

Sudan Government
Ministry of
Environment
And Tourism



HCENR



UNDP



CBD

IUCN

The Sudan's National Biodiversity Strategy and Action Plan



National Biodiversity Strategy and
Action Plan Project

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FOREWORD

The Convention on Biological Diversity (CBD) signed by Sudan in June 1992 and ratified in October 1995, addresses at global level the entire spectrum of biological diversity, the sustainable use thereof and the fair and equitable sharing of the benefits accruing from that use.

Sudan's National Biodiversity Strategy and Action Plan (NBSAP) finalized early May, 2000 envisages future sustainable national development plans to take into consideration the conservation of diversity, national heritage and indigenous knowledge. To a great extent this is in line with the country's ideological and political thinking over the past decade. The Ten Year Comprehensive National Strategy (CNS) 1992/2002, the Khartoum Treaty of 1997, Fashoda of 1998 and the 1998 Constitution all recognize and value the ethnic, cultural and resource diversity in the country.

It is hoped that national strategies such as that of Biodiversity, Environmental Conservation, Combating of Desertification, Water, Agriculture, Forestry and Wildlife will form the matrix for subsequent medium and long term national development strategies and plans. It is hoped that both the legislature and executive will foster such planning.

The wide consultative and participative process adopted by the Higher Council for Environment and National Resources (HCENR) in conducting the base studies and assessment, the synthesis of results and the various fora for the discussion thereof, the involvement of state authorities, professionals, researchers and NGOs is very much commendable. Also are the efforts of reviewers and the task force, which summarized it all. The support of GEF, UNDP and IUCN – East Africa Regional Office is appreciated.

ABBREVIATIONS AND ACRONYMS

ACSAD	Arab Centre for the Studies of Arid Zones and Drylands
ADB	African Development Bank
ALESCO	Arab League Educational, Cultural and Scientific Organization
AOAD	Arab Organization for Agricultural Development (LAS)
ARC	Agricultural Research Corporation
ARRC	Animal Resources Research Corporation
BADEA	Arab Bank for Economic Development in Africa
BNF	Bio-Nitrogen Fertilization
CBD	Convention on Biological Diversity
CGIAR	Consultative Group for International Agricultural Research
CIFOR	Centre for International Forestry Research
CITES	Convention on International Trade in Endangered Species Wild Flora and Fauna
CNS	Sudan's Comprehensive National Strategy for Development 1992 – 2002
COMESA	Common Market for Eastern and Southern Africa
CSD	UN's Commission on Sustainable Development
ENRRI	The Environment and Natural Resource Research Institute
FAO	Food & Agriculture Organization of the United Nations
FNC	Forests National Corporation
GATT	General Agreements on Tariffs And Trade
GDP	Gross Domestic Product
GEF	Global Environmental Facility

GMOs	Genetically Modified Organisms
HCENR	Higher Council for Environment and Natural Resources
ICGEB	International Centre of Genetic Engineering and Biotechnology
ICRAF	International Centre for Research in Agro-Forestry
IDB	Islamic Development Bank
IFAD	International Fund for Agricultural Development
IFF	Intergovernmental Forum on Forests
IGAD	Inter-Governmental Authority on Development
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
IPF	Intergovernmental Panel on Forests
IPGRI	International Plant Genetic Resources Institute
IUCN	International Union for the Conservation of Nature
IUFRO	International Union of Forestry Research Organization
LAS	League of Arab States
MAF	Ministry of Agriculture & Forestry
MCAB	Monoclonal antibodies
MEAT	Ministry of Environment And Tourism
MFNE	Ministry of Finance and National Economy
NGOs	Non-Governmental Organizations
OAU	Organization of African Unity
PCR	Polymerase Chain Reaction
RPA	Range and Pasture Administration (MAF)

SECS	Sudanese Environment Conservation Society
SNBSAP	Sudan's National Biodiversity Strategy And Action Plan
SSCP	Single Stranded Conformational Polymorphism Analysis
UNCCD	United Nations Convention to Combat Desertification
UNCED	United Nations Conference for Environment and Development
UNCTAD	United Nations Conference on Trade And Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCC	United Nations Framework Convention on Climate Change
WAO	Wild Animals Ordinance
WB	World Bank
WCGA	Wildlife Conservation General Administration
WFP	World Food Programme
WHO	World Health Organization
WRC	Wildlife Research Centre
WTO	World Trade Organization

UNITS OF MEASURE

Hectare (ha)	= 100 m × 100 m = 2.38 feddāns
Feddān (fed)	= 60 × 70 m = 0.42 ha
Square Kilometer (sq.km)	= 1000 × 1000 m.
Milliard cubic meters (md.c.m.) for water	= 1000 million cubic meters
Cubic meter c.m. (for water and fuelwood)	= 1.0 × 1.0 × 1.0

Glossary of Arabic Words/terms

<i>Mahal</i>	Dry years
<i>Haddam</i>	River bank erosion
<i>Sudd</i>	Papyrus swamps in Sudan
<i>Dar</i>	Tribal grazing lands

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EXECUTIVE SUMMARY

Sudan's National Biodiversity Strategy and Action Plan (NBSAP) was finalized mid May 2000. The plan envisages future sustainable development plans to take into consideration the conservation of the natural environment and its constituent biological, ethnic and cultural diversity. As such this concept is very much in line with the country's ideological and political thinking over the preceding decade. The Ten Year Comprehensive National Strategy (CNS) 1992-2002, the Khartoum Treaty of 1997 and Fashoda Treaty of 1998 together with the 1998 Constitution, all recognize and value the ethnic, cultural and resource diversity in the country. NBSAP as such, also comes in fulfillment of Sudan's obligations towards and aspirations to benefit from the Convention on Biological Diversity (CBD). Sudan signed the latter in June 1992 and ratified it in October 1995.

Sudan's NBSAP is presented in three parts: Part I which highlights basic background information and the synthesis of the results of biodiversity assessment, specially conducted for the purpose of developing the strategy. Part II which points out major threats, opportunities and constraints to biodiversity in Sudan. Part III which encompasses strategy, actions, implementation modalities and proposed projects.

Part I is made up of two chapters on background and a synthesis of the results of biodiversity assessment, status and trends.

Part II briefly illustrates some of the major threats, opportunities and constraints pertaining to biodiversity in Sudan.

In Part III the strategy aspires to attain a number of set objectives. The latter are based on several guiding principles that emanate from current political, socio-economic and constitutional happenings. The objectives cover aspects pertaining to biodiversity such as conservation, promotion of awareness, creation of enabling environment for and effecting sustainable utilization, complying with and benefiting from regional and other conventions /agreements Sudan is party to, together with essential legislative actions. A number of opportunities conducive to the realization of the strategy and possible impediment constraints are enumerated. Twelve projects (summarized in table 8) are proposed to achieve the objectives of the strategy. Funding for the projects is envisaged from Sudan Government with substantial contribution from the donor, development partners and international community. An implementation modality and a time frame together with monitoring and evaluation schedules are proposed at the end of the strategy.

The strategy stresses on the need for building a critical mass that can contribute essentially to the sustainable development and conservation of biodiversity.

To fulfill this objective, the strategy proposes several projects that emphasize conservation of biodiversity while building capacity and taking legal measures to preserve the indigenous knowledge and resources of flora and fauna.

The HCENR adopted a wide consultative and participatory approach in preparing NBSAP. The approach was followed throughout; from conducting the base studies and assessment, through the synthesis of results, organization of various fora for the discussion thereof, involvement of federal and state authorities, professionals, researchers and NGOs. The process culminated in summoning a task force to put the NBSAP together. The draft was presented to two renowned reviewers and was finally presented to a well-attended workshop. The task force incorporated the comments of reviewers and the outcome of the final workshop into the document. The NBSAP PC and IUCN-EARO team of the project reviewed and abridged the document to produce to the final version.

PART I

BACKGROUND TO BIOLOGICAL RESOURCES IN SUDAN

1. PHYSICAL, SOCIAL AND ECONOMIC FEATURES OF SUDAN

1.1 Introduction

The Sudan is a vast country extending gradually from the desert in the north, with hot dry climate and almost no vegetative cover, to the African Sahel Zone in the center, with light and dense Savanna, and to the sub-tropical region in the south with heavier rains and dense tree cover. This endows the country with various environments and different agricultural systems.

The Sudan is an Afro-Arab country well-placed geographically, median among the Arab countries in North Africa, the Arab countries across the Red Sea and the countries of east, central and west Africa. In this respect, the country serves not only as a bridge facilitating trade and human movement, but also as a melting pot of African and Arab cultures. The country by size and diversity is Africa in miniature with complex cultural, ethnic and religious entities. With 2.5 million square kilometers (sq. km.) in area, Sudan is the largest Arab and African country. It enjoys extensive arable land, estimated at some 85 million hectares (ha) (1ha = 2.38 feddans), that can mostly be rain cultivated with rainfall varying from about 50 millimeters (mm) in the extreme north to more than 1500 mm in the extreme south. Thanks to the extensive rains, most of central and all southern Sudan are largely covered with forests and grasslands, estimated at some 66 million ha. The Nile River with its various tributaries crosses the country from the south to the north with an annual flow of some 84 milliard cubic meters (md.c.m.), Sudan's share of which is 18.5 md.c.m. at Aswan. The country is also well endowed with underground water, which has hardly been tapped, in addition to numerous seasonal rivers outside the Nile Valley, which need to be controlled and regulated to maximize their utilization. These natural resources have allowed the build-up of a national herd of livestock, estimated at some 116 million head of cattle, sheep, goats and camels, as well as several million wild animals. The Nile Valley and the Red Sea are also rich in fish and aquatic life constituting a tourist attraction in addition to their role in food security. The country is becoming well known for its rich mineral resources, which include oil, gold, iron, lead, chrome, asbestos...etc. Indeed a 1600 kilometers of pipeline, Bashair Sea Port, Khartoum Refinery and other installations have been completed and the export of crude oil began on 30th August 1999. That of refined products is to commence early May 2000.

1.2. Ecological Zones

Harrison and Jackson (1958) have ably described the vegetation of the Sudan. Harrison and Jackson (1958) classified the vegetation ecologically into five major divisions. The Vegetation of the Sudan could be divided into the following zones:

Table (1): Ecological zones of Sudan.

Major division	Sub-division	App. Area square km.
I- Desert	-	726000
II- Semi-desert	<i>Acacia tortillis</i> – <i>Maerua crassifolia</i> desert scrub	187000
	Semi-desert grassland on clay	104000
	Semi-desert grassland on sand	86000
	<i>Acacia mellifera</i> - <i>Commiphora</i> desert scrub	86000
	<i>Acacia glaucophylla</i> - <i>Acacia etbaica</i> scrub	31000
III- Woodland Savanna	low rainfall on clay soils	
	<i>Acacia mellifera</i> thornland	96000
	On dark cracking clays	52000
	On soils formed in situ with <i>Commiphora</i> and <i>Boscia</i>	
	<i>Acacia seyal</i> – <i>Balanites</i> savanna woodland	119000
<i>anogeissus</i> – <i>Combretum</i> savanna woodland	49000	
	On sand	
	<i>Acacia seyal</i> savanna woodland	65000
	<i>Combretum cordofanum</i> - <i>Albizzia</i>	86000
	<i>Terminalia</i> - <i>Sclerocarya</i> - <i>Anogeissus</i> - <i>Prosopis</i>	65000
	Special areas	
	Toposa area	36000
	Hill catenas	70000
	Baggara catena	18000
	Ragaba catena	34000
	High rainfall	
<i>Anogeissus</i> - <i>Khaya</i> - <i>Isobertinia</i> savanna woodland	311000	
Woodland savanna recently derived from rain forest	36000	
IV. Flood region	<i>Cyperus papyrus</i> swamps of the "sudd" and "toich" area with <i>Hyphaene thebaica</i> , <i>Borassus aethiopum</i> , <i>Acacia seyal</i> , <i>A. siberiana</i> and <i>Balanites aegyptiaca</i> among the tree species.	25000
V. Montane vegetation	The montane areas include the Dongotona and Didinga Hills, the Immatong Mountains, the Red Sea Hills and Jebel Marra.	6500

1.3. Population

The total population of Sudan is estimated at 30 millions (1998). The annual rate of the increase in population is one of the highest in the Arab Region (about 2.7%), but the geographic density is one of the lightest; 12 persons per square kilometer, on average, varying from one state to another. The demographic constitution of the population is leaning towards the young generations offering adequate labor force. The latter (the age bracket between 10 and 64) totals about 16.6 millions, of whom about 7.9 millions are resident in the northern states. Among those 6.6 million are employed, leaving some 1.3 million unemployed, an unemployment rate of 16.6%.

Sudan was a leader among African and Arab countries in establishing education facilities which date back to the end of the 19th century. Primary education is well spread (up to 8th grade) and shall be universal by the year 2002. There are some 42 universities and higher education institutions, most of which have been established after 1990. Currently, only 20% of the students are enrolled for technical education. Plans, however, are underway to increase this ratio up to 60% to match the demand triggered by the enormous investments in industry, mining, communications and modern technology.

1.4. Water Resources

1.4.1. Rainfall

Summer is the main rainy season, extending from May to October, with precipitation ranging between less than 50 mm in the extreme north to more than 1500 mm in the extreme south. The rainfall, however, is characterized by significant variations in distribution as well as in timing and location thereby magnifying the risks of localized crop failure. To avert this risk, mechanized rainfed production schemes have been spread all over central Sudan. Apart from agriculture, the rains replenish the underground reserve and provide the scattered wadis and water points with annual quantities to support the enormous wealth of livestock and wildlife.

1.4.2. Nile water

Sudan is a meeting point of river tributaries that emanate from the Ethiopian plateau and the region of the Great Lakes. The Blue Nile with its tributaries, Dinder and Rahad, flows from the east annually providing some 54 md.c.m. The Atbara tributary adds another 12 md.c.m. On the other hand Bahr El Jebel commences from Lake Victoria with permanent rains, but the greater part of the runoff is lost in the *Sudd* area inside the Sudan. The Sobat River, which joins the White Nile at Malakal, flows from the Ethiopian plateau and is fed from tributaries inside and outside the Sudan. Almost all the water flow of Bahr El Ghazal River (estimated at 14 md.c.m.) to join the White Nile at Lake No.

The big variation in the Blue Nile and River Atbara flow between the high river during the flood season and the low river during the months from March to

May, has necessitated the construction of dams to store water for irrigation and for the generation of hydroelectric power. At present, there are three dams: Sennar (1 md.c.m.), Roseires (3.4 md.c.m.) and Khashm El Girba (1.3 md.c.m.). However, the accumulated silt in the dam lakes has reduced the storage capacity by 25% in Roseires dam and by 40% in both Sennar and Khashm El Girba dams. Thus, heightening the Roseires dam to increase the storage capacity to 7.3 md.c.m. and constructing Siteit Dam across upper Atbara River to install additional storage capacity for irrigation projects are being seriously considered by the Sudan Government.

Sudan is now utilizing about 14.6 md.c.m. of its share of the Nile water for irrigation, of which 9.5 md.c.m. are from the Blue Nile, 1.7 md.c.m. from River Atbara, 1.8 md.c.m. from the White Nile and 1.6 md.c.m. from the River Nile. The heightening of Roseires Dam and the construction of the new dams will enable the country to utilize a reasonable portion of its share.

1.4.3. Seasonal surface non-Nile waters

These include El Gash seasonal river which has an annual runoff of 600 million cubic meters (m.c.m.) and Khor Baraka with 500 m.c.m., in addition to about 40 smaller riverlets or wadis scattered all over the central plain, providing about 6.7 md.c.m., which was collected through soil dams and hafirs to be sustainably utilized.

1.4.4. Underground water

The water bearing rock strata comprise the Nubian Sandstone, the Um Rwaba Series and the basement complex which cover, respectively, 28.1%, 20.5% and 9.1% of the total area of the Sudan. The preliminary surveys are continuing to determine the underground water quantities to be sustainably utilized. Research is on-going to verify the actual amounts to be used for domestic purposes and irrigation.

1.5. Infrastructure

The development of the infrastructure is highly important for the Sudan because of its extensive area and diverse environment and agricultural systems. Thus, the railway lines draw their importance as lifelines connecting south, west and north Sudan to the main port on the Red Sea coast. The railway in the Sudan is the oldest on the continent and the longest, extending for 4570 kilometers (km) and together with the branch lines constitute some 5500 km.

The total length of the permanent roads in the country is estimated at 50000 km, of which 1700 km are tarmacked and work is underway on a number of intra-state highways.

Sudan Sea Line, which is government-owned, has a number of vessels for the transport of commodities and passengers around the world. Apart from Port Sudan; the main port, other ports are being rehabilitated and developed such as Suakin, Ausif and Bashair from which petroleum products are exported. The communication sector has developed significantly thanks to the introduction of modern technology.

1.6. Economy

The livelihood of the population and the source of internal and external trade is based on primary commodities. Over 80% of Sudan's employment takes place in the agricultural sub-sector of the economy and the contribution of this sub-sector has been the highest for the last four decades, at least. Again, 97% of Sudan export trade is in the form of low value primary commodities or agro-based industrial production. Sudan's principal exports are cotton lint, groundnuts, sesame seed, gum Arabic, sorghum grain, livestock, hides and skins together with cotton seed cake and meat.

Agro-based industrial production includes such goods as flour, sugar, biscuits & sweets, tomato paste, animal feed concentrates, vegetable oil, starch & glucose, spinning & weaving and leather work.

Forest products go directly to the household and to small enterprises. The household gets its energy requirements and building materials. The small enterprises receive energy in the form of wood for brick making and furniture timber. The non-wood forestry products are numerous and have mainly food and handicraft values. The most important non-wood product is the gum Arabic, which has an export value and fetches a handsome income of foreign currency.

Livestock export has accelerated in recent years as a result of demand in the Arab region. Its contribution to the GDP is increasing. It has reached about 23% in 1998.

From the above description it is evident that biodiversity is the source of Sudan's present wealth and the driving force of its economic activity. Although Sudan has started producing and exporting petroleum, it will continue to depend on commodity production for some time to come.

This situation means that Sudan has to very carefully conserve the sources of its present wealth in plants and animals. At the same time, and while developing and exporting its oil wealth, Sudan has to avoid and control the pollution hazards associated with the industry both in the hinterland where production takes place and the Red Sea coast where the export terminals are located.

1.7. Social Setup

Sudan population, at present, is estimated at 30 million. The growth rate is about 3.0% and the doubling time is 20-30 years. Population density is low but the distribution is not even. About one third of population is found on less than 7% of the land area and many parts of the country not occupied.

In many of the inhabited parts it appears that population has approached the carrying capacity of the environment under the prevailing agricultural and animal production technology. The recurrent conflicts between cultivators and herders, particularly in the arid zone, is an indicator of both degradation of resources as well as the growth of the human and livestock populations.

At the present the population of Sudan lives off land resources and their biodiversity. This takes the form of rainfed and irrigated agriculture, wood and non-wood forest products and livestock production. The agricultural sector contribution to GDP is about 40%, which is high compared to other developing countries. This is clear indication of the role of biodiversity in the livelihood of the population. There is growing sense of commitment to the conservation of resources at various levels of the society. The experiences of drought and desertification and displacement have taught the ordinary citizen that his livelihood is vulnerable if he continues to adopt his present survival strategies, which are becoming environmentally unfriendly. Changes have been made in the management of rural resources in order to cope with the new situation.

1.8. Legal and Institutional Aspects

There are several laws, acts or ordinances that deal with the environment, either for protection or conservation. What characterizes the current environmental legislation in Sudan is that it is sector based. Thus we have environmental legislation dealing with land tenure, health, forestry, wildlife, fisheries, agriculture, livestock, public health, etc. The sectoral legislation is closely connected to the structure of the government ministries, departments and parastatal corporations.

The legislation has mainly regulatory powers of harvesting some resources and powers of penalty for violation. The essence is both protection and conservation. The sector legislation is in some respects a reflection of the terms of reference of the different ministries and their internal structures.

It may be said that sector-based environmental legislation has been satisfactory for a long time, perhaps up to the early 1980s. The widely observed environment degradation, which arises from the use of resources, has given grave concern and raised the question of the necessity of integrating the work or programs of the different ministries to achieve much needed conservation through integration of planning and development activities in the fields of agriculture, range, forestry, rural water development and veterinary services.

The Higher Council for Environment and National Resources (HCENR) came into existence in 1990. The establishment of the council was in response to the country's internal environmental challenges and in fulfillment of Sudan's international post UNCED commitments.

The council's main role is coordination between the different ministries, which have protection roles of Sudan's resources, the manner of their development and their sustainable use. The council is under the minister of Environment and Tourism. The creation of the ministry is the response of Sudan Government to commitments arising from the UNCED.

The present need in terms of legislation is to advance the protection of resources phase into a phase of conservation and sustainable use. An initial step has been made in this regard by the promulgation in March 2000 of the Environmental Policy Act. The new act is now in force. The new law empowers the council with additional coordinating roles, requires that environmental impact assessment be part of the planning of big development projects and stipulates that environmental awareness becomes incorporated into the general and higher education curricula.

There is still room for further improvements in the institutional structures of the federal system of government. The most urgently needed is the clarification of the roles of the different levels of the government system with respect to responsibilities for planning of development. These levels are the central or federal, state government, provinces and local government units. Precise roles for these levels are yet to be developed and implemented.

Experience showed that each level claims full jurisdiction over the resources. The conflict was very clear in the case of forest resources as these, at present, represent, an invaluable source of the much-needed revenue at state level.

There also remains the question of the existing sectoral environmental legislation. Two issues need attention 1) should that legislation remain federal as it had originated? or 2) should it be amended and passed down to the states in accordance with the obligations given to them by the federal structure?.

2. THE STATUS AND TRENDS OF BIODIVERSITY IN SUDAN

Even though Sudan is rich in its diversity of ecosystems, habitats, species and genetic resources, no coordinated, comprehensive surveys or assessments have been carried out. Most surveys and studies on biodiversity components were fragmented and were tailored for limited academic or research and scientific purposes. Data collected or information gathered have most of the time been site-specific, local and at the particular institutional levels. However, indicators and observations show that there is a declining trend and diversity loss in many components. The BSAP assessment was carried out by multi-disciplinary teams. The BSAP project has taken the initiative of updating the information on biodiversity.

The recent biodiversity countrywide assessment undertaken by NBSAP project even though not very comprehensive, it constituted a benchmark and a base of information for the different ecosystems, habitats and species.

The effort made was to update the information on the different biodiversity components but future monitoring and filling in of the gaps in knowledge is imperative.

2.1. Agriculture

Let us not forget the indigenous fruits and vegetables, such as kursan and okra, which have saved us from starvation in times of drought. We must conserve and utilize the existing biodiversity that are the riches of Sudan.

In the Sudan, many plant species are grown to meet the demands for food, shelter, clothing, medicine and fodder. Some of these species have been grown in the country for a very long time, while some are recent introductions. Both cultivated and wild types of some species are known in the Sudan, while for other species only cultivated varieties are present. Diversity is observed within both cultivated and wild types constituting a wealth of genetic resources that need to be well conserved. This is true for both field and horticultural crop species in Sudan as described in the following.

2.1.1. Field crops

The list of field crops grown in Sudan is a long one. It includes cereals, oil crops, grain legumes, fiber crops, forage crops and others.

a. Cereals

The cereal crops grown in the Sudan are sorghum, pearl millet, wheat, maize, rice, finger millet and barley. Several authorities consider Sudan as a center of origin for sorghum (*Sorghum bicolor*). The Sudan flora includes all the three wild sorghums believed to be the progenitors of cultivated sorghum (viz. *S. aethiopicum*, *S. verticilliflorum*, and *S. arundinaceum*). It is the home of *S. sudanense* (Sudan grass) which attained international importance for forage.

Through centuries, Sudanese farmers have developed and conserved diversified varieties of sorghum well adapted to the conditions where they evolved. At present, such variability is observable in different regions of the country. In Darfur, for example, the grain sorghums grown are classified by farmers into three groups: the short season early maturing ones referred to as "Najad", and two late season groups, one is used for brewing and known as "Mareig", and another used as flour and known as "Fasikh". A list containing 118 farmers' varieties was reported indicating types of sorghum grown in south Kordofan (Kadugli area) only. Such list can be taken as a good example of the diversity of this crop in just a very small part of the country. These landraces are being replaced by new high yielding varieties developed and released by the Agricultural Research Corporation (ARC).

(i) Pearl millet

(*Pennisetum glaucum*) is another important cereal food crop in Sudan especially in the western parts of the country. Western Sudan is believed by some to be a center of origin for this crop. About 18 wild species of *Pennisetum* are found in the country. Genetic resources of this crop in Sudan include a variety of landraces grown by farmers mainly in Darfur and Kordofan states. In Kordofan for example local pearl millet varieties are classified into seven groups according to seed and head characters, mainly.

(ii) Wheat

(*Triticum aestivum*) constitutes an important food crop in Sudan. In the past, it was only produced in the northern region, which is considered as the traditional production area of wheat in Sudan. Old landraces of this crop in the northern region were eroded and what is cultivated now as local (*Beladi*) is either a mixture of unknown old and new cultivars or an old exotic called "Hindi 62". An old landrace of wheat known as Abu Ali having specific characteristic morphological features is currently seen as a rare off-type in wheat fields. Another traditional area of wheat production in Sudan is Jebel Marra area in Western Darfur State. A number of improved wheat cultivars have been released for production in northern, central, eastern and western Sudan.

(iii) Maize

(*Zea mays*) is another cereal crop introduced to Sudan and produced in different regions on a limited scale for local consumption. The grown cultivars of this crop are mainly variable local landraces as is the situation in the northern, central, western and southern parts of the country. Some improved varieties were introduced from Egypt, Syria, CIMMYT and South Africa for commercial production.

(iv) Rice

(*Oryza sativa*) although grown on a limited scale in Southern Darfur, Bahr El Ghazal and White Nile states, wild rice varieties are known to be found in water-logged swampy areas mostly in the "Sudd" region of southern Sudan. It is well known that wild red seeded rice is found in Radom area in Southern Darfur State.

(v) Barley

(*Hordeum vulgare*) is cultivated in some few pockets in Northern and Darfur states. Wild species were found in small pockets in the upper terraces of Jebel Marra.

(vi) Finger millet

(*Eleusine corocana* Gaertn) is cultivated mainly in Western Equatoria State. Due to its cultivation there for a long time, many adapted local cultivars have evolved. Some wild species are also known in Sudan like *E.indica* and *E.flagellitera*. The former is believed to be the progenitor of the cultivated species.

b. Oil crops

The most important oil crops grown in Sudan are sesame and groundnut. In the recent past, the country witnessed an expansion in the areas under sunflower. Large amounts of oil are extracted from cottonseeds.

(i) Sesame

(*Sesamum indicum* L.) is grown in Sudan under rain-fed conditions by subsistence, and semi-commercial farmers. Selection by subsistence farmers resulted in many landraces adapted to different ecological areas. Three wild relatives of sesame were recognized in Sudan viz. *S.alatum*, *S.latifolium radiatum* and *S.angustifolium*. The existing wide variability in the cultivated landraces and the wild species make Sudan an important area of sesame genetic diversity. New improved cultivars of sesame are being released for production especially in the central and eastern Sudan.

(ii) Groundnut

(*Arachis hypogea* L.) is another important oil crop grown in central, eastern and western regions of Sudan. It is believed to have been introduced to western Sudan by West African immigrants about two to three hundred years ago. Farmers' varieties previously grown in that area were of the runner type locally known as "Abu Hibilat". Unfortunately, such type is thought to have disappeared and it is difficult to collect it. The earliest forms of groundnut introduced in Sudan belonged to the sub-species *hypogaea*. Small-seeded runner types were established on the sandy soils of western Sudan and the bunch types were grown along the Blue Nile on heavy clays. These two groups of groundnut formed the landraces in Sudan. As a part of improvement program, new varieties belonging to the subspecies *fastigiata* were introduced.

(iii) Sunflower

(*Helianthus annuus* L.) is an oil crop that has started to occupy large area of production in Sudan since late 1980s. The varieties grown are hybrid varieties whose seeds are annually imported.

(iv) Niger

(*Guizotia abyssinica* Cass.) is a member of the family *Compositae*, and is an important oilseed crop in Ethiopia and parts of India. It was introduced to the Ingessana area from Ethiopia where it is grown on a limited scale. Andrews

(1956) recorded three of the known five wild species of the genus in the Sudan.

(v) Safflower

(*Crathmus tinctorius* L.) has been cultivated in the Nile valley for about 4000 years. It was introduced to the Northern State at a very early date, but has been on very limited scale. A collection from this area (N852) is the ancestor of the best varieties now being grown in U.S.A.

Only one species of *Crathmus*; namely, *C. persicus* (*C. leucaulos*) was recorded as occurring wild in the Red Sea Hills by Andrews (1956).

(vi) Castor

(*Ricinus communis* L.) is a potential source of vegetable oil in Sudan.

c. Grain legumes

The grain legumes constitute important food crops in Sudan. Several species are grown in Sudan including winter-adapted species and summer-adapted ones. The main winter-adapted crops include faba bean, haricot bean, chick-pea, lentils, lupin, and pea. The summer-adapted species include cowpea, pigeon pea and hyacinth bean. Some other legumes are grown on a very limited scale, of which the bambara groundnut is the most important.

(i) Faba bean

(*Vicia faba* L.) is the major winter-adapted cultivated legume grown in Sudan. It is grown in the Northern and Darfur states. The Northern and River Nile states produce 90% of the total production. The varieties grown are primarily landraces named after the localities of production like Aliab, Zeidab, and Agabat. In Darfur, faba bean is produced mainly on the upper terraces of Jebel Marra and the northern parts of the region where the climatic conditions are suitable for its production. Varieties grown there are mainly local cultivars introduced from the northern states. ARC including selections from the local "Beladi" type released a number of improved cultivars. The local cultivars are highly adapted and are strong competitors yield-wise to the released varieties.

(ii) Haricot bean

(*Phaseolus vulgaris* L.) is grown mainly in the River and Nile states. It is grown also on the lower terraces of Jebel Mara and in Northern Darfur State. Cultivars grown are generally landraces known as "Beladi". The ARC has released three improved cultivars for farmers.

(iii) Chick pea

(*Cicer arietinum* L.) is mainly produced in the River Nile State. It is also cultivated on the upper terraces of Jebel Marra and the northern parts of Northern Darfur State, and in El Hawata area of Gedarif State. Cultivars grown by farmers are landraces known as "Beladi". Although a number of improved cultivars were released to farmers, they still grow their local landraces.

(iv) Lentil

(*Lens culinaris* Medic.) is grown mainly in the River and Nile states (Rubatab area). Farmers grow a variety called Selaim. The ARC released three

improved varieties for farmers. Lentil is also grown in Darfur states, on the upper terraces of Jebel Marra area and the northern parts of Northern Darfur State.

(v) Lupin

(*Lupinus albus*) is a crop of minor economic importance grown in the Northern and River Nile states. The cultivated material is absolutely local landraces. As other winter-adapted legume, lupin is grown in Jebel Marra area and in the northern parts of Northern Darfur State.

Among other winter-adapted grain legumes grown in the northern states and Northern Darfur State is the pea (*Pisum sativum* L.)

(vi) Cowpea

(*Vigna unguiculata* (L) Walp.) is among the most important summer adapted food grain legumes. It is believed to have been introduced from West Africa to the western parts of Sudan. This has resulted in a considerable diversity of cowpea types especially in Kordofan states. In Darfur states, it is usually grown inter-cropped with cereals using mainly two local varieties known as "Hineteer" and "Gambaro".

(vii) Pigeon pea

(*Cajanus cajan* (L) Millsp.) is another important summer-adapted grain legume grown in appreciable areas in northern and central Sudan. It is also grown on small scale in Darfur states. The cultivars grown are local landraces

(viii) Hyacinth bean

(*Lablab niger* (Medick)) is grown on extensive areas in the River Nile, Northern and Darfur states mainly for fodder, although some is harvested for bean.

(ix) Bambara groundnut

(*Voandzeia subterranea* L. Thouras) is a minor leguminous crop in western Sudan. It is grown mainly in Northern Kordofan, and Western and Southern Darfur states. It is believed to have been introduced there by immigrants from West Africa. Cultivars grown are mixtures of several different lines originating from the original early introductions.

d. Fiber crops

Several plant species are used in Sudan as fibre producing plants. More than 30 species, indigenous to Sudan, are used for fibre production. Most of them grow wild, and the most widely used is perhaps the Dom palm (*Hyphaene thebaica*). The most important fibre crop grown in Sudan is cotton, while kenaf and sisal are potential crops worthy of mention.

(i) Cotton

(*Gossypium* sp. L) growing and spinning in Sudan seems to date back to a period before the Christian era. True wild cotton species were reported in Sudan, namely, *Gossypium somalense* and *G. anomalum*, both are lintless and perennial. There are also some local cultivars of *G. arboreum* that could be collected in various parts of Blue Nile, Equatoria, Darfur and Kordofan states. *G. herbaceum* var. *africanum* also existed in those same areas.

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 enseate*) 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 aethiopicum*, (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

Species	Wild Relative
<i>Sorghum bicolor</i>	<i>S. aethiopicum</i> , <i>S. verticilliflorum</i> <i>S. arundiaceum</i> <i>S. Sudanese</i>
<i>Pennisetum glaucum</i>	<i>Pennisetum</i> spp.
<i>Oryza sativa</i>	<i>O. punctate</i> <i>O. longistaminata</i> <i>O. barthii</i>
<i>Eleusine</i>	<i>E. indica</i> <i>E. flagellifers</i>
<i>Sesamum indicum</i>	<i>S. alatum</i> <i>S. latifolium</i> <i>S. angustifolium</i>
<i>Guizotia abyssinica</i>	<i>G. villosa</i> <i>G. scabra</i> <i>G. schimperi</i>
<i>Gossypium</i> spp.	<i>G. somalense</i> <i>G. anomalum</i> <i>G. arboreum</i> <i>G. herbaceum</i>
<i>Hibiscus cannabinus</i>	<i>H. cannabinus</i>
<i>Saccharum sinense</i>	<i>S. spontaneum</i> <i>Erianthus maximus</i>
<i>Cyamopsis tetragonoloba</i>	<i>C. senegalensis</i>
<i>Abelmoschus esculentus</i>	<i>A. ficulneus</i> <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 km²) 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 oases such as Erkawit and Elba have 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 Amara, 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. N₂ 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

these institutes has been directed towards research and educational purposes (Mahdi, 1994).

2.10.2. Biodiversity of microbes and food biotechnology

Dirar (1997) noted that Sudan has over 80 indigenous fermented foods and beverages that are distinctly different from each other. This indicates an extensive variety and biodiversity in the microflora of the country.

For example, "kisra", which is the staple food of the majority of Sudanese people, was studied by many workers (Mohamed *et al.*, 1991; Hamad *et al.*, 1992; El Khalifa and El Tinay, 1993, Hamad *et al.*, 1997, Farahat, 1998). In spontaneous sorghum fermentation, Mohamed (1991) isolated seven species of bacteria, two species of yeast and four species of moulds.

2.10.3. Biodiversity of industrial microbes and biotechnology applications in Sudan

Hamad (1986) isolated 29 different yeast species from samples taken from 9 locations in the Sudan. Some species were represented by up to 7 different strains (Baerwald & Hamad, 1984).

Some yeast strains were described as thermoat 50°C and osmotolerant in 60% sugar. Others have the ability to metabolize complex carbohydrates such as starch and inulin and to produce or alcohol. One of these yeast was tested for the production of single cell protein (SCP) and ethanol from molasses.

2.10.4. Biodiversity and biotechnology applications in livestock

a. Artificial insemination

The use of artificial insemination biotechnology for the development of livestock breeds in Sudan had been adopted since 1977 when the first center was established to disseminate this technology. A few state centers are currently providing such a service (e.g. Gezira, Darfur). This technology is mainly used for the development of cattle livestock only, as it has not yet been successfully applied in camels (Musa *et al.*, 1988).

b. Vaccination

To produce the rinderpest vaccine, scientists at the ARRC had already exploited a low-level biotechnology for the development of vaccine production and vaccination of animals in Sudan.

2.10.5. Biodiversity and biotechnology application in human health

Several studies had already used advance level of biotechnology including DNA techniques and the use of monoclonal antibodies (MCAB) for the diagnosis of diseases like leishmaniasis, bilharzia, malaria, onchocerciasis, mycetoma, and cancer.

a. Human genome project

Sudan has recently joined this international scientific activity that essentially aims to establish a complete database for the human genome. Sudan is represented by a research group at the Institute of Endemic Diseases (U of K).

2.10.6. Biosafety

Genetically modified organisms are developed to solve problems of food and energy supply, control of diseases, treatment of wastes and removal of environmental hazards. However, these GMOs can themselves be a source of hazards. Some scientists argue that it is difficult to predict the behavior of all GMOs when released into the environment. Proper biosafety measures must be developed for the assessment and the control of these potential hazards.

2.10.7. Biopiracy

Microbes of interesting properties are being continuously transferred from the Sudan to developed countries for research purposes. These microbes are kept in culture collections in these countries. No agreements are made which give the Sudan rights in sharing the benefits that may arise from the utilization of the genetic material of these microbes. This situation must change. The Sudan needs help to formulate regulations and agreements in this respect.

2.10.8. Biosafety and risk assessment

Special consideration should be given to the issue of biosafety. The introduction of GMOs must be controlled by a specialized and well authorized body. The establishment of a national center for biotechnology is inevitable, to shoulder such a responsibility. Regulations of dealing with biotech products must be revised and evaluated according to international standards. An international collaboration may be of great significance for the evaluation of biosafety measures with reference to biotechnology applications particularly when dealing with hazardous biological products and GMOs. The appropriate measurements are not yet introduced and Sudan needs help in assessment of such risks.

PART II

THREATS, OPPORTUNITIES AND CONSTRAINTS

3. MAJOR THREATS TO BIODIVERSITY IN SUDAN

Factors threatening the genetic diversity, species and ecosystems in Sudan are many. They include natural factors and man-made ones. Some of these can be summarized in the following:

3.1 Environmental Changes

Among these changes are the drought spells and fluctuations in the rains, floods and temperature. Such changes could result in genetic erosion due to failure in crops and loss of varieties. A good example of such situation is the loss of varieties and complete failure of crops like pearl millet in the western Sudan. Changes affect medicinal plants, livestock, Rangeland, Forestry, Wildlife and coastal and marine ecosystems.

3.2 Land Use Planning

These include construction and building of roads, factories, canals, dams and new residential areas. Such expansions, in many cases, take place in different regions that used to be cultivated by traditional farmers on a small scale in a system known as "*Bilda*". Such system of agriculture is characterized by using highly diversified local varieties of crops. Building new dams, as it is projected in the Northern region (Hamadab dam) and in the central states (heightening of Roseries dam), will affect the cropping systems and types of crops and varieties grown in these areas. In some situations these development construction disturb wildlife, and birds, rabbits and in many cases lead to deforestation and cutting or scarce important trees indiscriminately.

3.3 Socio-Economical Factors

Such factors have their impacts on the types of crops grown by farmers. The land tenure system and land fragmentation have forced farmers in the Northern states to shift to high yielding varieties or to crops with low input cost and high revenues. A good example of such situation is the shift to production of date palm in the Northern region in areas that used to be cultivated by annual food crops in the past. The migration of inhabitants from rural areas to cities due to security or economic factors, and therefore the abandoning of farming and shifting to other jobs, has its negative impacts on the agrobiodiversity. So too is the negative impact of increase in human and animal population. This associated with economic pressures leads to deforestation, overgrazing, poaching and overfishing, land degradation and ultimately poverty.

3.4 Modern Agriculture

Modern agriculture is characterized by the use of improved cultivars in a mono-cropping system of agriculture. This is taking place in the Sudan at present, where many improved high yielding varieties and livestock breeds are introduced. This occurs at the expense of indigenous landraces, old cultivars or breeds.

Expansion in the rainfed agriculture and irrigated schemes in central and western Sudan has been accompanied by changes in the vegetation

complexes in rangeland and forests areas and by shifting from the small-scale traditional agriculture to large-scale modern agriculture.

3.5. Overgrazing

Some regions are occupied by a large number of livestock beyond the optimal carrying capacity. This reflects on:

Considerable reduction in the proportion of livestock feed that comes from shrubs and trees. Most affected tree species are such as *Acacia senegal*, *Acacia seyal*, *Balanites aegyptiaca*, *Maerua crassifolia* "Serehe", *Cadaba glandulosa* (Kurmut) and *Grewia tenax* "Goddaim" as these are difficult to regenerate.

Deterioration in rangeland productivity has led to intrusion and grazing into the Red Sea coastal mangrove and halophyte areas.

Livestock have been competing with wildlife in grazing and habitat areas.

3.6. Biotic Factors

Pests and diseases can attack both plants and animals species resulting in negative impacts on the genetic variability within the species. They exert selection pressure on such crops leading to the extinction of those susceptible strains and breeds. Quarantine measures are ineffective and inadequate in restricting the introduction of new pests and diseases. Therefore, the biodiversity in agricultural crops is very much threatened by these factors under such a situation.

3.7. Fire

Seasonal bush and grassland fires are usually started for purposes such as preparing the land for cultivation, honey collection and for discouraging livestock herding nearby crop fields. Fire in most cases spread unintentionally over large areas. This has drastic effects on high temperature intolerant herbs and woody species. It also affects and destroys large quantities of seeds. Fire contributes to killing many wildlife species or destroy their habitats e.g. snakes and small mammals. Large animals flee their habitats to remote areas and might be subjected to death hazard.

3.8. Inadequate Institutional Capacities

Many institutions, sectors and departments have limited resources and funds to survey study, inventory and protect the biodiversity resources. This is evident in many biodiversity relevant sectors such as range, wildlife, fisheries and marine departments. These institutions are inadequately equipped to monitor and protect the resources. This also contributes to lack of information on the status and trends of biodiversity in the country. Furthermore, taxonomists in both plants and animals are lacking.

3.9. War and Civil Strife:

Many of the biodiversity rich areas in the country are incidentally in the war zone. A lot of diversity losses in plants and animals are caused directly by war or indirectly by destruction of habitats. Heavy military machinery has remarkable physical effects on vegetation cover. Important trees are removed indiscriminately to pave the road for military and other purposes. Animals either get killed or flee the area some times across the border to neighboring countries. The war that is waging in the southern part of the country is best example of such situation.

3.10. Farmers' Practices

Farmers used to select the outstanding strains of crops within their fields for the future cultivation. They tend to do so based on their knowledge of their environments and crops. Such selection practice results in the dominance of some genotypes at the expense of others. After the drought spells, farmers of pearl millet in western Sudan tended to select early maturing varieties rather than medium and late maturing varieties, providing a good example of the effect of such practice on the diversity of crops.

3.11. Legislation

Most governmental sectors having to do with biodiversity have inadequate or no legislation altogether especially in natural resources management. This can be seen in:

- Illicit felling and over-cutting of tree species.
- Unauthorized introduction of plant specimens (seeds, seedlings,...etc).
- Over-hunting and poaching of wildlife and over-fishing.
- Continuous expansion of agricultural land at the expense of rangeland areas.
- Export or smuggling of genetic material.
- No clear penalties on oil spills that destroy marine life in the Sudanese Red Sea.

3.12. Economic Distortions and Failures

Key contributors to environmental degradation are market, policy, institutional and implementation failures. In most cases in Sudan at least one or combinations of these failures are encountered.

4. OPPORTUNITIES AND CONSTRAINTS

4.1. Raising awareness of communities at all levels

There is a crucial need to raise awareness on biodiversity and its importance among various communities and stakeholders e.g. decision makers, communities, at village levels, institutions, universities, schools, farmers, pastoralists, foresters... etc.

Help is apt to be needed from the international community at large including NGOs to address all these sectors of the society. Through appropriate methods and approaches.

4.2. Exploration, collection, preservation and documentation of fauna and flora of the Sudan

Though some information is available on the flora and fauna of the Sudan, yet there is a need for more information on various aspects e.g. authentication, taxonomy, ecology including gene-ecology, utilization, indigenous knowledge and potential.

This could be realized by joint explorations by local and foreign experts. Participation from NGOs, universities and organizations at national and international levels is expected for the mutual benefit of all.

Such efforts are expected to result in herbaria at national and state level arboreta and natural museums to enrich the knowledge about these resources.

4.3. Conservation of representative areas of ecosystems

As several ecosystems are threatened by various factors including urbanization, agricultural expansion, deforestation, over-grazing etc, it is necessary to reserve certain areas for conservation of biodiversity. For this purpose the following areas are suggested: -

- A. Part of Wadi-Hawar as nature reserve;
- B. The relics of "Bowl Forests" such as Azaza, Leboni in Equatoria states;
- C. Part or several parts of the wetlands in the "Sudd" Region;
- D. Part of natural bamboo forests in Southern Kordofan, Blue Nile, Southern Darfur, Upper Nile, Equatoria and Bahr El Gazal states;
- E. Parts of hill vegetation in several parts of the country; and
- F. Parts of the watershed areas in Equatoria, Bahr El Gazal and Upper Nile.

4.4. Limiting cultivation of annual crops in marginal fragile ecosystems and their gradual replacement by suitable animal-raising activities

Extensive areas in the dry lands of the Sudan are devastated by the practice of annual crop cultivation in these fragile environments where the rainfall varies spatially and temporally and fluctuates quantitatively a great deal. In these areas "Mahl years" (dry years) are fairly common as in Northern Kordofan and Darfur. Cultivation of annual crops could not be prohibited by punitive or administrative measures, yet, it is feasible to replace this practice,

gradually by a pasture-based economy for animal raising. Models for application could be worked out.

4.5. Ex-situ Conservation

Germplasm of important species can be conserved in gene banks at Agricultural Research Corporation (ARC) both at Wad Madani and Soba the H.Q. of Forestry Research where initial facilities are available to build upon. Botanic gardens, arboreta and herbaria could be started at Soba and Wad Madani.

Also state herbaria, arboreta and botanic gardens are suggested to be established at El Fashir, Nyala, El Obeid, Singa, El Damazin, Kassala, Port Sudan, Juba, Wau and Malakal.

4.6. Re-organization of Coordination Mechanisms

Devastation of natural resources and conflicts often arise because of lack of coordination between the various units dealing with natural resources particularly with regard to its allocation and usage.

Coordination among various units is necessary for a successful conservation strategy. This coordination should be at all levels from the central authority down to the village level through appropriate means where all parties concerned are represented and where appropriate measures for conservation and sustainable development are not ignored. This is a central axis of this strategy and help from all sources including the international community, NGOs, on bilateral, multilateral and other basis will be necessary.

4.7. Legislation Particularly on Land Tenure

Land tenure is an important issue in the strategy for biodiversity together with the empowering laws for the various units concerned with biodiversity.

All lands in the Sudan belong to the Government unless registered with the registrar of lands under a title. Yet traditional laws and customs are upheld and applied in many parts of the country. Changes that transcend the written laws have occurred in the native administration systems because of various factors including the start of breakdown of "dars" in many parts of the country, urbanization, migration and other factors.

The whole of land tenure and land allocation issues need to be reviewed and developed to meet the national and international aspirations, to lessen local conflicts and to promote conservation of biodiversity. Other legal aspects need to be taken care of.

4.8. Economic Factors

Even though Sudan is going through a process of liberalizing the economy a step which might possibly enhance biodiversity conservation, it will not work properly unless efficient financial incentives and mechanisms are considered.

PART III

NATIONAL BIODIVERSITY STRATEGY AND ACTION PLAN

5. THE NATIONAL STRATEGY

The NBSAP project's steering committee formulated a task force of seven national experts to develop the BSAP for the country. The BSAP first draft document was prepared between November and end of December 1999. It was first reviewed by IUCN Eastern Africa Regional Office (EARO). As part of stakeholders involvement and building consensus the BSAP draft was distributed to ministries, institutes, agencies and departments of relevance for comments (listed below). To widen the circle of participation five regional-based workshops were held in different parts of the country. The BSAP was also presented in the project's final national workshop held from 17th to 18th April 2000. It was then subjected to more discussion and written comments were also received from expert individuals. The participants agreed to adopt the BSAP provided that useful comments that have emerged during the review and discussion of the BSAP draft are incorporated and it is amended.

5.1 Vision

The vision of National Biodiversity Strategy is:

“Conservation of diversity, and related indigenous knowledge for sustainable national development of Sudan”.

1. Guiding Principles

The following are guiding principles that were followed in developing the NBSAP:

- Protection of the natural environment and its constituent biological, ethnic and cultural diversity, the development and good use thereof is an authentic aspect of fulfilling man's role as vicegerent on earth. Conversely, the destruction of environment is a mischievous sort of corruption. Thus, furnishing a healthy social environment, its improvement and development is an essential demand in responding to the principle of sustaining the dignity of mankind;
- Every Sudanese citizen has a constitutional right to a healthy environment that secures health, abundance and prosperity;
- Stakeholders at the local, state and national level should have an equitable share of benefits accruing from biological and other dimensions of diversity;
- The formulation of a national biodiversity strategy and an attendant implementation action plan require the voluntary and democratic participation of the society at large; and
- Some aspects of the natural environment and its constituent biological, ethnic and cultural diversity recognize no political or geographical boundaries within or between countries which necessitate subregional, regional and international cooperation for the protection of the environment and its development in the context of international conventions and agreements.

5.2. Overall objective

To conserve and enhance biological diversity for the prosperity and development of the Sudan.

5.3. Specific objectives

The specific objectives are:

a. Conservation of biodiversity (CBD articles 12 and 17)

This is to ensure conservation of the biological heritage for present and future generations through:

- i. Strengthening research and monitoring and assessment activities: by improving inventories, database and documentation. This includes indigenous knowledge of the flora, fauna and microorganisms. Collaborative efforts from home and abroad will be necessary for the benefits of all concerned;
- ii. In-situ conservation (CBD article 8): Conservation of representative samples of ecosystems including terrestrial, marine and fresh water ecosystems through nature reserves, national parks, on-farm conservation, forest reserves and restorative procedures; and
- iii. Ex-situ conservation (CBD article 9):
- iv. Establishment of arboreta, botanic gardens, herbaria and zoological gardens at national and state levels; and
- v. Establishment of gene banks for the important species.

b. Promotion of sustainable use of biodiversity products (CBD article 10) this is to be through:

- i. Reducing, halting and ultimately reversing the over-exploitation of biological resources through appropriate land use, especially the horizontal expansion in crops on marginal lands of fragile ecosystems, overgrazing and deforestation, and by promoting efficient farming techniques and multiple use of the resources to realize their inherent potential;
- ii. Creating alternative products and sources of alternative income; and Controlling the formal introduction of germplasm especially noxious species in forests and food crops and in livestock.

c. Promoting awareness on biodiversity conservation (CBD article 13)

- i. This can be achieved through:
 - Informing the public and decision-makers by providing adequate information through the media, improved extension service and networks;
- ii. Assigning real economic and other values to biodiversity products, so as to formulate sound policies for stakeholders through incentives in conservation activities. Initiatives from NGOs (national and foreign) and the private sector should be encouraged. This

includes promotion of environment friendly activities like ecotourism, wildlife ranching and upfront preventive activities like environmental impact assessment.

d. Creating an enabling environment for biodiversity conservation by:

- i. Promoting political goodwill for the cause of biodiversity and availing incentives to stakeholders;
- ii. Strengthening the institutional technical capacity by improving the technical infrastructure and strengthening the manpower base through training to carry out the tasks;
- iii. Enacting a comprehensive and effective biodiversity conservation policy and practice that addresses, among other things, issues such as land allocation, land tenure and possible conflicts;
- iv. Adopting economically and socially sound measures that act as incentives for the conservation and sustainable use of components of biodiversity (CBD article 11); and
- v. Undertaking and considering financial resources and financial mechanisms as stated in articles 20 and 21 of the CBD.

e. Complying with and benefiting from regional and international agreements and mechanisms (CBD article 22 and COP decisions)

Through signature and/or ratification, Sudan is a party to a number of arrangements and mechanisms, legally binding and non-legally binding, which contain substantive elements, addressing different biodiversity and environmental aspects. Sudan should honor its commitments and benefit, to the maximum from ratified arrangements. The Sudan participated in and is party to the following agreements:

A. Global

- i. Convention on Wetlands of International Importance, especially as Waterfowl Habitats (Ramsar);
- ii. Convention for the Protection of the World Cultural and Natural Heritage;
- iii. United Nations Framework Convention on Climate Change (UNFCCC);
- iv. Convention on Biological Diversity (CBD);
- v. United Nations Convention to Combat Desertification (UNCCD);
- vi. Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES); and
- vii. General Agreements on Tariffs and Trade (GATT) / World Trade Organization (WTO).

B. Regional

- viii. League of Arab States (LAS) and its organizations e.g.:
 - Arab Organization for Agricultural Development (AOAD);
 - Arab League Educational, Cultural and Scientific Organization (ALESCO); and
 - Arab Center for the Studies of Arid Zones and Drylands (ACSAD).
- xi. Organization of African Unity (OAU).
- x. Lome IV Convention
- xi. The Common Market for Eastern and Southern Africa (COMESA)
- xii. Inter-governmental Authority on Development (IGAD)

C. Treaty-based organizations

- xiii. Center for International Forestry Research (CIFOR)
- xiv. Consultative Group for International Agricultural Research (CGIAR)
- xv. International Monetary Fund (IMF)
- xvi. Regional Development Banks
 - African Development Bank (AfDB)
 - Arab Bank for Economic Development in Africa (BADEA)
- xvii. Islamic Development Bank (IDB)
- xviii. Food and Agricultural Organization of the United Nations (FAO)
- xix. United Nations Educational, Scientific and Cultural Organization (UNESCO)
- xx. World Bank (WB)
- xxi. World Trade Organization (WTO)
- xxii. International Fund for Agricultural Development (IFAD)

D. Non-legally binding arrangements

D.1. Organizations and fora

- i. International Center for Research in Agroforestry (ICRAF)
- ii. Intergovernmental Panel on Climate Change (IPCC)
- iii. International Union for Conservation of Nature (IUCN)
- iv. International Union of Forestry Research Organizations (IUFRO)
- v. International Plant Genetic Resources Institute (IPGRI)
- vi. International Center of Genetic Engineering and Biotechnology (ICGEB)

D.2. Initiatives, processes and other political commitments

- vii. United Nations Programs (created by the General Assembly of UN)
 - United Nations Development Program (UNDP)
 - United Nations Environment Program (UNEP)
 - United Nations Conference on Trade and Development (UNCTAD)
 - World Food Program (WFP)
 - FAO Regional Commissions (including Near East and Africa Forestry Commissions)
- viii. Agenda 21, Chapter 11 (UNCED)
- ix. Non-legally Binding Authoritative Statement of Forest Principles for a Global Consensus on the Management, Conservation and Sustainable Development of All types of Forest (Forest Principles-UNCED)
- x. Commission on Sustainable Development (CSD)
 - Intergovernmental Panel on Forests (IPF)
 - Intergovernmental Forum on Forests (IFF)
 - Criteria and Indicators for Sustainable Forest Management
 - Dry Zone Africa Initiative
 - Near East Initiative
- xi. Global Environment Facility (GEF)

E. Legislative aspects

(CBD article 14, 15, 16 and 17)

- i. Promote appropriate institutional, legislative, technical or other arrangements to ensure that the environmental consequences of sectoral programs and activities that have or are likely to have impacts on biological diversity are taken into account, mitigated or reduced;
- ii. Promote appropriate conditions and measures for legal access to genetic resources and techniques deemed important for agriculture, forestry, animal husbandry and safety;
- iii. Emphasize biosafety and social considerations in the development and application of biotechnology; and
- iv. Build capacity and promote legal capabilities to safeguard the national interests and rights of the Sudan and Sudanese people over their intellectual property rights pertaining to biodiversity resources, indigenous knowledge and national heritage.

6. ACTIONS

Below are suggested general and specific actions that need to be taken:

6.1 General

- Goals are to promote institutional, legislative, technical or other arrangements to ensure that the environmental consequences of sectoral programs and activities that have or are likely to have impacts on biological diversity are taken into account, neutralized or reduced;
- Promote appropriate conditions and measures for legal access to genetic resources, indigenous knowledge and techniques deemed important for agriculture, forestry, animal husbandry and safety;
- Emphasize biosafety and social considerations development and application of biotechnology;
- To develop the CNS 1992-2002 into a new CNS 2002 – 2012 and to develop a national action plan. A land use plan is a priority within the action plan;
- The legislation in relation to establishment of the 26 states should be revised to cater for neglected ecological concerns e.g. dividing the states of Kordofan and Darfur into northern and southern states and causes further stress on their deteriorated resources;
- Revisions of laws dividing power and revenues in relation to natural resources between the central government and state government to come up with the best situation that emphasize conservation and sustainable use;
- Existing institutional set up related to biodiversity conservation should be subjected to critical evaluation and restructuring should dictate lines of coordination and integration;
- Capacity building is needed in the areas of genetic resources protection and biosafety. Necessary legislation should be established;
- To evaluate and suggest improvement measures of land use tenure legislation and practices to include regulations that requires sustainable use; and
- Facilitate popular participation in biodiversity conservation programs capacity building programs for NGOs and CBOs should be developed.
- Consolidation of the role of the HCENR as the national focal point and coordination body in relation to biodiversity and other environmental issues.

6.2. Specific

Strategies and actions should be directed to alleviate poverty. A participatory approach to development should be adopted. Awareness raising is needed and decision-makers should be won to the cause of environmental conservation. There are many actions that are in common between the different biodiversity components and need to be taken. The actions to be taken are summarized in the following:

6.2.1 In-situ conservation

The following in-situ conservation measures need to be considered:

- Systematic surveying and inventorying of plant and animal genetic resources;
- In-situ conservation of wild relatives of field and horticultural crops, endemic and indigenous herbaceous and woody species. Species and areas need to be determined, e.g. pearl millet in the west, okra in the center, watermelon in the north and medicinal in their locations;
- On-farm conservation of farmers' varieties: improvement of cultural practices for better yields by traditional varieties, e.g. sorghum, in Nuba Mountains, southern Blue Nile, southern Sudan and River Atbara; watermelon in western Sudan, date palm in northern Sudan and Darfur;
- Restoration of traditional varieties in war or disaster-affected areas, e.g. sorghum for the south and Nuba Mountains;
- Mitigation measures to reduce the negative impacts of natural and man-made factors upon in-situ conserved crops, e.g. floods, drought, riverbank erosion and fires; and
- Developing monitoring and early warning system for loss of genetic resources.

6.2.2. Ex-situ conservation

The following ex-situ actions should be taken:

- Priorities should be set for collecting plant and animal genetic resources throughout the country to rescue material that may soon disappear in the field or be subjected to catastrophes such as war, epidemics or drought;
- These genetic resources need to be collected through a national campaign that involves governmental and non-governmental institutions. Research centers, universities, agricultural departments, farmers, national societies, women,...etc. could participate;
- For such task of short- and long-term ex-situ conservation there is a need to strengthen the present PGR Unit at ARC to accommodate new collections that include natural vegetation species. New establishment for animal embryo and tissue culture is to conserve plant, domestic animals and wildlife genetic resources;
- Establishment of in-vitro conservation facility and field gene banks for the conservation of vegetatively propagated crops;

- Current field genebanks of fruit trees need to be maintained;
- Regeneration program is to be executed for the current collections in the PGR Unit/ARC;
- Establishment of program of surveys and research to generate and collect information-related to biotechnology
- Establishment of gene banks to preserve microbial cultures of importance
- Promotion of the effective use of plant tissue culture methods for conservation and propagation of endangered species.
- Proposal of projects that essentially aim to provide base data of microflora collections in Sudan.
- Retrieval of Sudanese germplasm conserved abroad;
- Creation of capable full-time collection team;

6.2.3. Utilization

Conservation and utilization are inextricably linked, because utilization provides the principal utilization purpose for conservation. Utilization of genetic resources involves the following:-

- Multiplication and characterization of collected materials in the regions where they are collected;
- Evaluation of local germplasm for the desirable characters;
- Participation between genebank, breeder and farmers in the utilization of the local germplasm or breed;
- Use of molecular evaluation techniques to develop core collections, and to avoid duplications;
- Purification of local diversified germplasm to produce varieties for commercial use;
- Production of multi-line varieties;
- Promotion of under-utilized, local varieties;
- Promotion of seed production systems both at local and national levels.

6.2.4. Documentation

- Many plant and animal breeders are deterred from using collections because of a lack of information and documentation. Documentation should include the following activities:
- Documenting while collecting or characterizing;
- Documenting of plant and animal genetic resources using a computerized system;
- Documentation of indigenous knowledge, practices and technologies;
- Establishment of information network between plant and animal genetic resources units and users in research centers and universities; and
- Publication of germplasm or breed catalogues.

6.2.5. Training, education and Extension

- Recruitment and training of staff for the national plant genetic resources center and the regional units. Training includes training at the postgraduate level for researchers, and long and short training courses for researchers and technicians in a number of technical, managerial and policy areas;
- Training staff of research centers, universities and agricultural departments to participate in the collection operations;
- Development of syllabi on plant and animal genetic resources in the curricula of universities and colleges;
- Training in the areas of taxonomy (both plant and animal);
- Strengthening extension and extension facilities to develop a feedback mechanism to help researchers to scientifically approach field problems; and
- Inclusion of biodiversity issues in the curricula of schools.

6.2.6. Institutional arrangements

- Establishment of centrally coordinated program for plant genetic resources under the umbrella of the ARC for the conservation of local germplasm of current and potential agricultural crops;
- PGR Unit/ARC is to be expanded into a national plant genetic resources center (in Khartoum or Wad Madani) where the base collection of crop germplasm in Sudan is maintained;
- The objectives of the national center include planning for collection, evaluating and use of the crop genetic resources as a coordinating body with the regional units. It will be responsible for the distribution of germplasm as regulated by legislation;
- The base collection is to be deposited in the national center while the active collections are to be held by the regional units;
- Some central facilities are to be attached to the national center for the conservation and evaluation of the collected germplasm. Examples of these are molecular biology laboratory and in-vitro conservation facility;
- Five regional plant genetic resources units are to be established in the north, west, south, east and center where active collections of the materials collected from those regions are maintained;
- Objectives of establishing regional units include collecting inside the regions, and evaluation of such materials collected in these regions;
- Consolidation of relationship and cooperation with relevant regional and international organizations; and
- Strengthening institutional capacities by determining the proper affiliations. For example, RPA should be affiliated to other natural resources administrations. The WCGA affiliations should be revised and its linkages with natural resources agencies strengthened. The relationship between the WCGA and WRC are to be formalized.

6.2.7. Legislative arrangements

- Development of national legislation to regulate access to biological resources including both crop and animal genetic resources;
- Development of national legislation to protect local communities, farmers and pastoralist rights to biological resources and their indigenous knowledge, practices and technologies;
- National legislation to safeguard and protect breeders rights;
- Development of national legislation to regulate the movement of germplasm and breeds to and out of the country;
- The rangeland legislation should be passed to address land use in rangelands, integration of animal production and crop production, establishment of range reserves. (unfenced through people participation), and develop land tenure system that recognizes rangeland use as a major land use type;
- Maritime, marine and coastal legislation need to be enforced;
- Enforcement of laws that regulate introduction of exotic biological specimens (Pathogenic);
- Endorsement and implementation of Biosafety and risk assessment laws,
- Endorsement and implementation of laws that protect patents of intellectual property rights;
- Endorsement and implementation of laws that prohibit Bio-piracy; and
- Adoption of plans to promote understanding of bioethics with emphasis on manipulation of human genome and gene transfer.

Table 4 links threats to biodiversity, opportunities and actions.

Table (4): Summary of threat, opportunities and proposed actions.

Threats	Opportunities	Actions
<ul style="list-style-type: none"> ▪ Environmental changes ▪ War and civil strife ▪ Biotic factors ▪ Fire 	<ul style="list-style-type: none"> -Exploration, collection, preservation and documentation of flora and fauna -Ex-situ conservation -Conservation of representative areas of ecosystems 	<ul style="list-style-type: none"> -In-situ conservation -Ex-situ conservation (establish genebanks, botanic gardens, arboreta... etc) -Documentation (information system, database, internet... etc) -Training, education and extension
<ul style="list-style-type: none"> ▪ Improper land use planning ▪ Modern agriculture ▪ Inadequate or lack of legislation 	<ul style="list-style-type: none"> -legislation, particularly on land tenure -limiting cultivation of annual crops in marginal fragile ecosystem and gradual replacement by suitable land use system 	<ul style="list-style-type: none"> -Develop national legislative arrangements that consider land allocation issues -Raise awareness of communities at all levels including decision makers -Empower laws for the various units concerned with biodiversity
<ul style="list-style-type: none"> ▪ Socio-economical factors ▪ Economic distortions and failures 	<ul style="list-style-type: none"> -Efficient financial incentives and mechanisms -minimize market, policy, institutional and implementation failures 	<ul style="list-style-type: none"> -Adopt economically and socially sound measures that act as incentives for the conservation of biodiversity components
<ul style="list-style-type: none"> ▪ Inadequate institutional capacities 	<ul style="list-style-type: none"> -Re-organization of coordination mechanisms -adequately provide institutions with skilled personnel and equipment 	<ul style="list-style-type: none"> -Strengthen institutional capacities by determining the proper affiliations -Consolidation of relationship and cooperation with relevant regional and international organizations -improve technical skills by training and education in areas of biodiversity and provide necessary equipment

7. IMPLEMENTATION MODALITIES

7.1. How the NBSAP should be put into effect and used

The Sudan NBSAP shall be a useful guide to the implementation of the CBD. Accordingly, the NBSAP should be:

1. Presented by the Ministry of Environment and Tourism (MEAT) to the Council of Ministers for Government approval. It should further be passed by Parliament and endorsed by the President of the Republic. This is to secure government ownership and commitment to its implementation. The approved NBSAP shall be publicized widely to secure stakeholder and public ownership and understanding. The latter could involve making it user-friendly through preparation of abridged versions for different stakeholders;
2. Used as a planning tool by the National Council for Planning and other levels of government planning to integrate biodiversity in the over-all national development and sectoral planning respectively;
3. Used by the MFNE as reference in budgeting and allocation of government resources;
4. Used as a useful tool for fundraising and co-ordination of donor support to biodiversity conservation and implementation of CBD, UNFCCC, UNCCD, CITES, Ramsar, Forest Principles and other related conventions, including facilitating synergy among the conventions. It is suggested that an environment/biodiversity donor liaison committee be formed immediately to harmonize funding strategy for implementation of the NBSAP and biodiversity related activities;
5. Used as a guiding tool for the HCENR as a Government agency responsible for the CBD. The NBSAP will greatly assist to oversee the implementation of Sudan's obligation to the CBD. In line ministries, the desk officers responsible for the related conventions will find this NBSAP a useful tool for coordinating implementation of CBD and the conventions they are responsible for;
6. Used as a guiding tool for assisting states to integrate biodiversity in their states development planning, policies and laws;
7. Used as a source of information for the National Information data bank(s), research institutions and sectoral agencies (e.g. Agriculture, Forestry, RPA, Livestock, Fisheries, Wildlife... etc.). It will also point out information gaps and research priorities that sectoral agencies should work on;
8. Used as a guide to the development agencies/partners that would identify programs for support to biodiversity conservation and sustainable development; and
9. Used as a guide to Government of the Republic of the Sudan in implementing regional and international conventions and agreements as well as the Horn of Africa and other regional frameworks.

7.2. Implementation of the NBSAP

7.2.1. Endorsement and approval

The draft NBSAP will be subjected to formal endorsement by a forum of key stakeholders. The Council of Ministers, Parliament and the president will then table it for approval. The key institutional stakeholders from whom endorsement will be sought will include:

- Government ministries particularly MAF, Animal Resources, Irrigation, MEAT, Interior, External Relations, National Finance & Economy, Culture and Information, Industry & Investment and Justice;
- Research institutions namely ARC, ARRC, NCR and universities;
- Training institutions including universities and training institutions affiliated to line ministries;
- Donor and development assistance partners such as UNDP, FAO, UNESCO, EC and member countries; and
- Relevant NGOs such as SOS Sahel (Sudan) and SECS.

7.2.2. The Launch of the NBSAP

The NBSAP will be launched on March 14th 2001, as part of commemorating the Sudan National Environment Day March 14th is the day that the Sudan National Environmental legislation was assented

7.2.3. Implementation

The NBSAP will be implemented through 12 projects (table 8) taking into consideration the specific objectives, and suggested actions in preceding chapter. The project approach is preferable in Sudan because:

- It is the appropriate mechanism for implementing activities that need multisectoral approach such as those suggested in NBSAP;
- The project lead agency will be in a better position to co-ordinate the resources requirements and delivery of outputs;
- Limited capacity that is also scattered in different sectoral institutions with limited experience in multisectoral planning and co-ordination; and
- Mobilization of fund will be much easier and facilitate its allocation to most pressing and priority areas.

7.2.4. Institutional arrangements

The HCENR is envisaged to be the federal agency responsible for coordinating management and conservation of biodiversity in the Sudan. Its organizational setup, hierarchy and mission need to be revised to reflect this and other roles. As such the HCENR is the lead agency for coordinating implementation of the NBSAP and especially the proposed projects. It is also to be the lead agency in implementing the following specific projects:

- Organizational setup for conservation of biodiversity in Sudan;
- Capacity building in systematic;

- Capacity building for biodiversity information management and monitoring;
- Any other projects that need capacity or multi-sectoral co-ordination if cannot be adequately implemented by the relevant sectors.
- The HCENR will establish a biodiversity coordinating unit that will be responsible for;
- Providing secretariat support for the national environment committee on biodiversity issues;
- Implementing all biodiversity projects under HCENR;
- Coordinating the overall implementation of the NBSAP; and
- Providing technical support to the government in the general implementation of the CBD and preparations for CBD events such as Conference Of the Parties (COP) and Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA), Africa and other regional biodiversity fora.

7.2.5. Implementation schedule

The NBSAP will be implemented over an initial period of six years, (Table 5). equivalent to two three-Year Programs in conformity with the planning cycle adopted in CNS as follows:

Table 5: Implementation Schedule of NSAP

Activity	Lead agency	YR. 1	YR. 2	YR. 3	YR. 4	YR. 5	YR. 6
Endorsement and Government approval	MEAT	-					
Establish Biodiversity Coordinating Unit	HCENR	-					
Launching	MEAT	-					
Fund raising for project development	MFNE		-	-	-	-	-
Projects approval and resources allocation for implementation	HCENR MFNE		-	-	-	-	-
Project implementation	*		-	-	-	-	-
NBSAP implementation Review	HCENR				-		
National Biodiversity report	HCENR						

* Various line ministries.

7.3. Prioritization of NBSAP Activities

Following approval and launching of NBSAP by early 2001, the proposed projects will be implemented in the order they appear in table (2) over a period of six years, 2001-2007.

7.4. Monitoring, Evaluation and Reporting

The implementation of NBSAP will require monitoring and evaluation of the progress as well as the assessment of biodiversity status and trends to follow up on the impact of the implementation. HCENR is the overall responsible for monitoring of biodiversity and NBSAP implementation. Through a participatory process, the council will identify areas for monitoring and develop a comprehensive monitoring programme. Among other areas the programme will include:

- Monitoring implementation of the NBSAP;
- Monitoring the state of biodiversity; and
- Monitoring reporting on biodiversity.

The council will also guide and build capacity of all participating institutions for their contribution in implementing the monitoring programme (Table 6).

Table 6: Key steps for developing a monitoring program.

Output 1: needs and capacity for monitoring assessed	
Action	Activities
Identify biodiversity issues (in addition to those mentioned above) for monitoring and respective responsible institutions.	Identify biodiversity Areas/themes/sectors/ecosystems/species/states etc. for biodiversity monitoring Identify focal co-ordinators for co-ordinators in different themes etc. Assess and build capacity
Output 2: Implementation of the NBSAP monitored	
Develop indicators for monitoring Institutional/management changes for biodiversity management and conservation	Develop indicators on monitoring: Planning, reforms and budget availability for incorporating NBSAP principles, goal and objectives Institutional arrangements and capacity enhancement to accommodate NBSAP implementation needs
Output 3: Biodiversity status and trend monitored	
Develop list of reporting requirements, types of reports, deadlines, types of audience e.g. biannual national biodiversity status report, report to COP, annual report to parliament, half-yearly sectoral reports etc.	Develop appropriate technologies for data processing and reports production as per reporting needs Prepare reports including mechanism for approving reports. Publish and distribute reports as per identified requirements

7.5. Financing the Implementation of NBSAP

Implementation of the proposed projects under NBSAP will be financed through public, donor and private sector resources. Public sector sources will include:

- allocation and reallocation of existing government funds;
- improved and new methods of public revenue regeneration and allocation;
- cost-saving through more efficient budgeting and use of funds.

Private sector financing and cost-sharing will be encouraged through the dismantling of existing barriers to investment in biodiversity and the setting in place of positive incentives such as:

- establishment and improvement of biodiversity prices and markets;
- appropriate property rights;
- increased devolution of responsibilities and opportunities for biodiversity management and utilization for profit and for non-profit purposes, through private, joint and collaborative management arrangements;
- use of appropriate fiscal instruments (such as differential taxes) and financial inducements (such as credit, funds and trusts).

Donor and international funding sources will include:

- Conventional grants, loans and development assistance;
- Innovative donor funding arrangements such as debt-for-nature swaps, trusts and compacts;
- Innovative international financial flows such as offsets, transferable development rights, biodiversity sales.

8. PROPOSED PROJECTS

8.1. Organizational set-up for conservation of biodiversity (Objectives a, b and d):

Background and justification: Biodiversity conservation is a cross cutting interest among all users of natural resources.

Administrations of landuse, range, forestry, wildlife, fisheries and agriculture are all involved in activities related to biodiversity conservation. There is an urgent need for strengthening coordination among different users of biodiversity.

The establishment of the HCENR in 1992 has resulted in the development of a national natural resources and environmental management coordinating body. The council is the focal point for biodiversity conservation, and state councils are already mandated to extend the role of the council in the different states.

Objectives and methodology:

- Establishment of a coordinating unit and a focal point for biodiversity conservation in the country.
- Harmonization of biodiversity related legislation;
- Developing an information bank for biodiversity;
- Identification of gaps in information, hot spots and urgent actions needed;
- Coordination of work of biodiversity conservation; and
- Support capacity building and infrastructure for conservation of biological resources.

Lead agency: HCENR.

Cooperating agencies: Line ministries involved in management and utilization of natural resources.

Estimated cost: US \$ 1,000,000

8.2. Raising awareness of communities at all levels on biodiversity and its importance (Objective c)

Background and justification: biodiversity conservation can only be achieved through participatory action that includes all stakeholders and communities. Raising awareness about biodiversity and its values is much needed among all communities to solicit support, commitment and participation of all stakeholders in biodiversity conservation and sustainable use.

Objectives and methodology:

- The project objective is to raise environmental biodiversity awareness among different stakeholders and communities;
- Different biodiversity awareness raising packages will be developed and used for different stakeholders and communities;
- Different audio-visual aids will be developed to assist in biodiversity awareness campaigns such as Video films, posters, exhibitions, pamphlets, booklets, radio and television programs and celebrations such as Labor-day, environment day, and
- Support community.

Lead agency: HCENR

Cooperating agencies: Extension and public relations departments of line ministries involved in management and utilization of natural resources, specialized ministries such as Culture & Information and indigenous NGOs such as SECS.

Estimated cost: US \$ 1,000,000

8.3. Strategic land use planning for conservation of natural resources

(objective d):

Background and justification: biodiversity conservation could only be achieved in the context of an accepted national land use plan. Stakeholders and communities should be consulted. The plan should be based on soil classification and soil capabilities survey and maps.

Natural resources distribution should also be included. Land use planning and mapping should cater for different stakeholders' needs without compromising conservation needs.

Objectives and methodology:

- Mapping soil and resources;
- Strategies and land use/resource use plans, and
- Involve different stakeholders and communities.

Lead agency: Ministry of Agriculture & Forestry (MAF).

Cooperating agencies: Line ministries involved in management and utilization of natural resources such as Irrigation & Water Resources, Animal Wealth, Industry & Investment, Finance & National Economy (MFNE), Survey and Residential Planning etc.

Estimated cost: US \$ 3,000,000

8.4. Exploration, collection preservation and documentation of flora and fauna of Darfur, central clay plains, River Nile, Northern, Equatoria, Bahr El Ghazal and Upper Nile regions (objective a):

Background: Flora and fauna studies were not recently conducted. All data were compiled in the past and the need for updating is evident. Enormous changes in flora and fauna need to be documented and knowledge need to be enriched as a lot is unknown and little explored.

Objectives and methodology:

- Conduct collections, identification and preservation of herbarium and museum specimens;
- Initiate a biodiversity monitoring; and
- Study groups should include plant and animal taxonomists

Lead agency: National Research Centre (NRC).

Cooperating agencies: Such line ministries as MAF (FNC – Range and Pasture Administration (RPA)), university faculties (Departments concerned with plant and animal systematics).

Estimated cost: US \$ 2,000,000

8.5. Conservation of representative areas of various ecosystems

(objective a):

Background and justification: Different ecosystems and their biodiversity are being destroyed at an alarming rate. Increased population, depletion of natural resources and drought are contributing to the loss of biodiversity. Areas under several forests and protected wildlife areas should be increased.

Objectives and methodology

- Conservation of representative ecosystems.
- The following areas are proposed for conservation, through legal, zoning, developing and implementation of management plans:
 - a. Wadi Hawar (historical heritage and wildlife in desert ecosystem).
 - b. Red Sea marine ecosystems;
 - c. Red Sea coastal plains and oasis;
 - d. Bowl Forests in Equatoria;
 - e. Sudd wetlands;
 - f. Natural Bamboo Forests in Southern Kordofan and Southern Darfur;
 - g. Hill vegetation in several parts of the country;
 - h. Parts of watershed areas of Equatoria, Upper Nile and Bahr El Ghazal states;
 - i. Parts of rangelands in Butana;
 - j. Parts of Gizzu areas in Northern Kordofan, and
 - k. Parts of Jebel Marra.

Lead agency: HCENR.

Cooperating agencies: Such line ministries as MAF (FNC - RPA), MEAT (WCGA), Survey, Justice.

Estimated cost: US \$ 11,000,000

8.6. Rangelands conservation and sustainable use (objective a, b and d):

Background and justification: Major changes are taking place in nomadic grazing patterns. Such changes are due to increased numbers of livestock and drought. Tribal seasonal use of land has not been studied recently. With recent development of water resources and increase in export of livestock, drastic changes in grazing systems could occur.

Objectives and methodology:

- To update information on rangeland utilization in Sudan;
- To study changes in nomadic systems; and
- To suggest new grazing systems and conservation measures.

Lead agency: MAF (RPA – FNC)

Estimated cost: US \$ 1,000,000

8.7. Ex-situ conservation (objective a)

Background and justification: establishment of arboreta, museums, marine and fresh water aquaria and zoological gardens could greatly enhance biodiversity conservation.

Objectives and methodology:

- To enhance biodiversity conservation; and
- To increase awareness about biodiversity.

The following ex-situ conservation initiatives are suggested:

- Establishment of arboreta and botanic gardens at the federal and the state levels (10 centers);
- Establishment of herbaria at the federal and the state levels (10 centers);
- Establishment of gene banks for some of the important species at Soba and Wad Medani;
- Establishment of marine aquarium and museum at Port Sudan;
- Establishment of zoological gardens at Gedarif, Nyala, El Obeid, Malakal, Juba and Wau, and
- Models for wildlife breeding farms and game ranching.

Lead agency: HCENR.

Cooperating agencies: MAF (FNC - RPA), MEAT (WGGA), Survey, Justice.

Estimated cost: US \$ 41,000,000

8.8. Capacity building in systematics (objective d)

Background and justification: To conserve biodiversity it is very important to have good knowledge of the varieties available, distribution and abundance. Monitoring change in biodiversity is a continuous task, which requires a good number of specialists in systematics.

Objectives and methodology:

1. Capacity building of several relevant departments in universities and research institutes; and
2. Training of young scientists in systematics on plants and animals in country and abroad.

Lead agency: HCENR.

Cooperating agencies: Systematic Departments in universities.

Estimated cost: US \$ 1, 500, 000

8.9. Conservation of local races of livestock (objectives a, b and d)

Background and justification: The Sudanese local races of livestock are threatened due to breeding with imported races. Conservation of pure races of different species of indigenous livestock is urgently needed.

Objectives and methodology: To conserve representative units of different races of different indigenous species of livestock in the Sudan.

Lead Agency: Ministry of Animal Wealth.

Estimated cost: US \$ 1, 500, 000

B.10. Conservation and sustainable utilization of agrobiodiversity (objectives b and d)

Background and justification: Due to introduced improved seeds several local varieties are being lost. The need to conserve local varieties should be emphasized for future development of agriculture in Sudan.

Objectives and methodology:

Conservation and sustainable utilization of agro-biodiversity in Sudan.

Lead Agency: MAF

Estimated cost: as in table 7.

Table 7. Proposed projects for the conservation and sustainable utilization of agro-biodiversity in Sudan

Project	Costs (US\$)
Establishment of national plant genetic resources center (buildings and equipment)	4,000,000
Establishment of the regional plant genetic resources units (5units)	2,000,000
Collection of crop genetic resources	1,000,000
Multiplication, regeneration and characterization of crop genetic resources	600,000
In-situ conservation (including on-farm conservation)	200,000
Establishment of in-vitro conservation facility and molecular biology laboratory	4,000,000
Documentation of crop genetic resources (establishment of networks and publication of information)	500,000
Training (including post graduate studies and other short and long term training)	2,000,000
National coordination and awareness activities (meeting, workshops, media, ...etc.)	500,000
Total	14,800,000

B.11. Establishment of national Center for biotechnology (objectives a, b and d)

Background and justification: Agenda 21 is a participatory plan of action jointly formulated and agreed upon by the world community at the earth summit in Rio, Brazil 1992. It proposes a number of plans and action programs aimed towards sustainable development. Chapter 16 of the Agenda highlights the significance of biotechnology in improvement of environmental protection, food quality and availability, feed and renewable energy, human health and biosafety in application and transfer of biotechnology.

An early attention to the potential advantages of biotechnology is indispensable if Sudan is to evolve into a modern state. Biotechnology represents a new pervasive technology but simple and mostly appropriate to a developing country like Sudan where many of its problems relate to poor conservation of environment, self-sufficiency in food and energy. Therefore, it is high time to call for the establishment of a national Centre for biotechnology that essentially aims to promote:

- Interest and awareness of the potential advantages of biotechnology application particularly with reference to conservation and biodiversity aspects;
- Capacity building by development of training and research programs in areas of biotechnology related to biodiversity and conservation of environment;
- Interaction and collaboration between national/international institutions that work in the fields of biotechnology and biodiversity e.g. gene banks, plant tissue culture labs., centers of animal breeding and artificial insemination etc;
- Programs for the biodiversity assessment and conservation of biological specimens exploited in biotechnology applications with special emphasis on microflora;
- Implementation of new rDNA technology in survey studies of biodiversity.
- Investment in biotechnology areas that aims at appropriate utilization and conservation of biological resources; and
- Legislations related to aspects of biosafety and biopiracy.

Lead agency: University of Khartoum.

Estimated Cost

-	Building	\$ 140, 000
-	Equipment	\$ 140, 000
	Total	\$ 280, 000

8.12. Reducing impact on biodiversity from civil strife:

Background and justification:

Sudan's biological resources suffer from long time civil wars and associated phenomena as much as refugees movements and settling of population. It is important that the issues of biodiversity conservation and sustainable use are made part of the negotiation's in conflict resolution and in resettling moving population from within and outside Sudan.

Objectives and Methodology:

- To bring to a halt the destruction of biological diversity caused by wars and civil strife
- Detailed assessment on the impact on biodiversity from civil strife and develop idea and actions to reduce impacts in effected areas;
- Raise awareness on impact of civil strife on biodiversity; and
- Initiate negotiations among relevant stakeholders and supporting parties on biodiversity management and conservation in war and civil strife torn areas.

Lead agency: UN agencies such as UNHCR and international organizations.

Estimated costs \$ 40,000

The proposed projects are summarized in table 8.

Table 8: Summary of Proposed Projects:

Project Title	Estimated Costs (US \$)
Organizational set-up for conservation of biodiversity	1,000,000
Raising awareness of all stakeholders at all levels of biodiversity and its importance	1,000,000
Strategic planning for conservation of natural resources	3,000,000
Exploration and documentation of flora and fauna of Darfur, central clay plains, River Nile, Northern, Equatoria, Bahr El Ghazal and Upper Nile regions	2,000,000
Conservation of representative areas of various ecosystems	11,000,000
Rangelands conservation	1,000,000
Ex-situ conservation	41,000,000
Capacity building in systematics	1,500,000
Conservation of local races of livestock	1,500,000
Conservation and sustainable utilization of agro-biodiversity	14,800,000
Establishment of national Center for biotechnology	280,000
Reducing impact on biodiversity from civil strife	40,000,000
Estimated Total Cost	118,800,000

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