribution: Central and southern Sudan.

Schoenefeldia gracilis Kunth., Rev. Grm.1:283,t.53(1830); Broun and Massey, F.S.:478(1929); Andr. F.P.S.3:530(1956).

Vern names: Zanab ElNaga(Ar.).

Erect annual herbs, up to 50cm.high; culms tufted. Laminas linear. Flowers in spikes, golden; spikelets dense, in 2 rows. Fruits caryopsis.

Habitat: Flat areas.

Distribution: Northern and Central Sudan.

Setaria verticillata (L.) P. Beauv., Ess. Agrost. 51.,178(1812).

Syn.: *Panicum verticillatum* L., Sp.Pl.ed.2.,:82(1762); *S.viridis*(L.)

P.Beauv. *var. insularis*, Terracc-in Ann. Ist. Bot. Roma, 5:93(1894).

Vern. names: Lussaig (Ar.).

Erect or ascending loosely tufted annual herbs, up to 120cm. high, with hollow cylindrical culms. Laminas broadly linear, up to 30x1.6cm. Flowers in spikes; spikelets ellipsoid. Fruits caryopsis.

Habitat: Waste lands and dampy sites.

Distribution: Northern and Central Sudan.

Medicinal uses: For diarrhoea, leaves and inflorescences are pounded, cold water added and juice drunk 3 times a day (Kokwaro,1993).

Sorghum purpureosericum (Hochst.) Aschers.& Schweinf., Andr., Fl. Pl. Sud.3:543(1956).

Vern. names: Adar (Ar.).

Erect annual herbs, up to 90cm.high, with stout, cylindrical culms. Laminas linear, up to 40x2cm. Flowers in spikes; spikelets sessile, lanceolate. Fruits caryopsis.

Habitat: Weed of cultivation.

Distribution: Central Sudan.



Plate (12). *Panicum turgidum* Forssk.

5.1.1. Endangered, threatened, extinct and famine food species at the study area:

The evidence for climatic fluctuations have been noted in the study area from both historical and meteorological records, whereas the sand drifts, the increasing human and animal populations were observed.

During the drought spells in 1975, 1984, some of the species at the study area were lost. Drought hit again the study area in 1990 but the losses were far less. A combination of factors has led to disappearance of some species.

Table (1): Endangered and threatened species at the study area:

Species	Family	Vern. names	Habit
<i>Acacia mellifera</i>	Mimosaceae	Kitir	Tree
<i>A. seyal var. seyal</i>	Mimosaceae	Talih Ahmer	Tree
<i>Commiphora africana</i>	Burseraceae	Gafal	Tree
<i>Dobera glabra</i>	Salvadoraceae	Maikah	Tree
<i>Salvadora persica</i>	Salvadoraceae	Arak	Tree

Table(2): Extinct plant species at the study area:

Species	Family	Vern. names	Habit
<i>Asparagus racemosus</i>	Liliaceae	Diayok	Climber
<i>Blechnum linariifolia</i>	Acanthaceae	Begail/ Seha	Herb
<i>Bergia suffruticosa</i>	Elatinaceae	El Rimmit	Undershrub
<i>Combretum aculeatum</i>	Combretaceae	Sheheit	Shrub
<i>Chrysopogon aucheri</i>	Poaceae	Aigrab	Herb
<i>Cienfuegosii digitata</i>	Malvaceae	El Gutub	Shrubby
<i>Cymbopogon proximes</i>	Poaceae	Maharieb	Herb
<i>Ceratotheca sesamoides</i>	Pedaliaceae	Abadie	Herb

<i>Dalbergia melanoxylon</i>	Fabaceae	Abanous	Tree
<i>Cordia rothii</i>	Boraginaceae	Andrab	Tree
<i>Grewia mollis</i>	Tiliaceae	Basham	Tree
<i>G. tenax</i>	Tiliaceae	Gudiem	Shrub
<i>G. villosa</i>	Tiliaceae	Geraigdan	Shrub
<i>Indigofera suavolens</i>	Fabaceae	Singid	Climber
<i>Tragus berteronianus</i>	Poaceae	El Rabul	Herb
<i>Trichodesma africanum</i>	Boraginaceae	El Herish	Herb

Table (3): Famine food plant species at the study area :

Species	Family	Vern. names	Habit	Parts used for food
<i>Balanites aegyptiaca</i>	Balanitaceae	Hegleig	Tree	Fruits
<i>Boscia senegalensis</i>	Capparidaceae	Mokhiet	Tree	Fruits
<i>Brachairia mutica</i>	Poaceae	Korieb	Herb	Seeds
<i>Cenchrus biflorus</i>	Poaceae	Haskaneit	Herb	Seeds
<i>Capparis decidua</i>	Capparidaceae	Tundub	Tree	Fruits
<i>Dactyloctenium aegyptium</i>	Poaceae	Um Asabie	Herb	Seeds
<i>Dobera glabra</i>	Salvadoraceae	Maikah	Tree	Fruits
<i>Grewia tenax</i>	Tiliaceae	Gudiem	Shrub	Fruits
<i>G. villosa</i>	Tiliaceae	Geraigdan	Shrub	Fruits
<i>Maerua crassifolia</i>	Capparidaceae	Sareh	Tree	Fruits
<i>Panicum turgidum</i>	Poaceae	Tumam	Herb	Seeds
<i>Ziziphus spina-christi</i>	Rhamnaceae	Sidr	Tree	Fruits

5.2. Ecological parameters:

The ecological parameters studied include: Density, Abundance, Frequency, Diversity, Similarity, Association, Biomass and carrying capacity, Soil seed bank and natural regeneration.

5.2.1. Ecological studies on woody species:

42 systematic sample plots (50x50m) were surveyed to investigate the trees and shrubs for the ecological parameters listed above. The results were as follows:

1. Density (D): The density of the trees and shrubs in the study area differs from site to another according to the topography. The densities of woody species (stems/ha.) at sites A, B and C were 20, 14.9 and 22.1 respectively. The mean density of the woody species for the whole study area was calculated according to the following formula:

$$D = \frac{203 \times 10000}{42 \times 2500} = 19.3 \text{ stems/ha.}$$

2. The relationship between abundance, density and frequency of

The dominant woody species at the study area: This was determined according to the following formula: $D = \frac{A \times F}{100}$

Table (4): Abundance, density and frequency of the dominant woody species at the study area:

Species	Abundance (Species/ ha.)	Density (Species/ha.)	Frequency %
<i>Acacia oerfota</i>	12.0	0.9	7.14
<i>A. tortilis subsp. raddiana</i>	6.7	3.1	45.23
<i>A. tortilis subsp. spirocarpa</i>	24.2	13.2	54.76
<i>Maerua crassifolia</i>	6.0	0.6	9.52
<i>Ziziphus spina-christi</i>	16.0	0.8	4.62

The density of *Acacia tortilis subsp. spirocarpa* was associated with high frequency and high abundance while that of *A. tortilis subsp. raddiana* was associated with high frequency and low abundance. The densities of *A. nubica*, *Maerua crassifolia* and *Ziziphus spina-christi* were associated with low frequency and low abundance.

5-2-2. Similarity coefficients between sites:

Similarity coefficients among sites were determined by using Sorensen coefficient (Ss) as follows:

$$Ss = \frac{2a}{2a + b + c} \times 100$$

**Table (5): The presence / absence of woody species at the study area:
(0 = absent , 1 = present)**

Species	Site	Site	Site
	A	B	C
<i>Acacia mellifera</i>	0	0	1
<i>A. nilotica subsp. nilotica</i>	1	0	0
<i>A. oerfota</i>	1	0	0
<i>A. tortilis subsp. raddiana</i>	1	1	1
<i>A. seyal var. seyal</i>	0	0	1
<i>A. tortilis subsp. spirocarpa</i>	1	1	1
<i>Balanites aegyptiaca</i>	1	0	0
<i>Capparis decidua</i>	1	0	0
<i>Maerua crassifolia</i>	0	1	1
<i>Ziziphus spina- christi</i>	0	0	1
Total	6	3	6

A -Similarity between site A and B:

$$Ss (A\&B) = \frac{4}{13} = 0.3076 \times 100 = 30.8\%$$

B-Similarity between site A and C:

$$Ss (A\&C) = \frac{4}{16} = 0.25 \times 100 = 25\%$$

C-Similarity between site B and C:

$$Ss (B \&C) = \frac{6}{15} = 0.4 \times 100 = 40 \%$$

5.23. Diversity between species:

This was calculated according to Simpson's Index (SiD) as follows:

$$\text{SiD} = \frac{N(N-1)}{\sum n(n-1)}$$

Table (6); Diversity index (SiD) between woody species at the study area:

Species	n	n-1	n(n-1)
<i>Acacia mellifera</i>	2	1	2
<i>A. nilotica subsp. nilotica</i>	1	0	0
<i>A. oerfota</i>	9	8	72
<i>A. tortilis subsp. raddiana</i>	32	31	992
<i>A. seyal var. seyal</i>	3	2	6
<i>A. tortilis subsp. spirocarpa</i>	139	138	19182
<i>Balanites aegyptiaca</i>	2	1	2
<i>Capparis decidua</i>	1	0	0
<i>Maerua crassifolia</i>	6	5	30
<i>Ziziphus spina- christi</i>	8	7	56
Total	203		20342

$$N(N-1) = 203 \times 202 = 41006$$

$$\sum n(n-1) = 20342$$

$$\text{SiD} = \frac{41006}{20342} = 2.02$$

$$20342$$

5.24. Association between dominant woody species:

Association between any two dominant woody species was determined using $X^2 = \frac{(a \times d - b \times c)^2}{N}$. The results are presented as

$$(a+b)(c+d)(a+c)(b+d)$$

follows:

Table (7): The degree of association between *Acacia tortilis subsp. spirocarpa* and *A. tortilis subsp. raddiana*.

Acacia tortilis subsp. spirocarpa

	+	-	
<i>A. tortilis subsp raddiana</i>	+	6 (c)	19 (a+c)
	-	13 (d)	23 (b+d)
	23 (a+b)	19 (c+d)	42

$$X^2 = \frac{(13 \times 13 - 10 \times 6) - 0.5 \times 42}{23 \times 19 \times 19 \times 23} = 1.703$$

The nature of association is determined by calculating the expected frequency of joint occurrence (Cell a): J.O = $\frac{(a+b)(a+c)}{N}$

$$N (=a+b+b+c+d)$$

$$J.O. = \frac{23 \times 19}{42} = 10.40$$

Table (8): The degree of association between *Acacia tortilis subsp. spirocarpa* and *A. oerfota*.

Acacia tortilis subsp. spirocarpa

A. oerfota

	+	-	
+	1	2	3
-	22	17	39
	23	19	42

$$X^2 = \frac{(1 \times 17 - 2 \times 22)^2}{23 \times 19 \times 3 \times 39} = 1.89$$

$$J.O. = \frac{69}{42} = 1.64$$

Table (9) :The degree of association between *Acacia tortilis subsp. spirocarpa* and *Maerua crassifolia*:

Acacia tortilis subsp. spirocarpa

Maerua crassifolia

	+	-	
+	4	-	4
-	19	19	38
	23	19	42

$$X^2 = \frac{(19 \times 4 - 19 \times 0)^2}{23 \times 19 \times 4 \times 19} = 3.82$$

$$J.O. = \frac{92}{42} = 2.19$$

Table (10) : The degree of association between *Acacia tortilis subsp. spirocarpa* and *Ziziphus spina-christi*.

Acacia tortilis subsp. spirocarpa

	+	-	
<i>Ziziphus spina-christi</i>			
+	1	1	2
-	22	18	40
	23	19	42

$$X^2 = \frac{(1 \times 18 - 22 \times 1) - 0.5 \times 42)^2}{23 \times 19 \times 2 \times 40} = 0.75$$

$$J.O. = \frac{66}{42} = 1.64$$

Table (11): The degree of association between *Acacia tortilis subsp. raddiana* and *A.oerfota*.

Acacia tortilis subsp. raddiana

	+	-	
<i>A.oerfota</i>			
+	-	3	3
-	19	20	39
	19	23	42

$$X^2 = \frac{(0 \times 20 - 19 \times 3) - 0.5 \times 42)^2}{19 \times 23 \times 3 \times 39} = 4.997$$

$$J.O. = \frac{57}{42} = 1.357$$

Table (12) : The degree of association between *Acacia tortilis subsp. raddiana* and *Maerua crassifolia*.

Acacia tortilis subsp. raddiana

	+	-		
<i>Maerua crassifolia</i>	+	3	1	4
	-	16	23	39
		19	24	42

$$X^2 = \frac{(3 \times 23 - 16 \times 1) - 0.5 \times 42)^2}{42} = 0.604$$

$$\frac{19 \times 24 \times 4 \times 39}{}$$

$$J.O. = \frac{76}{42} = 1.809$$

Table (13) : The degree of association between *Acacia tortilis subsp. raddiana* and *Ziziphus spina-christi*

Acacia tortilis subsp. raddiana

	+	-		
<i>Ziziphus spina-christi</i>	+	1	1	2
	-	18	22	40
		19	23	42

$$X^2 = \frac{(1 \times 22 - 18 \times 1) - 0.5 \times 42)^2}{42} = 0.347$$

$$\frac{19 \times 23 \times 40 \times 2}{}$$

$$J.O. = \frac{38}{42} = 0.904$$

Table (14): The degree of association between *Acacia oerfota* and *Maerua crassifolia*.

		<i>Acacia oerfota</i>		
		+	-	
<i>Maerua crassifolia</i>	+	-	4	4
	-	3	35	38
		3	39	42

$$X^2 = \frac{(0 \times 35 - 3 \times 4) - 0.5 \times 42)^2}{42} = 2.571$$

$$\frac{3 \times 39 \times 4 \times 38}{}$$

$$J.O. = \frac{12}{42} = 0.285$$

Table (15): The degree of association between *Acacia oerfota* and *Ziziphus spina-Christi*

		<i>Acacia oerfota</i>		
		+	-	
<i>Ziziphus spina-christi</i>	+	-	4	4
	-	3	35	38
		3	39	42

$$X^2 = \frac{(0 \times 37 - 3 \times 2) - 0.5 \times 42)^2}{42} = 3.27$$

$$\frac{3 \times 39 \times 2 \times 40}{}$$

$$J.O. = \frac{6}{42} = 0.14$$

Table (16): The degree of association between *Maerua crassifolia* and *Ziziphus spina-christi*

		<i>Maerua crassifolia</i>		
		+	-	
<i>Ziziphus spina-christi</i>	+	-	2	2
	-	4	36	40
		4	38	42

$$X^2 = \frac{(0 \times 36) - (4 \times 2) - 0.5 \times 42)^2}{4 \times 38 \times 2 \times 40} = 2.904$$

$$J.O. = \frac{8}{42} = 0.19$$

Table (17) : Summary of the degree of association between the dominant woody species, as determined by observed cell(a) values and expected joint occurrence:

Species	Obs.(a) values	Exp. J.O.	Sig.
<i>Acacia tortilis subsp spirocarpa</i> and <i>A. tortilis subsp. raddiana</i>	13	1.703	*
<i>Acacia tortilis subsp. spirocarpa</i> and <i>A. oerfota</i>	1	1.64	n.s
<i>Acacia tortilis subsp. spirocarpa</i> and <i>Maerua crassifolia</i>	4	2.19	*
<i>Acacia tortilis subsp. spirocarba</i> and <i>Ziziphus spina-christi</i>	1	1.10	n.s
<i>Acacia tortilis subsp. raddiana</i> and <i>A.oerfota</i>	-	1.35	n.s
<i>Acacia tortilis subsp. raddiana</i> and <i>Maerua crassifolia</i>	3	1.81	*
<i>Acacia tortilis subsp. raddiana</i> and <i>Ziziphus spina- christi</i>	1	0.90	*
<i>Acacia nubica</i> and <i>Maerua crassifolia</i>	-	0.29	n.s
<i>Acacia nubica</i> and <i>Ziziphus spina-christi</i>	-	0.14	n.s
<i>Maerua crassifolia</i> and <i>Ziziphus spina-christi</i>	-	0.19	n.s

From the results in the above table, it can be observed that: There was a positive association between each of the following two species: *Acacia*

tortilis subsp. spirocarpa and *A. tortilis subsp. raddiana*, *Acacia tortilis subsp. spirocarpa* and *Maerua crassifolia*; *Acacia tortilis subsp. raddiana* and *Maerua crassifolia*, *Acacia tortilis subsp. raddiana* and *Ziziphus spina-christi*. There was a negative association between any two of the other dominant woody species.

5.2.5. Soil Seed bank:

42 soil samples were taken from 3 sites in the study area (A,B &C) to determine the seed bank. The seeds were identified for each soil site and consequently species composition in each site was determined. Three soil depths (0-5, 5-10, 10-15cm.) were chosen for each site and seed densities and the number of live and dead seeds were determined for each depth.

Table (18) Soil seed bank at Site (A):

Depths (cm)

Species	0 -----5		5-----10		10 ----- 15		Total	
	Live	Dead	Live	Dead	Live	Dead	Live	Dead
<i>Aristida adscensionis</i>	9	39	-	1	-	7	9	47
<i>Abutilon figarianum</i>	-	-	-	-	-	2	-	2
<i>Acacia oerfota</i>	-	2	-	-	1	-	1	2
<i>A. tortilis</i>	1	-	-	-	-	-	1	-
<i>Brachiaria mutica</i>	5	2	-	-	-	-	5	2
<i>Brachiaria reptans</i>	12	75	3	26	-	8	15	99
<i>Cleome escaposa</i>	2	10	-	1	-	6	2	17
<i>Cyperus rotundus</i>	20	3	2	3	-	6	22	12
<i>Corchorus s.p</i>	4	8	-	3	2	-	6	11
<i>Cyperus sp.</i>	36	2	-	1	-	-	36	3
<i>Chloris virgata</i>	-	2	1	-	-	-	1	2
<i>Dactylectonium aegyptium</i>	15	3	3	-	-	1	18	4
<i>Euphorbia aegyptiaca</i>	8	60	-	6	4	26	12	92
<i>Eragrostis sp</i>	1	3	-	-	-	1	1	4
<i>Fimbristilis biss-umbellta</i>	7	-	-	-	-	-	7	-
<i>Indigofera hochstetteri</i>	3	2	4	-	1	-	8	2
<i>Mollugo nudicaulis</i>	3	3	1	9	-	3	4	15
<i>Ocimum sp</i>	5	-	1	1	-	-	6	1
<i>Panicum turgidum</i>	11	41	2	20	2	10	15	71
<i>Senna alexandrina</i>	6	4	-	3	-	-	6	7
<i>Solanum dubium</i>	5	-	-	-	-	-	5	-
<i>Schoenefeldia gracilis</i>	9	21	-	1	-	-	9	22
<i>Tribulus terrestris</i>	-	2	-	-	-	-	-	2
<i>Zornia sp</i>	1	1	-	-	-	-	1	1
Total	163	283	17	75	10	70	190	418

The number of seeds/m² was calculated by the following equation:

$$\text{No. of seeds/m}^2 = \frac{\text{Number of seeds/depth} \times 2 \times 100 \times 100}{\text{Quadrat area (m}^2) \times \text{Number of quadrats/depth}}$$

Quadrat area (m²) x Number of quadrats/depth

Depth 0- 5cm.

$$\text{Number of live seeds/m}^2 = \frac{163 \times 2 \times 10000}{100 \times 14} = 2329$$

$$\text{Number of dead seeds/m}^2 = \frac{283 \times 2 \times 10000}{100 \times 14} = 4043$$

Depth 5- 10 cm.:

$$\text{Number of live seeds /m}^2 = \frac{17 \times 2 \times 10000}{100 \times 14} = 243$$

$$\text{Number of dead seeds/m}^2 = \frac{75 \times 2 \times 10000}{100 \times 14} = 1071$$

Depth 10 – 15 cm.:

$$\text{Number of live seeds/m}^2 = \frac{10 \times 2 \times 10000}{100 \times 14} = 143$$

$$\text{Number of dead seeds/m}^2 = \frac{70 \times 2 \times 10000}{100 \times 14} = 1000$$

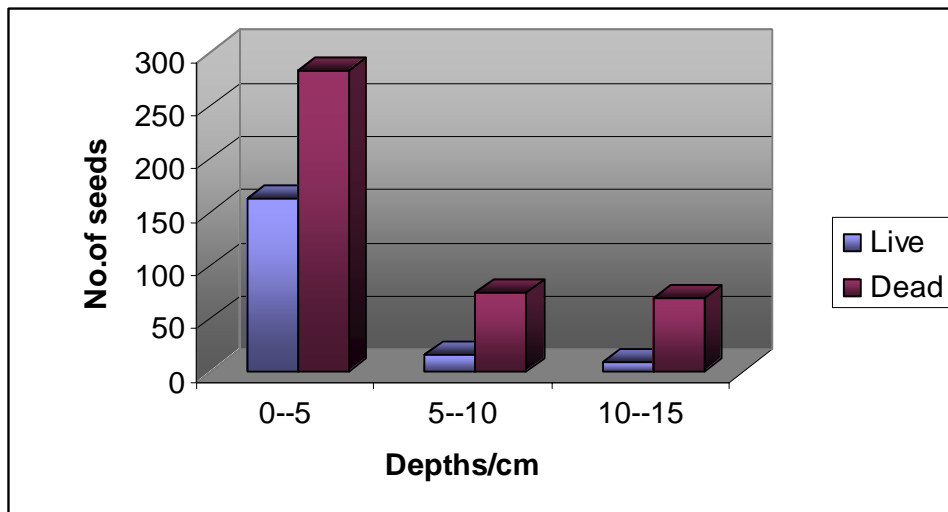


Fig. (10) Histogram showing the number of live and dead seeds at each soil depth for site. A.

Table (19) Soil seed bank at site (B):**Depths (cm)**

Species	0 ----- 5		5-----10		10 ----- 15		Total	
	Live	Dead	Live	Dead	Live	Dead	Live	Dead
<i>Aristida adscensionis</i>	13	18	6	14	8	7	27	39
<i>Abutilon figarianum</i>	-	-	-	-	4	-	4	-
<i>Achyranthes aspera</i>	-	-	-	1	-	-	-	1
<i>Brachiaria reptans</i>	18	19	20	20	3	2	41	41
<i>Brachiaria mutica</i>	3	-	1	2	-	-	4	2
<i>Cenchrus biflorus</i>	8	19	11	19	3	12	22	50
<i>Cleome escoposa</i>	1	-	-	8	-	-	1	8
<i>Cyperus rotundus</i>	7	42	6	13	4	13	17	68
<i>Chloris virgata</i>	-	-	3	2	-	-	3	2
<i>Corchorus spp.</i>	4	4	5	4	5	-	14	8
<i>Cyperus spp.</i>	5	10	4	15	-	7	9	32
<i>Dactyloctenium aegyptium</i>	28	27	43	34	8	18	79	79
<i>Euphorbia aegyptiaca</i>	1	2	-	-	-	2	1	4
<i>Eragrostis spp.</i>	3	5	-	2	2	-	5	7
<i>Fagonia cretica</i>	1	2	-	-	-	-	1	2
<i>Fimbristylis biss-umbellata</i>	1	5	-	1	2	-	3	6
<i>Hibiscus vitifollus</i>	-	1	-	-	-	-	-	1
<i>Indigofera arrecta</i>	42	5	1	11	-	-	43	16
<i>Indigofera hochstetteri</i>	17	12	13	17	2	1	32	30
<i>Leucas urticifolia</i>	1	-	-	-	-	-	1	-
<i>Mollugo nudicaulis</i>	6	-	2	1	-	2	8	3
<i>Ocimum spp.</i>	-	1	3	-	-	-	3	1
<i>Panicum turgidum</i>	10	18	8	34	5	14	23	66
<i>Senna alexandrina</i>	1	1	-	1	-	-	1	2
<i>Sesamum alatum</i>	-	1	-	-	-	-	-	1
<i>Schoenefeldia gracilis</i>	9	7	2	4	1	1	12	12
<i>Solanum dubium</i>	-	-	-	-	1	-	1	-
<i>Tribulus terrestris</i>	-	-	-	-	1	-	1	-
<i>Tephrosia uniflora</i>	19	-	-	-	-	-	19	-
<i>Zornia spp.</i>	3	-	1	2	-	1	4	3
Total	201	199	129	205	49	80	379	484

Depth 0 -5 cm.:

$$\text{Number of live seeds/m}^2 = \frac{201 \times 2 \times 10000}{100 \times 14} = 2871$$

$$\text{Number of dead seeds/m}^2 = \frac{199 \times 2 \times 10000}{100 \times 14} = 2843$$

Depth 5 – 10 cm.:

$$\text{Number of live seeds /m}^2 = \frac{126 \times 2 \times 10000}{100 \times 14} = 1800$$

$$\text{Number of dead seeds/m}^2 = \frac{205 \times 2 \times 10000}{100 \times 14} = 2971$$

Depth 10 – 15 cm.:

$$\text{Number of live seeds/m}^2 = \frac{49 \times 2 \times 10000}{100 \times 14} = 700$$

$$\text{Number of dead seeds/m}^2 = \frac{80 \times 2 \times 10000}{100 \times 14} = 1143$$

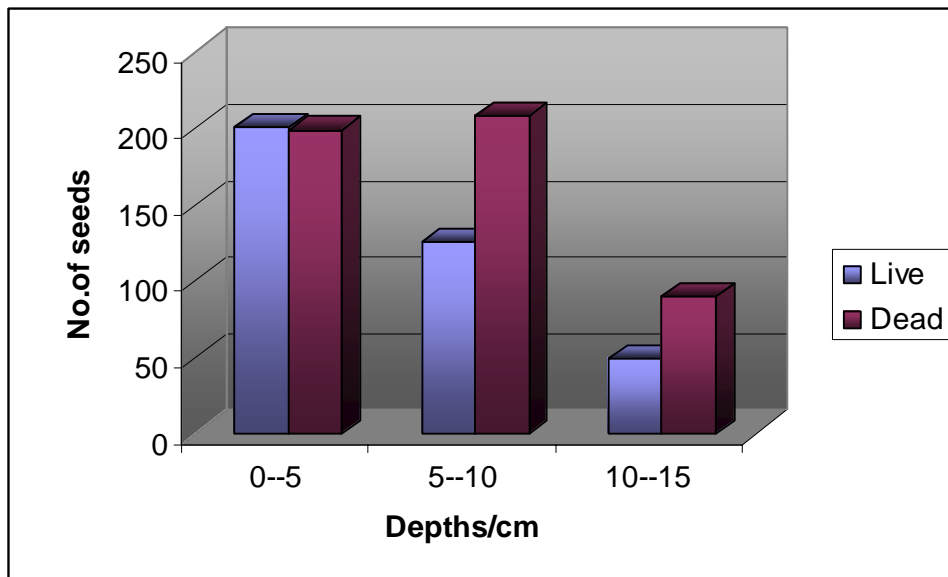


Fig. (11) Histogram showing the number of live and dead seeds at each soil depth for site. B.

Table (20) Soil seed bank at Site (C):

Depths (cm)

Species	0-----5		5-----10		10-----15		Total	
	Live	Dead	Live	Dead	Live	Dead	Live	Dead
<i>Aristida adscensionis</i>	14	65	5	8	1	6	20	79
<i>Brachiaria mutica</i>	2	-	1	1	-	3	3	4
<i>Brachairia reptans</i>	1	-	-	1	-	-	1	1
<i>Cenchrus biflorus</i>	-	2	1	-	-	4	1	6
<i>Cenchrus ciliaris</i>	-	-	1	2	-	-	1	2
<i>Cleome escaposa</i>	-	-	-	1	-	-	-	1
<i>Cyperus rotundus</i>	4	23	4	9	-	17	8	49
<i>Corchorus spp.</i>	-	-	2	3	3	-	5	3
<i>Cyperus spp.</i>	5	-	-	1	-	2	5	3
<i>Dactyloctenium aegyptium</i>	-	6	1	-	2	-	3	6
<i>Echinochloa spp.</i>	-	-	-	1	-	1	-	2
<i>Eragrostis spp.</i>	-	-	1	-	1	-	2	-
<i>Indigofera arrecta</i>	-	-	-	-	-	2	-	2
<i>Indigofera hochstetri</i>	2	-	-	-	-	1	2	1
<i>Mollugo nudicaulis</i>	2	10	1	11	3	5	6	26
<i>Ocimum spp.</i>	1	-	-	-	-	2	1	2
<i>Panicum turgidum</i>	-	-	-	-	-	3	-	3
<i>Schoenefeldia gracilis</i>	13	21	-	8	-	5	13	34
<i>Tribulus terrestris</i>	-	1	-	-	-	-	-	1
Total	44	128	17	46	10	51	71	225

Depth 0 – 5cm.:

$$\text{Number of live seeds/m}^2 = \frac{44 \times 2 \times 10000}{100 \times 14} = 629$$

$$\text{Number of dead seeds/m}^2 = \frac{128 \times 2 \times 10000}{100 \times 14} = 1829$$

Depth 5 – 10 cm.:

$$\text{Number of live seeds/m}^2 = \frac{17 \times 2 \times 10000}{100 \times 14} = 243$$

$$\text{Number of dead seeds/m}^2 = \frac{46 \times 2 \times 10000}{100 \times 14} = 657$$

Depth 10 15 cm. :

$$\text{Number of live seeds/m}^2 = \frac{10 \times 2 \times 10000}{100 \times 14} = 143$$

$$\text{Number of dead seeds/m}^2 = \frac{51 \times 2 \times 1000}{100 \times 14} = 729$$

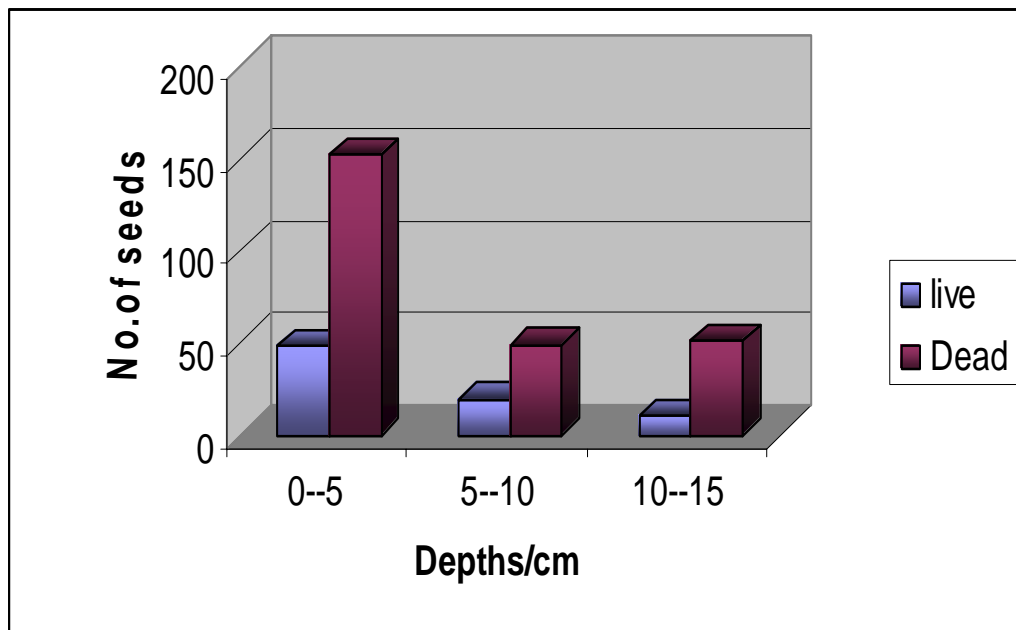


Fig. (12) Histogram showing the number of live and dead seeds at each soil depth for site. C.

5.2.5.1. Soil seed bank analysis:

1. Live seeds for species at the study area:

Table (21): Analysis of variance for the three sites:

Site	Source	Df	Mean.s.	F.Ratio	P.
A	species	23	23.940	0.7041	0.8178
			34.000		
B	species	29	136.454	3.0717	0.0001
			44.422		
C	species	18	8.957	1.3874	0.1938
			6.456		

2. Dead seeds for species at the study area:

Table (22): Analysis of variance for the three sites:

Site	Source	Df	Mean S	F.Ratio	P.
A	species	23	309.295	2.6267	0.0024
			117.750		
B	species	29	180.523	6.9610	< 0.0001
			25.933		
C	species	18	147.121	2.1748	0.0218
			67.649		

3. Summary of soil seed bank in the study area:

A reference seed collection was made from known species in the study area. This reference collection was used in identifying unknown species in the study area. The species composition was determined for each of the three sites in the study area. At Site A, 21 species were identified from the live seeds whereas 20 species were identified from the dead seeds. The most dominant species identified from the live seeds included

Indigofera arrecta , *Cyperus rotundus*, *Dactyloctenium aegyptium*, *Tephrosia uniflora*, *Brachiaria mutica* *Indigofera hochstetteri*, *Aristida adescensionis*, *Panicum turgidum* (Plate 13), *Schoenefeldia gracilis* (Plate 14), and *Euphorbia aegyptiaca*. The most dominant species identified from dead seeds included *Brachiaria sp.*, *Euphorbia aegyptiaca*, *Panicum turgidum*, *Aristida adescensionis*, *Schoenefeldia gracilis*, *Cleome escaposa*, *Mullugo nudicaulis*, and *Corchorus spp.*

At site B, 26 species were identified from the live seeds whereas 28 species were identified from the dead seeds.. The most dominant species identified from live seeds included *Indigofera arrecta*, *Dactyloctenium aegyptium*, *Tephrosia uniflora*, *Brachiaria mutica* (Plate 15), *Indigofera hochstetteri*, *Aristida adescensionis*, *Cenchrus biflorus* (Plate 16), *Panicum turgidum* The most dominant species identified from dead seeds included *Cyperus rotundus*, *Dactyloctenium aegyptium*, *Brachiaria eruciformis*, *Cenchrus biflorus*, *Aristida adescensionis*, *Panicum turgidum* and *Indigofera hochstetteri*.

At site C, 16 species were identified from live seeds whereas 18 species were identified from dead seeds. The most dominant species identified from live seeds included *Aristida adescensionis*, *Schoenefeldia gracilis*, *Mullugo nudicaulis*. The most dominant species identified from dead seeds included *Aristidsa adescensionis*, *Cyperus rotundus*, *Schoenefeldia gracilis* and *Mullugo nudicaulis*.

The seed bank density was high in the upper depths. The live seed density in the study area (semi-arid) was from 1015__5371 seeds/m² and the dead seed density was from 3215__6957 seeds/m². The soil seed bank density for both live and dead seeds in the study area (Semi- arid) was from 3034__8462 seeds/m²



Plate (13). *Panicum turgidum* Forssk.
Elliptical shape, 2 X 1.3 mm, glabrous,
shiny, brown to dark-brown



Plate (14). *Schoenefeldia gracilis* Kunth.
Compressed, cylindrical-oblong, 2 X 0.5 mm,
pubescent, grey.



Plate (15). *Brachiaria mutica* Stapf.
Cylindrical, oblong with tapering ends, 1.5 X 0.2 mm,
glabrous, brown.



Plate (16). *Cenchrus biflorus* Roxb.
Oval, with groove on one side, 2 X 1.5 mm,
glabrous, yellowish-brown, with black hilum.

5.2.6. Biomass determination at the three sites of the study area:

Biomass determination was carried out at each of the three sites in the study area. Two transects were chosen for each site and these are subdivided into 3 quadrats each. Seven replicates were studied to determine biomass (gm) at each quadrat. The results have been presented in tables 23, 24 and 25. Similarly, the biomass determinations were used to calculate the carrying capacity of the whole study area.

Table (23): Biomass determination at site (A):

Transect 1					Transect 2				
Sample No.	1 Biomass (gm)	2 Biomass (gm)	3 Biomass (gm)	Total	Sample No.	1 Biomass (gm)	2 Biomass (gm)	3 Biomass (gm)	Total
1	14.7	14.2	10.8	39.7	8	22.5	22.0	21.9	66.4
2	4.8	8.8	10.7	24.3	9	2.2	0.9	5.8	8.9
3	33.3	22.0	26.9	82.2	10	15.9	16.2	4.7	36.8
4	18.2	22.3	7.6	48.1	11	80.7	24.0	22.9	127.6
5	14.3	29.0	71.4	114.7	12	52.2	8.8	38.1	99.1
6	20.3	11.9	22.9	55.1	13	33.4	43.9	11.0	88.3
7	14.6	17.4	0.9	32.9	14	2.6	5.7	2.5	10.8
Total				397					437.9

Biomass determination:

$$\text{Biomass} = \frac{834.9}{1000} = 0.8349 \text{ kg}$$

$$\text{Proper use factor} = 0.5 \times 0.8349 = 0.41745 \text{ kg}$$

$$\text{Biomass/m}^2 = \frac{0.41745}{42} = 0.009939 \text{ kg/m}^2$$

$$\text{Biomass/km}^2 = 0.009939 \times 1000000 = 9939 \text{ kg/km}^2$$

According to Darag and Sulaiman (1988) the animal unit consumption was 10.5 kg/day.

Carrying Capacity of Site (A) = $\frac{9939.3}{315 \times 12} = 2.6 \text{ A.U./km}^2/\text{year}$.

315x12

Table (24): Biomass determination at Site (B):-

Transect 3					Transect 4				
Sample No.	1 Biomass (gm)	2 Biomass (gm)	3 Biomass (gm)	Total	Sample No.	1 Biomass (gm)	2 Biomass (gm)	3 Biomass (gm)	Total
15	25.8	23.2	24.1	73.1	22	24.6	19.1	4.0	47.7
16	14.9	22.2	20.4	57.5	23	6.2	4.5	0.1	10.8
17	38.4	13.2	5.4	57.0	24	55.2	27.4	7.1	89.7
18	37.8	12.4	19.6	69.8	25	22.6	20.6	21.6	64.8
19	46.2	31.9	12.3	90.4	26	22.2	12.3	17.1	51.6
20	74.8	49.6	25.7	150.1	27	20.2	26.3	32.5	79.0
21	23.3	16.9	22.4	62.6	28	42.5	73.8	66.0	182.3
Total				560.5					525.9

Biomass determination:

$$\text{Biomass} = \frac{1086}{1000} = 1.0864 \text{ kg.}$$

1000

$$\text{Proper use factor} = 0.5 \times 1.0864 = 0.5432 \text{ kg.}$$

$$\text{Biomass/m}^2 = \frac{0.5432}{42} = 0.0129333 \text{ kg/m}^2$$

42

$$\text{Biomass/ km}^2 = 0.0129333 \times 1000000 = 12933.3 \text{ kg/km}^2$$

Carrying capacity of Site (B) = $\frac{12933.3}{315 \times 12} = 3.4 \text{ A.U./km}^2/\text{year}$.

315x12

Table (25); Biomass deremination at site (C):-

Transect 5					Transect 6				
Sample No.	1 Biomass (gm)	2 Biomass (gm)	3 Biomass (gm)	Total	Sample No.	1 Biomass (gm)	2 Biomass (gm)	3 Biomass (gm)	Total
29	13.0	7.3	3.6	23.9	36	22.0	29.7	20.9	72.6
30	0.7	10.9	16.8	28.4	37	39.1	25.7	26.9	91.7
31	25.5	9.8	10.8	46.1	38	25.9	75.4	27.2	128.5
32	12.8	23.6	5.7	42.1	39	51.3	23.3	23.1	97.7
33	25.0	2.6	9.7	37.3	40	43.2	29.6	28.5	101.3
34	12.1	23.4	24.8	60.3	41	16.6	2.4	31.4	50.4
35	11.0	31.5	6.8	49.3	42	22.0	8.9	35.6	66.5
Total				287.4	Total				608.7

Biomass determination:

$$\text{Biomass} = \frac{896.1}{1000} = 0.8961 \text{ kg}$$

$$1000$$

$$\text{Proper use factor} = 0.5 \times 0.8961 = 0.44805 \text{ kg.}$$

$$\text{Biomass/m}^2 = \frac{0.44805}{42} = 0.0106679 \text{ kg/m}^2$$

$$42$$

$$\text{Biomass/ km}^2 = 0.0106679 \times 1000000 = 10667.9 \text{ kg/km}^2$$

$$\text{Carrying Capacity of Site (C)} = \frac{10667.9}{315 \times 12} = 2.8 \text{ A.U./km}^2/\text{year}$$

$$315 \times 12$$

$$\text{The carrying capacity of the study area} = \frac{8.8}{3} = 2.9 \text{ A.U./km}^2/\text{year}$$

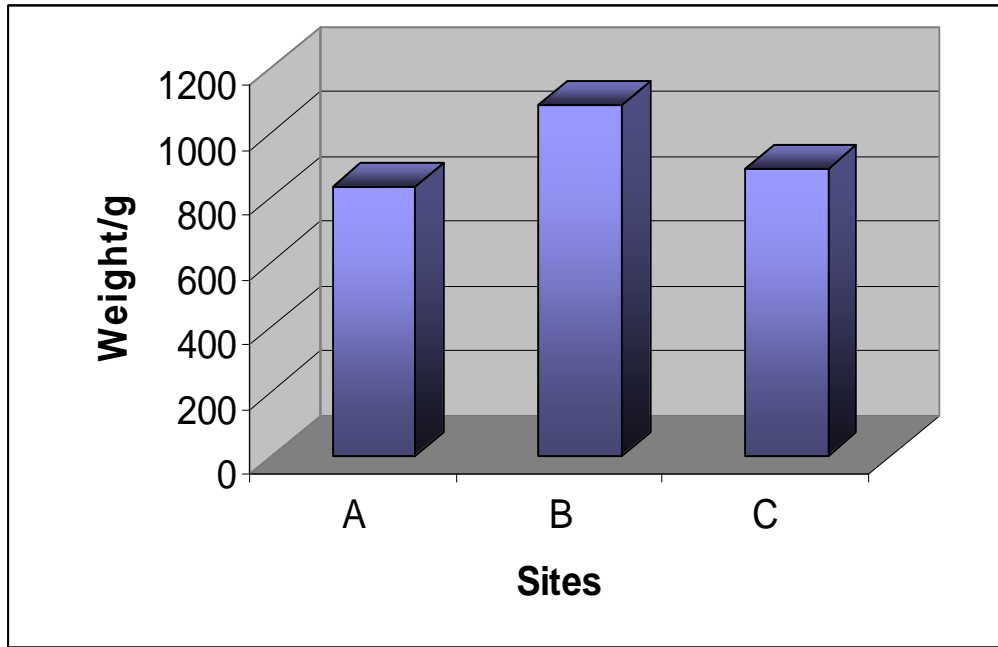


Fig. (13) Histogram showing biomass determination at each of the three sites of the study area.

5.2.7. Natural regeneration at the three sites of the study area:

Natural regeneration was determined at the three sites at the study area. 14 quadrats (10 x 10m.) for each site were studied. The results were presented in tables 26, 27 and 28 and the natural regeneration of the whole area was determined.

Table (26): Total number of seedlings at site (A):

Quadrats

<i>Species</i>	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
<i>Acacia nilotica subsp. nilotica</i>	2	-	1	-	-	-	-	-	-	-	-	-	-	-	3
<i>A. oerfota</i>	2	-	-	-	4	1	-	-	-	-	-	-	-	3	10
<i>A. tortilis subsp. raddiana</i>	1	3	1	-	-	3	1	-	-	1	-	-	-	-	10
<i>A. seyal var. seyal</i>	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
<i>A. tortilis subsp. spirocarpa</i>	-	2	-	-	4	15	6	-	-	6	-	2	-	-	35
<i>Balanites aegyptiaca</i>	-	5	-	-	-	1	-	-	-	-	-	-	-	-	6
Total	6	10	2	0	8	20	7	0	0	7	0	2	0	3	65

Natural regeneration was calculated as follows:

Total Number of seedlings

N.of quadrats x area/m²

$$\text{N.S. /m}^2 = \frac{65}{1400} = 0.0464286 \text{ seedlings/m}^2$$

1400

$$\text{N.S. /ha} = 0.0464286 \times 10000 = 464.3 \text{ seedlings/ ha.}$$

Table (27): Total number of seedlings at site (B):

Qaudrats

Species	15	16	17	18	19	20	21	22	23	24	25	26	27	28	Total
<i>Acacia mellifera</i>	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
<i>A. oerfota</i>	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1
<i>A. tortilis subs.raddina</i>	-	-	-	-	-	1	1	-	-	1	-	-	1	-	4
<i>A. tortilis subsp. spirocarpa</i>	-	2	-	5	-	-	9	-	2	-	3	3	-	-	24
<i>Leptadenia pryotechnica</i>	1	1	-	-	-	-	-	-	-	-	-	-	-	-	2
<i>Maerua crassifolia</i>	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1
<i>Ziziphus spina christi</i>	-	-	-	-	-	-	-	7	-	-	-	-	-	-	7
Total	-	3	1	5	-	1	12	7	2	1	3	4	1	-	40

$$\text{N.S. /m}^2 = \frac{40}{1400} = 0.0285714 \text{ seedlings /m}^2$$

1400

$$\text{N.S. /ha} = 0.0285714 \times 1000 = 285.7 \text{ seedlings/ha}$$

Table (28): Total number of seedlings at site (C):

Species	Quadrats														Total
	29	30	31	32	33	34	35	36	37	38	39	40	41	42	
<i>Acacia tortilis subsp. raddiana</i>	-	-	-	-	-	-	-	1	-	-	-	1	1	-	3
<i>A. tortilis subs. spirocarpa</i>	4	1	5	3	2	-	3	11	8	8	7	8	-	7	67
<i>Balanites aegyptiaca</i>	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
<i>Ziziphus spna-christi</i>	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
Total	4	1	5	4	2	-	3	12	8	8	8	9	1	7	72

$$\text{N.S./m}^2 = \frac{72}{1400} = 0.0514285 \text{ seedlings/m}^2$$

$$\text{N.S./ha} = 0.0507143 \times 10000 = 514.3 \text{ seedlings/ha}$$

The natural regeneration of the whole study area =

$$\frac{1264}{3} = 421 \text{ seedlings/ha.}$$

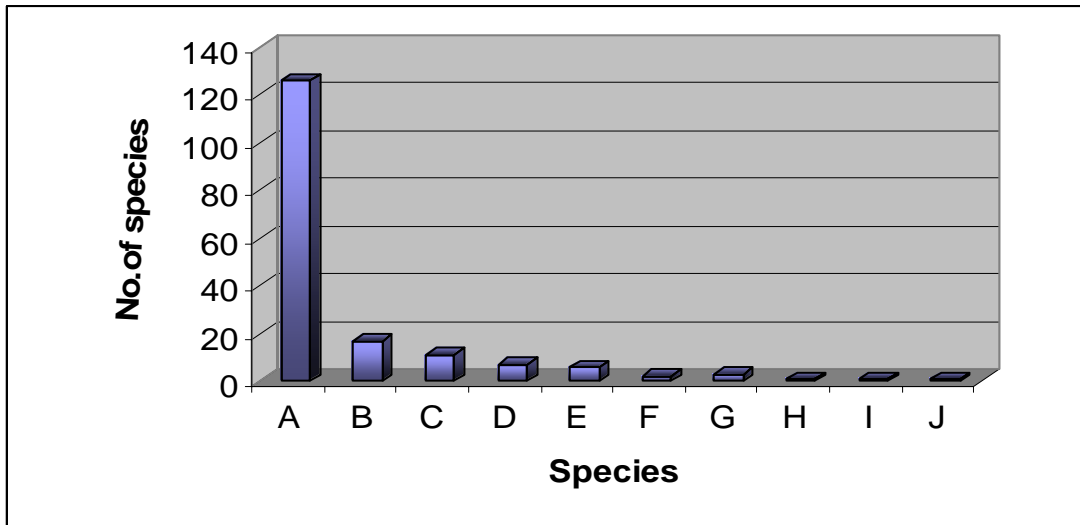


Fig. (14) Histogram showing natural regeneration of woody species at the study area.

Where:

A: *Acacia tortilis subsp. spirocarpa*.

B: *A. tortilis subsp raddiana*.

C: *A. oerfota*.

D: *Ziziphus spina-christi*

E: *Balanites aegyptiaca*.

F: *Leptadenia pyrotechnica*.

G: *Acacia nilotica subsp. nilotica*.

H: *A. seyal var. seyal*.

I: *A. mellifera*.

J: *Maerua crassifolia*

5.2.8. Canopy Cover:

The sites near the populated areas have less canopy cover (site A and B), whereas those far away from populated areas (site C) have more canopy cover(Fig.15).

Thus there is an inverse relationship between canopy cover and the nearness to populated areas. Results are given in tables 29, 30 and 31.

Table (29): Canopy cover at site (A):

Species	No. of trees/ Shrubs	Canopy area(m ²)
<i>Acacia nilotica subsp.nilotica</i>	1	3.2
<i>A. oerfota</i>	9	104.0
<i>A.tortilis subsp. raddiana</i>	6	80.3
<i>A. tortilis subsp spirocarpa</i>	54	667.8
<i>Balanites aegyptiaca</i>	2	49.4
<i>Capparis decidua</i>	1	6.2
Total	73	910.9

$$\text{Canopy cover area (m}^2\text{)} = \frac{910.93}{14 \times 50 \times 50} = 0.0260266 \text{ m}^2$$

$$\text{Canopy cover \%} = 0.0260266 \times 100 = 2.6\%$$

Table (30): Canopy cover at site (B):

Species	No.of trees/shrubs	Canopy area(m ²)
<i>Acacia tortilis subsp. raddiana</i>	14	345.5
<i>A. tortilis subsp. spirocarpa</i>	33	729.7
<i>Maerua crassifolia</i>	5	50.3
Total	52	1125.5

$$\text{Canopy cover area (m}^2\text{)} = \frac{1125.53}{35000} = 0.032158\text{m}^2$$

$$\text{Canopy cover \%} = 0.032158 \times 100 = 3.2\%$$

Table (31): Canopy cover at site (C):

Species	No.of trees/shrubs	Canopy area(m ²)
<i>Acacia mellifera</i>	1	24.4
<i>A.tortilis subsp. raddiana</i>	12	406.7
<i>A. seyal var seyal</i>	3	76.6
<i>Acacia tortilis subsp spirocarpa</i>	52	1101.8
<i>Maerua crassifolia</i>	2	15.9
<i>Ziziphus spina-christi</i>	8	55.2
Total	78	1680.6

$$\text{Canopy cover area (m}^2\text{)} = \frac{1680.6}{35000} = 0.0480171\text{m}^2$$

$$\text{Canopy cover \%} = 0.0480171 \times 100 = 4.8\%$$

$$\text{The canopy cover \% of the study area} = \frac{10.6}{3} = 3.5\%$$

3

The study area was classified as other wooded land, according to the FAO (Global Forest Resource Assessment, 2000).

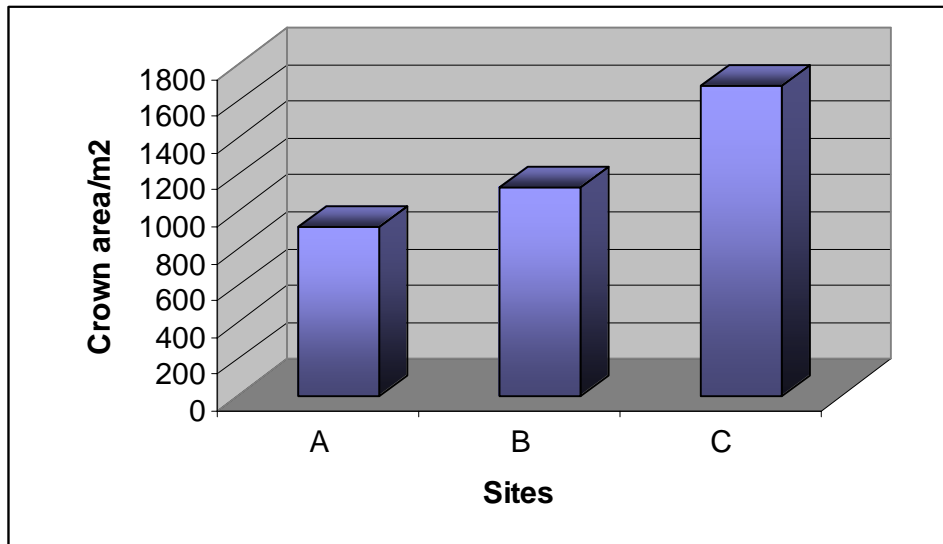


Fig. (15) Histogram showing the crown area (m²) at the three sites:

5.2.9. Soil analysis:

1. Moisture Content (M.C.):

Depth 0- 30 cm. At three sites:

Site A has the highest moisture content whereas site B has the lowest. Site C has an intermediate value of soil moisture.

Depth 30 – 60 cm at three sites:

The same trend as for depth 0 – 30cm.

Interpretation of results:

Site A, the soil texture is a mixture of clay and sandy soil with clay representing the major component of the soil and therefore high moisture retention capacity.

Site B, is predominantly sandy soil which is represented by sand dunes. No clay is observed even at a soil depth of 60cm.

Site C is a mixture of clay, sand and brown gravels with the clay as the dominant component, but to a lesser extent than in site A. The moisture can be represented in ascending order as B→C→A. Results of the moisture content at each site are given in tables 32,33 and 34 with a summary in table 35.

Table (32) : Moisture content at site (A):

Depths (cm)

Sample No.	0 _____	_____ 30	M.C.%	30 _____	_____ 60	M.C.%
	F.W. (gm)	O.D.W. (gm)		F.W. (gm)	O.D.W. (gm)	
3	683.2	520	31.4	693.2	600	15.5
5	713.2	550	29.7	813.2	650	25.1
13	493.2	453.2	8.8	523.2	511.2	2.2
Total						

*F.W. = Fresh weight (gm). * O.D.W. = Oven dry weight (gm).

Table (33) : Moisture content at site (B):

Depths (cm)

Sample No.	0 _____	_____ 30	M.C.%	30 _____	_____ 60	M.C.%
	F.W. (gm)	O.D.W. (gm)		F.W. (gm)	O.D.w. (gm)	
17	763.2	750	1.8	613.2	600	2.2
25	743.2	700	6.2	843.2	825	2.2
27	843.2	776.1	8.7	893.2	873.2	2.2

Table (34): Moisture content at site (C):

Depths (cm)

Sample No.	0 _____	_____ 30	M.C.%	30 _____	_____ 60	M.C.%
	F.W. (gm)	O.D.W. (gm)		F.W. (gm)	O.D.W. (gm)	
37	593.2	555	6.9	753.2	700	7.6
41	733.2	653.5	12.2	673.2	650	3.6
42	803.2	745.7	7.7	683.2	650	5.1

Table (35): Summary of moisture content at the study area:

The summary results confirm the results that have already been found for the individual sites.

Sites	Depths(cm)		Mean
	0-----30	30-----60	
A	23.3%	14.3%	18.8
B	5.6%	2.2%	3.9
C	8.9%	5.4%	7.2
Mean	12.6	7.3	9.92

During the field work in November (2004) the soil moisture content was measured at the three sites. It can be seen that the soil moisture content was relatively low in the three sites of the study area. This is because in arid and semi-arid zones, the total annual precipitation is small and highly fluctuating besides that the topography encourages runoff in these zones and evaporation is also high.

2. Soil chemical analysis:

Table (36): Results of soil chemical analysis:

Sites	Depths (cm)	pH	K (Mmo1 ⁺)	O.M. (%)	N (%)	P (mg)
A	0-----30	7.01	0.17	0.014	0.08	1.54
	30----60	7.45	0.34	0.012	0.11	3.37
B	0-----30	6.10	0.18	0.012	0.11	2.67
	30----60	5.60	0.11	0.012	0.10	1.33
C	0-----30	5.40	0.32	0.014	0.07	1.65
	30-----60	7.71	0.11	0.012	0.06	1.43

Soil analysis revealed that all the primary nutrients for plant growth are available (N, P, K), but with different quantities and percentages.

The PH:

The soil of site A is more or less alkaline and has a mixture of sand & clay, clay being dominant. That of site B is more or less acidic and sandy. Site C acidic at depth 0 – 30cm and alkaline at depth 30 – 60cm and mixture of sand + clay with the clay being dominant.

K⁺:

No significant differences in the three sites.

Organic matter:

No significant differences in the three sites.

N:

No significant differences in the three sites.

P:

No significant differences in the three sites.

The summary of soil chemical analysis:

It can be seen that there are no significant differences between the three sites in the results of chemical analysis except for the PH.

CHAPTER SIX

Discussion, Conclusions and Recommendations

6.1. The flora of the study area:-

The collection from the study area has covered different habitats and a total number of (85) plant species belonging to 30 families were studied (28 Dicotyledons and 2 Monocotyledons).

Some families were represented by a number of species while others are represented by only one species. The flowering plants of the study area were recognized and the names and synonyms have been updated in accordance to the most recent published corrections.

The identified species were briefly described in attempt to highlight their diagnostic characteristics. From the identified species of the present study, (42) species were found to have medicinal values, and these represented (49.4%), of the total flora.

The most common dicotyledonous families were Amaranthaceae, Fabaceae and Mimosaceae, whereas the most important monocotyledonous families were Cyperaceae and Poaceae. The most common dicotyledonous woody species were *Acacia tortilis subsp. spirocarpa*, *A.raddiana* and *Commiphora africana* whereas the herbaceous species were *Ipomoea cordofana*, *Indigofera spp.* and *Corchorus spp.* The most common monocotyledonous species were *Dactyloctenium aegyptium*, *Dicanthum annulatum*, *Eragrostis spp.*, *Brachiaria spp*, *Setaria spp.* and *Schoenefeldia gracilis*.

6-2. The vegetation of the study area:-

The vegetation of the study area was described as part of the regional vegetation zones of the Sudan by various authors (Andrews, 1948; Smith,

1949; Harrison & Jackson, 1958; Noordwijk, 1984; Bebawi *et al*, 1991 and Wickens, 1991).

Andrews (1948) reported that the most dominant tree species were *Acacia spp.* (*Acacia nubica* and *A. mellifera*). Other common trees and shrubs were *Ziziphus spina-christi*, *Boscia senegalensis*, *Balanites aegyptiaca*, *Cadaba farinosa*, *Salvadora persica*, *Calotropis procera*, *Faidherbia albida* and *Acacia seyal*.

The associated common species were *Cymbopogon nervatus*, *Schoenefeldia gracilis*, *Aristida spp.*, and *Cenchrus biflorus*.

In the present study it was found that the most dominant trees were *Acacia tortilis subsp. spirocarpa*, *Acacia tortilis subsp. raddiana*. Other common trees and shrubs were *Ziziphus spina-christi*, *Boscia senegalensis*, *Balanites aegyptiaca*, *Acacia mellifera*, *Acacia oerfota*, *Salvadora persica*, *Calotropis procera*, *Faidherbia albida* and *Acacia seyal*.

Associated grasses were *Schoenefeldia gracilis*, *Aristida spp.*, and *Cenchrus biflorus*. The results of the present study, as compared to Andrews (1948), have shown that the species *Cadaba farinosa* and *Cymbopogon nervatus* had completely disappeared from the study area. This may be attributed to fluctuations in rainfall and excessive land use or selected pressure on these species.

Smith (1949) found that the dominant woody species in the study area were *Acacia raddiana*, *Maerua crassifolia*, *Capparis decidua*, *Acacia senegal* and *Boscia senegalensis*.

The present study found similar findings to those of Smith (1949) with respect to *Acacia raddiana*, however, there are differences with respect to other shrubby and tree population.

Harrison and Jackson (1958) reported that the dominant tree species were *Acacia tortilis*, *Maerua crassifolia*, *Acacia mellifera*, *Commiphora*

africana and *Balanites aegyptiaca* whereas the common shrubs are *Leptadenia pyrotechnica*, *Salvadora persica*, *Capparis decidua*, *Ziziphus spina-christi*, *Acacia oerfota* and *Calotropis procera*.

The dominant annuals were *Aristida spp.*, *Schoenefeldia gracilis*, *Cenchrus spp.*, *Cymbopogon proximus*, and *Blepharis linariifolia*.

In the present study it was found that the dominant trees were *Acacia tortilis* and *Maerua crassifolia*. Other common trees and shrubs include *Acacia mellifera*, *Commiphora africana*, *Balanites aegyptiaca*, *Leptadenia pyrotechnica*, *Salvadora persica*, *Capparis deciuia*, *Ziziphus spina-christi*, *Acacia oerfota* and *Calotropis procera*, the dominant grasses were *Aristida spp.*, *Schoenefeldia gracilis* and *Cenchrus spp.*

Comparing the results of the present study with those of Harrison and Jackson (1958), it can be seen that *Cymbopogon proximus* and *Blepharis linariifolia* had completely disappeared from the study area. This may be attributed to fluctuations of rainfall, sand drifts, over-grazing and excessive land use.

Wickens (1976) reported that the dominant trees and shrubs in the study area were *Acacia tortilis subsp. tortilis*, *Leptadenia pyrotechnica*, and *Salvadora persica*. He also found that the dominant grasses were *Aristida spp.* and *Panicum turgidum*.

The present study reported similar findings to those of Wickens (1976) except that *Salvadora persica* has become a rare species. This may be due to the demand and heavy use of this tree as a source of income through marketing its branches as a substitute for tooth brushes.

Noordwijk (1984) reported the following woody species: *Acacia tortilis*, *Maerua crassifolia*, *Acacia mellifera* and *Commiphora africana*.

The Present study reported the same findings for the species *Acacia tortilis* and *Maerua crassifolia* but has noted that *Acacia mellifera*

and *Commiphora africana* were very small in numbers. This is probably due to the felling of the former for charcoal production and the latter for building construction by the locals.

Wickens (1991) found that the dominant woody species were *Acacia tortilis subsp tortilis*, *Leptadenia pyrotechnica*, *Salvadora persica*, *Maerua crassifolia* and *Capparis decidua*. The major grasses were *Aristida spp.*, *Stipagrostis plumosa*, *Cenchrus setigerus* and *Panicum turgidum*.

The findings of the present study were the following: The dominant tree species were *Acacia tortilis subsp tortilis* and *Maerua crassifolia*. Other common woody species were *Leptadenia pyrotechnica*, *Salvadora persica* and *Capparis decidua*. Associated grasses were *Aristida spp.*, *Cenchrus setigerus* and *Panicum turgidum*. *Stipagrostis plumosa* had completely disappeared from the study area. This may be attributed mainly to over-grazing since this species is highly palatable.

The present study revealed that some woody species are threatened, as seen from their low abundance in the study area. These species included *Salvadora persica*, *Commiphora africana*, *Acacia mellifera*, *A. seyal* and *Dobera glabra*. The threat is probably due to soil deterioration, excessive use, drought periods, rainfall fluctuations, over-grazing and the increasing human and animal populations. Similarly some herbs and grasses had completely disappeared from the study area e.g *Cymbopogon proximus* and *Blepharis linariifolia*. This may be attributed to over-grazing and utilization, sand drifts and rainfall fluctuations.

6.2.1. Threatened , endangered and extinct species:

The threatened and endangered species have been presented (Table 1). Some species have completely disappeared from the study area while other species are now threatened. The main causes of these vegetational changes can be summarized as follows:

Drought spells, multiple- uses of these species, excessive felling of woody species to satisfy human needs, over- grazing, increased shifting cultivation, climatic changes, excessive drilling of wells in the region, increased human and animal population, voluntary or compulsory settlement of the nomads whose mode of life adversely affects vegetation cover and the petroleum industries.

6.2.2. Famine food species:

During the drought spells of 1980s, there was a severe shortage of food and hence the locals had to find alternative plant sources for food. Such alternative plant species are currently referred to as famine foods. These species supported the locals during the periods and bridged the gap in food supplies. A list of famine food species is presented (Table 3).

6.2.3. Woody vegetation of the study area:-

In the present study, the woody species identified (Table 5) were as follows: *Acacia tortilis subsp. spirocarpa*, *A. tortilis subsp. raddiana*, *A. oerfota*, *A. mellifera*, *A. seyal var. seyal*, *Maerua crassifolia*, *Balanites aegyptiaca*, and *Ziziphus spina-christi*.

The density of woody species was 19.3 stems/ha. This small value is probably due to excessive agricultural practices, population requirements, economic reasons (to raise income), browsing and grazing, natural crises, road building and pipe lines installation.

6.2.4. The relationship between the dominant woody species:

The density of *Acacia tortilis subsp. spirocarpa* was associated with high frequency and high abundance whereas the density of *Acacia tortilis subsp.raddiana* was also associated with high frequency but low abundance (Table 4). This explains that these two species are evenly distributed in the study area. *Maerua crassifolia*, *Acacia oerfota* and

Ziziphus spina-christi, were observed to have low frequency and low abundance. This indicates that these species are not regularly distributed. The woody species at the study area were confined to the lowland depressions, seasonal water courses, wadis and khor banks.

6.2.5. Association between the dominant woody species:

Statistical analysis using Chi-square test (Table 17) showed a highly significant association between *Acacia tortilis subsp. spirocarpa* and *Acacia tortilis subsp. raddiana*. Significant associations were also observed between pairs of the following species: *Acacia tortilis subsp. spirocarpa* and *Maerua crassifolia*, *Acacia tortilis subsp. raddiana* and *Maerua crassifolia*, *Ziziphus spina-christi* and *Acacia tortilis subsp. raddiana*. This indicates that the nature of association was positive and that every two positively associated species were found together more frequently than anticipated by chance. This confirms that positively associated species have the same environmental requirements.

Negative associations were observed between pairs of the following species: *Acacia tortilis subsp. spirocarpa* and *Acacia oerfota*, *Acacia tortilis subsp. spirocarpa* and *Ziziphus spina-christi*, *Acacia tortilis subsp. raddiana* and *A. oerfota*, *Acacia oerfota* and *Maerua crassifolia*, *Acacia oerfota* and *Ziziphus spina-christi*. This indicates that every two negatively associated species do not appear together and may only do so by mere chance.

6.2.6. Diversity index between woody species and Similarity between sites:

The diversity index between the woody species at the study area was found to be 2.02 (Table 6). This is considered a moderate index, as

compared with Pielou (1969) diversity index (1.5- 3.5). This may indicate that the vegetation cover was ancient and its stability was affected.

The Similarity coefficients for the sites A, B and C were determined qualitatively and then transformed to numbers (1= present; 0= absent). These were found to be 25%, 30% and 40%, respectively. These low similarities between sites are probably due to over- grazing, agricultural practices, utilization and excessive felling of woody species and topography or site variations.

6.3. Biomass productivity:

The study area was located in the semi-desert region which covers 478000 km². The results of biomass productivity for sites A, B and C have been presented in (Tables 23, 24 and 25 respectively) and are graphically been shown in fig. 13. From the results, it can be seen that the three sites differ in their total biomass production. This may be attributed to many factors such as floristic composition, growth rates, the ability of moisture utilization, intensity of grazing, erosion impacts and rainfall distribution within the sites and the seasons. Le Houeru and Hoste (1977) reported that biomass production depends on various factors such as climate, nature of soil, botanical composition and vegetation structure.

In the present study, the average carrying capacity was found to be 3 a.u./km²/year. Harrison (1955) reported that the carrying capacity of the region was 26 a.u./km²/year. This big difference reveals a trend of deterioration in the present situation of rangeland in the study area. The deterioration is probably due to a combination of biotic and abiotic factors. The abiotic factors include drought spells and rainfall fluctuations. The biotic factors include human activities such as cultivation, over-grazing, felling of woody species and increased human and animal population (Plates 17&18). All these factors together led to

the complete disappearance of some species and therefore the loss of seed source. Extinct herbaceous species include *Blepharis linarriifolia*, *Chrysopogon aucheri*, *Trichodesma africanum*, *Tragus berternianus* and *Bergia suffruticosa*.

6.4. Soil seed bank:

The soil seed bank of the study area was quantitatively determined at each of sites A, B and C. The herbs and grasses recorded the highest number of seeds, as compared to the other life forms across the three sites (Tables 18, 19 and 20 respectively). The woody species recorded a low number of seeds, which agrees with Mustafa (1997), Tybrik et al (1994) and Kaarakka (1996). This may be attributed to land over-use through a number of practices including the use of fruits as forage, marketing of seeds, excessive felling of trees, predators, pathogenicity, seed suffocation in water-logged areas and wild fires used in land clearance for shifting cultivation.

In the depth (0-5cm), the density of live seeds was 5829 seeds/m² whereas the dead seeds recorded a density of 8715 seeds/m². In the depth (5- 10cm), the density of live seeds was 2286 seeds/m² as compared to a density of 4699 seeds/m² for the dead seeds. In the depth (10-15cm) the density of live seeds was 986 seeds/m² while that of the dead seeds was 2872 seeds/m². From these results, it can be seen that the vertical distribution and soil seed density were higher in the upper layers and that both vertical distribution and soil seed density decrease with increasing depth. This is in line with what was found by Clements and Bentiôt (1996) and Dessaint *et al* (1991). The total soil seed bank density in the study area was low when compared with Demel and Granstrom (1995). That is explained by the fact that they determined the density under forested areas, whereas the present study was conducted at non-forested areas.

The density of live seeds was low in the study area as compared with Roberts and Stocks (1966). This may probably be due to the differences in site conditions and environmental factors.

The study also revealed that the percentage of dead seeds was higher as compared to that of live seeds. The low viability of seeds may be attributed to suffocation resulting from water-logging, predation, shedding of seeds before maturity and high temperatures.

The study has also revealed that the live seeds in (0-5cm) depth belong to 21 species, while the dead seeds belong to 20 species. In the (5-10cm) depth the live seeds belong to 8 species, and the dead seeds belong to 12 species. However, the (10-15 cm) depth the live seeds belong to 5 species and the dead seeds belong to 10 species. The number of species to which the live and dead seeds belong confirm the previous findings with respect to vertical distribution and seed density for the three soil depths. That is the number of species to which the seeds belong decrease with increasing depth.

The dominant soil seed flora were *Indigofera arrecta*, *I. hochstetteri*, *Dactyloctenium aegyptium*, *Schoenefeldia gracilis*, *Aristida adscensionis*, *Brachiaria spp.*, *Panicum turgidum*, *Euphorbia aegyptiaca*, *Cenchrus biflorus*, and *Cyperus spp.* The dominance of the above mentioned species in the soil seed bank may be attributed to their prolific seeding and good growth and establishment. Moreover, these species are: tolerant to decay, protected from predators and resistant to several adverse climatic conditions.

There are differences among the dominant species in the percentages of the total live seeds. For instance, the frequencies of the total live seeds for *Dactyloctenium aegyptium*, *Cyperus spp.*, *Indigofera spp.*, and *Brachiaria spp.* were 15%, 14.9%, 13.1% and 10.2% respectively. From field observations and soil seed bank identification at



Plate (17). Camel browsing (ecological factor).



Plate (18). Sheep grazing (ecological factor).

the study area, it was found that some grasses and herbs were dominant and this agreed with Hafliges (1990). This indicates that some of the dominant species have different seed production capacities at the different sites and can survive for a long time because of their ability to resist several adverse climatic conditions. However, some species have different percentages of the total number of dead seeds as follows: *Aristida spp.* and *Panicum turgidum*, have frequencies 14.4% and 12% respectively. This may be due to the intolerance of these species to adverse climatic conditions, predation, suffocation, decay besides the shedding of seeds before maturity.

The soil seed bank data was statistically analyzed by JMP programme (Tables 21 and 22) for the live and dead seeds within the three sites of the study area. A very highly significant difference was found for the live seeds in site B and non-significant differences were found for sites A & C. The very highly significant difference of live seeds at site (B) was probably due to site conditions, diversity of species, prolific seeding and resistance to decay. The non-significant differences in sites A & C may be attributed to different seed production capacities of the species under different sites.

As for the dead seeds at the three sites, a very highly significant difference was found at site (B), a highly significant difference was found at site (A) and a significant difference was found at site (C). This may probably be due to the site conditions and floristic composition. The soil seed analysis had also shown that the less palatable species were dominant. This agrees with O'Conner and Pickett (1992), who reported that heavy grazing results in the dominance of the less palatable species.

6.5. Natural regeneration:

Natural regeneration was studied and the results showed that the most dominant naturally regenerating species were: *Acacia tortilis subsp. spirocarpa* and *Acacia tortilis subsp. raddiana*. These species have very large numbers of wild seedlings which indicates that they have high

adaptability to site and adverse environmental conditions, besides tolerance to over-grazing. The other species e.g *Ziziphus spina-christi*, *Balanites aegyptiaca*, *Acacia oerfota*, *Acacia mellifera*, *Capparis decidua*, *Acacia seyal var.seyal* and *Maerua crassifolia* showed small numbers of wild seedlings. This may be attributed to the small number of live seeds and lack of resistance of these species to predators, adverse conditions and over-grazing.

The present study has found an average of 421 seedlings/ha for the woody species in the sites of the study area. This inventory was done by using global positioning system (GPS) and 10x10m. quadrats to assess the wild seedlings/ha., based on Krebs, (1989). The factors affecting natural regeneration in the area include over-grazing pressure, climatic conditions, excessive land use, and predation of young plants and low production of live seeds.

6.6. Tree cover assessment:-

The crown area is the feature that is commonly used to define trees as well as forests. The biomass productivity and natural regeneration are affected by crown area. According to FRA (2000), FAO (1998) and FAO (2000), the forest is defined as the land with a tree canopy more than 10% and an area of more than 0.5ha. In the present study, the average crown cover was found to be 3.5% and according to FAO (2000) the study area can be classified as other wooded lands. Similarly, the tree numbers for sites A, B and C were 73, 52 and 78 stem/ha. respectively. *Acacia tortilis subsp .spirocarpa* was observed to be the most dominant species across the three sites. This makes it more suitable for rehabilitation and afforestation due to its adaptability to the environmental conditions.

Some species showed a decrease in number e.g *Acacia mellifera*, *Commiphora africana* and *Acacia seyal var.seyal*. This may be attributed

to the excessive felling, intensive utilization and poor resistance to adverse environmental conditions.

6.7. Soil analysis:

The results of the soil moisture analysis are presented (Table 35). The moisture content in the study area was very low. This is probably due to the decrease in the vegetation cover, increase in run-off & erosion, low quantity of organic matter and rainfall fluctuations.

The results of the soil characteristics were outlined (Table 36). The soils of the study area were classified as alkaline and acidic soils. The organic matter and nutrients were less available. The low availability may be affected by the scarcity of vegetation cover, run-off and erosion.

6.8. Summary and Conclusions:

- A total number of 85 plant species belonging to 30 families were identified. About half of these species (49.4%) have medicinal values.

- The dominant woody species were *Acacia tortilis subsp. spirocarpa*, *A. tortilis subsp. raddiana*, *Maerua crassifolia*, *Acacia oerfota*, *Ziziphus spina-christi*, *Leptadenia pyrotechnica*, *Capparis decidua* and *Balanites aegyptiaca*.

- *Acacia tortilis subsp. spirocarpa* and *A. tortilis subsp. raddiana* have high frequencies and low abundance, an indication of regular distribution.

- *Acacia oerfota*, *Maerua crassifolia* and *Ziziphus spina-christi* have low frequencies and low abundance i.e contagious distribution.

- Diversity index (or Simpson's index) for woody species was 2.02.

- Similarities between sites: (A and B, A and C, B and C) for woody species were 30.8%, 25%, and 40% respectively.

- Significant associations between woody species were found for each pair of the following: *Acacia tortilis subsp. spirocarpa* and *A. tortilis subsp. raddiana*; *A. tortilis subsp. spirocarpa* and *Maerua crassifolia*; *Acacia tortilis subsp. raddiana* and *Maerua crassifolia*; *Acacia tortilis subsp. raddiana* and *Ziziphus spina-christi*.

- Non-significant associations were reported between pairs of the following : *Acacia tortilis subsp. spirocarpa* and *Acacia oerfota*; *Acacia tortilis subsp. spirocarpa* and *Ziziphus spina-christi*; *Acacia tortilis subsp. raddiana*, and *Maerua crassifolia*; *Acacia oerfota* and *Ziziphus spina-christi*; *Maerua crassifolia* and *Ziziphus spina-christi*.

- The range of density of soil seed bank for live seeds was 1015- 5371 seeds/m² while that for dead seeds was 3215- 6957 seeds/m². It was found that the density of soil seed bank decreases with increasing depths.

- Biomass productivity was found to be 33540.5 kg/km².

- The average carrying capacity was found to be 3 a.u./km²/year

- The average density of natural regeneration of woody species was 421 seedlings/ha.

- The % canopy cover was 3.5%.
- The soils of the study area are alkaline and acidic soils with low moisture content.
- The total number of extinct plants was 16 plant species.
- The total number of famine food species was 12 plant species.
- The study area is generally sparsely vegetated and has very low species diversity.
- U- shaped wadis or depressions are widely distributed over the study area and dominated by *Acacia tortilis subsp. spirocarpa* and other associated species.
- Sand dunes have covered a great part of the study area which is mainly fixed by *Leptadenia pyrotechnica* and *Panicum turgidum*.

6.9. Recommendations:

- There is vital need for efforts that can reduce desert encroachment and preserve plant species of economic and medicinal importance. This is evident from field observations, meteorological data and personal communication with the elderly people in the study area.

- There is need for reseeding or replanting extinct plant species. Management of these plants should conform to the ecological factors prevailing in the study area.
- There is need for national, regional and global financial and technical support to rehabilitate the study area and other similar deteriorated lands.
- There is need for more research on soil seed banks of the area and water harvesting techniques.
- There is vital need for more research on nutritional values of famine food plants which will provide a potential substitute for traditional food crops.
- Attention should be paid to land use planning and resource utilization and conservation in accordance with The National Land Commission regulation.

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