Chapter 6.Rainfall Savannah Woodland

By
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1. Introduction

The Sudanese were aware of problem of drought and desertification that caused severe hardships and misery to the rural dwellers of the country since the early seventies. The problem was most seriously manifested in the northern states and in the eighties it increased the conflicts between nomadic and settled communities that developed into ethnic and tribal wars.

This situation was the outcome of inappropriate use and the wrong assumption that of the natural resources are inexhaustible (Karrar *et al*., 1986). Moreover, agricultural expansions ignored the link between field crop and the environmental and the human needs for forest goods and services.

2. Ecological Zones of the Forests of the Sudan.

Andrews (1948) classified seven principal vegetation zones from north to south of Sudan. Later, Harrison and Jackson (1958) produced an ecological classification of the vegetation recognizing five major divisions (zones) based on floristic composition, rainfall and soil type. The divisions were further elaborated into subdivisions (belts). With the exception of the bare desert and semi desert those divisions were almost fully stocked with trees and shrubs (Fig.1).

The following brief description of these belts will facilitate understanding of the problems facing the wet savannah woodlands:

2.1.1. The desert:

The desert covers the Northern Sudan from a point north of Lat 16, following a curve to Mohamed Qul on the Red Sea and westwards across Northern Kordufan and Darfur. The annual rainfall is below 75mm. The vegetation is virtually absent except along water courses represented by *Fagonia cretica*, *Indigofera oblongifolia* and *Aerva javonica*. Ephemerals and herbs appear after the rare rain showers.

2.1.2. The semi desert:

This belt spreads in the northern parts of the country, the southern limits of which fall approximately at Wad Medani, ed Duiem after which it crosses lat 140 N to Um Dam in Kordufan and Um Kaddada in Darfur. The rainfall varies from about 75-300mm, very variable and unreliable. The vegetation is a variable mixture of grasses and herbs with a variable scatter of low shrubs and bushes interspersed with bare areas. The belt is represented by various vegetation formations according to changes in rainfall and soils. *Acacia toritllis* and *Maerua crassifolia* are dominant in the eastern clay plains, Acacia mellifera and *Commiphora africana* in the sandy soil of the west.

The bushes are the main source of feed for livestock in the dry season. Accordingly, the type of vegetation is a grazing climax where the palatable

browse species are reduced or eliminated. With a rainfall below 300 mm. the land is marginal for rain fed crop production.

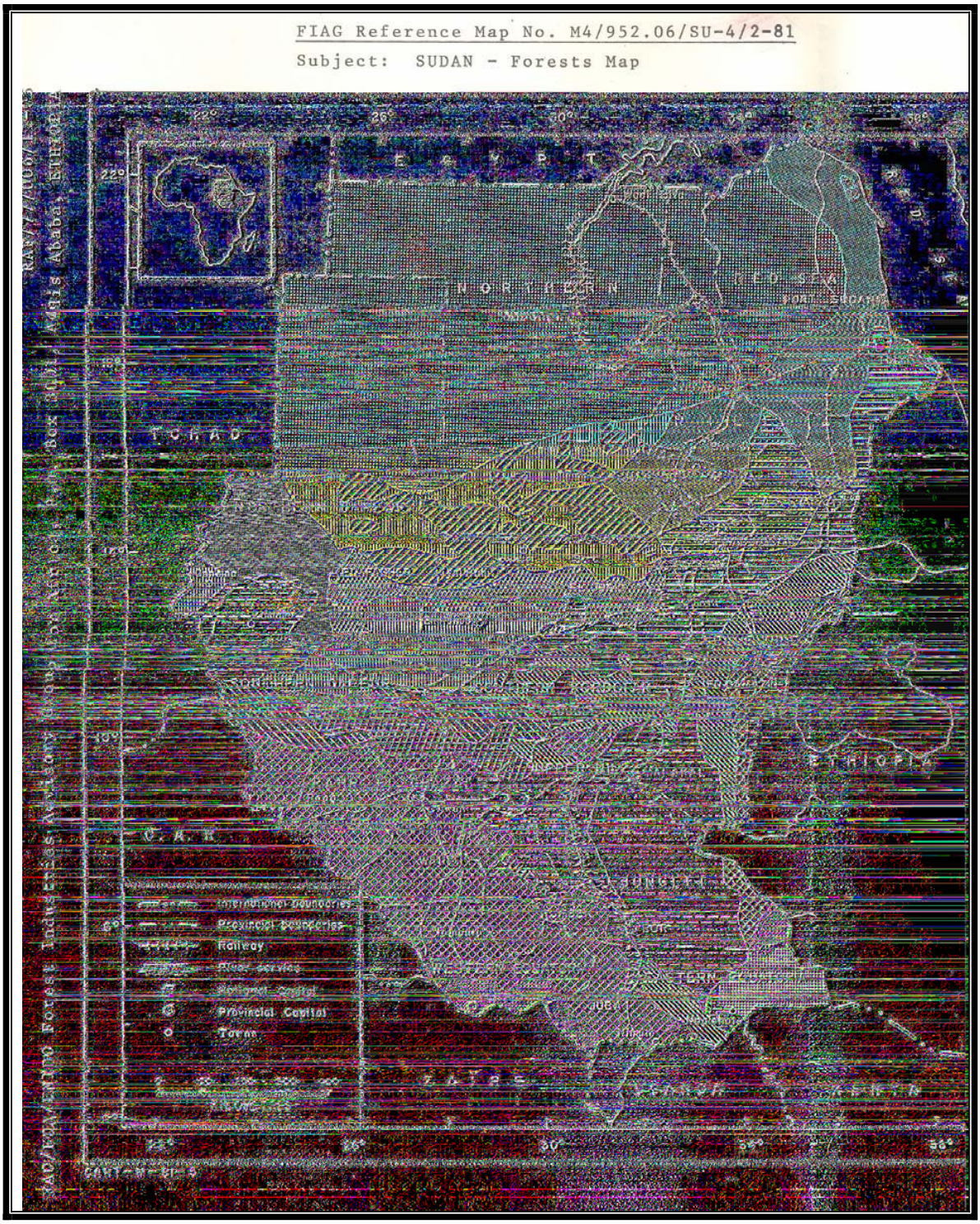

Fig. 1. Vegetation belts of the Sudan (Sudan Forest Map)

2.1.3. Woodland savannah:

Woodland savannah starts immediately, south of the semi desert in the form of a belt stretching from east to west to cover the remainder of the country. It is a mixture of vegetation types composed of grasses, shrubs and trees thriving under annual rainfall between 300 to over 1500 mm. In view of the wide range of rainfall and soil variation, the woodland savannah is sub divided into: (a) low rainfall savannah and (b) high rainfall savannah. The latter is confined to small areas in south of Talodi and south of um Dafoug in south Darfur, and southwards to cover the entire South represented by the Vuba belt in Bahr el Ghazal and in Equatoria. The boundary between the two types lies between the isohyets 800-1000 mm.

a- Low rainfall savannah woodland:

- Low rainfall savannah on clay: The species of the low rainfall savannah are generally thorny with thick bark, thus highly resistant to fire. The drier northern parts on clay are covered with low bushes of *A. mellifera*; the southern limits are marked by Gedaref, Suki, Renk and Gelhak in Upper Nile, Abu Gabeha and Dalanj in Kordofan. Increase in annual rainfall to 570 mm causes a change to taller trees of *Acacia seyal–Balanites agypetiaca* that spread in Gedarif State into Blue Nile, Southern Kordofan and Upper Nile. The two species mix with *Acacia senegal*. In the south eastern parts of the states of Gedarif, Blue Nile and Upper Nile, in the vicinity of hills or in the presence of rock fragments, the species are by *Anogeissus leiocarpus*-*Combretum hartmannianum*. The latter species indicate a transitional stage towards the high rainfall savannah where the trees are taller, broad leaved with thin bark. The vegetation is a fire climax.
- Low rainfall savannah on sand: The northern part in North Kordofan and North Darfur are covered by *A. senegal* savannah that stretches towards en Nuhud to el Fasher. The *A. seyal–B. agypetiaca* on the eastern clays and the *A. senegal* on Kordofan and Darfur sands, form the Gum Arabic belt. *Combretum cordofanum*, *Delbergia*, *Albizzia sericocephala* woodland extends over a large area from Sa'ata on the east to include en Nuhud, Abu Zabad to Lagawa, Babanusa in Kordofan to Nyala in Darfur. The western parts of Darfur northwards from Nyala, the soils formed in situ are affected by the mountainous nature especially towards Jebel Marra. In the northern parts, extends, *A. mellifera* thornland associated with *C. africana* and *B. senegalensis*. West of Nyala from Idd el Ghanam towards the international boundary and Geneina, are hill catenas. Near the mountain are associations of species such as *Boswellia papyrifera*, *Sterculia setigera*, *Terminalia brownii*, *A. leiocarpus* and *C. hartmannianum*. Seasonal water courses from Jebel Marra flowing westwards carry luxurious *Acacia albida*, *Khaya senegalensis*, *Cordia africana* and *Tammaridus indica*. Jebel Marra itself is a unique ecosystem surrounded by low rainfall types of vegetation. The high precipitation that maintain forest vegetation close to that in the wetter parts of the low rainfall savannah, the high rainfall savannah and tropical forest. Between lat 100 30´ and 110 30´ are

woodlands of well-stocked forests of *Terminalia brownii*, *Scelerocarya birrea*, *A. leiocarpus* and *Prosopis africana*. This type is a transitional stage to high rainfall savannah, starts south of Kadugli in Kordofan and south of Babanusa and west of Buram towards Reheid el Birdi in Darfur.

b- High rainfall savannah woodland:

This high rainfall savannah woodland formation is typical to the iron-stone region, occurs under annual rainfall of 900-1300 mm., extends from the southern parts of Blue Nile, Kordofan and Darfur to cover the greater parts of Equatoria and Bahr el Ghazal. It occupies a sizeable area south of Safaha in Darfur and south of Talodi in Kordofan. The most important species are *K. senegalensis* and Isoberlinia doka. Other species are *Parkia oliveri*, *Daniellia oliveri*, *Afzelia africana*, *Monotes kerstingii*, *Terminalia mollis*, *Burkea africana* and *Butyrospermum niloticum*. The trees are lofty high, broadleaved with thin bark. Thorny trees are infrequent. The vegetation is highly sensitive to fire. The shallow iron- stone soil and hard pan with the undulating terrain and high rainfall provide a highly fragile ecosystem.

c- Woodland Savannah Recently Derived from Rain Forest:

This type extends in a strip along the Nile- Congo water dividing line, the trees are large composed of species such as *Terminalia glaucesens*, *Albizzia zygia*, *Combretum binderianum*, *Bridelia scleroneuroides* and *Dombeya quinqueseta*. Included in this type there are small areas of tropical rain forests some of which are declared nature reserves such as Lotti, Laboni and Talanga in the east bank, Azza and Aloma plateau in the west bank of the White Nile. The trees are large with big girth. The most dominant species are *Celtis zenkeri*, *Chrysophyllum albidum*, *Mildbraediodendron excelsum* and *Holoptelea grandis*. The ecosystem is highly sensitive to human interference. The principal woody areas of the Sudan are given in Fig. 2.

Other issues such as the flood region and environmental crisis are well covered by El Moghraby *et al*., (2009) this issue.

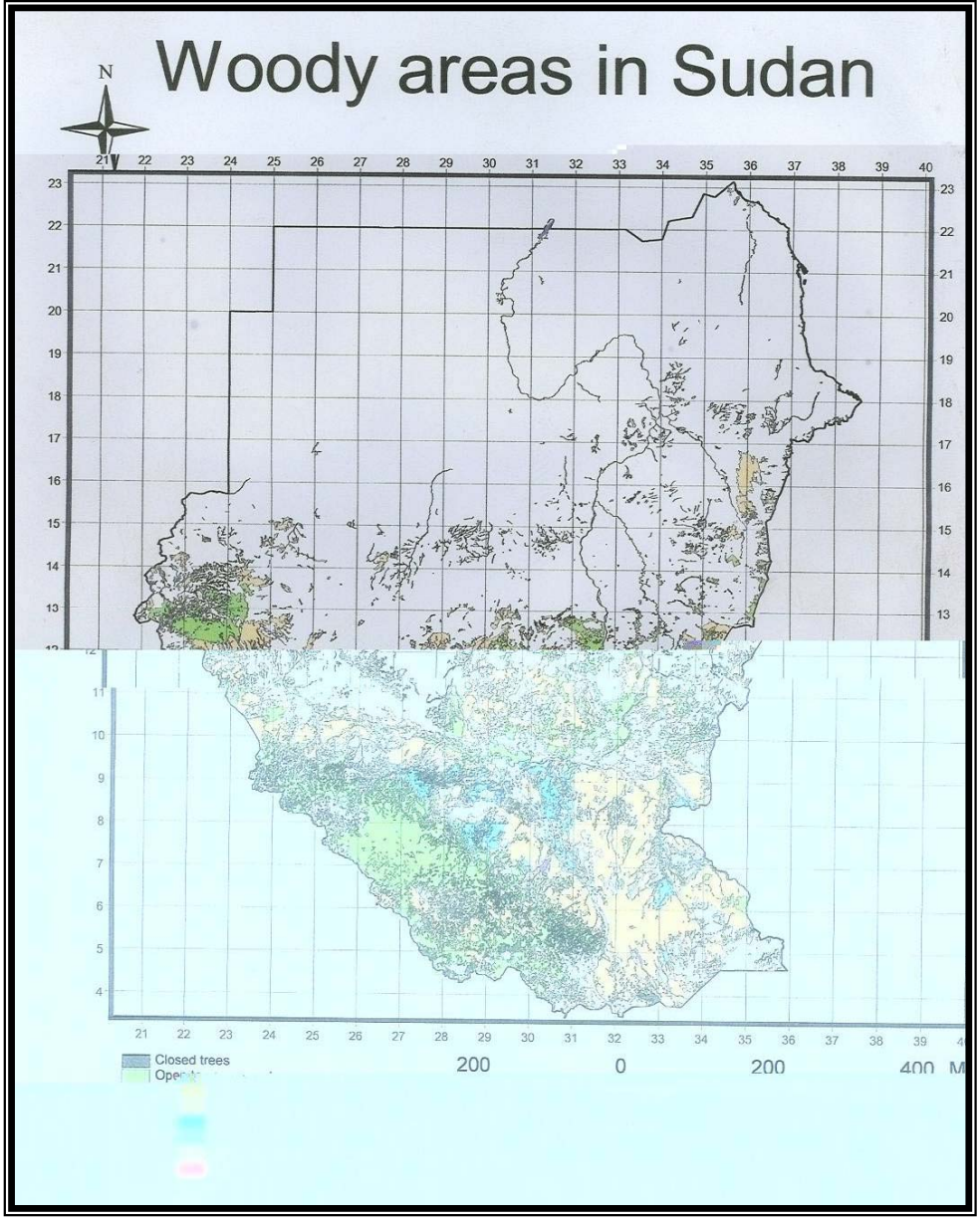

Fig. 2. The woody areas of the Sudan

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Chapter 7: Freshwater Invertebrates of the Nile

By

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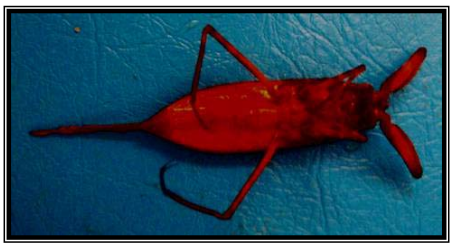
1. Introduction

An array of aquatic invertebrates are directly associated with wetlands. These range from zooplankton which is important components of the food pyramid in the aquatic ecosystem to invertebrate parasites and their vectors or intermediate hosts. Several fish species, waterfowl, shorebirds and herons depends on them as a source of food. True aquatic invertebrate organisms include dragon flies and damselflies (Odonata), mayflies (Ephemeroptera), mosquitoes (Diptera), various beetles (Coleoptera) such as water and diving beetles, medical leeches (Hirudinea), and snails (Gastropoda) see Fig. 1.

Fraser and Keddy (2005) reorted 20 Odonata spp; 70 Coleoptera spp., and 24 mosquito's species from the Sudd region. In the Sudd region according to Bailey and Litterick (1993) large quantities of macroinvertebrates in hyacinth root-mats were obtained. They were dominated by coleopterans, odonatans and gastropods. Outer edges of the fringe offer easy access, good dissolved oxygen concentrations, and a variety of potential food resources for aquatic invertebrates. By contrast the less hospitable landward zone contained a reduced fauna in which coleopterans and gastropods were prominent. A marked reduction in the numbers of invertebrates in detached hyacinth rafts was attributed to browsing by fish. Hyacinth root-mats appear to have replaced the niches formerly provided by those of the Nile cabbage for aquatic invertebrates in the Sudd.

The most important water related diseases in the Sudan are malaria (human), schistosomiasis (bovine and human schistosomiasis), fascioliasis (in animals) and to a lesser extent dracunculiasis (in man).

Bulinus sp. *Limnea* sp.



Water scorpion

Anopheles sp. Odonata: Dragonfly

Fig.1. Some aquatic invertebrates

2. Zooplankton

Several researchers contributed to our knowledge of the plankton at different stretches of the Nile. Examples are the work of Rzoska *et al* (1955) on the White and Blue Nile near Khartoum; Abu Gideiri (1969 a and b) at the Mogran and Khartoum; Monakov (1969) on the White Nile; Rzoska (1974) in the swamps of the White Nile; Talling and Rzoska (1967), Mousa (??) on the plankton of Jelehak area (White Nile) and El Moghraby (1972) on the Blue Nile; Ali (1984) and Dumont (1984 a and b) on Lake Nubia and Dumont *et al* (1984) on the valley of the main Nile, Ahmed (2002) and El Hassan (2007) on the plankton of Atbara River. Special attention should be given to the reviews of Rzoska (1976), Dumont (1986 a and b), Martens (1984), de Ridder (1984) and Verheye and Dumont (1984). De Ridder (1984). Studied various water samples from different parts of the Sudan and reviewed previous data on rotifers. From his work rotifers genera of the Nile system was compiled (Table 1) and their relative diversity index was calculated (Table 2).

Table 1: Rotifers genera of the Nile Basin in the Sudan
(compiled from de Ridder, 1984).

Genus	No. of species				Genus	No. of species			
	BN	AR	WN	N		BN	AR	WN	N
Brachionus	8	4	4	4	*Platyias*	1	-	2	-
Keratella	3	2	3	3	*Euchalinus*	-	1	1	2
Anaraeopsis	2	-	1	1	*Synchaeta*	-	-	1	1
Lepadella	4	-	8	6	*Heterolepadella*	-	-	1	-
Lecane	16	-	21	6	*Cephalodella*	-	1	1	2
Trichocerca	11	2	4	4	*Testudinella*	-	-	2	-
Polyarthra	2	1	2	4	*Dipleuchanis*	-	1	1	
Filinia	2	-	2	2	*Macrochaetus*	-	-	1	-
Lophcharis	1	-	-	1	*Tetramasix*	1	1	1	-
Asplanchna	1	1	1	1	*Pompholyx*	1	1	-	-
Asplanchnella	1	-	-	-	*Sinantherina*	1	-	-	-
Asplanchnopus	-	-	-	2	*Mantredium*	-	-	-	1
Conchibus	2	-	-	-	*Wolga*	-	-	-	1
Aexarthra	2	1	1	4	*Notommata*	-	-	-	1
Colurella	2	-	-	2	*Dicronophorus*	-	-	-	1
Rotaria	1	-	-	-					

* BN=Blue Nile; AR=Atbara River; WN=White Nile; N=Nile.

It is apparent from Table 5 that there are great differences in the species encountered and their diversity. Out of the 25 *Lecane* species only *L. furcata* was not encountered in the Nile system. Two Trichocercan (*Trichocerca cavia* and *T. longiseta*) out of 17 species were not encountered in the Nile. Members of some genera e.g. *Brachionus*, *Keratella*, *Trichocerca*, *Hexarthra* are found in all water bodies. Others are confined to one water body e. g. *Rotario*, S*inaantherina*, *Wolga*. The relative diversity index of species and genera (Table 2), calculated from de Riddre (1984) clearly illustrated this discrepancy in the encountered taxa.

A simple relative diversity index for species as well as for genera (Table 3) was calculated for some of the Nile sub basins. Calculation was based:
Relative diversity index (RDI) = No. of taxa in a basin / No. of taxa in the Nile

Table 2: Relative diversity index (RDI) of Rotifers genera and species (after various authors)

Index	Blue Nile	Atbara River	White Nile	The Nile
No. of genera	18	11	20	20
Genera RDI	0.49	0.30	0.54	0.54
No. of species	61	16	60	49

Species RDI	0.42	0.11	0.41	0.34

Rozska and Talling (1966) demonstrated that the zooplankton of the Blue Nile reproduces in fre-flowing river conditions and is not merely potamoplankton drifting with the current, an indication that there is true river plankton. They further related productivity to abundance of phytoplankton and to the regime of annual flow of the Nile. El Moghraby (1975) confirmed the presence of seasonal peaks of abundance of zooplankton with its complete disappearance in the flood silt- laden, fast-flowing waters. He gave an insight into the continuity of productivity in such torrential tropical rivers through the phenomenon of "diapause" and elucidated the role of wetlands.

According to Martens (1984) the Nile has a crustacean community (Table3) composed of pelagic species identical to those found in its lake sources. *Moina micrura* and *Thermodiaptomus galebi* are the most typical of the Nile system. According to Verheye and Dumont (1984) *Tropodiaptomus kraepelini* is fairly common. Both authors are of the opinion that *Metadiaptomus maureanicus* can not survive under the heavy fish perdition and competition with *Thermodiaptomus* sp. and *Tropodiaptomus* sp.

Table 3: Crustacean species of the Nile basin in the Sudan
(modified from Martens, 1984)

Species	BN	AR	WN	N	LN
Bosmina longirostris	-	-	+	+	-
Chydrorus sphaericus	-	-	+	-	-
Ceriodaphnia cornuta	-	+	+	+	+
Ceriodaphnia dubia	-	-	+	+	-
Daphnia barbata	-	-	-	+	+
Daphnia longspinosa	+	-	+	-	-
Daphnia humholtzi	-	+	-	+	-
Diphansoma excisum	-	+	+	+	+
Leydigia ciliata	-	-	+	-	-
Moina micrura	+	+	+	+	+
Metadiaptomus mauretanicus	+	-	-	-	-
Thermodiaptomus galebi	+	+	+	+	+
Thermodiaptomus mixus	+	-	-	-	-
Tropodiaptomus orientalis	-	+	-	-	-
Tropodiaptomus kraepelini	+	-	+	+	+
Parapseudoleptomesochra attirei	-	-	+	-	-

+ (present), - (absent)

3. Nonplanktonic arthropods

Of the many species of green and black midges indigenous to the Sudan, three riverine ones *Tanytarsus lewisi*, *Simulium daminosum* and *Simulium griseicollis* appears to be of economic importance (Abu Shama, 1974). The

larvae of *T. lewisi* (Chironomidae) constitute a significant contribution to the food of fishes while the adult cause allergy to man. *Simulium daminosum* (Simuliidae) is a vector of human onchocerciasis especially in areas around cataracts and rapids. *Simulium griseicollis* (Simuliidae) causes annoyance to human beings and sometimes biting but mainly birds. All *Ancula* spp. and some *Tabanus* spp. are riverain houseflies. The small aquatic mites (*Limnohalacrus africanus* and *L. fontinalis)* were encountered from Lake No by Green (1984). The dragonflies of the main Nile included 14 genera and 16 species (Dumont and Martens, 1984). Bailey and Litterick (1993) reported on the association of 1 Conchostraca, 2 Malacostraca, 5 Ephemeroptera, 2 Trichoptera, 23 Odonata, 7 Hemiptera and 27 Coleoptera species with water hyacinth in the sudd swamps.

4. Zoobenthos

Few studies has been carried out on the benthic comminutes of the Nile and most of the work concentrated on molluscs and insects. Jickleli (1874) was perhaps the first to publish on freshwater snails of the Sudan. He reported *Bellamya unicolour* from Kordofan and the White Nile and *Segmentorbis angustus* from the White Nile. Since then several workers contributed to our knowledge on freshwater snails from parasitological and/or ecological point of view. Pallary, 1902; Longstaff, 1914; Archibald, 1933; Tothill, 1946; Ayad, 1956; Malek, 1958; Pain, 1961; Martin, 1968; Monakov, 1969; Williams and Hunter, 1968; Brown and Mandahl-Barth, 1973 Brown, 1980; Majid *et al.*, 1980; Brown *et al.,* 1984; Rzoska, 1976; Madeson *et al.*, 1988; and Abd el Halim *et al.*, 1998. The total number of species described and/or cited amounts to 33. The work of Jickleli (1874); Longstaff, 1914 and Brown *et al.,* 1984; Abdel Halim *et al.*, 1998 comprises the most important account from Western Sudan, Southern Sudan and the Nile State, respectively.

The association between snails and the parasites they transmit was extensively studied in the irrigated agriculture schemes (see Archibald, 1933; Ahmed, 1987; Madeson *et al.*, 1988 and the references therein).

The freshwater molluscs' fauna of the Sudan is diverse. It includes:

4.1. Clear running water with *Vossia* and *Eichhornia*; lagoons with *Eichhornia*; seasonal pools with *Echinochloa*, *Ipomoea* and water-lilies; standing water, ditches and rain pool with *Eichhornia*, *Pistia* and *Typha* in Southern Sudan (Brown *et al.,* 1984).

4.2. Irrigated canals where papyrus and grass dominates the vegetation (El Sheikh, 1998).

4.3. Grassy muddy substrates and granite rocky beds dominated by algae in the Nile State (Abd el Halim *et al.*, 1998).

Thirty-three freshwater snails belonging to nine families were encountered in the country.

A simple relative diversity index for species as well as for families (Table 4) was calculated for some of the Nile sub-basins.

Table 4: Relative diversity index (RDI) of species /families of Molluscs in the Nile (after various authors)

Index	South	W. Nile	B. Nile	West	Nile	Canals
No. of species	23	17	6	8	12	8
Species RDI	0.70	0.52	0.18	0.24	0.36	0.24
No. of Families	7	6	2	4	6	2
Family RDI	0.78	0.67	0.22	0.44	0.67	0.22

It is apparent from Table (8) that the habitats in Southern Sudan, the White Nile and to a lesser extent the Nile State are favourable for molluscs as can be judged from the number of families and species found. The most diverse family in the Nile in terms of genera and species is Planorbidae while Vivparidae, Lymnaeidae and Ancylidae are the least represented (one genus and one species each) Table 5.

Table5: Molluscs families in the Nile basin in Sudan
(after various authors)

Family	No. of genera	% of total	No. of species	% of total
Vivparidae	1	5.3	1	3.1
Ampullariidae	2	10.5	4	12.1
Bithyniidae	2	10.5	4	12.1
Thiaridae	2	10.5	2	6.1
Lymnaeidae	1	5.3	1	3.1
Ancylidae	1	5.3	1	3.1
Planorbidae	6	31.6	15	45.5
Physidae	3	15.8	3	9.1
Corbiculidae	1	5.3	2	6.1
Total	19	100	33	100

A total of 23 species were collected from the sudd region (Brown *et al.,* 1984) and 12 species from the Nile State (Abdel Halim *et al.*, 1998). Both works were parts of a base line survey to assess possible future ecological effects of Jongolei canal project and the proposed Merowie dam project, respectively. Out of the 23 species recorded from the sudd region, 14 were associated with with permanent wetland habitats where *Eichhornia* was present (Bailey and Litterick, 1993). *Theodoxus niloticus* and *Valvata nilotica* were reported to be living in the Sudan for the first time from the Nile State by Abd el Halim *et al.*, (1998). However, Martin (1968) recorded these as fossils and modern shells from the second cataract in the far north of the country.

5. Health hazards

5.1. Schistosomiasis

Parasitological observations indicated that *Biomphlaria pfeifferi*, *Bulinus forskali*, *Bulinus globosus* and *Bulinus truncatus* are host snails for human schistosomiasis (Malek, 1958; Ahmed, 1987). While *B. forskali*, *B. globosus* and *B. truncatus* are host snails for bovine schistosomiasis (Majid *et al.*, 1980) and *Lymnaea natalensis* as host snail for liver fluke (Malek, 1958). These medically important snails have the following pattern of distribution. *Biomphlaria pfeifferi* was found in all basins; *B. forskali* in all basins except the Nile State; *B. globosus* in Southern Sudan and irrigated canals; *B. truncatus* in Southern Sudan, the Blue Nile and irrigated canals; *L. natalensis* was neither encountered from the Blue Nile nor from the Nile State. The coefficient of similarity index (Table 6) was calculated from the data given in Table (4).

Table 6: Coefficient of similarity index

	South	W. Nile	B. Nile	West	Nile	Canals
South	-	0.538	0.160	0.291	0.296	0.240
W. Nile	0.538	-	0.211	0.316	0.208	0.316
B. Nile	0.160	0.211	-	0.273	0.059	0.400
West	0.291	0.316	0.273	-	0.176	0.214
North	0.296	0.208	0.059	0.176	-	0.176
Canals	0.240	0.316	0.400	0.214	0.176	-

From Table (6) the following points can be made:

5.1.1. The highest similarity between Southern Sudan and White Nile and between the Blue Nile and the irrigated agricultural schemes is expected;

5.1.2. The continuity of flow explains the relatively high similarity index between the Nile State, White Nile and Southern Sudan as compared with other basins; and

5.1.3. The various indices between Western Sudan and other basins might be an indication of an expansion of the fauna sometime during the past.

5. 2. Fascioliasis

The trematodes *Fasciola hepatica* and *Fasciola gigantica*, are parasites of herbivores that can infect humans accidentally. Fascioliasis is a zoonosis, i.e. a disease of animals that can be transmitted to humans. Susceptible animal reservoir hosts for *Fasciola* species in Sudan include the main domestic animals: cattle, sheep and donkeys; other domestic animals: horses and goats; and hares, rabbits and rodents. Parasite eggs are passed in the faeces of infected animals or humans and contaminate water where they develop within snails. The snails release mature larvae that attach to vegetation and encysted as metacercariae.

Humans typically become infected by ingesting encysted metacercariae attached to aquatic or semi-aquatic plants. Evidence also indicates that infection may occur by drinking water contaminated with floating metacercariae and by ingesting metacercariae attached to the surface of food or kitchen utensils washed with water contaminated with floated metacercariae. Although no such cases have been reported in Sudan, the possibility of its occurrence in the vast wetlands should not be overlooked.

5. 3. Dracunculiasis

The survey made by Idris *et al*., (2007) indicated that the major vectors of Dracunculiasis (Guinea worm disease) in the Sudan were *Mesocyclops aspericornis* (from Dali, Mazmum, Wau, Westren Sudan, Dinder National Park and Khartoum) *Mesocyclop kieferi* (from Mairam area, Westren Sudan) and a *Cryptocyclop* sp (from Dali, Mazmum, Wau, Westren Sudan and Khartoum). The southern states of the Sudan are shouldering 80% of the Global cases (Sudan Guinea Worm Eradication Programme, 2002).

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Chapter 8: Diversity of Freshwater Fishes of the Sudan

By

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1. Introduction.

According to Hammerton (1972) and some other researchers the Nilotic fauna is rich and diverse in fish species, with over 300 species falling at least into 54 genera. This diversity is related to diversification of the habitat of the Nile system itself (natural and man-made lakes, falls, cataracts, swamps, canalization systems etc). In some instances deliberate introduction of exegenous species into parts of the Nile system or canalization system contributes to diversity of fish species.

The interest in freshwater fishes of the Sudan dates back to the 19th century. Since then descriptive illustrations with keys for identification, distribution habitats and notes on features of biological interest are well documented by scientist among whom are Boulenger (1907); Pekkola, 1918 and 1919 around Khartoum; Girgis (1948) Upper Nile; Sandon (1950); Amirthalingham and Khalifa (1965); Abu Gideiri (1967), Khartoum and Roseires; Mishrigi (1970) Lake Roseires; Abu Gideiri (1984); Adam (1986) Gebel Aulia; Mahmoud (1986) Dinder National Park; Bailey (1994); Salih (1994); Abd el Halimn *et al*., (1997) between Abu Hamed and Merowi island; Ahmed (2002) and El Hassan (2007) Khasm el Girba Dam; Mouso *et al*., (2008) Jelhak. The Sudd fisheries received especial attention. Hickley and Bailey (1987) studied the fish communities in the eastern, seasonal-floodplain of the Sudd; Ahmed (1999) described the diversity of fish fauna in inland waters of Southern Sudan and Bailey (2008) made an assessment of the fisheries of the Sudd wetlands.

2. List of freshwater fish of the Sudan.

The list of freshwater fishes of the Sudan (given in Table 2 are representative fsh species are given in Fgis. 1 to 5) was compiled from the work of Boulenger (1907), Sandon (1950), Amirthalingham and Khalifa (1965), Abu Gideiri (1984) and Bailey (1994). No attempt was made to include the local names. There is a recent list of freshwater fishes of the Sudan available on line at Fishbase.org. This list, first created by Jen (2003) and modified by Eli (2004), will be commented upon at the end of this section.

Table 1. Freshwater fishes of the Sudan.

Families	Genera	Species	No. of Genera	No. of Species
Protopteridae	*Protopterus*	*aethiopicus*	1	2
		annectens		
		bichir		
		endlicheri		
Polypteridae	*Polypterus*	*senegalus*	1	3
Arapaimidae	*Heterotis*	*niloticus*	1	1
Notopteridae	*Papyrocranus*	*afer*	2	2
	Xenomystus	*nigri*		
Mormyridae	*Hippopotamyrus*	*Harringtoni*	7	16
		pictus		
	Hyperpisus	*bebe*		
		cyprinoides		
		macrolepidotus		
	Marcusenius	*senegalensis*		
	Moromyrops	*anguilloides*		
		caschive		
		Hasselquistii		
	Mormyrus	*Kannume*		
		niloticus		
		bane		
		bovei		
	Pterocephalus	*keatingii*		
	Pollimyrus	*isidori*		
		petcherici		
Gymnarchidae	*Gymnarchus*	*niloyicus*	1	1
Kneriidae	*Cromeria*	*nilotica*	1	1
Alestiidae	*Alestes*	*Baremoze*	4	9
		Dentex		
		macrolepidotus		
	Brycinus	*nurse*		
	Micralestes	*acutidens*		
		elongates		
	Hydrocynus	*Brevis*		
		Forskalii		
		vittatus		
Distichodonidae	*Distichodus*	*Brevipinnis*	1	4
		Engycephalus		
		Niloticus		
		rostratus		
	Citharinus	*citharnus*		
		latus		
	Ichthyborus	*besse*		

	Nannocharax	*niloticus*		
	Neolebias	*trewavasae*		
Citharinidae			4	5
		anema		
		bynni		
		leonensis		
		negluctus		
		nigeriensis		
		prince		
		pumilus		
	Barbus	*stigmatopygus*		
		tongaensis		
		yeiensis		
	Chelaethiops	*bibie*		
	Garra	*dembeensis*		
		coubie		
		forskalii	6	21
		horie		
Cyprinidae		*meroensis*		
		niloticus		
		parvus		
	Labeo	*tongaensis*		
	Leptocypris	*niloticus*		
	Raiamas	*senegalensis*		
	Auchenoglanis	*biscutatus*		
		occidentalis		
	Bagrus	*bajad*		
		docmak		
	Chrysichthys	*auratus*		
		rueppelli		
Bagridae	*Clarotes*	*laticeps*	4	7
Schilbeidae	*Parailia*	*pellucida*		
		intermedius		
		mystus	2	4
	Schilbe	*uranoscopus*		
Amphiliidae	*Andersonia*	*lepyura*	1	1
		alluaudi		
		anguillaris		
		elongeseni		
		gariepinus		
	Clarias	*liocephalus*		
		werneri		
Clariidae	*Heterobranchus*	*bidorsalis*		
		longifilis		
Malapteruridae	*Malapterurus*	*electricus*	1	1

	Chiloglanis	*niloticus*		
	Mochokus	*brevis*		
		niloticus		
		batensoda		
		caudovittatus		
		clarias		
		eupterus		
		filamentous		
		frontosus		
		khartoumensis		
	Synodontis	*membranaceus*		
		nigrita		
Mochokidae		*schall*	3	15
		serratus		
		sorex		
	Cyprinodon	*dispar*		
	Epiplatys	*spilargyreius*		
	Nothobranchius	*vigratus*		
		hutereaui		
		Kingi		
	Aplocheilichthys	*normani*		
Cyprinodontidae	*Gambusia*	*affins*	6	8
	Micropanchax	*loati*		
Channidae	*Parachanna*	*obscura*	1	1
Latidae	*Lates*	*niloticus*	1	1
	Haplochromis	*loati*		
		wingatti		
	Hemichromis	*fasciatus*		
		letourex		
	Oreochromis	*niloticus*		
	Pseudocrenilabrus	*multicolor*		
Cichlidae	*Sarotherodon*	*galilaeus*	6	8
	Tilapia	*zilli*		
Eleotridae	*Kribia*	*nana*	1	1
	Ctenopoma	*Muriei*		
		Petherici		
Anabantidae	*Microctenopoma*	*pekkolai*	2	3
Tetraodontidae	*Tetraodon*	*lineatus*	1	1

Fig. 1 *Lates niloticus* (Khartoum Fish Market, February 2006)

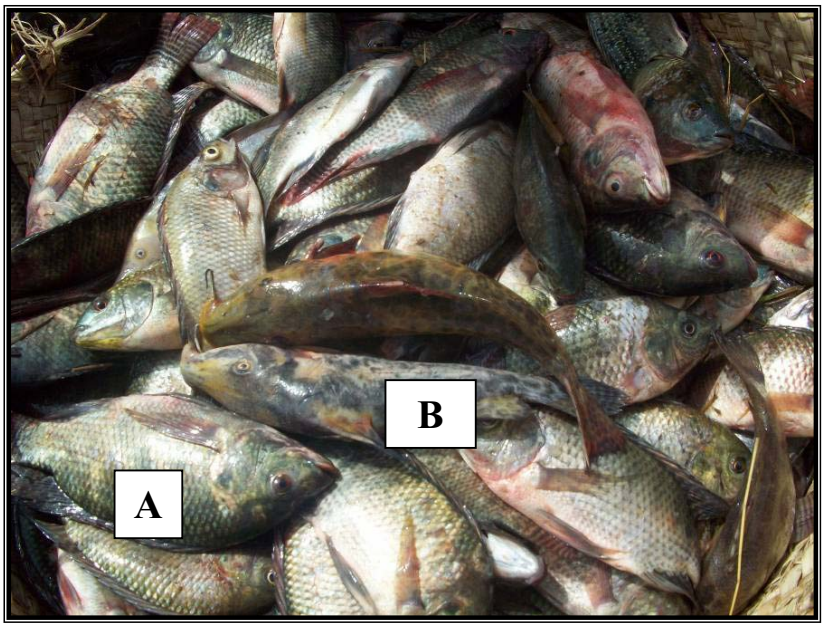

Fig. 2. A collection of fish from Gebel Aulia Khartoum, December, 2008
A= *Oreochromis niloticus* , B= *Auchenoglanis occidentalis*

Fig. 3. *Labeo coubie* "Kadan" from Lake Roseries January, 2009.

Fig. 4 *Clarias anguillaris* "Garmut" from Lake Roseries February, 2009

Fig . 5. *Malapterurus electricus*

3. Comments

3.1. The list given above (Table 1) indicates that the researchers and authors have enlisted 24 families that include 60 genera and 124 species. *Angulia vulgaris* (Anguilidae) was not included in the list as it was last recorded by Pekkola (1918).

3.2. The Fishbase.org list of freshwater fishes of the Sudan first created by Jen (2003) and modified by Eli (2004) included:

3.2.1. Species that were introduced some decades ago and of which there is no recent records of those are: *Ctenopharyngodon idella* and *Cyprinus carpio* (Cyprinidae) and *Oncorhynchus mykiss* (Salmonidae).

3.2.2. Species which were reported from other African countries and not from Sudan such as: *Nothbranchius nubanisis* (Cyprinodontidae), *Brienomyrus niger* (Mormyridae), *Siluranodon auritus* (Schilbeidae) and *Claris engelseni* (Clariidae).

3.2.3. Species to which either a wrong generic name (*Alestes macrolepidotus* and not *Brycinus macrolepidotus*) or a species name (*Hemichromis letourex* and not *Hemichromis letourneux*) was attached.

3.2.4. Some fish species which are inhabitant of the Red Sea and not the fresh water environment. These are: *Cyprinnodon dispar* (Cyprinodontidae), *Megalops cyprinodis* (Megalopidae), *Siliago sihama* (Sillaginidae) and *Acanthopagrus berda* (Sparidae).

3.2.5. The family Cyprinodontidae was split into Cyprinodontidae, Aplocheilidae (*E. bifasciatus*, *E. spilargyreius* and *N. vigratus*) and Poeciliidae

(*A. hutereaui*, *A. kingi*, *A. normani*, *G. affins* and *M. loati*). This contradicts the agreed upon classification.

3.3. The fish genera and species are unevenly distributed in the inland water masses of Sudan as summarized in Table 2.

Table 2. Number of families, species and genera in the different water masses and their relative diversity index (modified from Abu Gideiri and Ali, 2002).

Water body	Families		Genera		Genera	
	No.	Diversity index	No.	Diversity index	No.	Diversity index
White Nile (WN)	21	0.875	45	0.750	95	0.776
Bahr El Jebel (BJ)	18	0.750	42	0.700	87	0.702
Main Nile (MN)	17	0.703	38	0.633	66	0.532
Bahr El Ghazal (BJ)	17	0.703	36	0.600	73	0.589
Lake Nubia (LN)	13	0.542	28	0.467	56	0.452
Blue Nile (BN)	12	0.500	29	0.483	50	0.403
Sudd (SD)	8	0.333	10	0.167	12	0.097
Other (O)	6	0.250	7	0.117	8	0.065

3.4 The coefficient of similarity index (Table 3) calcaulated from Abu Gideiri and Ali (2002) indicated that the least similarity in species was 53% (the Blue Nile and the White Nile) and the highest similarity index was 92% (Bahr El Jebel and the White Nile).

Table 3. Coefficient of similarity index (calculated from Abu Gideiri and Ali, 2002).

Location	WN	BJ	BG	N	LN	BN
WN	-	0.92	0.77	0.69	0.60	0.53
BJ	0.92	-	0.84	0.76	0.64	0.57
BG	0.77	0.84	-	0.90	0.76	0.63
N	0.69	0.76	0.90	-	0.85	0.76
LN	0.6	0.64	0.76	0.85	-	0.89
BN	0.53	0.57	0.63	0.76	0.89	-

4. Recommendations

It follows from the above that there is a need to:

4.1. Reclassify fish species through classical, numerical, chemotaxonomy and molecular taxonomy.

4.2. Survey all inland water masses (a long-term study) using traditional gears and modern electric fishing methods (vital for collecting grass dwelling fish) in order to:

4.2.1. Update the locality records.

4.2.2. Check out the current distribution bearing in mind the impact of the constructed hydro-projects, canalization systems and drilling activities at the sudd region on the fish fauna.
4.3. Compare the fish species in Sudan with those found in freshwater masses in adjacent countries, to work out their phylogenic relationships.

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Chapter 10: Waterbirds of Sudan

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1. Introduction

The Republic of Sudan is the largest country in Africa, extending 2075 km along its North–South axis and 1810 km east to west. It has an area of 2,505,815 Km^2 and bordered by the Red Sea to the east (Robertson, 2001). The habitat ranging from desert to tropical rainforest, the country is mainly flat with an average altitude of 500 m, there are some important mountain ranges, these are Jebel Marra, in the west, Nuba Mountain in central Sudan, and Imatong, Dongotona and Didinga in the South (Nikolaus, 1987).

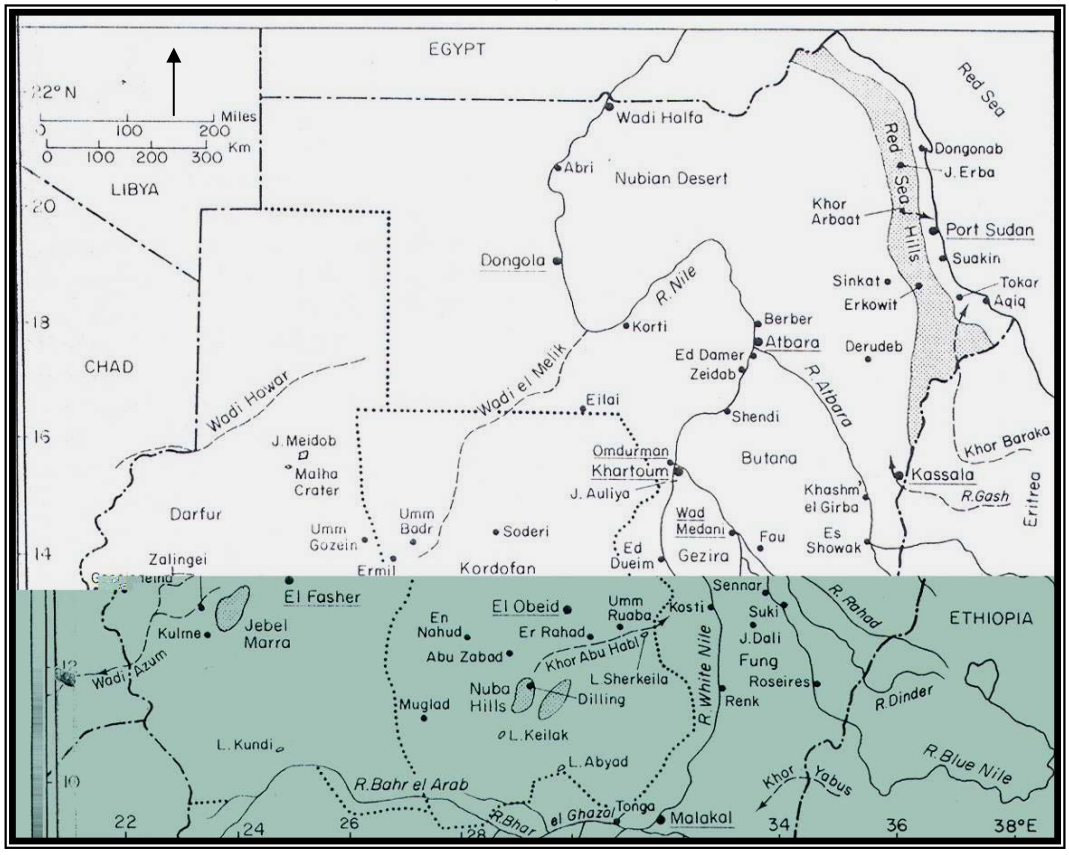
The Sudan has a coast line of 850 km bordering the Red Sea. The most interesting features are the fringing reefs, coastal lagoons, Tokar delta, the Suakin archipelago, a series of islands lies off the Town of Mohammed Qol and near the town of Halaib (Robertson, 2001).

The Nile and its tributaries, the Red Sea Coast, the Sudd and all inland natural and man made wetlands (Fig. 1) which attract and support important breeding population of water birds are well covered in chapter 1 of this edition.
The Sudan has only one rainy season from April/May to September becoming shorter towards the desert in the north. Along the Red Sea the rainy season is between December and February, and Lake Turkana in the south east with two short rainy seasons in April- May and November – December. The average rainfall in the North is between 75 in desert and 800 m per annum in the Savannah belt. In the South it average between 800–1200 mm per annum and reaching 2000 mm in the Imatong Mountains.

A way from the Niles the central Sudan has open water of about a dozen small lakes, pools, oases and excavated Fulas scattered across 1100 km of the western Sudan in Kordofan and Darfur (Hogg, P. *et al*., 1984). Three of these are permanent lakes (Keilak, Kundi and Abyad) between 10 and 11ºN, three large rain pools (El Rahad, Abu Zabad and Umm Badr), two oases (Malha crater and Mellit) at 14-16 ºN, and four Fulas (El- Obeid, El. Fasher, El Nahud and Umm Ruaba) (Figure. 1).
These waters are only of local importance because of their small sizes.
There are vast irrigated schemes in the Gezira and further up south up the Blue Nile which attracts waterbirds.

Waterbirds in this respect are bird species associated with wetlands.

Figure 1: Places Names mentioned in the text (Redrawn from Hogg *et al*., 984).



2.The avifauna

The avifauna of Sudan numbers 938 species of which 616 are residents and 312 regular seasonal migrants, including 216 species from the Palaearctic. There are 219 species of water birds (of these 12 species live near water), of these 102 species are Palaearctic and 117 species are residents. The 219 species of water birds (Table 1) fall in 42 families. Table 1 have been compiled from Cave and Macdonal (1955) and Nikolaus (1987).

Table 1. Water birds of Sudan.

Species common name	Scientific name	Status
Family: Podicipedidae		
Blacked-necked Grebe (PM)	*Podiceps nigricellis*	Rare
Little Grebe (R)	*Tachybaptus ruficollis capensios*	Seasonally common
Family: Hydrobatidae		
Leach's Petrel (PM)	*Oceanodroma leucorhoa*	Vagrant
Family: Phaethontidae		
Red-billed Tropicalbird	*Phaethon aethereus indicus*	Uncommon

(R)		
Family: Pelecanidae		
White Pelican (PM)	*Pelecanus onocrotalus*	Seasonally common
Pink-back Pelican (R)	*Pelecanus rufescens*	Fairly common
Family: Sulidae		
Brown Booby (R)	*Sula leucogaster*	Common
Family: Phalacrocoracidae		
Long-tailed Cormorant (R)	*Phalacrocorax africanus*	Seasonally common
Greater Cormorant (R)	*Phalacrocorax carbo*	Vagrant, rare
Socotran Cormorant (R)	*Phalacrocorax nigrogularis*	Recorded twice at Port Sudan
Family: Anhingidae		
Darter (R)	*Anihinga rufa rufa*	Fairly common
Family: Ardeidae		
European Bittern (PM)	*Botaurus stellaris*	Rare
Little Bittern (PM)	*Ixobrychus minutus*	Uncommon
Dwarf Bittern (R)	*Ixobrychus stummii*	Uncommon
Grey Heron (PM)	*Ardea cinerea*	Common
Goliath Heron (R)	*Ardea goliath*	Fairly common
Black-headed Heron (PM)	*Ardea melanocephala*	Common
Purple Heron (PM)	*Ardea purpurea*	Common
Squacco Heron (PM)	*Ardea ralloides*	Common
Cattle Egret (PM)	*Bubulcus ibis ibis*	Very common
Green-backed Heron (R)	*Butorides striatus*	Uncommon
Great White Egret (PM)	*Egretta alba melanorhyncus*	Fairly common
Black Heron (R)	*Egretta ardesiaca*	Rare
Little Egret (PM)	*Egretta garzetta*	Common
Reef Heron (R)	*Egretta gularith asah*	Common
Yellow-billed Egret (R)	*Egretta intermedia branchrhyncha*	Common
White-backed Night Heron (R)	*Gorsachius leuconotus*	Rare
Night Heron (PM)	*Nycticorax nycticorax*	Locally common
Family: Balaenicipitidae		
Shoebill (R)	*Balaeniceps rex*	Locally common
Family: Scopidae		
Hamerkop (R)	*Scopus umbretta*	Fairly common
Family: Ciconidae		
Open-billed Stork (R)	*Anastomus lam,elligerus*	Very common
Abdim's Stork (R)	*Ciconia abdimii*	Very common
White Stork (PM)	*Ciconia ciconia*	Locally very common

Wooly-necked Stork (R)	*Ciconia episcopus microscelis*	Uncommon
Black Stork (PM)	*Ciconia nigra*	Uncommon
Saddle-billed Stork (R)	*Ephippiorhynchus senegalensis*	Fairly common but never numerous
Yellow-billed Stork (R)	*Myctteria ibis*	Fairly common
Family: Threskiornithidae		
Hadeda (R)	*Bostrychia hagedash brevirostris*	Fairly common
Walddrapp (PM)	*Geranticus eremita*	Extremely rare
Glossy Ibis (PM)	*Plegadis falcinellus*	Uncommon but locally common during passage
Sacred Ibis (R)	*Threskiornis aethiopicus*	Common
African Spoonbill (R)	*Platalea alba*	Uncommon
Eurasian Spoonbill (PM)	*Platalea leucorodia*	Uncommon
Family: Phoenicopteridae		
Lesser Flamingo (R)	*Phoeniconias minor*	Could occur near lake Turkana
Greater Flamingo (PM)	*Phoeniconias rubber roseus*	Locally common
Family: Anatidae		
White –fronted Goose (PM)	*Anser albifrons*	Vagrant
Fulvous Whistling Duck (R)	*Dendrocygna bicolor*	Fairly common
White-faced Whistling Duck (R)	*Dendrocygna viduata*	Common
Egyptian Goose (PM)	*Alopochen aegyptiacus*	Locally common
Pintail (PM)	*Anas acuta*	Very common
Cape Wigeon (R)	*Anas capensis*	Rare
Shoveler (PM)	*Anas clypeata*	Very common
Teal (PM)	*Anas crecca*	Common
Red-billed Teal (R)	*Anas erythrorhychos*	Rare
Hotten Teal (R)	*Anas hottentota*	Rare
Wigeon (PM)	*Anaspenelope*	Common
Mallard (PM)	*Anas platyrhychos*	Rare
Garaganey (PM)	*Anas querquedula*	Very common
African Black Duck (R)	*Anas sparsa leucostigma*	Fairly common
Gadwall (PM)	*Anas strepera*	Rare
Northern Pochard (PM)	*Aythya ferina*	Fairly common
White-eyed Pochard (PM)	*Aytha nycroca*	Rare
Tufted Duck (PM)	*Aytha fuligula*	Fairly common
African Pygmy Goose (R)	*Nettapus auritus*	Locally fairly common

Maccoa Duck (R)	*Oxyura maccoa*	Rare
Spurr-winged Goose (R)	*Plectropetrus gambensis*	Fairly common
Hartlaub's Duck (R)	*Ptenonetta hartlaubii*	Uncommon
Knob-billed Duck (R)	*Sarkidiornis melanotos*	Seasonally common
Ruddy Shelduck (PM)	*Tadrona ferruginea*	Uncommon
Shelduck (PM)	*Tadrona tadrona*	Vagrant
White-backed Duck (R)	*Thalassornis leuconotus*	Vagrant
Family: Accipitridae		
Eurasian Marsh Harrier (PM)	*Cirus aeruginosus*	Fairly common
Montagu's Harrier (PM)	*Cirus pgyargus*	Common
African Marsh Harrier (R)	*Cirus ranivorous*	Uncommon to rare
Harrier Hawk (R)	*Polyboroides radiatus*	Uncommon
Fish Eagle (R)	*Haliacetus vocifer*	Common
Family: Pandionidae		
Ospery (PM)	*Pandion haliaetus*	Uncommon
Family: Gruidae		
Demoiselle Crane (PM)	*Anthropoides vigro*	Very common
Crowned Crane (R)	*Balearica pavonina ceciliae*	Very common
Family: Rallidae		
Lesser Moorhen (R)	*Gallinula angulata*	Rare
Moorhen (PM)	*Gallinula chloropus*	Uncommon to rare
Black Crake (R)	*Limnocorax flavirostra*	Fairly common
Allen's Gallinule (R)	*Porphyrio alleni*	Locally common
Purple Gallinule (R)	*Porphyrio porphyrio*	Rare
Little Crake (PM)	*Porzana pava*	Rare
Spotted Crake (PM)	*Porzana porzana*	Uncommon
Lesser spotted Crake (PM)	*Porzana pusilla*	Rare
African Water Rail (R)	*Rallus caecclenscens*	Uncommon to rare
Coot (R)	*Fulica atra atra*	Uncommon
Family: Jacanidae		
Jacana (R)	*Actophilornis africanus*	Very common
Lesser Jacana (R)	*Microparra capensis*	Rare
Family: Rostratulidae		
Painted Snipe (R)	*Rostratula benghalensis*	Uncommon
Family: Haematopodidae		
Oystercatcher (PM)	*Haematopus ostralegus*	Rare
Family: Charadriidae		
Kentish Plover (PM)	*Charadrius alexandrinus*	Locally common
Caspian Plover (PM)	*Charadrius asiaticus*	Locally common
Little Ringed Plover (PM)	*Charadrius dubius*	Uncommon
Great Sandplover (PM)	*Charadrius leschenaultii*	Common, rare

		inland
Ringed Plover (PM)	*Charadrius hiaticula*	Common
Mongolian Sandplover (PM)	*Charadrius mongolus atrifrons*	Uncommon
Dotterel (R)	*Charadriu morinelluss*	Occurrence is uncertain
Kittliz's Sandplover (PM)	*Charadrius pecuarius*	Fairly common
Three-banded Plover (PM)	*Charadrius tricollaris*	Uncommon
Lesser Golden Plover (PM)	*Pluvialus dominica fulva*	Rare
Grey Plover (PM)	*Pluvialis squatorola*	Fairly common
White-headed Plover (R)	*Vanellus albicepus*	Rare
Long-toed Plover (R)	*Vanellus crassirostris*	Common
Social Plover (PM)	*Vanellus gregarius*	Rare
White-tailed Plover (R)	*Vanellus leucurus*	Uncommon
Spur-winged Plover (R)	*Vanellus spinosus*	Common
Family: Scolopacidae		
Common Sandpiper (PM)	*Actitus hypoleucos*	Common
Curlew (PM)	*Numenius arquata*	Common
Whimbrel (PM)	*Numenius phaeopus*	Uncommon
Spotted Redshank(PM)	*Tringa erythropus*	Uncommon to rare
Wood Sandpiper (PM)	*Tringa glareola*	Common
Greenshank (PM)	*Tringa nebularia*	Common
Green Sandpiper (PM)	*Tringa ochropus*	Common
Marsh Sandpiper (PM)	*Tringa stagnatilis*	Very common
Redshank (PM)	*Tringa totanus*	Common
Terek Sandpiper (PM)	*Xenus cinereus*	Common
Common Snipe (PM)	*Gallinago gallinago*	Common
Great Snipe (PM)	*Gallinago media*	Uncommon
African Snipe (R)	*Gallinago nigripennis aequato*	Uncommon to rare
Jack Snipe (PM)	*Lymnocryptes minimus*	Uncommon to rare
Sanderling (PM)	*Calidris alba*	Uncommon to rare
Dublin (PM)	*Calidris alpina*	Common
Knot (PM)	*Calidris canutus*	Vagrant
Curlew Sandpiper (PM)	*Calidrisferruginea*	Common
Little Stint (PM)	*Calidris minuta*	Very common
Temminck's Stint (PM)	*Calidris temminckii*	Uncommon
Broad-billed Sandpiper (PM)	*Limicola falcinellus*	Rare
Bar-tailed Godwit (PM)	*Limosa lapponica*	Rare
Black-tailed Godwit	*Limosa limosa*	Very common

(PM)		
Ruff (PM)	*Philomachus pugnax*	Abundant
Turnstone (PM)	*Arenaria interpres*	Common
Family: Recurvirostidae		
Black-winged Stilt (PM)	*Himantopus himantopus*	Common
Avocet (PM)	*Recurvirostra avosetta*	Uncommon
Family: Phalaropidae		
Red-necked Phalarope (PM)	*Phalaropus lobatus*	Rare
Family: Dromadidae		
Crab Plover (R)	*Dromas ardeola*	Common
Family: Burhinidae		
Senegal Thick knee (R)	*Burhinus senegalensis*	Common
Family: Clareolidae		
Egyptian Plover (R)	*Pluvianus aegypticus*	Common
Black-winged Partincole (PM)	*Glareola nordmanii*	Uncommon
White-collared Partincole (R)	*Glareola nuchalis*	Vagrant, rare
Common Partincole (PM)	*Glareola partincola*	Common
Family: Laridae		
Herring Gull (PM)	*Larus argentatus heuglini*	Rare, vagrant
Grey-headed Gull (R)	*Larus cirrocephalus*	Uncommon
Lesser Black-backed Gull (PM)	*Larus fuscus*	Common
Slender-billed Gull (PM)	*Larus genei*	Uncommon
Sooty Gull (R)	*Larus hemprichii*	Very common
Glaucous Gull (R)	*Larus hyperboreus*	Uncommon
Greater Black-headed Gull (PM)	*Larus ichthyaetus*	Rare
White-eyed Gull (LM,PM)	*Larus leucophthalmus*	Common
Mediterranean Gull (PM)	*Larus melanocephalus*	Vagrant
Little Gull (PM)	*Larus minutus*	Rare, vagrant
Black-headed Gull (PM)	*Larus ridibundus*	Locally very common
Noddy (R)	*Anous stolidus plumbeigularis*	Rare
Whiskered Tern (PM)	*Childonias hybrida*	Locally very common
White-winged Black Tern (PM)	*Childonias leucopterus*	Locally abundant
Gull-billed Tern (PM)	*Gelochelidon nilotica*	Very common

Little Tern (PM)	*Sternaalbifrons saundersi*	Uncommon
Bridled Tern (R)	*Sterna anaethetus*	Uncommon
Lesser Crested Tern (R)	*Sterna bengalensis par*	Very common
Crested (Swift) Tern (R)	*Sterna bergii velox*	Fairly common
Caspian Tern (PM)	*Sterna caspia*	Common
Sooty Tern (R)	*Sterna fuscata*	Uncommon
Common Tern (PM)	*Sterna hirundo*	Uncommon
Arctic Tern (PM)	*Sterna paradisaea*	Vagrant
White-cheeked Tern (R)	*Sterna repressa*	Very common
Sandwich Tern (PM)	*Sterna sandvicensis*	Rare, vagrant
Family: Rhynchopidae		
African Skimmer (LM)	*Rhynchops flavurostris*	Fairly common
Family: Tytonidae		
African Marsh Owl (R)	*Asio capensis*	Uncommon
Family: Alcedinidae		
Giant Kingfisher (R)	*Ceryle maxima*	Uncommon
Pied Kingfisher (R)	*Ceryle rudis*	Common
Eurasian Kingfisher (PM)	*Alcedo atthis*	Common
Malachite Kingfisher (R)	*Alcedo cristata*	Common
Shining-blue Kingfisher (R)	*Alcedo quadribrachys*	Uncommon
Half-collard Kingfisher (R)	*Alcedo semitorquata*	Uncommon
Woodland Kingfisher (R)	*Halcyon senegalensis*	Fairly common
Family: Meropidae		
Blue Cheeked Bee-eater (PM)	*Merops pecsicus*	Common
Family: Hirundinidae		
Red-rumped Swallow (R)	*Hirundo daurica*	Fairly common
Ethiopian Swallow (R)	*Hirundo aethiopica*	Common
Grey –rumped Swallow (R)	*Hirundo griseopyga*	Uncommon
Red Sea Cliff Swallow (R)	*Hirundo rupestris*	Rare
Mosque Swallow (R)	*Hirundo senegalensis*	Fairly common
African Sand Martin (R)	*Riparia paludicola minor*	Fairly common
Sand Martin (PM)	*Riparia riparia*	Very common
Family: Turdidae		
Snowy-headed Robinchatt (R)	*Cossypha niveicapilla*	

Abyssinian Ground Thrush (R)	*Turdus piggiae*	Uncommon
Family: Sylviidae		
Orphean (PM)	*Sylvia hortensis crassirostris*	Uncommon
Barred Warbler (PM)	*Sylvia nana nana*	Uncommon
Yellow (flycatcher) Warbler (R)	*Choropeta natalensis massaica*	Rare
Winding Cisticola (R)	*Cisticola galactotes*	Very common
Zitting Cisticola (R)	*Cisticola juncidis*	Common
Red-winged Grey Warbler (R)	*Drymociche incana*	Rare
Savi's Warbler (PM)	*Locustella luscinioides*	Uncommon
Grey-winged Ground Robin (R)	*Dryocichloides polipterus*	
Desert Warbler (PM)	*Sylvia nisoria*	Uncommon
Family: Muscicapidae		
Swamp Flycatcher (PM)	*Muscicaapa caerulescens*	Uncommon
Family: Motacillidae		
Yellow-throated Longclaw (R)	*Macronyx croceus*	Locally common
African Pied Wagtail (R)	*Motacilla aguimp vidua*	Locally common
White Wagtail (PM)	*Motacilla alba alba*	Very common
Grey Wagtail (PM)	*Motacilla cinerea*	Uncommon
Yellow Wagtail (PM)	*Motacilla flava*	Very common
Family: Malaconotidae		
Black-headed Gonolek (R)	*Laniarius* (*barbarus*) *erythrogaster*	Common
March (Blackcap) Techagra (R)	*Tchagra minuta*	Uncommon
Family: Laniidae		
Red-tailed Shrike (PM)	*Lanius isabellinus speculigerus*	Common
Wood Chat Strike (PM)	*Lanius senator*	Common
Family: Ploceidae		
Yellow-crowned Bishop (R)	*Euplectus afer*	Locally common
Northern Red Bishop (R)	*Euplectes franciscanus*	Common
Black-headed Weaver (R)	*Ploceus cucllatus*	Common
Yellow-backed Weaver (R)	*Ploceus melanocephalus*	Uncommon
Cinnamon Weaver (R)	*Ploceus lbadius*	Common
Northern Masked	*Ploceus taeniopterus*	Common

Weaver (R)		
Family: Estrildidae		
Zebra Waxbill (R)	*Amandava subfalva*	Uncommon
Waxbill (R)	*Estrilda astrilda peasei*	Uncommon
Black-rumped Waxbill (R)	*Estrida troglodytes*	Fairly common
Quailfinch (R)	*Ortygospiza atricollis*	Uncommon
White-rumped Seed-eater (R)	*Serinus leucopygius*	Fairly common

Key: R: Resident, PM: Palaearctic Migrant, LM: Local Movement

There are 27 species of wildfowl Anatidae in Sudan. There are found along the Niles, mainly on the White Nile. The Blue Nile, with its predominantly sandy bed is less attractive as a feeding site, although many ducks are found above the Sennar Dam and on Mayas in that region (e.g. many are found in Dinder National Park). Mayas seasonally inundated mud flat pool.

Sixteen families are represented by single species, and twelve of these have one species in Sudan. The thirteen, fourteen, fifteen and sixteen families, are the Strigidae (Owls) which has twelve species, Muscicapidae (Flycatchers) has twenty nine in Sudan, Burhinidae (Thick knees) has three species and family Meropidae (bee-eaters) has twelve species in Sudan. These sixteen families are: Hydrobatidae (Leach's Petrel), Phaethontidae (Tropical birds), Sulidae (Boobies), Anthingidae (Darters), Balaenicipitidae (Shoebills), Scopidae (Hamerkops), Pandionidae (Ospreys), Rastratulidae (Painted Snipes), Haematopodidae (Oystercatchers), Phalaropidae (Phalaropes), Dromadidae (Crab Plovers), Burhinidae (Thick knees), Rhynchopidae (African Skimmers), and Strigidae (African Marsh Owls), Meropidae (Bee-eaters) and Muscicapidae (Flycatchers).

The most widespread species are Shoveler *A. clypeata*, Garganey *A. querquedula*, Pintail *A. a. acuta*, Egyptian Goose *A. aegyptiacus*, Fulvous Whistling Duck *D. bicolor*, White–faced Whistling Duck *D. viduata*, Teal *A. crecca,* Wigeon *A. penelope*, Northern Pochard *A. ferina*, Tufted Duck *A. fuligula*, Spur-winged Goose *P. gambensis*. The rest are rare. Fifteen species are winter visitors, while twelve are residentials.

There are 17 species Ardeidae (Herons, Bitterns and Egrets) only the Cattle Egret *B. i. ibis* (Fig. 2) is very common. The following species are common: Grey Heron *A. cinerea*, Black-headed Heron *A. melanocephala*, Squacco Heron *A. r. rolloides*, Great White Egret *E. alba*, Little Egret *E. g. garzetta*, Yellow- billed Egret *E. intermedia*. The rest are rare. This family forms one of the most conspicuous elements in avifauna of the Nile, most of the species are resident (Green, 2009).

There are eight species of Storks Ciconiidae of which Abdim's Stork *C. abdimii* and Open-billed Stork *A. lamelligerus* are very common, Marabou *L.s crumeniferus* is common. Yellow-billed Stork *M. ibis* and Saddle-billed Stork *E. senegalensis* and White Stork *C. ciconia* are fairly common.

There are six species of Threskiornithidae (Ibises, Spoonbills). Sacred ibis *Threskiornis aethiopicus aethiopicus* (Fig. 3) is common in any wetland habitat. Hadeda *Bostrychia hagedash* is common. Family Rallidae has seven species. Five of them are palaearctic migrants.

There are 25 species of Scolopacidae Sandpipers, Snipes. Ruff *P. pygnax* is abundant. Marsh Sandpiper *T. stagnatilis*, Little Stint *C. minuta*, Black-tailed Godwit *L. limosa* are very common (all Palaearctic migrants). 9 species are common and these are: Common Sandpiper *A. hypoleucos*, Curlew *N. a. arquata*, Wood Sandpiper *T. glarcola*, Greenshank *T. nebularia*, Green Sandpiper *T. ochropus*, Redshank *T. cotanus*, Terek Sandpiper *X. cinereus*, Common Sandpiper *G. gallinago*, Dunlin *C. a. alpina*, Curlew Sandpiper *C. ferruginea* and Turnstone *A. interpres* (all palaearcitc migrants). The rest of Scolopacidae are either uncommon or rare. These waders exploit all available wetland habitats (Hogg *et al.,* 1984). Black-winged Stilt *H. himantuspus* of family Recurvirostridae are common on swamps, rivers, shallow lakes and coast (Nikolaus, 1987). The majority of the species are palaearctic migrants.

Plovers of the family Charadriidae has 14 species. 7 species either common or fairly common and these are: Little Rined Plover *C. dubius*, Great Sand Plover *C. leschenaultii* long-toed Plover *V. crassirostris*, Kentish Plover *C. alexanidrinus*, Kittitz's Sand Plover *C. pecuarius*, Grey Plover *P. squatarola* and Spur-winged Plover *V. spinosus*. There are two species of family Gruidae, Demoiselle Crane and Crowned Crane (Fig. 5). The rest are uncommon or rare.
Rallidae (Rails, Crakes) contains 12 water birds. Only two species are fairly common, Black- crake *L. flavirostra* and Allen's Gallinule *P. alleni*. The rest are rare or uncommon.

There are 25 species of Terns and Gulls Laridae. Only Black-winged Black Tern *C. leucopterus* and Gull-billed Tern *G. nilotica* are very common (both are Palaearetic migrants). There are 8 species which locally common: Sooty Gull *L. hemprichii*, Greater Black-headed Gull *L. ichthyaetus*, White-eyed Gull *L.leucophthalmus* Black-headed Gull *L. ridibundus*, Whiskered Tern *C. hybrida*, Lesser-Crested Tern *S. bengalensis*, Crested (Swift) Tern *S. bergii velox*, Caspian Tern *S. caspia*, White-Cheeked Tern, *S. repressa*. These birds are found mainly in White Nile and Sennar reservoir, some are found on the coast littoral habitats.

There are seven species of Kingfishers (Alcedinidae). Four of these are common or fairly common, these are Pied Kingfisher *Ceryle rudis rudis*, Eurasian Kingfisher *Alcedo atthis*, Malachite Kingfisher *Alcedo cristata*, and the rest are uncommon.

There are 8 species of Warblers Sylviidae among water birds. Four species are common or (fairly common) these are: Clamorous Reed Warbler *A. stentoreus*, Great Swamp Warbler *A. r. niloticus*, Red-faced Cisticola *C. erythrops*, and winding *C. galactotes*. The rest of the species are uncommon or rare.

There are six species of Wagtails, Pipits and Longclaws (Motacillidae) that live along rivers and swampy habitats. Only White Wagtail *M. a. alba* and

Yellow Wagtail *M. flava* are very common along rivers and swampy habitats. Only 5 species of family Accipitridae (Birds of sprey) are found among water birds. These are: fish Eagle *H. vocifer*, Eurasian Marsh Harrier *C. aeruginosus*, African Marsh Harrier *C. ranivorus*, Montagu's Harrier *C. pygarus*, and Harrier Hawk *P. r. typus*. The fish Eagle is the top avian predator in the Nile system (Green, 2009).

The family Pandionidae has only one raptor the Osprey *P. haliaetus*.

Pelicans (Pelecanidae) are represented by two species, the White Pelican *P. onocrotalus* and the Pink-backed Pelican *P. rufescens*. The former is seasonally common, but the latter is uncommon.

Five species of Swallows and Martins (Hirundinidae) frequent rivers and swamps. Only Sand Martin is very common *R. riparia*. The rest are fairly common or uncommon. Family Ploceidae has six species, most of them are common. Family Estrildidae has five species, and all are residents.

There are important wetland sites that need protection for water birds. The most important wetland for water birds is the Sudd swamps. The Sudd swamps are the seasonally inundated flood-plain of the upper White Nile (Robertson, 2001). It holds by far the largest population of Shoebill *B. rex* (Fig. 4), which is very much endangered by destruction of papyrus swamps by cattle and fire (Nikolaus, 1987). The Sudd is probably also important for White-eyed Pochard *A. nyroca.* 22 species of water birds were recorded in the Sudd (Peter Robertson). The Nile and its tributaries attract and support most of waterbirds of Sudan. They provide food for birds in form of fish, invertebrates and plants (Green, 2009).

The other important sites for water birds are: Wadi Halfa is located in the north of Sudan close to the border with Egypt, on the east bank of Lake Nubia. The site comprises an area of Lake margin (Robertson, 2001). Information on water birds using the Lake is due to Pettet *et al.* (1964) who reported 15 waterbirds in Lake Nubia Mukwwar island and Dunganab bay, these are small archipelago lying offshore of town of Mohammed Qol, on the Red Sea coast north of Port Sudan. Suakin archipelago is the largest group of islets on the Red Sea coast of Sudan (Robertson, 2001). The islets support breeding colonies of five species of Tern: Crested (Swift) Tern *S. b. velox*, White-cheeked Tern *S. repressa,* Bridle Tern *S. anaethetus*, Lesser-crested Tern *S. bengalensis pa*r, Noddy *A. stolidus*, numbering 3,500 pairs in total. Small numbers of Brown Booby *S. l. leucogaster*, Sooty Gull *L. hemprichii* and Crab Plover *D. ardeola* also breed (Robertson, 2001).

Um Bader Lake lies in the southern of the Sahara desert, between El Obeid and El Fasher ((Robertson, 2001). Average annual rain is 200 mm. it is important as stop over site for water birds. Lake Kundi lies in southern Darfur, at the mouth of Wadi Ibra, which drains the slopes of Jebel Marra. The Lake is important for waterfowl: a total of 20795 individual birds were counted in 1993, comprising 22 species of water bird e.g Knob-billed Duck *S. m. melanotos* and Spur-winged Goosa *P. gambensis* (Robertson, 2001). Fish Eagle *H. vocifer* also occurs. Water birds are threatened by hunting.

Fig. 2. Cattle Egret

Fig. 3. Sacred Ibis

Fig. 4. Shoebill

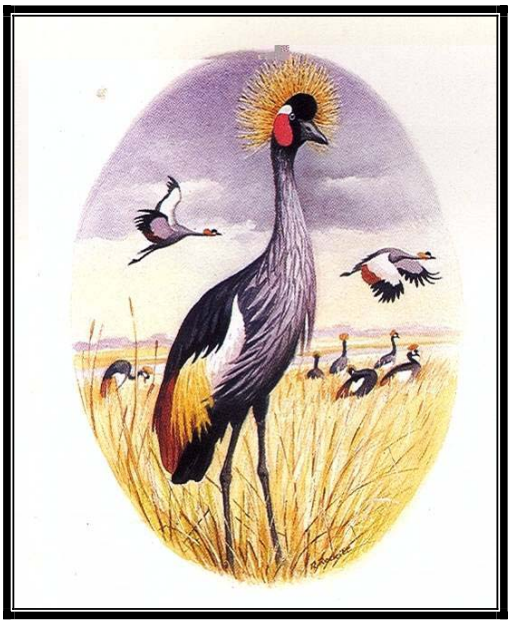


Fig. 5. Crowned Crane

Fig. 5. mix flock of White Stork *Ciconia ciconia* (flying) and Cattele Egret *Bublucus ibis* (Abu Na'ama, Feb 2009, Source: Eiman El Siddig)

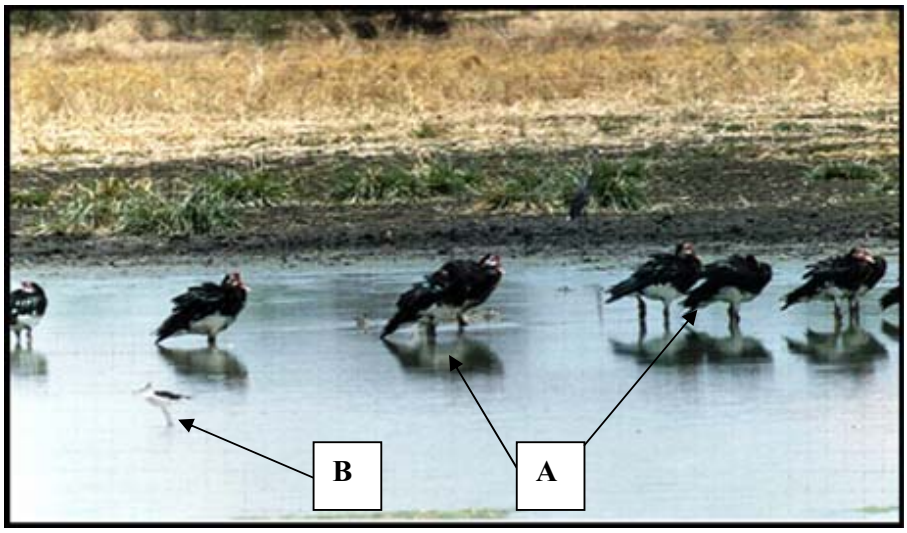


Fig. 6. **A: (**Spur-winged Geese**)** *Plectropterus gambensis***, B: (**Black-winged Stilt**)** *Himantopus himantopus himantopus* (Dinder National Park, March 1986, Source: Prof. Z. N. Mahmoud).

2. Recommendations

More survey and study is needed on waterbirds in Sudan, their identification, distribution and status. Most of our information on wetlands and their birds are old and need to be updated.

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Chapter 11: Mammalian biodiversity in Sudan.

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1. Introduction

Sudan is famous of being the largest country of Africa. It embraces about 2 million Km² that is characterized by nine ecological zones. These ecological zones roughly comprise ecological systems that dictate the distribution of mammals. In this context, the largest ecological system is the desert; the least is the montane (Fig. 1). The distribution and proportions of these ecological systems are presented in Table I.

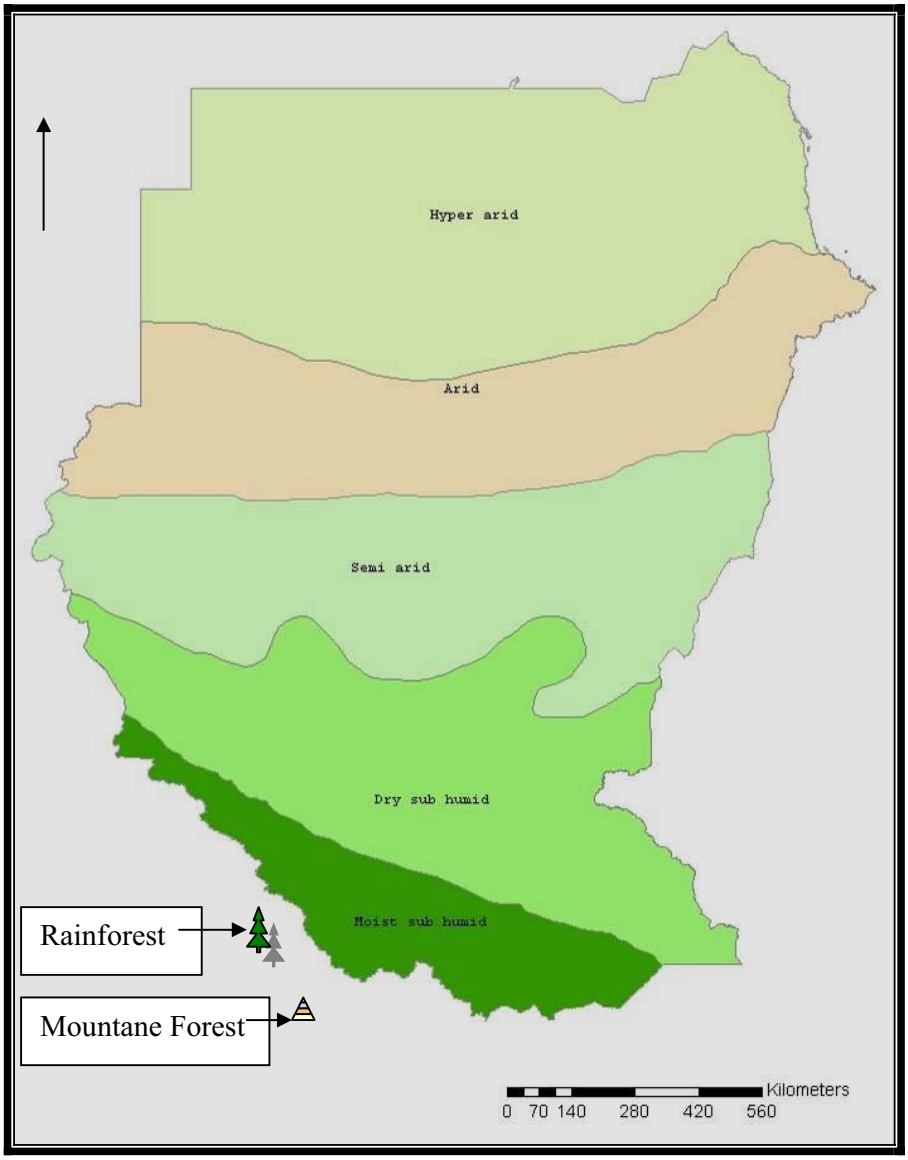

Fig 1: Sudan Ecological Zones

Table 1: Ecological Zones of Sudan

Ecological zone	approx. area Km^2	% Sudan's area
Desert	823,800	35.3
Arid	236,000	10.1
Savannah Grassland	729,200	31.3
Wooded Grassland	398,100	17.1
Sudd Swamp	26,560	1.1
Floodplain Grassland	112,700	4.8
Rain Forest	4,160	0.2
Mountane Forest	960	<0.1
Marine (shoreline):	800 km long	

Source: Hillman (1985).

Biological diversity is closely associated with ecosystem productivity. The desert ecosystem is notorious of being least in terms of primary productivity; the savannah ecosystem the most. Because of the sparse distribution of plants, the desert ecosystem supports only a few herbivorous mammals with a subsequent few carnivores i.e. the food chain is very short. In contrast, the primary productivity is high in the savannah ecosystem, resulting in a maximum secondary productivity that is mostly represented by herbivorous ungulates. The Equatorial forest ecosystem, on the other hand, harbors fruigivorous mammals that depend, more or less, on forest fruits.

2. Ecosystem Diversity

The broad nine ecological zones (ecological systems) are more diversified by the riverine network and inland wetlands. Seasonal tributaries of the Nile River, oases, and the wetlands are the key areas for mammals. In the savannah ecological zone, however, the networks of rivers are always associated with meadows that are called mayas in the Blue Nile; regab in South Kordofan and Dahal in South Dar Fur. These meadows are important habitats for wildlife in general and mammalian species in particular. Their ecosystem diversity has furnished Sudan with unsurpassed mammalian biodiversity (Table 2).

The Nile River divides Sudan in two parts: the eastern part and the western part. The Nile as a natural barrier plays an important role in mammalian speciation.

Table 2: Mammalian taxa occurring in Sudan.

1- Order Insectivora	Family Anomaluridae
Family Erinacedae	Family Pedetidae
Family Tenrecidae	Family Hystricidae
Family Soricidae	Family Thryonomyidae
Family Macroscelididae	Family Petromyidae
2- Order Chiroptera	Family Bathyergidae
Family Pteropodidae	7- Order Mysticeti
Family Emballonuridae	Family Baleanidae
Family Nycteridae	8- Order Carnivora
Family Megadermatidae	Family Canidae
Family Rhinolophidae	Family Mustelidae
Family Mormoopidae	Family Viverridae
3- Order Primates	Family Hyaenidae
Family Lorisidae	Family Felidae
Family Glagidae	9- Order Proboscidea
Family Cercopithecidae	Family Elephantidae
Family Pongidae	10- Order Hyracoidea
Family Hominidae	Family Procaviidae
4- Order Pholidota	11- Order Perissodactyla
Family Manidae	Family Equidae
5-Order Tubulidentata	Family Rhinocerotidae
Family Oryteropodidae	12- Order Artiodactyla
6- Order Rodentia	Family Suidae
Family Muridae	Family Hippopotamidae
Family Dipodidae	Family Camelidae
Family Rhizomyidae	Family Giraffidae
Family Sciuridae	Family Bovidae
Family Ctenodactylidae	

Source: Kingdon (1987); Vaughan (1978).

3. Mammal Diversity

There are 40 mammalian families occurring in Sudan in 12 Orders (Table 3). These represent 37% and 63% of the world families and Orders, respectively. Mammalian Orders that are not found in Sudan include Monotermata, Marsupialia, Dermoptera and Edentata. The number of mammalian species occurring in Sudan is estimated as 248, representing 6% of the world species (Table 3). This must be an under estimate because species like mice and rats have not been surveyed extensively. The Walo rat (*Amodillus imbe*) was reported in 2008 at El Ain Forest Reserve near El Obied (Khalda S. Mahgoub, pers. Communication). This species has only recently been reported in Somalia (Kingdon, 1997).

Taking antelopes as an example, Sudan with 35 species comes second only to Kenya with 36 antelope species. Sudan is the only country in Africa that

has two species of Oryx, Scimitar-horned oryx, *Oryx dammah* in the desert ecological zone, and Beisa oryx, *Oryx gazelle* in the Savannah. Because The Nile River is a natural barrier, *O. dammah* is represented by two subspecies that are reproductively isolated: the eastern subspecies and the western subspecies. This is true also for the Addax, *Addax nasomasculatus*. Furthermore, there are three subspecies of Dorcas gazelle (*Gazala dorcas*): The Sahara gazelle, *Gazala dorcas osiris* on the western side of the Nile, the Eritrean gazelle, *Gazalla dorcas isabella* in the Red Sea Mountains and the Egyptian Gazelle, *Gazella dorcas dorcas* in the north beyond Dongala.

No rigorous studies have been made on small mammals except in Dinder National Park (Hashim and Mahgoub, 2007). However, there are on-going research programmes in the desert and the arid land ecosystems, specifically at El Ain Forest Reserve near El Obeid in Shimal Kurdofan and at Jebal Hassania National Park in Nahr Annil.

Table 3: Cosmopolitan number of taxa vs. taxa found in Sudan

	Number of			
Order	**Families**	**Families in Sudan**	**Species**	**Species in Sudan**
Monotermata	2	0	3	0
Marsupialia	12	0	242	0
Insectivora	8	4	406	117
Dermoptera	1	0	2	0
Chiroptera	18	6	853	15
Primates	11	9	166	6
Edentata	3	0	31	0
Pholidota	1	1	8	3
Lagomorpha	2	0	63	2
Rodentia	32	11	1690	16
Mysticeti	3	1	10	1
Odontoceti	7	0	74	0
Carnivora	10	4	284	38
Tubulidentata	1	1	1	1
Proboscidea	1	1	2	1
Hyracoidea	1	1	11	3
Sirenia	2	1	5	1
Perissodactyla	3	2	16	4
Artiodactyla	8	4	171	40
Total	126	46	4038	248

Source: Kingdon (1997); Hillman (1985); Vaughan (1978).

4. Biodiversity erosion

Biodiversity in Sudan is eroding rapidly due to human population growth, habitat degradation and destruction, meat hunting, diseases, and poor conservation of protected areas (East, 1998). Geographic ranges of most mammals and their habitats are fragmented, to the extent that some of them are exterminated, others are critically endangered.

In the desert ecosystem, *A. nasomasculatus* and *O. dammah* are exterminated; the Dama gazelle, *Gazella dama* and Slender-horned gazelle, *Gazella leptoceros* are critically endangered, the *G. dorcas* threatened. In the Savannah ecosystem, most of the larger mammals are found only in protected areas which cover about 3% of Sudan's area with poor distribution in the States of the country (Table 4).

Table 4. Distribution of Protected Areas in Northern Sudan.

State	Protected
Ash Shimaliyya	1
Nahr Annil	2
El Bahar Al Ahmar	2
Shamal Darfur	1
Janub Darfour	1
Al Qadarif, Annil Al Azrag	2
Kassala	Nill
Shimal Kurdofan	Nill
Janub Kurdofan	Nill
Annil Al Abyad	Nill

Source (Hashim, 2008).

The erosion of mammalian biodiversity in protected areas is accelerating at and alarming rate. From 1950 to 2000, Tora hartebeest, *Alcelaphus buselaphus tora*, Soemmering's gazelle, *Gazalla soemmeringiii*, Giraffe, *Giraffa camelopardalis* and Tiang, *Damaliscus lunatus tiang* has been exterminated in Dinder National Park in Annil Al Azrag, the rate being a species every 10 years. The situation in Radom National Park in Janub Dar fur is even worse. From 1976 to 1990, African elephant, *Loxodonta african*, Waterbuck, *Kobus ellipsiprymnus*, roan antelope, *Hippotragus equinus*, Lewel hartebeest. *Alcelaphus buselaphus lewel*, *D. tiang* and Uganda kob, *Kobus kob* have been exterminated in the park; the rate of extinction is even higher than that of Dinder National Park, being approximately two animal species per year.

Although they are important components of ecosystems, small mammals are always overlooked in the overall strategy of wildlife conservation. It is worth mentioning that there is a gap in knowledge about small mammals, particularly rats. Most of species of rats in the savannah ecosystem have not been even identified. Mammalogy books written about Africa do not cover Sudan.

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Chapter 12. Socio-economics of wetlands in the Sudan

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1. Introduction:

Because of the concentration of the rainfall in most of the Sudan on half of the year, few rivers and streams and watercourses actually hold water all the year round. In the extreme south, where the rainy season is longer and dense vegetation checks rapid run-off, the only rivers to flow continuously are those that are fed by lakes and swamps acting as natural reservoirs. Examples of these are the Blue and White Niles which are fed by lakes from beyond Sudan and Bahr el Ghazal flowing from large perennial swamps. Adequate coverage of wetlands with illustrations is given in Chapter 2.

All the other rivers even the Atbara which makes an important contribution to the Nile in the summer, dry up into pools or disappear wholly beneath its sandy beds in the dry weather. It is important as a source of drinking water for man and animals in the area.

Recently works is in progress to establish dams in areas like Setit and Basalam (Atbara tributaries), in the southern and northern Sudan as well. These are expected to make invariable contribution to the country irrigation schemes through canalization system and to wetlands through man-made lakes.

Commercial fish species, such as groupers, sea bass, and emperors, utilizes different ecological habitats, while shrimps, oysters, clams, and crabs inhabit wetlands. The skins of alligators and crocodiles and the Nile monitors in tropical areas are of high economic value.

This paper addresses the socio-economic of the wetlands of the east and west Nubian deserts, the Red Sea coast and the Suud region of Southern Sudan.

2. The Eastern (Nubian) Desert.

The eastern or Nubian desert enjoys at the present time an almost completely arid climate. Towards the eastern margin however, there are several Khours originating from the Red Sea Hills. There are no oases, and the underground water is scarce because of the absence of suitable permeable rocks; nevertheless, water is found at a few points in Khours beds. Certain parts of this desert has gained economic importance due to commercial explication of gold at Ariab in Red Sea State.

3. The western Desert.

The extensive permeable beds of the Nubian Sandstones, permits the percolation of the occasional rains and their movement horizontally over long distance. In locations where the level of ground water is low the water-table approaches the surface or may even attain it to form an oasis such as Selima and Bir en Natrun. However, these are too small to support settled population except for periodic military or customs bases and stations. They have been of importance in providing a possible route for caravan's away form the Nile (Darb el Arbain from Darfur to Asyut in Egypt). At Bir en Natran there are deposits of

natron (Sodium carbonate 49.6%, Sodium bicarbonate 27.4%) which is dug up and transported to El Fasher for sale. To the east of the western desert, there are some fertile paleolakes and paleochannels (e. g. Wadi el Qa'ab, Fig. 10 chapter 1) which supports settled populations (Fig. 1).

Fig. 1 a. A well at Wadi el Qa'ab
(Source: Dr. Yahia Fadal Tahir)

Fig. 1 b. Agriculture at Wadi el Qa'ab
(Source: Dr. Yahia Fadal Tahir)

There are several wells (Fig. 1), date palms and numerous bushes and low trees which provide little grazing and the possibility of some small folk industries like mat making.

4. The Red Sea Coastal Plain.

The coastal plain between the Red Sea Hills and the Sea is of varying width. Its largest extent is in the south, where around Tokar and the Delta of Baraka it stretches as much as 55 km. inland. In the north the width is of 25 km. There are many different ways of life and economic activities to be observed along the coastal plains. In the south, around Tokar, the delta of Baraka River provides chances for cotton growing, sorghum, vegetables and water melons. In Suakin the establishment of a new passenger's port led to flare up in services like hotels, restaurants commercial agencies etc. The Tarmac road had opened extra chances for commerce, industries and services. Along the coast between Port Sudan and Suakin so many oil expertise terminals had been established. Near to Port Sudan, there are deposits of gypsum and lime stone that are quarried for building materials and by the Sea numerous salt ponds for salt production is found. Along the coast primitive and modern boats are engaged in fishing. In Port Sudan town a wide spectrum of commerce, industries and banking facilities are found.

The interaction between marine and terrestrial environments and their associated human activities coupled with sound and effective resource and environmental management has the potential of yielding economic, environmental, public health and safety, and social benefits. The development of the coast requires sharing of ideas with a broad range of stakeholder interests, including governmental, NGO, private sector, and international organizations.

In 2009 two Ramsar sites (Dongonab Bay-Marsa Waiai and Suakin-Gulf of Agig) were designated in the Red Sea State. This justifies the inclusion of the Red Sea as a wetland in this chapter.

4.1. Dongonab Bay-Marsa Waiai.

The site is rich in biological diversity and provides support to various threatened species and provides permanent habitats, breeding grounds and areas of refuge for various fish and shrimp. The Bottlenose Dolphin and various shark species have also been recorded within the site. The main land uses within the site are animal breeding, mainly of camels, goats and sheep; fisheries; oyster culture; and tourist activities such as scuba diving. Potential threats arise from major land use changes: a proposed shrimp and fish farming industry project along the southern stretch of coastline, livestock fodder production and ice plants, and overgrazing by nomads and camel herders, as well as declining rainfall.

4.2. Suakin-Gulf of Agig.

The site boundary follows the Suakin Archipelago, a proposed Marine Protected Area that occupies the southeastern quarter of the site. It is comprised of diverse forms of wetlands such as sand flats, coral reefs, lagoons, sand shores amongst others, a diversity which allows for a rich range of fauna and flora to thrive at the site – marine turtles such as the Hawksbill Turtle (*Eretmochelys imbricata*) and Green Turtle *(Chelonia mydas*); seabirds; commercial bony fish and shrimp species. Sightings of the Sea Cow (*Dugong dugon)* and Bottlenose Dolphin (*Turciops truncates)* have also been noted. Various socio-economic activities take place within and around the site, but the most common practice is nomadism with camels, which are of great social and economic value. The Tokar Delta is the sole area with significant potential for cultivation in the whole coastal zone, with cotton, sorghum, millet and vegetables. The proposed shrimp and fish farming industry project, as well as efforts to widen the entrance and ship channels and reconstruct the port of Suakin, pose major threats to the character of the site.

The future growth of the coastal plains is clearly dependent on the level of infra-structure like roads, communication and the exploitation of the oil and gas reveres discovered earlier in the region.

5. The Sudd Wetland

Its size is highly variable, average with 30, 000 km^2 and may, during the wet season be over 130, 000 Km^2 depending on the inflowing waters, with the discharge from Lake Victoria being the main control factor of the flood levels, and areas inundated. The shallow and flat inland delta between 5.5 Nº and 9.5 Nº covers an area of 500 km south to north and 200 km east to west between Mongalla in the south and Malakal in the north. The Sudd swamp (Figs. 1, 2 and3, chapter 2, part I) contributes to food security by alleviating poverty of the Dinka, Nuer and Shilluk communities that inhabit the Sudd flood plains (Fig. 2).

Fig. 2. A typical house in the Sudd region.
(Source: Joseph L. Achaye)

According to Bailey (2008) the occupants living within and adjacent to the Sudd region are almost exclusively Dinka, Nuer and Shilluk and their socio-economic and cultural activities entirely dependent on the Sudd wetland and on its annual floods and rains to regenerate floodplain grasses to feed their cattle. They move from their permanent settlements on the highlands to dry season grazing in the intermediate lands (*toich*) at the beginning of the dry season and return to the highlands in May-June when the rainy season starts (Bailey, 2008). Threats to the Sudd were adequately covered in Chapter 2. The Sudd region has potentials for a number of socioeconomic activitives including:

5.1. Cattle Rearing:

The cattle kept in the Nile swamps and southern clay is quite distinct from those owned by the Baggara for instance. At present and because of the civil strife that prevailed in southern Sudan a lot has to be done to increase cattle commercial use. Compared with other types of cattle in Sudan, the herds of the Nilotics show marked ability to tolerate biting flies, ticks and other insects. The Nilotics attach a quite exceptional importance to their cattle. Most of their social activities concern cattle. The grazing lands available for them are limited and when the flooding has been exceptionally high the animal suffers severely from under nourishment.

Along the rivers the flood plains provide further grazing, which at the present levels of animal population is quite sufficient to last until the early rains, when with the new growth of grass conditions for animals are at their most favorable.

The vegetation in wetlands is a potential hazard to animals when heading to drink from the main water courses (Fig. 3).

Fig. 3. Cattles in a wetland (Source: Prof. Z. N. Mahmoud).

5.2. Agriculture:

Agriculture is much less important in the southern clay plains than animal husbandry, land are ill-suited to crop production with pests (insects and birds), droughts and flood. Millet is the staple crop of the area, other food crops include maize, groundnuts and sesame. Various beans and marrows and some tobaccos are grown near the houses in summer.

The implementation of modern concept of agro-ecosystems to boost production needs agro-ecological characterization (climate, lithology, landform, soils and hydrology) and biotic parameters (vegetation and land use).

5.3. The fisheries of the wetlands:

According to Bailey (2008) the fisheries survey of fisheries in the Sudd, River Nile, southern Sudan, carried out between 1980 and 1983, indicated that the wetland had more than doubled its size since the 1950s. Seasonal fishing continued to be an integral part of the subsistence economy of the region. Hickley and Bailey (1987) and Bailey (2008) reported that few species of fish e.g. *Clarias* spp, known as garmout, were caught in large quantities with spears on the floodplain during dry down, and a wider variety of fish (e.g. *Distichodus* spp, *Citharinus* spp, *Heterotis niloticus*, *Lates niloticus*, Gymnarchus *niloticus*, tilapias and large mormyrids, catfishes and characids) with nets and hooks in the channels, lakes and vegetation of the perennial wetland (see Fig 2, chapter 2). From a total of 23 species caught in seasonal habitats, 7 contributed over 97% of total estimated numerical and biomass densities (Hickley and Bailey 1987). Year-round fishing had increased as a result of the loss of grazing by swamp encroachment. Canoe estimates ranged between 4000 and 7500, and daily landings of 17–28kg per canoe were recorded in the southern Sudd. Fish were consumed fresh or sun-dried. In 1982 commercial production was estimated at 700t and 68t respectively of processed sun-dried and salted fish (Bailey, 2008).

5.4. Potential for Ecotourism Development

The potentials for ecotourism include several falls e. g. Fulla Rapids at Nimule (proposed site for hydroelectricity) and wildlife. In its different micro-ecosystems there are fascinating areas of scenic attractions with unique and endemic plant, fish, reptiles, birds and mammals species some of which have not been discovered scientifically but are known by the local people. The area used to be home to the northern white rhinoceros (*Ceratotherium simum*) now believed to be locally extinct. However, sporadic reports from patrol rangers say there were some occasional sightings of the white rhino. This information need to be confirmed. Other spectacular forms of wildlife (Figs. 5 and 6) includes the Nile lechwe (*Kobus megaceros*), the resident sitatunga (*Tragelaphus spekei*), hippopotamus (*Hippopotamus amphibious*), white eared kob (*kobus kob leucotis* Fig.), tiang (*Damaliscus lunatus*), Mongalla gazelle (*Gazella rufifrons albonotata*), buffalo, waterbuck, bushbuck and Oribi that utilize the flood plains grassland together with livestock during the dry season.

More than 470 bird species have been recorded from the Sudd including the biggest population of Shoe bill stork *Balaeniceps rex* in the World. Hundreds of birds' species use the Sudd as a stop over on migration. Migratory species include the endangered black crowned crane *Balaerica paronia*, white pelican *Pelecanu onocrotalus* and white stork. Other birds found here are the two endemic species called the River prinia (*Prinia fluvialis*) and the Fox's weaver (*Ploceus spekeoides*) and unknown diversity of amphibians and reptiles (see chapter 2, part I of this edition).

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Chapter ; Hereptiles of the Wetlands of Sudan

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Amphibians and reptiles are two large classes of vertebrates that include morphologically different groups. The amphibian fauna of the Sudan is poorly known, except for *Bufo regularis* (Fig. 1) a dissection specimen type for biology students. Several tree frogs were reported from Damazin, Kurmuk, Sudd and some other forms such as *Rana* sp. and *Dacoglosss* spp., but no attempts were made to classify them.

Fig. .*Varanus niloticus*.

Fig. . *Crocodylus niloticus*

Fig. 1. *Bufo regularis*, Bufoinidae

Reptiles received much attention as compared with amphibians and 106 species of reptiles have so far been recorded in the Sudan. The reptilian species that use the Nile and its tributariesas, Sudd, lakes and irrigation canals as a media for living include three species of turtles, the Nile Monitor, and the Nile crrocodile: These are:

Order: Testudines
Family: Trionychidae
The Nile Soft- shelled Terrapin, *Trionyx triunguinis,* Fig. 2.
Family: Pelomedusidae
The Side-necked Terrapin, *Pelomedusa subrufa*, Fig. 3.
Adanson's Hinged Terrapin, *Pelusios adansoni*.
Order:Sauria, Family:Varanidae,
The Nile Monitor, *Varanus niloticus*, Fig. 4.
Order: Crocodylla Family: Crocodylidae)
The Nile Croocodile, *Crocodylus niloticus*, Fig. 5.

All the five species spend most of their time in water but they have to come to the surface to breathe. The Nile Monitor and the crocodile spend some of the daytime on land to bask in the sun because they are piokothermic. All five species lay eggs in holes which they dig on land adjacent to the water bodies in which they live.

Other groups of reptiles are all terrestrial and most of them come to the water only to drink. However, during hot weather, most species of snakes submerge in the water leaving only their nostrils above the surface to breathe. As predators most snakes come to the water to drink and to hunt for amphibians, birds and small mammals (such as rats and mice) on which they feed. In fact snakes and most other reptiles are themselves prey to birds like herons, storks and other wading birds which come to the water bodies to feed. As a result snakes form an important part of the ecosystems of rivers and other fresh water bodies in the Sudan.

The reptiles mentioned above, are seldomly eaten by fishermen, but crocodiles and Nile monitor constituted an important component of the leather industry and handcraft market.

It is recommended that due attention to be given to thr herpetile fauna of the Sudan because of its importance enviornmentally and medically. In addition many sites in the Sudd and the Nile and its tributaries are suitable for corocodile and Nile monitor farms. Such farms have a dual function in conservation and oriented industry.

Fig.2 *Trionyx triunguinis*

Fig.3 *Pelomedusa subrufa*.

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