

Status of *G. arboreum* and *G. herbaceum* may be truly indigenous or very old introductions. Some local races of *G. hirsutum* were also present in various parts of Sudan. Types of *G. barbadense* var. *brasiliense* occurred for many years in Equatoria states. *G. Barboclense* is also found as perennial in Darfur. At present, cotton is a major cash crop in Sudan, and grown as irrigated and rainfed crop in central, western and eastern Sudan. Two officially released improved varieties of cotton are grown in Sudan, namely *G. hirsutum* and *G. barbadense*.

**(ii) Kenaf**

(*Hibiscus cannabinus* L.) is grown in Sudan on small scale. Wild types of *H. cannabinus* are indigenous to many parts of the country.

**(iii) Sisal**

(*Agave sisiliana*) and Jute (*Corchorus olitorius* L.) are also found wild or cultivated in many parts of the country.

**e. Forage crops**

In the Sudan some cereal species are also used as forage crops, namely sorghum, maize and millet. Other crop species are known mainly as fodder crops like alfalfa, clitoria and phillipesara.

The sorghum type known as *Abu sabeen* is a popular fodder crop in Sudan, and the varieties used are landraces e.g. Dibeikri; hybrids. Landraces of maize are also cultivated as green forage. Alfalfa (*Medicago sativa*) is an important fodder crop in Sudan. The only alfalfa cultivar in Sudan is called *Berseem Higazi*, and biodiversity in this fodder is expected to be very narrow.

**f. Other field crops**

Other important field crops in Sudan include sugarcane, roselle and guar.

**(i) Sugarcane**

(*Saccharum sinense*) is one of the cash crops used for the production of sugar in Sudan. Wild sugarcane relatives were reported in Sudan, namely *S. spontaneum* and *Erianthus maximus*. Western Equatoria State appears to be the home of *E. maximus* in Sudan. Local forms of sugarcane are also grown in many locations in the central Sudan, Darfur and near to Khartoum. These are used mainly for chewing purposes. For the production of sugar, sugarcane is cultivated by the sugar manufacturing factories using mainly improved released varieties.

**(ii) Roselle**

(*Hibiscus sabdariffa* L.) is produced mainly on the sand dunes of western Sudan. The type of roselle produced in Sudan belongs to the botanical variety *sabdariffa*. It is believed to have originated in West Africa and from there it has been introduced to western Sudan. Kordofan states, particularly Northern Kordofan State, is the main area of production of this crop in Sudan. The cultivated varieties are mixtures of different strains. Several local strains can be identified on the basis of calyx shape and color and other plant characteristics.

### (iii) Guar

(*Cyamopsis tetragonoloba* (L.) Taub.) is produced in central Sudan and Kordofan states. One wild species of the same genus is known in Sudan, which is *C. senegalensis*, but no landraces are known. Improved varieties are being introduced to the country for evaluation and production.

## 2.1.2. Horticultural crops

Horticultural crops grown in Sudan comprise a long list of vegetables, fruit trees, ornamental plants, and medicinal and aromatic plants. Some of these crops are indigenous to the country while others are exotic. Some are considered of major importance in the world while others are of minor importance and local usage.

### a. Vegetables

The vegetables grown in Sudan include okra; onion; solanaceous vegetables like tomato, potato, peppers, and eggplant; cucurbits like melons, watermelon, pumpkins and squash; root vegetable crops like sweet potato, radish and carrot; and leafy vegetables like jew's mallow, purslane, rocket and chard.

#### (i) Okra

(*Abelmoschus esculentus* (L.) Moench.) is the most traditional popular vegetable in Sudan, and is produced in the different parts of the country. Wild types of okra exist in the Sudan, some of these belong to the cultivated species *A. esculentus* and others belong to other species like *A. ficulneus* and *A. manihot*. Okra seems to be a crop of a very long history in Sudan as it is evident from the presence of wild types and the wide range of observable variability within the cultivated types.

Farmers depend almost completely on the use and production of landraces, which in many cases are designated names relevant to the localities where they are usually produced. Improved Indian and American cultivars have been introduced in the country but they are still grown on a limited scale.

A large amount is harvested from the wild to be used as the dried and ground "waika", so widely used throughout the country.

#### (ii) Onion

(*Allium cepa* L.) is a very important vegetable crop produced almost all over the Sudan. It is a crop that seems to have been introduced into Sudan a long time ago. Since then, farmers in the different parts of the country have known a range of cultivated landraces. Important areas of onion production include Northern and River Nile states, Kassala area in eastern Sudan, Gezira area in central Sudan and western Darfur. Differences between these landraces are very prominent, particularly in bulb characters like shape, skin color and storability. Those landraces proved to be superior to introduced improved varieties. New improved lines have been selected from the local germplasm and released to farmers.

#### (iii) Tomato

(*Lycopersicon lycopersicum* (L.) Karst) constitutes one of the most important vegetables in Sudan, and is used for salad and paste. It is an introduced

vegetable, and old introduced cultivars are known in the different parts of the country. At present, the old salad cultivars known as local (*Beladi*) are produced in some areas especially in the northern and western parts of the country. Tomatoes of cherry-like fruits are produced in Darfur especially in Jebel Marra area for dried tomato paste. Introduction of new improved cultivars started since the sixties and areas cultivated with these varieties are expanding especially in central Sudan.

#### **(iv) Hot pepper**

(*Capsicum* spp. L.) is a widely grown vegetable crop in Sudan, and was introduced a long time ago. Variable local cultivars are well known in the country. In western Sudan, some unique and distinct local cultivars are very famous. For example, the type called "*Dingaba*", which is extremely hot, is produced in Darfur states, while the type called "*Gabaneef*", which is also very hot is produced in the Nuba Mountains in Kordofan State. Introduced sweet pepper cultivars like California Wonder and Yolo Wonder are popular in the urban areas.

#### **(v) Potato**

(*Solanum tuberosum* L.) is a vegetable crop that is produced in Sudan using several introduced cultivars the seeds of which are imported. An old introduced type of potato is still produced in Jebel Marra area in Darfur, and is known locally as Zalingi.

#### **(vi) Eggplant**

(*Solanum melongena* L.) is a popular vegetable in Sudan. Old introduced cultivars have almost disappeared as only new improved varieties, like Black Beauty and Long Purple, are grown. Other cultivated species of eggplant like *S. aethiopicum* are grown in some parts like south Sudan. Wild *Solanum* species are reported in Sudan e.g. *S. incanum* and *S. dubium*.

#### **(vii) Melons**

(*Cucumis melo* L.) are believed to have originated in eastern Africa including Sudan. Four cultivated types of melons are grown in Sudan: sweet melon (*C. melo cantalupensis*), snake melon (*C. meloflexuosus*), the salad melon known locally as "*Tibish*", and melon type used for eating its seeds after roasting and known locally as "*Seinat*". Wild melons belonging to the group *C. melo agrestis* grow in Sudan especially in the central and western parts. Traditional local cultivars of sweet melon were grown in the past in the White Nile area in wide areas. Such traditional cultivars are being rapidly replaced by new improved cultivars imported from abroad. Snake melon cultivars used are totally of local landraces of which some are named after the areas where they were developed. *Tibish* and *Seinat* cultivars are of local landraces.

#### **(viii) Watermelon**

(*Citrullus lanatus* Thunb. Mansf.) is a major crop in Sudan, which is a part of the African center of its origin. Variable landraces are grown in western Sudan, and are especially widely spread in Kordofan states. Several improved cultivars were introduced since the sixties. The most extensively cultivated varieties are Congo and Charleston Grey. Wild relatives of watermelon are

found in Sudan; one of these is *C. colocynthis* (bitter apple) which is widely growing in northern Sudan.

#### **(ix) Pumpkins and Squashes**

(*Cucurbita* spp. L.) are popular types of cucurbit vegetables. Variable landraces of pumpkins are grown in Sudan especially in the center. Zucchini squash is a type of squash well-known by vegetable growers in Sudan.

#### **(x) Root crops**

Several root crops are grown in Sudan. Among those having local cultivars are cassava (*Manihot* sp.), yam (*Dioscorea* sp.) sweet potato (*Ipomea batatas*) and radish (*Raphanus sativus*). Recently, other types of root crops have been introduced and their uses and areas of production keep increasing like carrot (*Daucus carota*) and table beet (*Beta vulgaris*).

#### **(xi) Leafy vegetables**

Have an important role in the diet of the Sudanese people. Jew's mallow, purslane and rocket are the most important types of leafy vegetables. Jew's mallow (*Corchorus olitorius*) is grown in many parts of the country using local selections of this species germplasm. Wild *Corchorus* species are found in different regions of the country. Purslane (*Portulaca oleracea*) is as important as Jew's mallow, and local landraces are being grown. Wild *Portulaca* species also exist in Sudan. Rocket (*Eruca sativa*) is the main leafy salad vegetable grown, and its production depends mainly on local types in which the growers report a degree of variability. Newly introduced leafy vegetables like lettuce and cabbage are being grown and used in the urban areas.

### **b. Fruits**

Several varieties of fruit trees are grown in Sudan. Some of them are ancient in the country while others were introduced not long ago. The most well known fruit trees in Sudan include date palm, banana, guava, citrus fruits and mango.

#### **(i) Date palm**

(*Phoenix dactylifera* L.) is believed to have been grown in the Northern and River Nile states and upper Nubia since 3200 BC. Dry date cultivars might have originated in southern Egypt and northern Sudan. Different local cultivars are grown in Sudan, and are classified into three categories: dry dates, soft dates and semi-dry dates. The main area of date production in Sudan is the Northern and River Nile states. Date palms are also grown in the Northern Darfur State. A wild relative of date palm (*P. reclinata*) exists in Jebel Marra area in Western Darfur State and was reported in southern Sudan. It produces an edible fruit that is occasionally eaten. Recently, some new soft date cultivars have been introduced from Arab countries for evaluation. Due to the out-breeding system in date palm, a large number of seedling varieties (gaw) have evolved.

#### **(ii) Mango**

(*Mangifera indica* L.) is believed to have been introduced into Sudan via Egypt, and about 57 cultivars are reported to exist in Sudan. They are categorized into three groups: True Indian cultivars, Egyptian seedling

cultivars of Indian origin and Sudanese seedling cultivars of Indian origin. The main area of mango production in Sudan extends along the main Nile banks in Northern and River Nile states. It is also grown on a small scale along the Blue Nile banks in central Sudan, and in some parts of South Kordofan and in Darfur states where the other cultivated species of Mango (*M. odorata* Lour) is found. A large portion of mangoes in Sudan is also grown in the southern parts of the country.

### **(iii) Citrus**

The most important citrus fruit trees grown in Sudan include sweet orange (*Citrus sinensis* Osbeck), grapefruit (*C.paradisi* Macf.) and lime (*C.aurantifolia*). Other citrus trees are grown but on a limited scale, like mandarin (*C.reticulata* Blanco), lemon (*C.limon*) and pummelo (*C.grandis*). This is in addition to other types of citrus trees used mainly as rootstocks, of which the sour orange (*C.aurantium*) is the most widely used. The northern, eastern and central regions are important areas of production. Jebel Marra area in Western Darfur State is of a special importance in citrus production as almost all the sweet navel orange fruits (seedless fruits) are produced there. Small areas of citrus fruits are found in some parts of Kordofan states. All cultivars of citrus fruits grown are introduced old varieties. The distinct old cultivars in citrus fruits are five for sweet orange, three for grapefruit, and three for lime. Some wild citrus trees are also reported to be growing in some parts of western and central Sudan. During the eighties, some new orange and grapefruit varieties were officially released.

### **(iv) Guava**

(*Psidium guajava* L.) is an introduced fruit. Its method of propagation, which is by seed, has resulted in many variable types, reported to be more than 20 in Darfur states only. Guava types in Sudan are generally classified into two groups. the white-fleshed and the red-fleshed guava. Some local cultivars have got names of the areas where they are mainly produced.

### **(v) Banana**

(*Musa*. sp.) is a popular fruit species in Sudan. An old cultivar, which is dwarf Cavendish is the type produced since 1896. The main areas of production are the southern part of the River Nile State, Khartoum State, along the Blue Nile banks in the central Sudan and Kassala State. It is also produced in some parts of Darfur where in certain parts of the flood plains fruit growers described certain banana relatives (types) with very small edible fruit (finger type). According to Fagusan (1953), a wild banana (*Musa enseat*) occurs in southern Sudan and produces edible seed though not edible fruits. Recently, new cultivars and lines were introduced for evaluation. Some types of plantain are also grown in southern Sudan.

### **(vi) Other fruits**

There are also other fruit trees grown in Sudan, but on limited scale. These include paw paw (*Carica papaya* L.) and pine apple (*Annona* spp.) which is mainly grown in the south, and grapes (*Vitis Vinifera*). In Jebel Marra area, some fruit trees of the Mediterranean climate are grown. They include apple, pear, apricot, fig and others.

Some indigenous tree species in Sudan are also known to produce edible fruits, which are used by the inhabitants. More than ten species could be named in this regard like (eldom) *Hyphaene thebaica*, (daleib) *Borassus aethiopum*, (nabag) *Ziziphus spina-christi*, (aradieb) *Tamarindus indica*, (goddaim) *Grewia mucronata*, (laloub) *Balanites aegyptiaca*.

Wild fruits used in the Sudan include "Tamr hindi" (*Tamarindus indica*), wild fig (*Ficus* spp.); "tundub" (*Capparis decidua*), "tabaldi" (*Adansonia digitata*), "dom" (*Hyphaene thebaica*) and "kursan" (*Boscia senegalensis*).

### **c. Other horticultural crops**

#### **(i) Tobacco**

(*Nicotiana* spp.) is a traditional crop in some areas of the Sudan. It is produced mainly in Western Darfur and the Equatoria States. It is also grown on a limited scale in the Nuba Mountains of Southern Kordofan State, southern part of the Blue Nile State, the far north of the Northern State. Two species are known in Sudan: *N. tabacum*, which is known locally as "tomback" and *N. rustica* known locally as "gamsha". Since the crop is an old one in its areas of production, several adapted and variable local cultivars have evolved.

#### **(ii) Ornamental Plants**

Used at present, are derived mainly from exotic material introduced earlier by the British and later by the Sudanese. Nevertheless, the wild flora of Sudan includes many plant species having the potential of being used as ornamental plants. They are species from different ornamental groups like shrubs, trees, bulbous crops, cacti, succulents, palms, vines, foliage plants and turf grasses and ground covers.

### **2.1.3. Underutilized food crops**

Some indigenous communities use several plant species, existing in the wild flora, on a limited scale, as food plants. Examples of such species include *Brachiaria obtusiflora*, known locally as "Um chirr", *Cassia obtusiflora* known locally as "kawal", *Echinochloa colona*, locally known as "difra", *Oryza punctata* known as "roz el wadi", and *Sonchus* spp. Known locally as "moleita". These underutilized species contribute substantially to household food and livelihood security. Some of them have potential for more wide spread use, and hence promotion to food security, agricultural diversification and income generation.

**Table (2): Field and horticultural crop species that have wild relatives in Sudan**

| <b>Species</b>                 | <b>Wild Relative</b>   |
|--------------------------------|--|
| <i>Sorghum bicolor</i>         | <i>S. aethiopicum</i> ,<br><i>S. verticilliflorum</i><br><i>S. arundiaceum</i><br><i>S. Sudanese</i> |
| <i>Pennisetum glaucum</i>      | <i>Pennisetum</i> spp.   |
| <i>Oryza sativa</i>            | <i>O. punctate</i><br><i>O. longistaminata</i><br><i>O. barthii</i>                                  |
| <i>Eleusine</i>                | <i>E. indica</i><br><i>E. flagellifers</i>   |
| <i>Sesamum indicum</i>         | <i>S. alatum</i><br><i>S. latifolium</i><br><i>S. angustifolium</i>                                  |
| <i>Guizotia abyssinica</i>     | <i>G. villosa</i><br><i>G. scabra</i><br><i>G. schimperi</i>   |
| <i>Gossypium</i> spp.          | <i>G. somalense</i><br><i>G. anomalum</i><br><i>G. arboreum</i><br><i>G. herbaceum</i>               |
| <i>Hibiscus cannabinus</i>     | <i>H. cannabinus</i>   |
| <i>Saccharum sinense</i>       | <i>S. spontaneum</i><br><i>Erianthus maximus</i>   |
| <i>Cyamopsis tetragonoloba</i> | <i>C. senegalensis</i>   |
| <i>Abelmoschus esculentus</i>  | <i>A. ficulneus</i><br><i>A. manihot</i>   |
| <i>Solanum melongana</i>       | <i>Solanum</i> spp.  |
| <i>Cucumis melo</i>            | <i>C. melo agrestis</i>  |
| <i>Citrullus lanatus</i>       | <i>C. colocynthis</i>  |
| <i>Corchorus olitorius</i>     | <i>Corchorus</i> spp.  |
| <i>Portulaca oleracea</i>      | <i>Portulaca</i> spp.  |
| <i>Phoenix dactylifera</i>     | <i>P. reclinata</i>  |

**2.1.4. Crop species that might have originated in Sudan**

Pearl millet (*Pennisetum glaucum*)  
 Sorghum (*Sorghum bicolor*)  
 Melon (*Cucumis melo*)  
 Watermelon (*Citrullus lanatus*)  
 Okra (*Abelmoschus esculentus*)

### 2.1.5. Medicinal Plants

The flora of this country is described as rich and broadly diversified due to variation and diversity of climate and soil types. According to White (1983), five major regions of flora had been described but more recently Wickens (1991), adopted a more detailed classification of 8 floral regions in Sudan.

Several studies conclusively indicated that a total of 3156 plant species that represent 1137 genera and 170 families were identified in Sudan. An estimate of 11% of all dicotyledenous plant species was claimed to have medicinal value. This portion comprises 266 species selected from 200 genera and 67 families. Only, 1.5 % of monocotyledons including 12 species that represent 10 genera and 5 families were also exploited for their medicinal value.

The experience of traditional use of medicinal plants in Sudan had evolved for centuries as a part of the Sudanese authentic culture that had been continuously influenced by influxes of ethnic groups of West African and Middle East origin. Consequently, such an interaction had already encouraged the introduction and exploitation of more exogenous plant species in traditional medicine e.g. *Acanthospermum hispidum*.

However, Wellcome Research Laboratory (1909), Braun & Money (1929) and Wickens (1976) had firstly attempted documentation for diversity of plant species used in traditional medicine. Then, more recently a series of publications that document the results of many survey activities of medicinal plants in Northern and Central Sudan has been produced by the National Center for Research during 1986-1998.

## 2.2. Forestry

**We must not simply see the trees for wood, and not the forest; see the forest as a whole, with all its biodiversity: the trees, shrubs, ground flora, insects and fauna. Preserve an ecosystem, not just a species.**

### 2.2.1. Tree cover

Harrison and Jackson (1958) estimated the tree cover in Sudan at 36-43%. Extrapolation from the Forest Resources Assessment by FAO in 1990 indicated a tree cover of 19%. This was explained as being a consequence of the expansion in agriculture, urban expansion, fuelwood production and grazing. The Forests National Corporation (FNC) with the cooperation of FAO was able to undertake a National Forest Inventory in 1997, which covered the central part of the country between latitudes 16°N and 10°N. The area covered was 62.3 million ha (622.700 km<sup>2</sup>) or 24.9% of the total area of the Sudan. The area covered is mainly in the low rainfall savanna region, where almost all-present activities of irrigated and rain-fed agriculture, forestry, grazing, human settlements and oil fields are concentrated. A large part of forest products come from this inventoried area. This survey resulted in a forest cover in the inventoried area of 12% based on the FAO Definition of Forest (10% canopy cover). This might be close enough to the FAO

estimate of 19% for the whole country as the southern part of the country with a denser forest coverage had not been included in this inventory.

### **2.2.2. Diversity in trees and shrubs**

It is estimated that there are about 533 trees species in the Sudan 25 of which are exotics. Also there are about 184 shrub species in the Sudan of which 33 are exotics. However, the vegetation of Sudan forests, is not adequately explored or adequately documented. Some of the species have a wide range of distribution and considerable variation within the species. Opportunities are great for collaborative efforts at national, regional and international levels for exploration, and establishment of herbaria and arboreta at national and state levels.

Some forest formations are unique in the Sudan e.g. relics of Rain Forests termed "Bowl Forests" in Eutoria e.g. Azza, Talanga, Leboni. Also the Mangrove Forests along the Red Sea Coast and other unique forests on mountains and hills. It is suggested these areas be reserved.

### **2.2.3. Current state of natural forests and perspectives for the future**

Sudan had never had a national forest inventory. The first national inventory for Sudan was launched early 1995 and was completed in 1997. However, some tracts of forests have previously been inventoried e.g. Biomass resources east of the Nile (1991), southern Blue Nile and northern Bahr El Ghazal (1984), parts of Kordofan and Darfur (1990-94), parts of northern Blue Nile (1994), besides the regular inventory of forest reserves under management plans. The state of natural forests can only be extrapolated from these ad hoc surveys and from global ones such as that by FAO (1990).

Forests and woodlands not constituted as forest reserves (the latter only makes about 2.8% of the total land area), are continuously being encroached upon by agriculture and urbanization or otherwise degraded by uncontrolled felling. The forest reservation process which started in 1923 was only able to settle and finally gazette 3.0 million feddans – 1.7 million ha. (equivalent to 0.4% of the total area of the country). A number of government decrees passed in September 1993 brought the area under forest reserves to 16.81 million feddans (5.0 million ha) equivalent to 2.8% of the total country area. In view of the rising official and public awareness and the official enthusiasm for the sector, it is expected that more land will be explicitly allocated to forestry, range and pasture and wildlife as spelled out by the Comprehensive National Strategy 1992-2002.

The latter called for allocation of 150 million feddans (63 million ha) for natural resources; i.e. 25% of the country's area. That area would eventually need to be put under management plans (Abdel Nour 1996).

### **2.2.4. The role of forestry in the national economy**

The forestry sector contributes some 12% of the Sudanese GDP, besides the indirect benefits it renders in the way of environmental protection, biodiversity conservation, soil amelioration, work opportunities for rural population etc. perhaps the most tangible benefit derived by the people of the Sudan from their forests in fuelwood (firewood and charcoal). In 1999 according to the results of the Forest Products Survey (1994), Sudan consumed energy equal

to seven million Tons of Oil Equivalent (TOE), 80% of this was in the form of wood, charcoal and other biomass, 18% as petroleum products and 2% as electric power.

The annual exports of gum Arabic range between 20-40 thousand tons and earn some 50-80 million.

### **2.2.5. Endangered and threatened trees and shrubs**

A recent survey conducted at the request of the general manager FNC indicated that a number of trees and shrubs, both indigenous and exotic are either on the verge of being extinct or are seriously threatened. Kamil (1996). Those deemed nearly extinct are of indigenous trees or shrubs whose existence is confined to limited locations. Those considered seriously threatened are 241 tree or shrub species which showed marked retreat in their distribution and/or regeneration due to climatic conditions and also due to the intensity of their removal for wood, fodder or clearance for cultivation. Also endangered are 43 exotic shrub or tree species.

### **2.3. Range and Pasture**

**The whole Sudan is rangeland that encompasses a variety of habitats.**

Rangelands in Sudan are very variable and extend over seven ecological zones: desert, semi-desert, low rainfall savanna on sand, low rainfall on clay, flood region, high rainfall savanna and mountainous regions. These variations support diversity of vegetation and production systems. Rangelands is estimated to be 110 million ha, and it is estimated that the total forage production is about 85.6 millions tons (dry matter), which includes natural range production estimated at 62.4 million tons and 23.2 million tons is agricultural residue, green fodder, dry fodder and concentrates.

About 204 range species have been collected and identified. However, no complete ecological surveys of the rangelands were made since the comprehensive study of Harrison (1958).

The rangelands cover has been subjected, particularly in the semi-desert and savanna ecological zones, to recurrent droughts in the last three decades. Rangelands are showing a decrease of palatable "desirable" species and increase in unpalatable and invader species. The livestock populations are tremendously increasing due to improved veterinary and drinking water services. However, high rates of mortality of livestock took place during drought years. Over-grazing is among the causes of desertification in the Sudan.

Pastoralism is integrated with traditional crop production which is combined with village based livestock raising. Also, it is practiced by rural and by traditional sedentary population, traditional pastoralism, practiced by tribal groups, through nomadic and transhumance systems. The nomads population, as percentage of the total population of Sudan, decreased from 13.5% in 1956 to 3.4% in 1993.

The gizzu vegetation is an example of unique range plants. It is a group of plants, which grow in desert areas after the scarce rainfall which rarely, falls in the desert. The nomads seek the gizzu as highly desirable nutritious winter grazing.

The gizzu disappeared from the desert areas during the drought periods for more than 20 years. However, during the last few years, the gizzu appeared in vast areas of the desert in Darfur.

The Butana area in Gedarif, Kassala and Khartoum states is also an important grazing area used by nomads during the wet season. The Bahr Al Arab areas in Southern Kordofan and Southern Darfur states are important dry season grazing land for cattle herders. Baggara traditional nomadic routes and tribal grazing lands "Dar" had been subjected to changes due to horizontal expansion of mechanized rainfed cultivation, drought and increased numbers of livestock. Conflicts often occur over the use of the resource. Large areas of rangelands are under communal use with no formal (legal) land tenure systems.

Examples of change and decline in the annual grass *Dactyloctenium aegyptium* and increase of the annual *Cenchrus biflorus* and *Eragrostis tremula*. The perennial *Andropogon gayanus* is also on the decline. Endangered species include *Blepharis ciliaria* and *Blepharis Linarifolia*

The Range and Pasture Administration (RPA) is the governmental agency entrusted with the administration of rangelands in the Sudan. With the devolution of some aspects of agriculture to the states, the RPA seems to have lost in both levels. For the last few decades, The administration has been suffering from a high turn over of leadership. There is no legislation governing rangelands use, and material and financial support for RPA is not adequate.

## 2.4. Wildlife

**Biodiversity is dynamic, and therefore needs to consider species in time and space.**

Out of the 13-mammalian orders in Africa, 12 occur in the Sudan. Setzer (1956) reported on 224 species of mammals in the Sudan (Bats were not included). Cave and Macdonald (1955) reported on 871 species of birds and their habitats in the Sudan. Among the important habitats for migratory and resident birds in the Sudan is the "Sudd" area, which is the home for the shoebill stork endemic to Sudan, Kenya and Uganda. The Sudan falls within the migration routes of birds between Africa, Europe and Asia, and millions of migratory species visit the Sudan yearly. Nicholas (1987) reported on 931 species of birds and mapped their distribution. Nimir (1983) reported 106 species of fresh water fish and about 90 species of reptiles in the Sudan. Hillman (1982) made an extensive review of wildlife in southern Sudan, which included information on 83 species and 19 conservation areas.

The Sudan Government issued the Preservation of Wild Animals Ordinance in 1935 and the Game Regulation in 1939. The Wildlife Ordinance provides for three classes of protected wild animals. Wild animals' schedules include mammals, birds and reptiles. Animals in schedule I are completely protected, animals in Schedule II are to be hunted by virtue of a special license issued by the Minister, and animals in schedule III could be hunted by holders of an ordinary license. Bird hunting license is also issued for hunting mainly bustards, sandgrouse, doves, ducks and geese. Prohibited methods of hunting are also included in the Ordinance, which includes also 3 categories of protected areas: National parks (with highest degree of protection), Game reserves (limited use of resources could be permitted) and Game sanctuaries (protection for specific species). One bird sanctuary exists in Khartoum "Sunt" Forest while most of the other protected areas emphasize mammals. However, birds and reptiles occur in almost all of the protected areas.

Eight national parks exist with a total area of about 8.5 million ha representing 3.2% of the area of the country. Two national parks are declared "biosphere reserves". The national parks also include a marine park in the Red Sea Coast. There are also 11 game reserves with a total of 3.3 million ha constituting 1.3% of the area of the Sudan, and 3 game sanctuaries with a total area of 95 000 ha. The total area of protected areas is about 11.9 million ha or 5.4% of the area of the country. Conservation status of all protected areas is rated as unsatisfactory.

Wildlife habitats and wild animals are subjected to deterioration due to expansion in agriculture, overgrazing, drought, felling of trees and poaching. 17 mammals, 8 birds and one reptile are considered as threatened species. Nimir (1983) stated that the following animals are considered threatened: *Oryx gazelle*, *Sommering gazelle*, *dama gazelle*, *addax gazelle*, *wild sheep*, *wild ass*, *cheetah* and *dugong*. The ostrich had disappeared from its range in the semi-desert and its presence in the Savanna is limited. The Guinea fowl presence also declined seriously. Bustards are subjected to over-hunting.

Revenue from wildlife is very limited, restricted to dues on the limited hunting licenses sold yearly, and export of live animals and animal parts. Tourism potentials are great in the Sudan; however, it is still very limited due to lack of infrastructure and to the war in the south where most of the rich wildlife areas exist. Although about 27 wildlife-breeding farms were established, most of them are unsuccessful due to lack of scientific supervision and extension support. The Khartoum Zoological Garden, which was one of the oldest zoos established in Africa, was lost by the Wildlife Conservation General Administration (WCGA) due to city planning decisions. Another site is designated for a new zoo in Khartoum. However, no funds are available. Several sites for zoos are planned in several cities and towns in Sudan. Development of these zoos too has not started due to lack of resources.

The WCGA is the official governmental agency responsible for wildlife conservation in the Sudan. It is affiliated administratively to the Ministry of Interior and affiliated technically to the Ministry of Environment and Tourism. This dual affiliation of WCGA is considered the main reason for its weakness. The Wildlife Research Center (WRC) is a part of the Animal Resources Research Corporation. There are no official links between the WCGA and

WRC. Research recommendations are not implemented, and the WCGA major approach to wildlife conservation is policing and licensing with no efforts in the area of involving the people in participatory wildlife management or applying scientific wildlife management practices.

## **2.5. Freshwater (Inland) Ecosystem**

### **2.5.1. Microfauna**

In general, the microfauna are more dominant in the southern Sudanese water bodies and are characterized by monotony and homogeneity in species composition. The zooplankton is extremely poor in quantity within the stretch of the Nile from Bor to Malakal. The high rate of river current and abundance of detritus dispersed along the water column impedes the development of zooplankton.

### **2.5.2. Fish Fauna**

Studies along the whole River Nile revealed that it contained at least 54 genera of fish (over 300 species). In Sudan 29 fish genera and 126 species were detected - many authors described and identified Sudan fresh water fishes.

In the White Nile 24 families, 52 genera and 106 species of fish have been identified. Southern areas are the most favorable condition for reproduction and growth of juvenile fish where there are no considerable fluctuation of water level, and vegetation overgrowth are widely dispersed serving as substratum for ovipositor, sanctuaries and feeding grounds for juvenile fish. This is not confined to fish of southern watercourse since there is no demarcation between them and the Gebel Aulia reservoir, both, are major sites for production of fish in the Sudan.

It is worth mentioning that the southern Sudanese region is considered as an under-fished resource, a phenomenon as dangerous as over-fishing because it leads to suppression in fish growth and reproduction. These biological processes may be conveyed genetically to the coming generation and will prevail even under better conditions. Besides, under the high competition for food and breeding sites, some species of fish will disappear or desert the area to the further north where they are exposed to over-fishing.

### **2.5.3. Macrophytes**

The biology, ecology and control of aquatic macrophytes (hydrophytes) in the Sudan are well documented by many workers. There are four major life forms of aquatic hydrophytes; emergents, floating-leafed, free floating and submerged.

The literature contains no data as to the richness of macrophytes of the White Nile in Southern Sudan. Although during the Range and Swamp Survey (1979-83) which was sponsored by Environmental Development Fund (EDF), 350 species of higher plants were identified within the Jonglei Project area; the percentage of true aquatics within this number was not specified. There is only one endemic plant, the remarkable swamp grass *Suddia sagitifolia* discovered in 1979 as a new genus.

The wetlands of the Southern Sudan of which the macrophytes are the major component are a very important complex of ecosystem. They have economic, cultural and historical importance.

Many workers studied the aquatic vegetation of the Blue Nile. The Blue

Nile is a torrential river with clear-cut seasonal variations in level and flow. It is characterized by mud flats, which are seasonally inundated, by the river, and by Sennar Dam, if the mud flats lie within its influence. These flats provide very favorable ecological habitats for aquatic macrophytes such as *Najas pectinata*, *Ottelia alismoides*, and *Chara globularis*.

The lentic aquatic environment of Gezira irrigation canals has two main canals that were constructed to irrigate the Gezira scheme and the Managil Extension. These canals take from the Sennar Dam and major canals branch off and supply minor canals. Minor canals supply the field outlet channels, which irrigate cropped land (tenancies).

There are three types of grasslands according to the types of grass found: *Echinochloa haploclada*, *Sporobolus pyramidalis* and *Hyparrheina rufa*.

#### **2.5.4. Microphytes**

Unlike the macrophytes, the microphytes reflect a brighter picture. Lake Ambadi lies at the junction of Bahr el Ghazal and River Jour and supports a rich community, in quantity and diversity of desmids.

It is renowned for having a rich community of the desmid algae. The samples collected in 1955 revealed 21 new species, 32 varieties and 7 forms. Two of these new discoveries acquired new nomenclature. These algal groups are all desmids. A rich phytoplankton community is also present. Another group of algae was found as epiphytic on the submerged *Ceratophyllum demersum*, which included two new species. The list is quite long.

#### **2.6. Coastal and Marine Life**

The Sudanese Red Sea coast extends about 720 km. The Red Sea coastline is characterized by specific zonation. Salinity is the decisive factor for vegetation zonation. Mangroves characterize the latter, *Avicennia marina* on the coastline, halophytes, the coastal plain, which receives both summer and winter rainfall, the mountainous areas and plateaus, and the semi-arid areas to the west. The area is characterized by having the northern most representation of several savanna species. Mist oasis such as Erkawit and Elba has their unique vegetation characteristics.

The coastal zonation is also important for fisheries biodiversity. Marine fisheries resources include mainly bony fishes. Of these 450 species are known in the Red Sea, 250 species of which are known in the Sudanese Red Sea and 93 species are of commercial importance. The Red Sea is one of the three major regions of the world which possess ornamental fishes of potential to ornamental fish trade. 17 families of ornamental fishes have been identified. Shrimps have also been caught from various locations.

The Sudan oyster shell potential has not been evaluated. Wild mother-of-pearl shells (*Pinctade margaritifera*) are found along the whole Sudanese shallow coastal water. Mother-of-pearl shell has also been cultivated in Dongonab Bay since 1905. *Trochus dentatus* Kokian is also found along the whole Sudanese coastal shallow water. Sharks and sea cucumber are also found along the whole Sudanese coastline.

Sudan has one of the most beautiful coral reefs in the world. There are three types of corals reefs: the fringing reefs formed by continuous masses of luxuriant growth of stony coral, the barrier reefs (outer reefs) three to six miles off-shore and Sanganeb atoll which has already been declared as a marine park.

## **2.7. Livestock**

The Sudan possesses an immense and diversified wealth of animal resources, ranging from the domesticated livestock species to the wild and aquatic life which contribute significantly to the food security as well as a considerable base for the economy of the country. Indeed, the livestock accounts for some 20 – 22% of the country's GDP and 53 – 56% of the agricultural GDP. The country is self-sufficient in meat and the raw material of hides and skins for industry.

### **2.7.1. Livestock production systems**

The livestock production systems in the country generally fall under five major systems:

- a. Pastoralist system (i) nomadic and (ii) transhumant
- b. Sedentary and semi-sedentary
- c. Intensified livestock/crop production system
- d. Commercial fattening, dairy and poultry production system
- e. Intra-urban backyard production system

#### **A. The Traditional system**

##### **(i) Pastoralist nomadic**

Pastoralists depend on rangelands and move animals where feed and water are available, in specific geographical zones (camel and cattle owners in Kordofan and Darfur). These groups own 80 – 90% of the total number of cattle, 100% of camels, 80% of sheep and 60% of the goats of the country. The herd sizes in the system vary, averaging 200, 70, 90 and 200 for cattle, sheep, camels and goats, respectively. The system is the main source of meat for the local demand and for export.

##### **(ii) Transhumance system**

This is practiced in the southern part of the country where herdsmen move away during the flood time and to it when it recedes. The herds are kept in enclosures (luaks). The seasonal movement is short for distances as compared to the nomadic system. Herd sizes are small and are mainly cattle, which represent the pivot for the economic and social life of the people.

### **(iii) The sedentary and semi-sedentary system**

This includes livestock owners who practice rainfed agriculture and also send their animals with the nomads to feed on agricultural by-products in the area. The system also includes farmers in the irrigated schemes who raise small ruminants for supplementary financial support. Owners keep milking animals and send dry ones with the pastoralist nomads. The system supplies milk to towns and urban areas, and is characterized by low technology.

### **(iv) The Intra-urban backyard system**

In this system, mainly goats and poultry are kept for domestic supply. This system is widespread in rural and around urban areas for "productive families". Animals and birds live on household waste and as scavengers.

## **B. Improved modernized systems**

### **(i) Integrated intensive livestock/crop production system**

In this system, intensive dairy production is practiced using irrigated fodder and concentrates with exotic breeds or indigenous local breeds. This system is seen as the promising system for the future supply of milk and meat for the increasing demand of the communities in the country.

### **(ii) Commercial production system: which includes**

- a. Milk cooperatives, specialized large dairy enterprises and individuals that own high producing milking cows. The system is particularly seen around big towns;
- b. Feedlots for fattening cattle and sheep trekked for long distances from the western regions of the country to urban areas and markets. Fattening is also practiced in big privately owned rainfed mechanized agricultural schemes on crop residues; and
- c. Poultry commercial production business around big towns.

### **(iii) Transitional system**

Improvement of the traditional systems is a progressive activity recently practiced where animals are raised on natural range (especially sheep), and water and feed supplements are transformed to those areas. Another recent activity is raising animals on mechanized rainfed agricultural schemes.

## **2.7.2. Livestock feed resources**

About 86% of the feeds for animals in the Sudan are derived from rangelands. Crop residues and agricultural by-products contribute 10% whereas 4% of the feed is from the irrigated forage and concentrates. The Sudan produces all the raw material necessary for feeding cattle and small ruminants on feedlots and dairy farming systems. The agro-industrial by-products of the country include molasses, cottonseed cakes, groundnut cakes, sesame cakes, sunflower cakes and wheat bran.

## **2.7.3. Livestock census**

Attempts to carry out the livestock census in the country started as early as 1916. These were often complemented with data from other sources such as

vaccination figures, livestock taxes etc.. In 1975/76, an intensive effort was made to carry out an aerial survey: Till now this was considered the most reliable census undertaken in the country. The livestock figures that follow were estimates based on growth rates, mortalities, off-takes ...etc extrapolated from that source.

The recent estimates for the livestock in the country stand at 116,419,000 head of animals as follows: -

|        |                 |
|--------|-----------------|
| Cattle | 34,584,000 head |
| Sheep  | 42,363,000 "    |
| Goats  | 36,498,000 "    |
| Camels | 2,974,000 "     |

Table (3) shows the distribution percentage of livestock in the different states of the country.

**Table (3): The percentage distribution of livestock per region in the Sudan.**

| State           | % Cattle | % Sheep | % Goats | % Camels |
|-----------------|----------|---------|---------|----------|
| Western states  | 36.0     | 39.7    | 36.2    | 60.0     |
| Eastern states  | 4.8      | 11.7    | 6.9     | 25.2     |
| Central states  | 26.8     | 20.5    | 20.1    | 10.2     |
| Northern states | 3.1      | 3.6     | 5.4     | 3.1      |
| Southern states | 28.8     | 23.3    | 30.3    | -        |
| Khartoum State  | 0.05     | 1.2     | 1.1     | 1.5      |

Source: Ministry of Animal Wealth, (1998).

#### **2.7.4. Types and breeds of livestock**

The majority of the livestock breeds or types is raised within tribal groups and often carries the name of the tribe or locality. The same type may also carry different names. However, major classifications of the different ecotypes were agreed upon.

##### **a. Cattle**

Cattle of the Sudan are descendents of the *Bos indicus* (Zebu). These are well adapted to the tropical environment because of their high degree of heat tolerance, partial resistance to tick and many tick borne diseases and other diseases and their low nutritional requirements, because of their small size, low metabolic rate and possibly more efficient digestion at low feeding levels. The productivity of milk is generally low. They are late maturing both physiologically and sexually.

##### **Cattle in the Sudan are generally classified into:**

1. The northern Sudan shorthorn Zebu that includes three main types:

The Kenana and the Butana of the central Sudan and the Baggara of the western Sudan. Both the Kenana and the Butana are considered dairy breeds because of their high potential of milk production while the Baggara together with the Nilotic type of the southern Sudan are regarded as beef animals.

The Kenana, Butana and Baggara cattle represent 15.3, 8.7 and 22.6 percent of the total cattle population of the country, respectively.

The Kenana type is mainly found on the western bank of the Blue Nile area extending from Sennar to Upper Nile and between the Blue Nile and the White Nile. They are steel-grey in color.

The Butana type is reddish in color, resembles the Kenana in size and productivity. dwells mainly in the Butana plateau in a triangle of River Atbara, Blue Nile and the River Nile.

The Baggara cattle are considered the meat animals for local consumption as well as for export. Milk production is extremely poor. Small sized animals of various coat colors are found mainly in the western region of the country.

Other types of northern Sudan Zebu cattle include Ayrashai (of eastern Sudan), White Nile cattle, Fuga or Dar El Reeh cattle of the North Kordofan, and the Nuba Mountain cattle.

2. The Dinka, Nuer and Shiluk tribes raise the southern Sudan Zebu (Nilotic) cattle, which includes the Taposá and Mangala, and are characterized by longhorns.

#### **b. Sheep**

The sheep of the Sudan belongs to what is called the Sudan Desert Sheep. It is a large animal with excellent meat and carcass characteristics. It is an export animal and live-weights of 65 – 77 kg can be achieved. A number of ecotypes and tribal types exist. The Kababish, Meidob, Hammar, Bija, Dubasi, Asghar, Wateesh of the northern, western and central Sudan; the small size Nilotic of the southern Sudan; and the Taposá of the southern/east Equatoria.

#### **c. Goats**

The Black Nubian Goat is the predominant type existing in the country. It is a milk breed, large relatively long-legged with pendulous ears. It is commonly found in central Sudan. The Nubian goat represents 50% of the goat population in the country. Weights of up to 40 kg were recorded.

The Desert goat (17% of the population), with long-legs, dark brown in color, is raised by the nomadic tribes of Baggara and Kababish, in the semi-desert regions.

The Nilotic goat: black or white or both colors is found predominantly south of 12 latitude and represents 30% of the goat population of the country.

The mountain goats have short legs, grey or brown in color, and represent 3% of the goat population.

A number of exotic breeds of goats have been imported into the country. Toggenburg, Anglo-Nubian, Saaneen (temperate breeds) and Damascus (Middle East) are to be mentioned. The Anglo-Nubian is a British crossbreed from our indigenous Nubian goats. Saaneen proved to be an adequate breed. Crosses with selected indigenous Nubian goats produced milk yield as high as 4.5 kg/day.

#### **d. Camels**

Two major types of the one-humped camel (*Camelus dromedarius*) exist in the Sudan: The slender riding camels and the heavy-built pack or baggage camel.

- (1) The riding camels are slender and include (a) the Anafi (Shukri), found in Kassala State and (b) the Bishari, owned by the Bija, and Hadandawa, stronger than the Anafi and an excellent race camel, also found in Gedarif and Red Sea states.
- (2) The pack or baggage type, is a heavier animal and constitutes 90% of the total camel population, and is widely distributed in the desert and semi-desert regions. This type includes:
  - Rashaidi: a strong, short-legged animal raised by the Rashaida in the Red Sea, Tokar and Kassala.
  - Arab camel makes up the majority of camels raised by Hadandawa, Beni Amir and Amarrar, and the large sized is raised by Shukria and Bataheen.
  - The Kababish distributed west of the Nile and raised by the Kababish, Hawawir and Kawahla in Kordofan and this is the largest in size of the baggage types in the country.
  - The Gharbawi (western): mainly found in Darfur States.

#### **e. Equines**

##### **1. Horses**

Two groups of horses are recognized in the Sudan:

- (a) Arabian type: this is raised specifically in Northern and Southern Darfur states and in Kordofan states. This type has a light brown color, some are white in color
- (b) Dongolawi type: found in north and central Sudan and Northern Darfur State. The color varies from brown to dark brown. Both the above types are of medium size.

Crossing with exotic breeds of horses (mainly English breeds) is practiced in Khartoum, Nyala and El Fashir and excellent hybrids are now recognized as race horses.

##### **2. Donkeys**

Typical pack donkeys, carrying local names such as Mackady, Dongolawi and Darawy, are found almost everywhere in the country. The Dongolawi type is a high, fast animal used for riding.

#### **f. Pigs**

Indigenous breeds of pigs are raised by the Maban tribes in the Upper Nile State in restricted areas and in limited numbers.

## g. Poultry

The local beladi fowl (*Gallus gallus*) is well adapted in the backyard system everywhere in the country. It is a small bird, supporting families in rural areas with eggs.

With the developing poultry industry in the country, a number of exotic breeds were introduced: White leghorn, Brown sussex, Fayoumi for both broiler and egg production.

## 2.8. Diversity in other Animals

The diversity in larger mammals has been covered in previous sections dealing with livestock, wildlife, fresh water and marine life. Microorganisms are dealt with in the section that follows this. Here is an attempt to touch upon the major pests of crops and livestock together with major disease vectors, venomous and beneficial arthropods.

Pests of crops were very ably dealt with by Schmutterer (1969). They span four phyla viz. Mollusca, Platyhelminthes, Arthropoda and Chordata. Of the Molluscans, Order Pulmonata (snails and slugs) is represented by one species; *Limicolaria kambeul*. Class Nematoda (Nematodes and Eelworms) of the platyhelminthes is also represented by one member which reaches pest status viz. *Meloidogyne javanica*. The bulk of crop pests, beneficial insects and harmful ticks and scorpions belong to the Arthropods (ten orders in three classes) and Chordates (eleven orders in two classes).

The major crop pests and beneficial insects and harmful Arachnids include: Millipedes (surfa) fam. Julidae, cl. Myriapoda; Mites and Spider mites e.g. *Eutetranychus pantopus*, *Oligonychus afrasiaticus* and *Tetranychus cinnabarinus* fam Tetranychidae cl. Arachnida. The class also encompasses harmful scorpions and ticks, particularly *Hyalomma anatolicum* and *Ornithodoros savignyi*. In the Ord. Orthoptera cl. Insecta of particular importance are: *Schistocerca gregaria* (desert locust), *Locusta migratoria migratorioides* (African migratory locust), *Aiolopus savignyi*, *Catantops axillaris*, *Pnorsia carinata* (grasshoppers), *Anacridium melanorhodon melanorhodon* (Sariel lail), *Homorocoryphus nitidulus vicinus* (long-horned grasshoppers), *Gryllus bimaculatus* (Two-spotted cricket); and *Gryllotalpa africana* (Mole cricket). In the Order Isoptera, 28 termite species have been identified (Harris (1968)) of which *Macrotermes bellicosus* (War-like termite), *M. thoracalis* (Cotton-soil termite) *Odontotermes smeathmani* (Date palm termite) are the most pronounced. In the Ord. Thysanoptera Thrips tabaci (Onion and Tobacco thrips), *Caliothrips impurus* (Dark cotton leaf thrips) and *C. sudanensis* are the most important. Ord. Hemiptera, is perhaps the most represented order in plant pests in Sudan with 92 species in 15 families recorded as pests of almost all field crops. The following species are but examples:

The Stainer bugs *Dysdercus fasciatus*, *D. superstitiosus*, the Helopeltis bug *Helopeltis schoutendeni*, the Dura and sesame andat *Elasmolomus sordidus*; the Harlequin bug *Bagarda hilaris*; the watermelon bug *Aspongopus viduatus*, the Egg plant bug *Urentius hystricellus*, the Green stink bug *Nazara viridula*, the cotton jassid *Empoasca lybica*, the Cotton and Tobacco white fly

*Bemisia tabaci*, the Cotton and Melon aphid *Aphis gossypii* and the Date Palm scale *Parlatoria blanchardii*.

In the Ord. Hymenoptera, despite the great number of species present, non is of pest status except for the Harvester ant *Messor barbarus*. Ichneumon flies are valuable parasites on harmful insects together with the Honey bee *Apis mellifera* and *A. florea* (exotic). In the Ord. Coleoptera, inspite of the large number of beetles which occur in Sudan only a limited number is of pest status e.g. The Flea beetle of Cotton, okra and kenaf *Podagrica puncticollis*, the African melon ladybird *Henosepilachna elaterii* and Blister beetle *Epicaulta aethiops*. Numerous Coccinellids are useful beetles, which destroy harmful aphids, scale insects and leafhoppers. Ord. Lepidoptera is economically the most important group of insects in Sudan, particularly the Cotton bollworms *Heliothis armigera*, and *Diapropsis watersi* and the Cereal stem border *Chillo partellus*. In the Ord. Diptera a relatively small number of true flies are pests of crops in Sudan. These include the sorghum gall midge *Contarinia sorghicola*, the sesame gall midge *Asphondylia sesami* and the fruit fly *Pardalaspis quinaria*. Numerous blood-sucking Diptera are very harmful to man and livestock causing such illness as malaria, yellow fever, kala-azaar, onchocerciasis and sleeping sickness. These have been well dealt with by Abu Shama (1974). These include: Sandflies, of which 36 species have been identified in Sudan of which *Phlebotomus clydei* and *P. orientalis* are the most common. Of the green flies only *Tanytarsus lewisi* (Green nimitti) and *Simulium damnosum* are important. Of 26 anopheline mosquitoes identified in the country, malaria is specifically attributed to *Anopheles gambiae*. The true vector of yellow fever is *Aedes aegypti*, widely distributed in the southern third of Sudan. The Culex mosquitoes *Culex pipiens* and *C. quinquefasciatus* are vectors of human flarial worm *Wucheria bancrofti*. 70 species of Surret fly (Gad or Horse flies) have recorded in Sudan of which *Atylotus agrestis* and *Tabanus gratus* are the most important in transmitting trypanosomiasis in camels and probably cattle. Tsetse fly, *Glossina palpalis* which transmits *Trypanosoma gambiense* the causative agent of the human sleeping sickness together with *G. morsitans* which transmits the diseases Nagana in domestic animals are restricted to the extreme tip of southern Sudan. Of the actual or potential menace to human health - the house fly - thirteen species and one subspecies have been identified in the Sudan of which the most common is *Musca domestica ricina*.

## 2.9. Microbes and Parasites

We arrogant macro-organisms choose to disregard microorganisms, which are often responsible for the production of a large portion of our food, diseases and cures and make up the larger portion of the entire kingdom of living organisms.

### 2.9.1. Biodiversity in microbes and parasites of man

#### a. Pathogenic bacteria in man

All major groups of bacteria (*Schizomycetes*) associated with diseases in man and animals are well reported in Sudan. Health records indicated the occurrence of pathogenic bacteria species that represent 11 families and about 35 genera of bacteria in Sudan.

## **b. Pathogenic Protozoan in man**

Estimates of 13 species of pathogenic protozoan that represent all orders of the two major classes (*Zoomastigophorea* and *Sporozoa*) are currently diagnosed in Sudan. Sporozoans are exemplified by the most prevalent species of *Plasmodium* genus (Order *Eucoccidida: Haemosporidina*) that cause malaria in all regions of Sudan i.e. *P.falciparum*, *P.vivax*, *P.ovale* and *P.malariae*.

## **c. Pathogenic helminthes in man**

A minimum of 12 species of nematodes that represent 8 families of nematodes are identified as pathogenic agents; they occasionally cause endemic loci of diseases in many parts of the country. Five species of filarial nematodes that essentially disrupt the human lymphatic system e.g. *Loa loa*, *Onchocercus volvulus*, causing edema and blindness. Other species are associated with the muscular and alimentary systems of hosts.

Of the trematode fluke worms, 3 parasite species, namely, *Fasciola hepatica*, *Schistosoma mansoni* and *S. haematobium* are common parasites among the Sudanese population inhabiting irrigated agricultural areas, particularly in central Sudan. However, the zoonotic species, *Schistosoma bovis*, *Fasciola hepatica* and *Fasciola gigantica*, are predominantly associated with infections of livestock.

Cestode worms that belong to the family Taenididae e.g. *Echinococcus granulosus*, *Taenia* spp. and the family Hymenolepidae (*Hymenolepis nana*) are widely prevalent in Sudan affecting human health and livestock.

### **2.9.2. Biodiversity of microbes and parasites in livestock**

Livestock in Sudan is subject to infection by many bacterial pathogens of economic importance. These include *Bacillus anthracis*, *Brucella abortus*, *B. suis*, *Clostridium botulinum* and *C. tetani*, which are associated with contaminated milk and meat. Tuberculosis and bovine pleuroneumonia that widely affect cattle and sheep in Sudan are caused by bacteria species of the genus *Mycoplasma*. (Bornstein and Musa, 1988).

### **2.9.3. Biodiversity of microbes and parasites in agriculture**

#### **a. Pathogenic fungi in plants**

An estimate of 26 pathogenic fungal species representing 12 families had been well documented as microorganisms associated with many diseases of plant species of Sudan including cereals, sugarcane, cotton, oil crops, plantation crops, fruit and forest trees. However, few species of bacteria appeared to be the principal cause of plant diseases in Sudan (Gaddoura et Tal, 1983; Suheib, 1983; Giha, 1987; Ibrahim, 1994).

#### **b. Pathogenic bacteria in plants**

Only five species of bacteria were described as prevalent pathogens of sorghum, cotton, sesame, soybean and cassava.

### **c. Plant parasitic nematodes in Sudan**

A total of 85 species of plant parasitic nematodes was recorded in association with the roots of various field crops throughout the Sudan, and 55 nematode species had been isolated from the roots and soil environment of horticultural crops. Of these as many as 20 were found related to orchard crops, whereas 14 had been associated with vegetables. Several species of the identified plant parasitic nematodes, such as *Meloidogyne javanica*, *M. incognita*, *Pratylenchus* sp. and *Xiphinema* sp., have an economic impact.

### **2.10. Biodiversity and Biotechnology**

The significant role of Biotechnology applications in the development and conservation of natural resources is emphasized in Articles 16 and 19 of the Convention on Biological Diversity. Chapter 16 of agenda 21 (UNCED) also noted that the world community at large could only benefit maximally from biotechnology if it is developed and applied judiciously. In fact, the UNEP Guidelines for Safety in Biotechnology states in 1.12 that adequate safety mechanisms and international agreements on safety in biotechnology can contribute to the sustainable development of biotechnology and to the international trade in biotechnological products.

#### **2.10.1. Biodiversity and biotechnology applications in agriculture**

##### **a. N<sub>2</sub> fixation and bio-fertilization**

Khairi (1967) studied rhizobia isolated from 21 different indigenous legumes. Habish and Ishag (1974), Mahdi (1975) and Karsisto (1988) similarly evaluated the effect of the environmental conditions on the interaction between the leguminous plants and different strains of *Rhizobium* bacterium using imported and locally isolated rhizobia isolates.

ARC played an active role in Bio-Nitrogen Fertilization (BNF) research that has been introduced in 1977. Sudan had already contributed to UNEP/UNESCO project for the establishment of a Microbial Resource Center (MIRCENS, FP/1108-75-3).

The Environment and Natural Resource Research Institute (ENRRI) of the NCR currently maintains a collection of 22 isolates of *Rhizobium* collected from different origins. These isolates are occasionally used to produce inocula for farm use at small-scale levels (Adelgani, 1993).

##### **b. Biodiversity and biological control of pests**

Water hyacinth *Eichorina crassipes* (Mart) infests about 3200 Km in the White Nile river and its tributaries. Several insect species of weevils, *Neochetina eichhornia* Warner, and *N. bruchi* Hustache, the moth *Sameodes albiguttalis* (Werren) and the mite *Orthogalumma terbrrenatis* Walkwork were effectively introduced for the control of water hyacinth (Tigani *et al.*, 1997).

##### **c. Biodiversity and plant tissue culture**

In Sudan, recently the importance of plant biotechnology was emphasized as many research or educational institutes and the private sector successfully built their own tissue culture laboratories. However, most of the activity in