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DRAFT

ENVIRONMENTAL PROFILE

of

THE DEMOCRATIC REPUBLIC OF SUDAN

AID RSSA SA/TOA 1-77
National Park Service Contract No. CX-0001-0-003
with the U.S. Man and the Biosphere Secretariat
Department of State
Washington, D.C.

SEPTEMBER 1982

THE UNITED STATES NATIONAL COMMITTEE FOR MAN AND THE BIOSPHERE
Department of State, IO/UCS
WASHINGTON, D. C. 20520

An Introductory Note on Draft Environmental Profiles:

The attached draft environmental report has been prepared under a contract between the U.S. Agency for International Development (AID), Bureau of Science and Technology (ST/FNR) and the U.S. Man and the Biosphere (MAB) Program. It is a preliminary review of information available in the United States on the status of the environment and the natural resources of the identified country and is one of a series of similar studies now underway on countries which receive U.S. bilateral assistance.

This report is the first step in a process to develop better information for the A.I.D. Mission, for host country officials, and others on the environmental situation in specific countries and begins to identify the most critical areas of concern. A more comprehensive study may be undertaken in each country by Regional Bureaus and/or A.I.D. Missions. These would involve local scientists in a more detailed examination of the actual situations as well as a better definition of issues, problems and priorities. Such "Phase II" studies would provide substance for the Agency's Country Development Strategy Statements as well as justifications for program initiatives in the areas of environment and natural resources.

Comments on the attached draft report would be welcomed by US MAB and ST/FNR and should be addressed to:

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1.0 Introduction

This draft environmental profile summarizes information available in the United States on the natural resources and environment of the Democratic Republic of Sudan. The report reviews the major environmental problems of Sudan and the impact of the development process upon resources and the environment. This draft report represents the first step in developing an environmental profile for use by the U.S. Agency for International Development (U.S. AID) and Sudanese government officials. The next step in this process should be a field study to evaluate the information presented here, obtain additional information, and define the issues, problems, and priorities in greater detail. This entire process should help provide direction in future efforts to deal with the management, conservation, and rehabilitation of the environment and natural resources.

The information and interpretations in this report are preliminary and are not intended to attain the detail and accuracy required for development planning. The report represents a cooperative effort by the Man and the Biosphere (MAB) project staff of the Arid Lands Information Center (ALIC). The primary research, writing, and analysis of most of this profile were done by Mark Speece, through the resources of ALIC and the University of Arizona Library. Steven L. Hilty did the work on sections pertaining to fauna and conservation measures. The cooperation of James Corson, AID/MAB Project Coordinator, and other AID personnel is gratefully acknowledged.

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2.0 General Description

2.1 Geography and Climate 1/

The Democratic Republic of Sudan covers an area of approximately 2,506,000 sq km in northeast Africa. The country possesses a coastline on the Red Sea, with one important port (Port Sudan), but is actually not particularly seaward oriented. Bordering countries (clockwise from the Red Sea Coast) are Ethiopia, Kenya, Uganda, Zaire, Central African Republic, Chad, Libya, and Egypt. According to O'Conner (1978), Sudan spans three major African ecological zones: desert, semi-desert, savanna. The northern half of Sudan is classified as arid to hyperarid by UNESCO (1977). Most of the rest of the country ranges from semiarid to subhumid in UNESCO's classification. Only the southwest corner does not suffer from any significant moisture deficit. Figure 2.1 gives an overview of climatic regions in Sudan.

Sudan has few highland areas, and most of these are found on the fringes of the country. In Darfur, Jebel Marra's elevation is nearly 3,100 m, and Mt. Kinyeti on the frontier with Uganda reaches nearly 3,200 m. The Red Sea hills range from between 2,200 to 2,700 m. Aside from these three areas of highlands, only Jebal an-Nuba is particularly distinctive in Sudan's relief, but the highest point is only around 1,450 m. The vast majority of the country is under 800 m, and most of the Nile Valley lies between 300 and 400 m (Figure 2.2). Several geographical regions are usually distinguished, based on a combination of climatic zone and topography. They include:

Northern Desert region (approximately D1.1, D1.2, D2 of Figure 2.1) is nearly uninhabited except for the densely populated Nile Valley which runs through it.

Plains include most of the country outside of mountainous regions, the Nile Valley, and the northern desert region. These plains are relatively featureless, characterized by

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1 Sources: Buursink. 1971.
Europa. 1981.
Nelson. 1973.
Oliver. 1965.
Oliver. 1969.
Thimm. 1979.
el-Tom. 1969.
U.S. AID. 1981a.
Whiteman. 1971.

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Symbol	Climatic Zone	Humid Months	Dry Months	Growing Season	Average Annual Rainfall (mm)	Mean Max. Temp. in Hottest Month (°C)	Mean Min. Temp. in Coldest Month (°C)	Diagnostic Characteristics
D1.1	DESERT, summer rain, warm winter	0	12	0	100	42–44	13–15	Rw Tc 0.2Ew 13
D1.2	DESERT, summer rain, cool winter	0	12	0	100	42–44	8–13	Rw Tc 0.2Ew 13
D2	DESERT, winter rain	0	12	0	75	42–44	13–18	Rw Tc 0.2Ew 13
D3.1	SEMI-DESERT, summer rain, warm winter	0	12	0	100–225	40–42	13–16	Rw = 0.2–0.5Ew Tc 13
D3.2	SEMI-DESERT, summer rain, cool winter	0	12	0	100–225	40–42	8–13	Rw = 0.2–0.5Ew Tc 13
D4	SEMI-DESERT, winter rain	0	12	0	75–225	40–42	18–20	Rw = 0.2–0.5Ew
A1.1	ARID, summer rain, warm winter	0	10–11	1–2	225–400	40–42	13–17	Rw = 0.5–1.0Ew Tc 13
A1.2	ARID, summer rain, cool winter	0	10–11	1–2	225–400	40–42	8–13	Rw = 0.5–1.0Ew Tc 13
A2	ARID, winter rain	0	10–11	1–2	225–600	40–42	13–20	Rw = 0.5–1.0Ew
A3	ARID, no marked seasons	0	8–9	3–4	550–750	37–38	18–20	Rw = 0.5–1.0Ew
S1.1	SEMI-ARID, summer rain, warm winter	1	9	3	400–750	39–40	13–17	Rw Tc 1.0Ew 13
S1.2	SEMI-ARID, summer rain, cool winter	1–2	9	3	300–600	35–39	8–13	Rw Tc 1.0Ew 13
M1.1	DRY MONSOON, long dry season, warm winter	3–5	5–7	5–7	750–1000	36–41	17–20	Rw Ln = 0.44E 0.1–0.2E
M1.2	DRY MONSOON, long dry season, cool winter	3–4	7	5	600–850	38–39	5–13	R Ln = 0.44E 0.1–0.2E
M2	DRY MONSOON, medium dry season	2–3	4–6	6–8	850–1000	36–38	18–21	R Ln 0.44E 0.1E
M3	WET MONSOON, medium wet season	5–7	3–5	7–9	950–1400	34–39	12–10	R Ln 0.44E 0.2E
M4	WET MONSOON, long wet season	7–8	1–2	10–11	1200–1600	34–35	14–19	R Ln 0.44E 0.2E
H1	HIGHLAND, short wet season, warm summer	3	7	5	600–1000	36–39	6–8	Ln Tc 0.2E 8
H2	HIGHLAND, medium wet season, cool winter	5–6	3–4	8–9	1000–1600	23–33	10–17	Tw 33.5

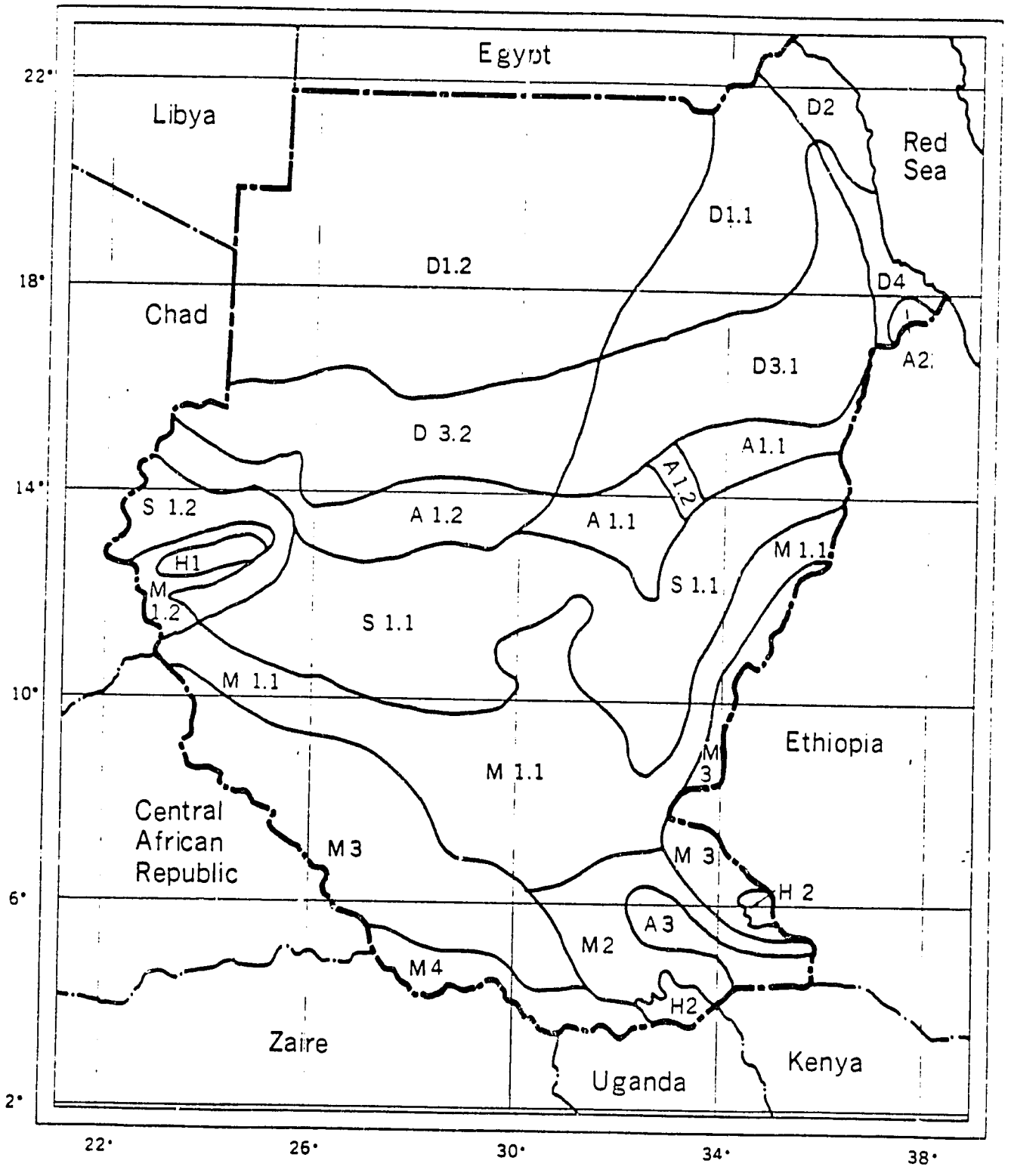

Figure 2.1. Climatic Zones in the Sudan

Source: Thimm. 1979.

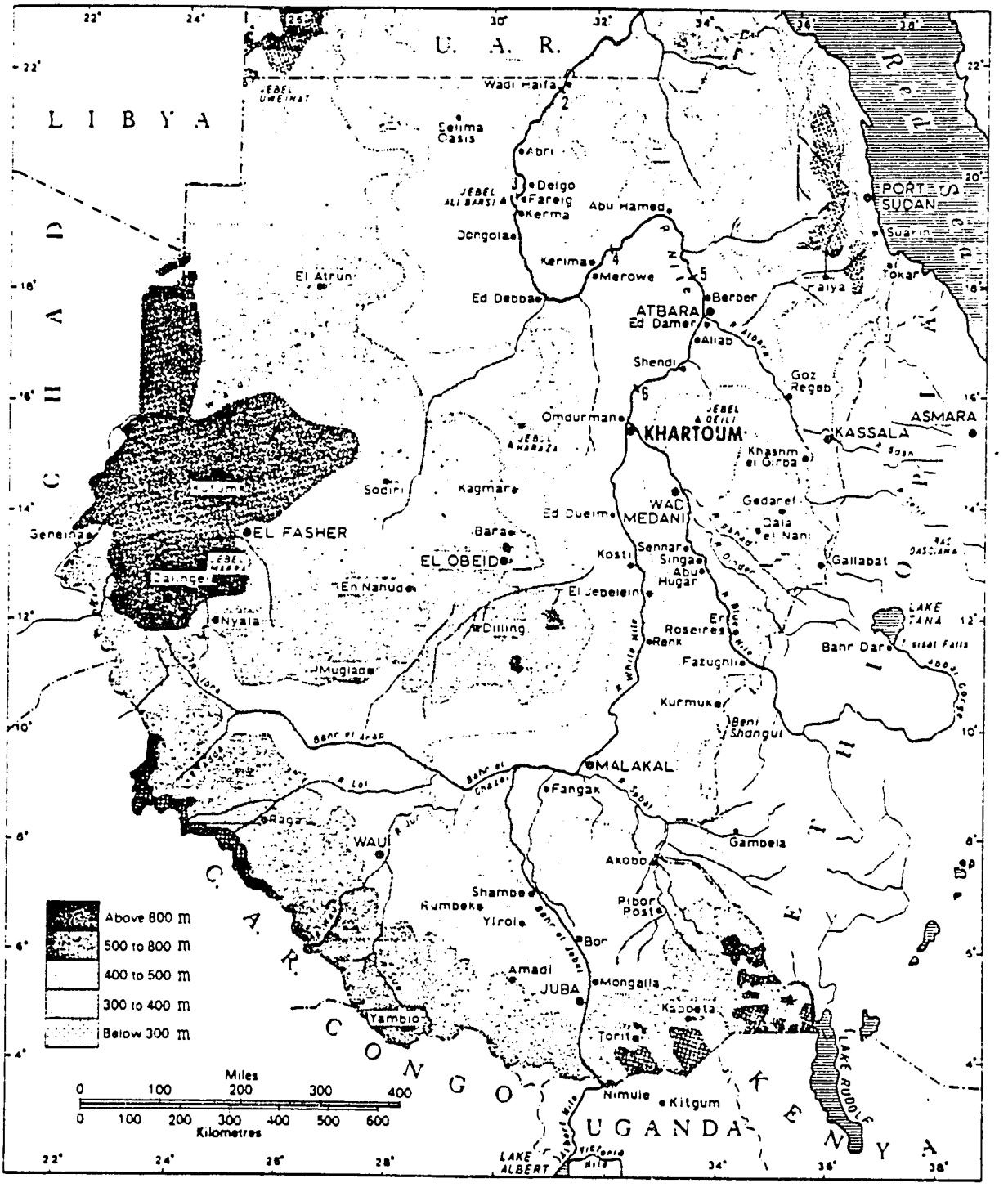

Figure 2.2. Physical and General Locality Map

Source: Whiteman. 1971.

low rolling hills or stabilized sand dunes. Savanna vegetation varies from relatively sparse on the fringes of the desert to fairly lush in the south.

Mountains include those highlands described above. The Red Sea Hills are arid and inhospitable to human settlement. The Jebel Marra area is somewhat better watered, and supports sedentary agriculture, as does the Jebel Nuba region of Kordofan. The Immatong and Dongotona Mountains along the southern border are relatively sparsely populated, and are covered partially by rainforest.

The Sudd swamp region of southern Sudan is sometimes distinguished separately, as is the Nile Valley.

Rainfall averages less than 25 mm annually in the northernmost part of the country (Figure 2.3). It generally increases toward the south, averaging 200 mm annually around Khartoum, and 800 mm on the northern fringes of the swamps. The southern borderlands receive over 1,400 mm annually. The rainy season lasts from April to October in the south, decreasing in length toward the north. At Atbara July and August are generally the only months to receive substantial rainfall. The reliability of rainfall also decreases rapidly from south to north.

Mean daily temperatures are fairly high throughout Sudan (Figure 2.4). Mean daily maximum in the hottest month is above 40° C throughout the northern half of the country, and generally in the high 30s throughout the rest of the country except the highlands along the southern border. The mean daily minimum generally ranges from 10° to 20° C except in Jebel Marra, where it is about six to eight degrees C (cf Figure 2.1, legend). Additional climatic data may be found in Appendix I.

2.2 Population Characteristics 2/

U.S. AID (1980) estimates, which agree fairly well with most other figures, placed Sudan's population at approximately 18,340,000 in mid 1980. The growth rate is apparently unknown; estimates range from 2.1 (U.S. AID 1978) to 2.6 (U.S. AID 1981a) to 3.0 (U.S. AID 1980).

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2 Sources: el-Bushra and el-Sammani. 1977.
Europa. 1981.
U.S. AID. 1978.
U.S. AID. 1980.
U.S. AID. 1981a.
World Bank. 1981.

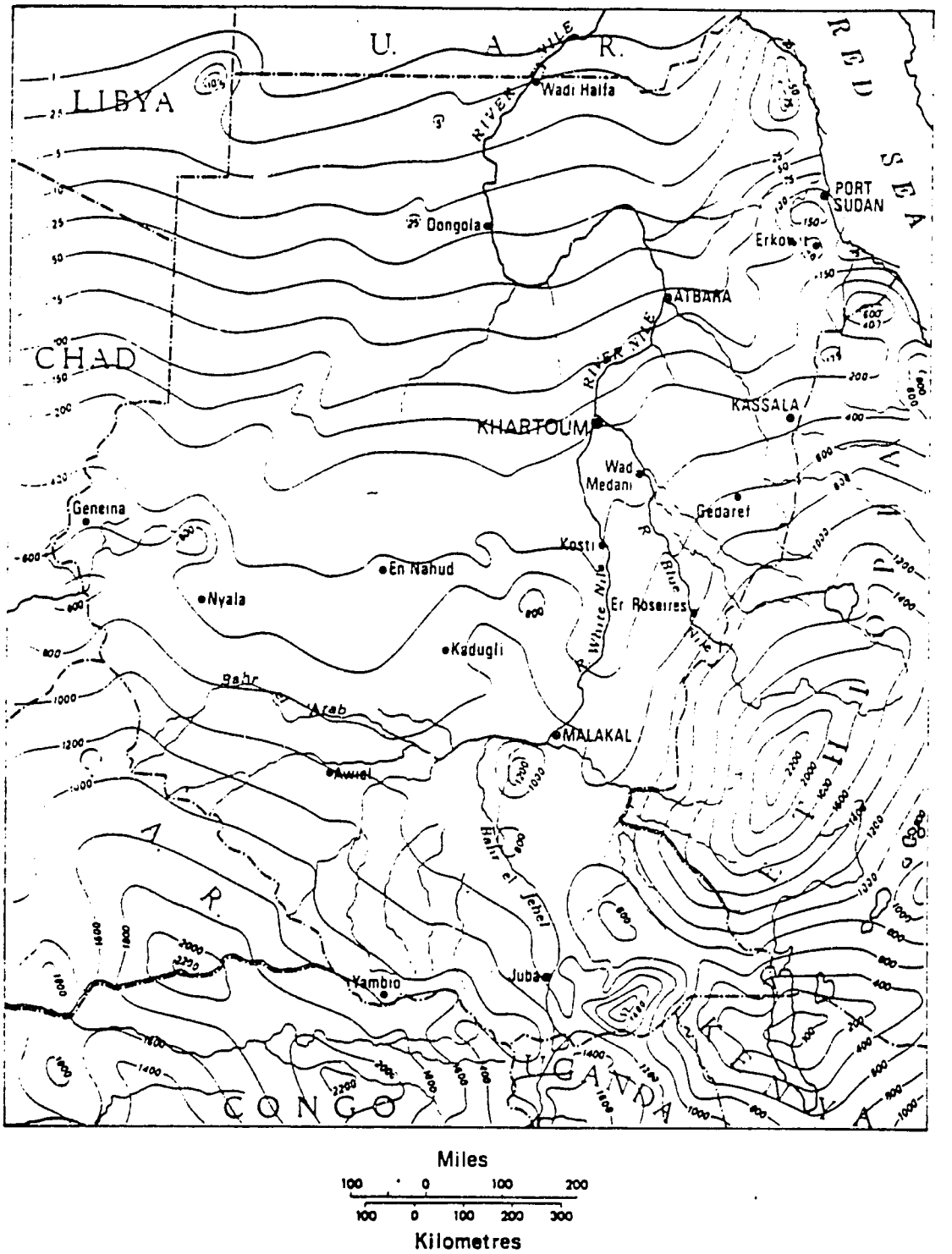

Figure 2.3. Mean Annual Rainfall (in mm.)

Source: Whiteman. 1971.

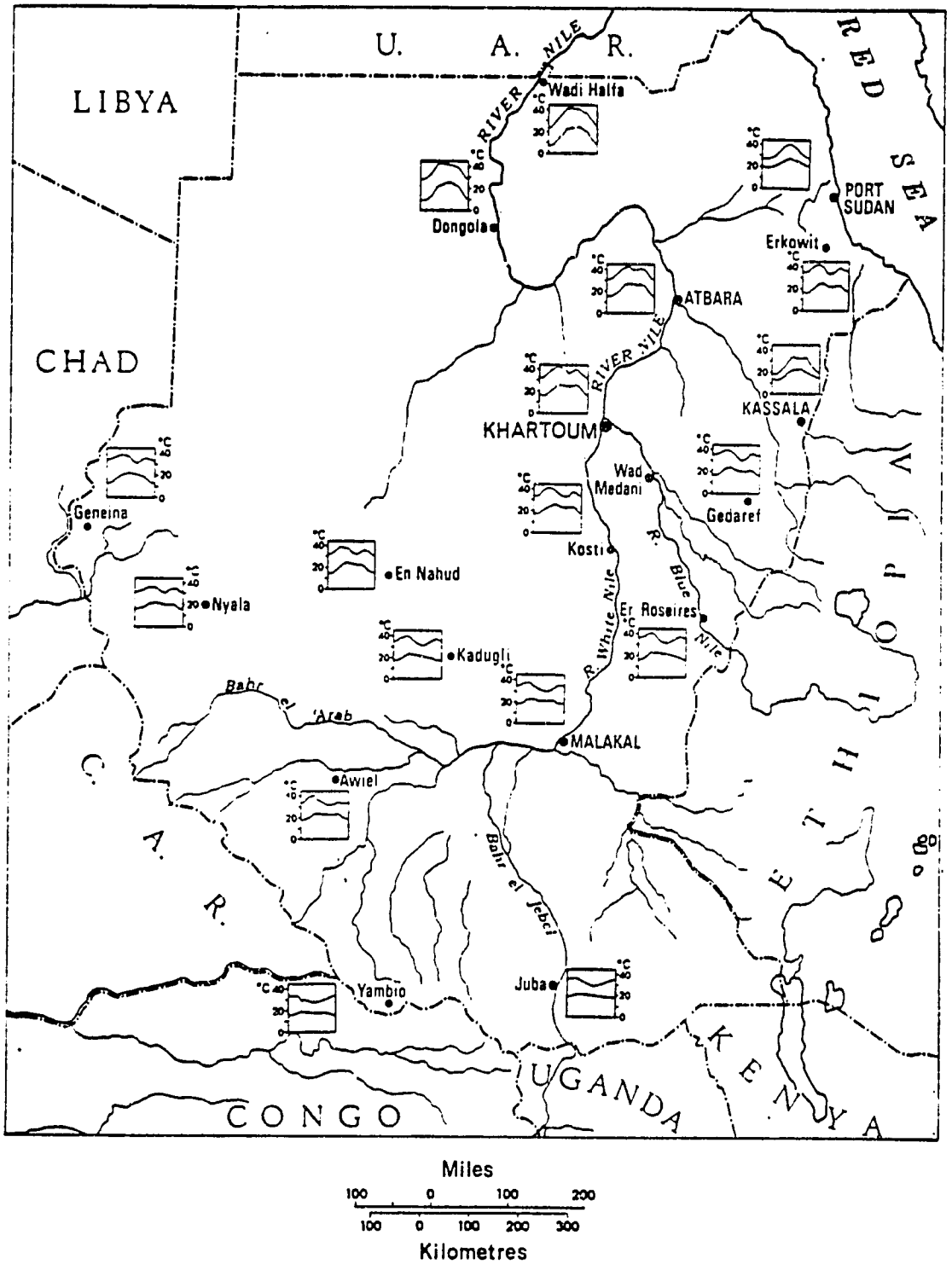

Figure 2.4. Mean Daily Temperature

Source: Whiteman. 1971.

2.2.1 Distribution

Based on the 1973 census, which has not been officially accepted, 17 percent of Sudan's population was considered urban in that year. Urban growth rates averaged around 7.2 percent annually, so that by 1978, 24 percent was urban. A projected 31 percent of Sudan's 20.3 million people will live in urban areas by 1985, according to U.S. AID (1979). The proportion of urban population is usually higher in the north than in the south (Tables 2.1 and 2.2). Principal urban centers are noted in Table 2.3.

Average population density is estimated at about seven persons per sq km with rates rising to 55 persons per sq km on arable land (U.S. AID 1980). The areas of highest concentrations are around Khartoum and along the Blue Nile south of Khartoum (Figure 2.5). The northernmost part of the country is nearly uninhabited except for villages along the Nile River.

2.2.2 Composition 3/

The 1955/56 census listed 56 separate ethnic groups, subdivided into 597 subgroups. The results also indicated that 115 different languages were spoken in Sudan. Ethnic group and language do not always coincide, and distinctions are often confusing between similar groups or languages. A rough division can be made between Arabs and arabized northern Sudanese, and the African southerners. Differences have been so great that civil war broke out along these lines in the mid 1950s. The conflict was not resolved until 1972, when a negotiated settlement was reached.

Arabs had been migrating to Sudan at least since the first century AD, but only moved into the region in great numbers after the decline of the Nubian Kingdoms in the thirteenth century. They soon spread throughout the area north of the Sudd, and mixed with indiginous ethnic groups. They now form the largest single group in Sudan, constituting 38.8 percent of the population according to the 1955/56 census (Table 2.4).

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[3] Sources: Europa. 1981.
Nelson, et al. 1973.
U.S. AID. 1981a.

Table 2.1. Population, Urbanization and Growth

	1955/56		1973		
	Population (000's)	Percent	Population (000's)	Percent	Growth Rate
Northern Provinces					
Urban	690.4	9%	2,213.0	19%	6.9%
Rural	6,789.0	91%	9,520.4	81%	2.0%
Total	7,479.4		11,733.4		2.6%
Southern Provinces					
Urban	46.7	2%	274.7	9%	10.7%
Rural	2,736.4	98%	2,750.2	91%	-
Total	2,783.1		3,024.9		.5%
Total Sudan					
Urban	737.1	7%	2,487.7	17%	7.2%
Rural	9,525.4	93%	12,270.6	83%	1.5%
Total	10,262.5		14,758.3		2.1%

Source: U.S. AID. 1978.

Table 2.2. Projection of Urban/Rural Population in the Sudan

	1973	1978	1985
Urban Population			
Towns 20,000+	1,854.2	2,795.0	4,580.9
Towns 10-20,000	412.6	586.8	930.0
Towns under 10,000	470.1	597.1	834.7
Total Urban	2,736.9(18%)	3,978.9(24%)	6,345.6(31%)
(Growth Rate)	(+7.2%/yr)	(+7.8%/yr)	(+6.9%/yr)
Rural Population	12,082.1(82%)	12,898.0(76%)	14,002.9(69%)
(Growth Rate)	(1.5%/yr)	(+1.3%/yr)	(+1.2%/yr)
Total Sudan	14,819.0(82%)	16,876.9	20,348.5
(Growth Rate)	(+2.1%/yr)	(+2.6%/yr)	(+2.7%/yr)

Source: U.S. AID. 1978.

Table 2.3. Urban Centers Ranked by 1973 Population

City (Province)	Resident Population (000's) 1955-56	1964-66	1973-74	Annual Growth Rate 1955-56 1964/66	1964/66-1973/74
Khartoum (Khartoum)	93.1	173.5	349.1	6.8%	8.6%
Omdurman (Khartoum)	113.6	185.4	300.5	5.3	5.8
Khartoum North (Khartoum)	46.9	80.0	150.2	5.8	7.7
*Greater Khartoum Urban Area	253.6	438.9	799.8	5.9%	7.3%
*Port Sudan (Red Sea)	47.6	78.9	135.1	5.5	5.5
*Wad Medani (Gezira)	47.7	63.7	118.0	3.1	7.3
*Kassala (Kassala)	40.6	68.1	100.5	5.6	4.7
*El Obeid (Northern Kordofan)	52.4	62.6	92.2	1.9	4.7
*Gedaref (Kassala)	17.5	45.1	66.2	10.5	4.6
*Atbara (Nile)	36.3	48.3	64.3	3.1	3.4
*Nyala (Southern Darfur)	12.3	26.2	62.8	8.3	10.8
*Kosti (White Nile)	22.7	37.9	60.6	5.5	5.7
Juba (Eastern Equatoria)	10.7	19.8	56.7	6.7	13.2
*El Fashir (Northern Darfur)	26.2	40.5	54.5	4.7	3.6
Wau (Bahr el Ghazal)	8.0	14.8	53.4	6.7	16.3
*El Genaina (Northern Darfur)	11.8	20.7	38.6	6.1	7.6
Malakal (Upper Nile)	9.7	17.9	37.1	6.7	9.0
Sennar el Medina (White Nile)	8.1	17.6	32.6	8.5	7.5
*El Nahud (Northern Kordofan)	16.5	19.8	27.6	1.9	4.0
*Duiem (White Nile)	12.3	15.9	26.8	2.7	6.3
Halfa el Gadida (Kassala)	8.7	12.1	24.3	3.5	8.5
El Gezira Aba (White Nile)	11.4	16.7	22.3	4.1	3.5
El Deain (Southern Darfur)	6.3	8.9	20.7	3.7	10.4
Total 22 Urban Centers	660.4	1074.4	1894.1	5.3%	6.9%

*The 13 cities given priority in the Six Year Plan

Source: U.S. AID. 1978.

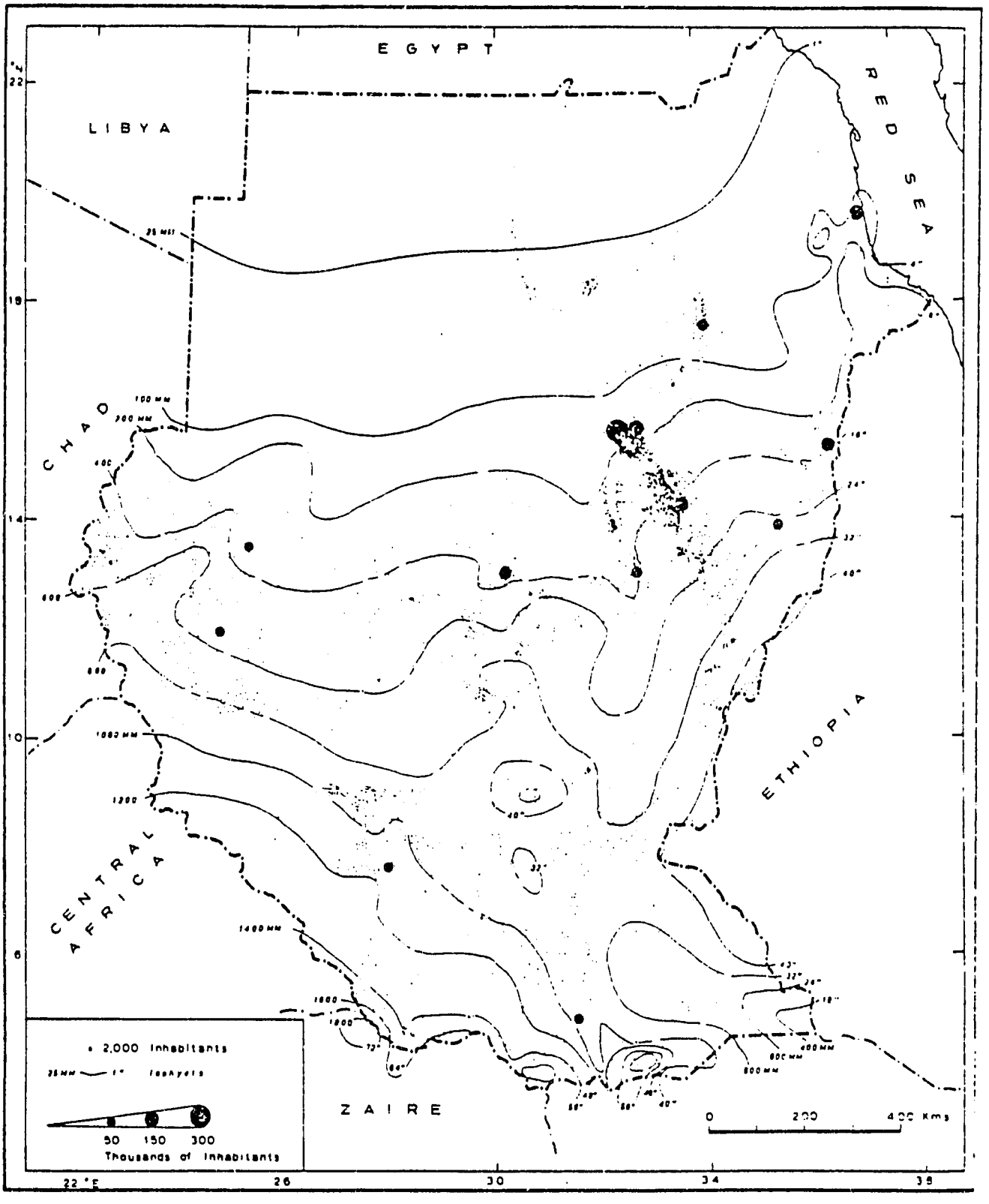


Figure 2.5. Distribution of Population, 1973

Source: el-Bushra and el-Sammani. 1977.

Table 2.4. Major Ethnic Groups in Sudan, 1955/56 Census

Ethnic Group	Principal Location (by province)	Number of Persons	Percentage of Total Population
Northern Region			
Arabs	Blue Nile, Northern, Khartoum, Kordofan, Darfur	3,990,000	38.8
Nubians	Northern	330,000	3.2
Beja	Kassala	646,000	6.3
Nuba	Kordofan	573,000	5.5
Fur	Darfur	170,000	1.6
Zaghawa	do.	60,000	0.6
Darfung peoples	Blue Nile	173,000	1.6
West Africans[1]	Kassala, Blue Nile	602,000	5.8
Other	Various	936,000	9.0
Southern Region			
Dinka	Bahr el Ghazal	1,152,000	11.2
Nuer	Upper Nile	460,000	4.5
Shilluk	do.	100,000	1.0
Bari[2]	Equatoria	211,000	2.0
Lotuko	do.	116,000	1.0
Toposa[2]	do.	120,000	1.2
Didinga	do.	51,000	0.5
Azande	do.	212,000	2.0
Moru[2]	do.	110,000	1.1
Bongo and Baka	Bahr el Ghazal-Equatoria	47,000	0.5
Ndogo[2]	Bahr el Ghazal	71,000	0.7
Other	Various	133,000	0.1
Total		10,263,000	98.2[3]

[1] Africans originating in countries west of Sudan.
[2] And related peoples.
[3] Does not total 100 because of rounding.

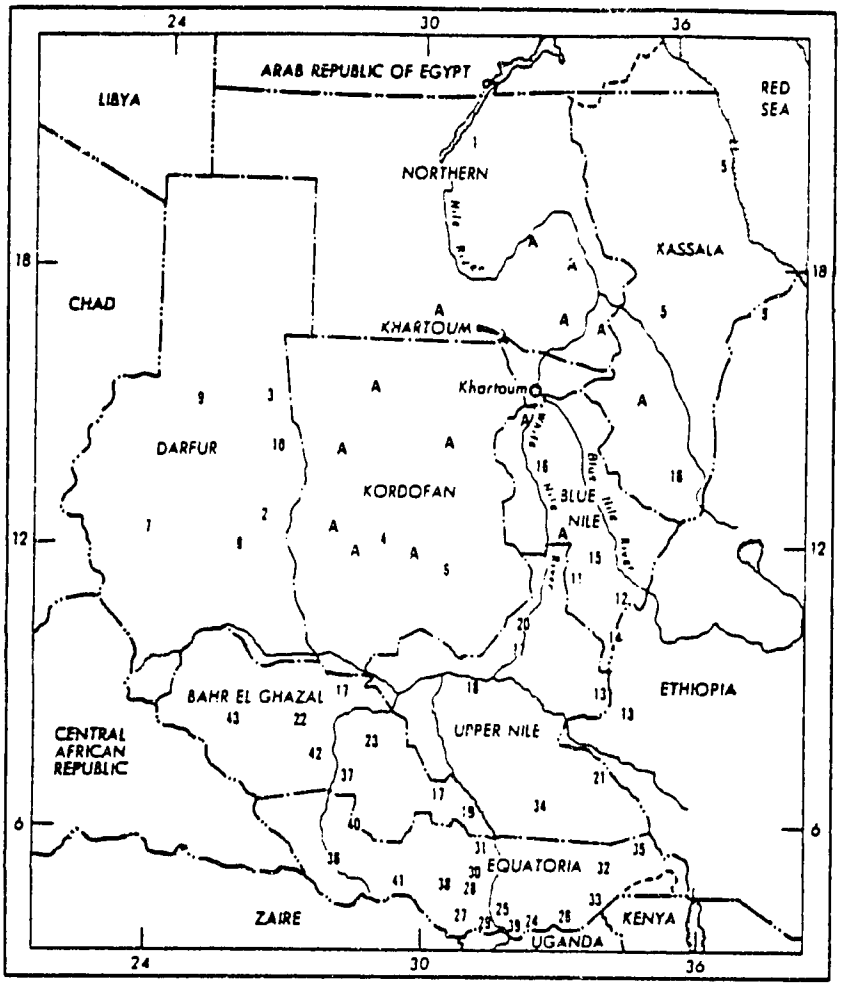
Source: Nelson et al. 1973.

Arabs are still found in all areas of Sudan north of the Sudd, but still have not penetrated the southern provinces in any great numbers (Figure 2.6). Arabic language is even more widespread; over half the population of Sudan uses Arabic as their primary language, and everywhere but in the southern provinces it serves as a linga franca. Arabic is one of Sudan's official languages.

The Nubians were concentrated primarily in the Northern Nile Province along the river. However, a tendency to migrate for better work opportunities as well as resettlement schemes to compensate for land lost to Lake Nasser has spread them to many other areas. Khartoum, Kassala, and Khashm al-Girba are three areas of particularly high Nubian concentrations. Nubians enthusiastically adopted Islam after the thirteenth century, and remain thoroughly Muslim today. Their continual striving for education, combined with a willingness to migrate has given the Nubians somewhat more influence in government and the economy than their 3.2 percent of the population would lead one to expect.

The Beja are another northern Muslim people found mostly in the Red Sea and Kassala Provinces. While Nubians are mostly sedentary cultivators, Beja are mostly nomads. The third major non-Arab northern people are the Nuba, who are mainly sedentary and inhabit Kordofan, particularly the southern part. Like the other northern peoples, the Nuba are Muslim. Darfur, in western Sudan, also contains a number of peoples who are included in the overall category of northern Muslims, although they are generally less Arabized than most other non-Arab northerners. The Fur and the Daju are sedentary, while the Zaghawa are nomadic.

While the southern non-Muslim peoples often have little in common, they may be contrasted with the Muslim and fairly Arabized north. Southern ethnic groups are often grouped into Nilotes and "Sudanic" peoples. Both groups are more closely related to the Black African cultures in surrounding countries than to the Arabized Muslim culture of the northern part of Sudan. Various African religions predominate, with some Christian influence. Arabic is not widely understood, and there is fairly great resistence to importing Arabic or other aspects of northern culture.



A	Arabs	15	Gule	30	Nyangbara
1	Nubians	16	West Africans	31	Mandari
2	Berkid	17	Dinka	32	Toposa
3	Midob	18	Nuer	33	Didinga
4	Hill Nubians	19	Atuot	34	Beir
5	Beja	20	Shilluk	35	Murle
6	Nuba	21	Anuak	36	Azande
7	Fur	22	Thuri	37	Belanda
8	Daju	23	JoLuo	38	Moru
9	Zaghawa	24	Acholi	39	Madi
10	Berti	25	Bari	40	Bongo
11	Ingassana	26	Lotuko	41	Baka
12	Berta	27	Kakwa	42	Ndogo
13	Koma	28	Pojulu	43	Feroge
14	Uduk	29	Kuku		

Figure 2.6. Principal Ethnic Concentrations in Sudan, 1972

Source: Nelson et al. 1973.

Since the negotiated end of the civil war in 1972, English has been given semi-official status in Sudan in deference to southern wishes.

Major Nilotic peoples include Dinka, the second largest single group in Sudan after Arabs; the Nuer; and the Shilluk. Numerous other smaller groups are also classified as Nilotic. Dinka are primarily found along the Bahr al-Arab, Bahr al-Ghazal, and along the White Nile north of Malakal. The Nuer primarily inhabit the area around the Bahr az-Zaraf, and the Shilluk inhabit the area to the north near the mouth of the Sobat. The economy of all of these tribes is based on various combinations of cattle herding and cultivation.

The Azande are the largest Sudanic group. They inhabit the Western Equitoria Province, but most Azande are found in Zaire. Other Sudanic groups also found in the border regions of the south, likewise inhabit both Sudan and neighboring countries. Most practice various forms of cultivation.

2.2.3 Migration and Urbanization 4/

As noted in Section 2.2.1, urbanization is proceeding quite rapidly in Sudan. The three city area of Khartoum, Khartoum North, and Omdurman forms the largest urban cluster, and projections indicate a population of over five million by the year 2,000 (Table 2.5). The three cities area may be the largest urban concentration in Sudan, but other cities are growing much faster. Juba and Waw, in particular, showed very high growth rates, and in general the urban growth rate is higher in the southern part of the country (Figure 2.7; cf Table 2.3; Appendix II, Table 2).

Migration from rural areas is clearly the primary factor, but a significant proportion of migrants in some cities come from abroad. Sudan is on the

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4 Sources: el-Bushra. 1979.
el-Bushra and el-Sammani. 1977.
Heinritz. 1981a.
Heinritz. 1981b.
Nelson et al. 1973.
U.S. AID. 1978.
U.S. AID. 1981a.

Table 2.5. Projection of Population in Selected Cities (thousands)

	1973	1978	1985	1990	2000
Khartoum (3 City Area)	800	1,050 (1)	1,740	2,500(1)	5,150
	(+7.3%/yr)	(+5.6%/yr)	(+7.5%/yr)	(+7.5%/yr)	(+7.5%/yr)
Port Sudan	135	250 (2)	388	530	1,000
	(+6.5%/yr)	(+13.1%/yr)	(+6.5%/ r)	(+6.5%/yr)	(+6.5%/yr)
El Obeid	92	107 (3)	136	165	245
	(4.7%/yr)	(+3.5%/yr)	(+3.5%/yr)	(+4.0%/yr)	(+4.0%/yr)
Juba	57	90 (4)	150	215	440
	(+13%/yr)	(+9.6%/yr)	(+7.5%/yr)	(+7.5%/yr)	(+7.5%/yr)

Source: U.S. AID. 1978.

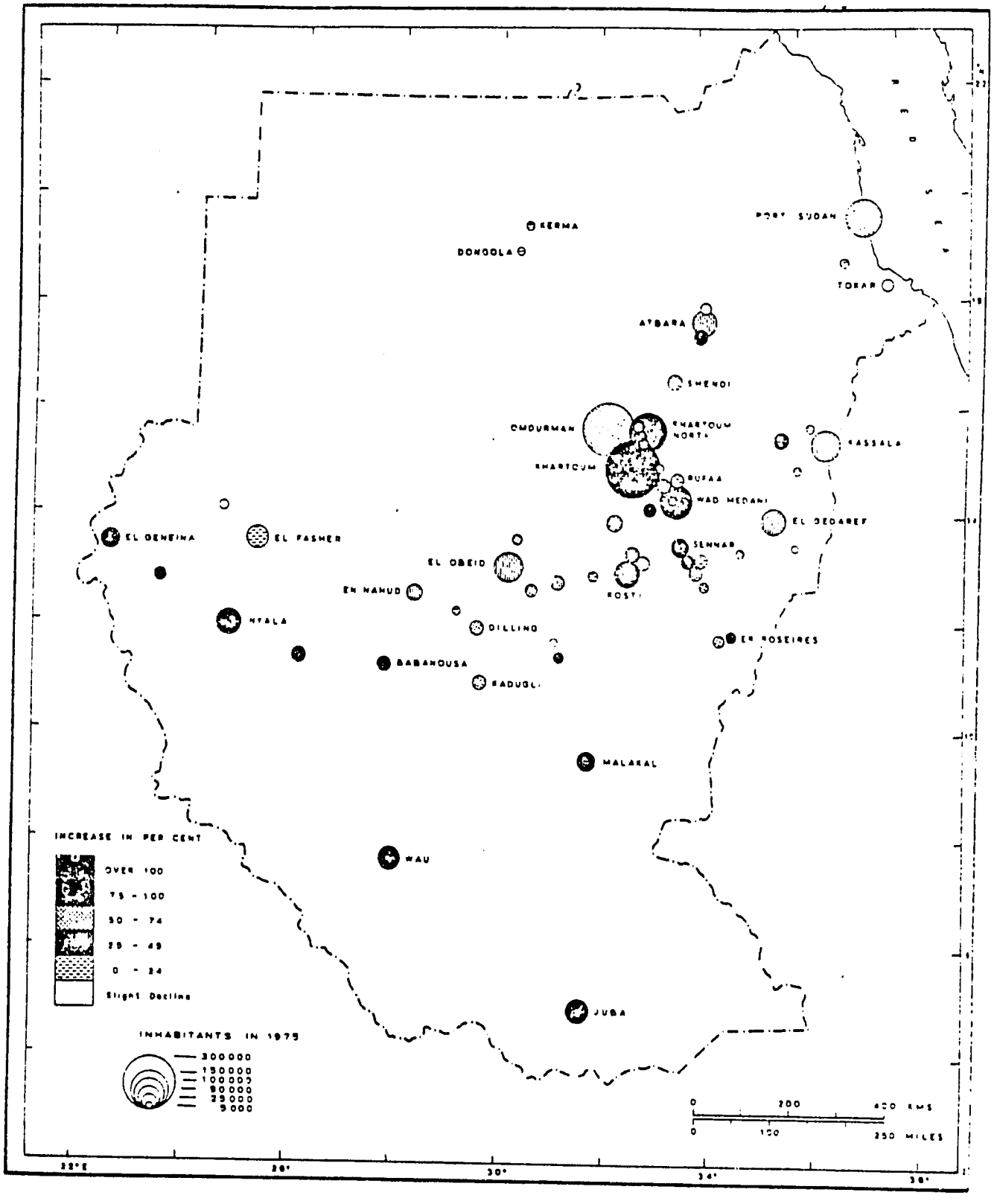

Figure 2.7. Main Urban Centers and Growth, 1965-75

Source: el-Bushra and el-Sammani. 1977.

pilgrim route for West Afrcian Muslims traveling to Saudi Arabia. A sample survey of migrants to the Khartoum area revealed that nearly 30 percent were from abroad, nearly all from Chad, Nigeria, Niger, and Upper Volta (Table 2.6). Within Sudan, the majority of migrants in the Khartoum area come from Darfur and Kordofan.

2.2.4 Public Health 5/

Sudan has given health care high priority since independence in 1956, and many experts consider Sudanese health planning activities to be an excellent example of health care development at its best (U.S. AID 1976). Rapid progress has been made in combatting many diseases, such as typhus, plague, yellow fever, cholera, and small pox. Nevertheless, the overall health situation still requires much progress, and many serious problems have yet to be overcome. The crude death rate was estimated at about 18 per 1,000 in 1978, an improvement from 25 per 1,000 in 1960. Death rates among children one to four years of age were about 31 per 1,000 in 1977, also down from 46 per 1,000 in 1960. The infant mortality rate in 1973 was around 132 per 1,000 and life expectancy at birth in 1978 was about 46 years. Poor health conditions, particularly outside the major urban areas, may be partially attributed to malnutrition, lack of sanitation facilities, and absence of knowledge about personal hygiene or preventive health measures. Shortages of medical personnel and facilities further exacerbate public health problems.

Diseases (Table 2.7). Malaria is endemic throughout most of Sudan, with sporadic epidemic out-breaks. Once largely seasonal in incidence, malaria now occurs year round, due to irrigation development over the last several decades. Sudan was one of the first countries in the world to institute malaria control programs over 30 years ago, and by 1960 was receiving substantial aid

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5 Sources: Hasseeb et al. 1972.
Nelson et al. 1973.
U.S. AID. 1976.
U.S. AID. 1980.
U.S. AID. 1981a.
U.S. AID. 1981b.

Table 2.6. Birthplace of Migrants in Khartoum by Province

Region/Province	Numbers	%
West	98	29.3
by Province		
Northern Darfur	16	4.8
Northern Kordofan	26	7.8
Southern Darfur	34	10.2
Southern Kordofan	22	6.5
South	35	10.5
by Province		
Bahr el Ghazal	26	7.8
Eastern Equatoria	1	0.3
El Buheyrat	1	0.3
Jonglei	3	0.9
Upper Nile	1	0.3
Western Equatoria	3	0.9
Central	55	16.5
by Province		
Blue Nile	17	5.1
Gezira	11	3.3
Khartoum	10	3.0
White Nile	17	5.1
North	46	13.8
by Province		
Kassala	46	13.8
Red-Sea	0	0
Nile	0	0
Northern Province	0	0
Foreign	98	29.3
Nigeria	15	4.5
Upper Volta, Niger	6	1.7
Chad	75	22.4
Zaire	1	0.3
Central African Republic	1	0.3
Unknown Origin	1	0.3

Source: Heinritz. 1981a.

Table 2.7. Common Diseases in Sudan, 1972

Disease	Mode of Transmission	Area of Greatest Incidence
Bilharziasis (now called schistosomiasis or snail fever)	Infection acquired from water contaminated with larval forms (cercariae) derived from snails.	Mainly in the north along the Blue Nile and White Nile and in Jazirah, Qadarif, and some parts of Darfur.
Cholera	Ingestion of contaminated water or food.	No major outbreak since 1898.
Diphtheria	Contact with a patient or carrier. Raw milk can serve as a vehicle.	Mainly northern and eastern provinces.
Dysentery		
Amebiasis	Contaminated water.	Prevalent throughout.
Shigellosis	Contaminated food, milk, water; direct contact, spread by flies.	Do.
Filariasis (including loiasis and onchocerciasis)	By bite of mosquito, infected "mangrove fly," or infected black fly.	Nuba Mountains and southern provinces.
Hookworm	Infected larvae on the ground penetrate the bare skin, usually the foot.	Serious in the south, especially Bahr al Ghazal and Equatoria; very moderate in Northern Province.
Kala azar (visceral leishmaniasis)	By bite of infective sandflies.	Kassala and Fung districts, in the southeast, and in Darfur.
Leprosy	Spread (presumably) through close household contact with infectious patients.	Widespread in the south, especially in the southwest.
Malaria	By bite of infective mosquito.	Prevalent throughout.
Meningitis	By direct contact.	Southern half of country, especially Nuba Mountains.
Oriental sore (cutaneous leishmaniasis)	By bite of infective sandfly.	Bahr al Ghazal and Equatoria.
Pneumonia	Direct oral contact.	Prevalent throughout.
Relapsing fever	By bite of infective louse.	Almost disappeared through control measures, but outbreaks occur in Jazirah and along travel routes in Darfur, Kordofan, and Kassala.
Sandfly fever	By bite of infective sandfly.	Endemic in widely distributed areas.
Sleeping sickness (trypanosomiasis)	By bite of infective tsetse fly.	Limited to southern borders of Equatoria and Bahr al Ghazal.
Smallpox	By close contact with patient.	Occasional outbreaks through constant exposure to immigrants along major lines of traffic. Eradication was started in 1962, but according to World Health Organization, Sudan registered five or more cases per 100,000 inhabitants in 1971.
Trachoma	By direct contact with discharges of patient, or materials soiled therewith.	Northern provinces.
Tuberculosis	By contact with infected person.	Widespread, predominantly in the north, but increasing in south.
Typhoid and paratyphoid fever	By direct or indirect contact with excreta of patient or carrier.	Prevalent, heaviest in urban areas and main traffic routes.
Venereal disease		
Gonorrhea	Sexual contact.	Urban areas, increasing in the south. Prevalent, especially in Darfur and Kordofan.
Syphilis	do.	
Yaws (nonvenereal treponematosis)	By direct contact with skin lesions of infected persons.	South, mainly Bahr al Ghazal and Equatoria.
Yellow fever	By the bite of an infective mosquito.	Endemic in southern half of country, but effectively controlled since last severe epidemic in 1940; rare in urban areas.

Source: Nelson et al. 1973.

from UNICEF and WHO in its programs. Success has been mixed however, and in 1974, one million cases of malaria were reported. The true incidence is believed to be much higher due to inaccurate reporting. Recently, eradication efforts have tended to focus on areas of major economic importance, such as the Gezira.

Schistosomiasis accounted for six percent of all visits to health facilities in 1974. The number of reported cases per 100,000 population had increased by 33 percent from 1965 to 1974. The former Blue Nile Province (now Blue Nile, White Nile, and Gezira), with the major concentration of irrigation schemes, by far leads Sudan in total incidence (cf Appendix II for incidence of schistosomiasis and other diseases).

Enteric diseases are probably one of the three most serious health problems along with malaria and schistosomiasis. Children are particularly vulnerable, and represent 63 percent of all reported enteric disease cases reported annually. Of reported cases, about 25 per 1,000 require hospitalization. The case fatility rate of hospitalized cases is the third highest cause of death reported in hospitals.

Onchocerciases (River Blindness) is a water borne or riparian related disease, occuring primarily in the Southern Region of Sudan. An estimated 160,000 were affected by the disease in the mid 1970s, with approximately 37,000 (17½ percent) of young males (15-24) suffering from "economic blindness". The trend in incidence is climbing rapidly, with a projection of 200,000 youths (5-14) being infected and 49,000 cases of economic blindness by 1984, unless the present trend is interrupted.

Trypanosomiasis (Sleeping-sickness) represents one of the major endemic parasitic diseases affecting the Southern Region of Sudan. It is an important human health problem although the actual incidence in humans is unknown. Trypanosomiasis also represents an economic problem due to its effects on animals, particularly livestock.

Pulmonary tuberculosis decreased by 35 percent between 1968 and 1974 (from 404,000 to 263,750 reported cases). Sudan has carried out a program of B.C.G. vaccinations which seems to be achieving some success, although 11,666 children with severe cases of TB were hospitalized in 1974.

Cerebro-spinal meningitis, although a major health problem, probably represents one of the lowest causes of hospital admission. Reported incidence is fairly stable, but sporadic outbreaks may occur during the hot dry summers.

Other common diseases are noted in Table 2.7.

Diet and Nutrition. Many health problems in Sudan are exacerbated by inadequate or unbalanced diet. Diet varies greatly with ethnic group and livelihood. The nomads of the north and west, for example, get nearly half of their protein from milk and clarified butter. Their diet is high in protein and fat and low in vitamins, minerals and carbohydrates. Southern pastoralists add fish to their diet in the dry season, and some wild fruits and vegetable roots, but otherwise have similar patterns. Sedentary cultivators, on the other hand, eat mostly sorghum and millet. Their diets are high in carbohydrates and low in protein.

Malnutrition seems most prevalent in the eastern districts of the Red Sea and Kassala Provinces, and in western Darfur. Severe cases of malnutrition throughout Sudan constituted 43 per 1,000 of all reported cases in 1974. One survey of children revealed that 1,567,352, or about 50 percent, suffered some degree of malnutrition, including 31,352 severe cases.

2.3 Economic Characteristics 6/

The economy of Sudan is still heavily oriented toward agriculture and pastoralism. Agriculture, including forestry, livestock, and fishing, contributed 39.2 percent of the GDP in 1977/78 (Table 2.8). It accounts for over half of government revenues, employs about 80 percent of the labor force, and contributes nearly 95 percent of all exports. Per capita GDP is around US$ 320, and Sudan is generally considered one of the world's least developed countries.

Agriculture is still largely subsistance oriented for the majority of the population. There are

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6 Sources: Europa. 1981.
MEED. 1977.
Nelson et al. 1973.
U.S. AID. 1981a.
U.S. AID. 1981b.

Table 2.8

GROSS DOMESTIC PRODUCT BY ECONOMIC ACTIVITY
at current market prices, 1969 to 1978

Sector	1969/70 LSm.	1969/70 %	1970/71 LSm.	1970/71 %	1971/72 LSm.	1971/72 %	1972/73 LSm.	1972/73 %	1973/74 LSm.	1973/74 %	1974/75 LSm.	1974/75 %	1975/76* LSm.	1975/76* %	1976/77* LSm.	1976/77* %	1977/78 LSm.	1977/78 %
Agriculture	263.7	37.6	294.4	38.7	324.1	39.0	344.6	38.4	516.4	41.4	585.3	38.5	691.0	38.9	817.7	39.1	871.7	39.2
Commerce, Finance, and Services	236.0	33.6	255.6	33.6	284.1	34.1	313.3	34.9	411.5	33.0	518.5	34.3	608.7	34.3	714.6	34.2		34.5
Industry and Mining	66.8	9.5	69.2	9.1	76.8	9.2	82.9	9.2	111.3	8.9	142.9	9.1	167.2	9.4	195.6	9.4	209	9.6
Transport and Communications	51.1	7.3	50.7	6.7	51.3	6.2	61.5	6.9	74.8	6.0	89.4	6.2	100.4	5.7	112.7	5.4		5.3
Construction	24.3	3.5	23.3	3.1	26.4	3.2	31.2	3.5	61.0	4.9	65.0	2.8	81.8	4.6	103.0	4.9	106.5	4.8
Electricity and Water	16.5	2.4	16.6	2.2	16.9	2.0	17.5	2.0	18.6	1.5	20.9	2.[illegible]	21.9	1.2	23.0	1.1	23.5	1.1
Sub-total (A)	658.4		709.8		779.6		851.0		1,193.6		1,422.0		1,671.8		1,966.6		2,096.9	
Percent of Total		93.9		93.3		93.7		95.0		95.8		94.1		94.1		94.1		94.3
(B) Customs duties	43.1	6.1	51.3	6.7	52.8	6.3	45.8	5.0	52.6	4.2	88.8	5.9	105.1	5.9	124.4	5.9	127.5	5.7
GDP TOTAL (A + B)	701.5	100%	761.1	100%	832.4	100%	896.8	100%	1,246.2	100%	1,510.8	100%	1,776.9	100%	2,091.0	100%	4,421.3	

*Estimates based on an average rate of growth in each sector during the period 1969/70 to 1974/75.

Source: U.S. AID. 1978.

however, several major commercial farming schemes, including the state run Gezira/Managil and Khashm al-Gerba areas. The major commercial crop is cotton, but groundnuts, wheat, fruits and vegetables, gum arabic, and sesame are also important. Sorghum is the principal grain and the main subsistance crop. Livestock contributes an estimated ten percent to GDP, and an estimated 1,427,000 metric tons of milk and 408,000 tons of meat were produced in 1978. Livestock products accounted for about five percent of total exports in that year, but exports are expected to decline because domestic demand is increasing faster than production.

Industry's contribution to GDP has risen from practically nothing two decades ago to 9.6 percent in 1978. Sudan has concentrated its industrial efforts to date on light industry, stressing import substitution of basic consumer goods and processing of Sudan's agricultural output. Commerce, finance, and services account for 34.5 percent of GDP. Figure 2.8 indicates major economic activity.

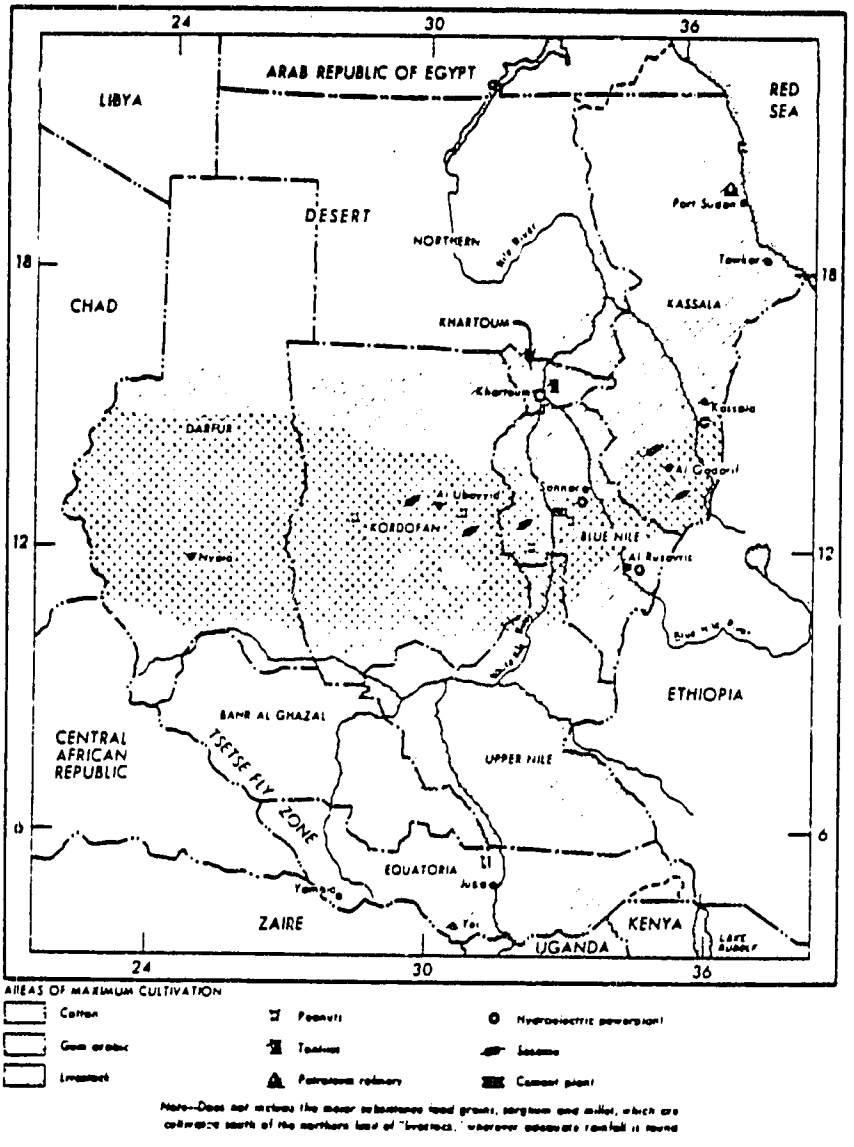

Figure 2.8. Economic Activity of Sudan, 1970

Source: Nelson et al. 1973.

3.0 Environmental Resources

3.1 Geology and Mineral Resources

3.1.1 Geology

The following discussion is based on Whiteman (1971), who presents a very detailed account of Sudan's geology. Excluding superficial deposits, the most extensive formations in the country are those of the Basement Complex (Table 3.1; Figure 3.1). Basement formations are thought to be mainly Pre-Cambrian in age, and consist of igneous, metamorphic, and sedimentary rocks. According to Whiteman, various basement formations occur in different regions of the Sudan, and a satisfactory comprehensive classification has not yet been established.

Paleozoic formations occur in Sudan only in a few limited areas. The major areas are found near el-Obeid in Kordofan and along the western border with Chad and Libya. Nubian Sandstone formations, possibly of Late Cretaceous age, occur widely in northern and central Sudan, and small outcrops of the equivalent Yirol Formation are found in the southern part of the country. Nubian Sandstone is probably the most important water bearing formation (cf Sec. 3.2.2). Also important in groundwater considerations are the Umm Ruwaba and el Atshan Formations (Quaternary-Tertiary), which are extensive in the southern half of the country. Lavas and chert formations are not very extensive, but occur especially in the extreme southeastern corner, along the eastern border with Ethiopia, and in Darfur.

3.1.2 Mineral Resources 7/

Sudan is not currently a major producer of any mineral, and minerals constituted only a few percent of the country's exports by value in 1980. Nevertheless, a number of minerals are known to occur in the country. Copper, iron, mica, and chromite are currently exported in small

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7 Sources: Ahmad. 1972.
Europa. 1981.
Nelson et al. 1973.
U.S. Bureau of Mines. 1976.
Whiteman. 1971.

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Table 3.1. Major Geological Formations

Name of unit	Age	Surface area (%)
Superficial deposits	Quaternary–Tertiary	Not differentiated
Continental–marine formations Red Sea Littoral	Quaternary–Tertiary–Mesozoic	<1
Gezira Umm Ruwaba and El Atshan Formations	Quaternary–Tertiary	19
Volcanic and intrusive rocks, mainly lavas (undifferentiated)	Quaternary–Tertiary	2
Hudi Chert Formation	Tertiary? (Oligocene?)	<1
Nubian Sandstone Formation	L. Cretaceous?	28
Yirol Formation (? equivalent to Nubian Formation)	L. Cretaceous?	<0·1
Gedaref Sandstone Formation	Jurassic (pre-Oxfordian)	Included in Nubian estimate
Nawa Formation	Palaeozoic?	<1
Palaeozoic Formations (undifferentiated)	Palaeozoic?	<0·5
Basement Complex Group	Pre-Cambrian mainly	49

Source: Whiteman. 1971.

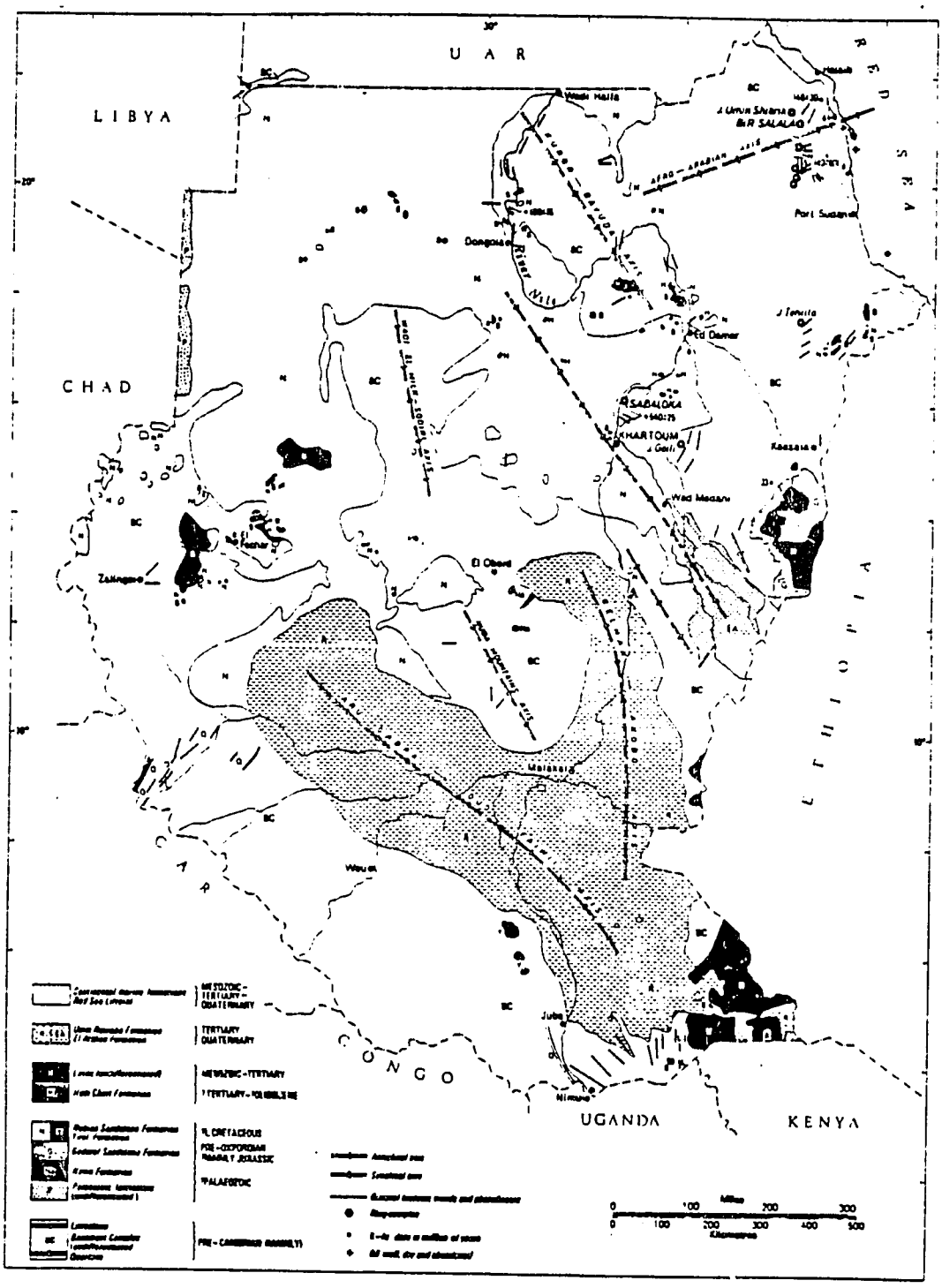

Figure 3.1. General Geological Map of Sudan

Source: Whiteman. 1971.

quantities. Sudan also plans further development of mineral extraction capabilities, although it is unclear whether most deposits are sufficient for economic exploitation. Table 3.2 gives a partial view of production in 1974, while Figure 3.2 shows locations of major deposits. More detailed data is available in Appendix IV. The following discussion of individual minerals is based on Whiteman (1971).

Table 3.2. Mineral Production

(Thousand metric tons, unless otherwise specified)

Map symbol	Major commodities	1974 production	Estimated share of production exported (%)	Share of world output (%)	Reserves	Share of total world resources (%)
Cem	Cement	300	0	(1)	NA	NA
Cr	Chromite ore	20	100	(1)	1,500	(1)
Gy	Gypsum	30	0	(1)	Medium	(1)
Mg	Magnesite	0.1	0	(1)	2,500	(1)
Salt	Salt	50	1	(1)	NA	NA
Talc	Talc	5	-	(1)	Small	(1)
Δ	Petroleum products (thousand 42-gal bbl)	6,000	2	(1)	NA	NA

NA Not applicable. (1) Less than 1%.

Source: U.S. Bureau of Mines. 1976.

Coal. No workable deposits of anthracite or lignite were known by the early 1970s. Small deposits of lignite and low-grade coals are known, particularly in the Dongola region. Graphite frequently occurs in small quantities in many Basement Complex formations.

Oil and Gas. The geological formations throughout most of Sudan are very unlikely to contain oil or gas, and areas with any potential actually constitute only about one percent of the total surface area. Exploration has largely concentrated on the Red Sea Littoral, where conditions appear similar to those in the Gulf of Suez and Egypt's Red Sea coast. Jebel Uweinat, in the northwest corner on the borders with Libya and Egypt, has also received some attention because of discoveries in Libya.

International interest after 1973 resulted in exploration concessions covering 1,360,000 ha on the Red Sea Coast and offshore. Most of the international companies involved were American. Chevron announced an economically exploitable find

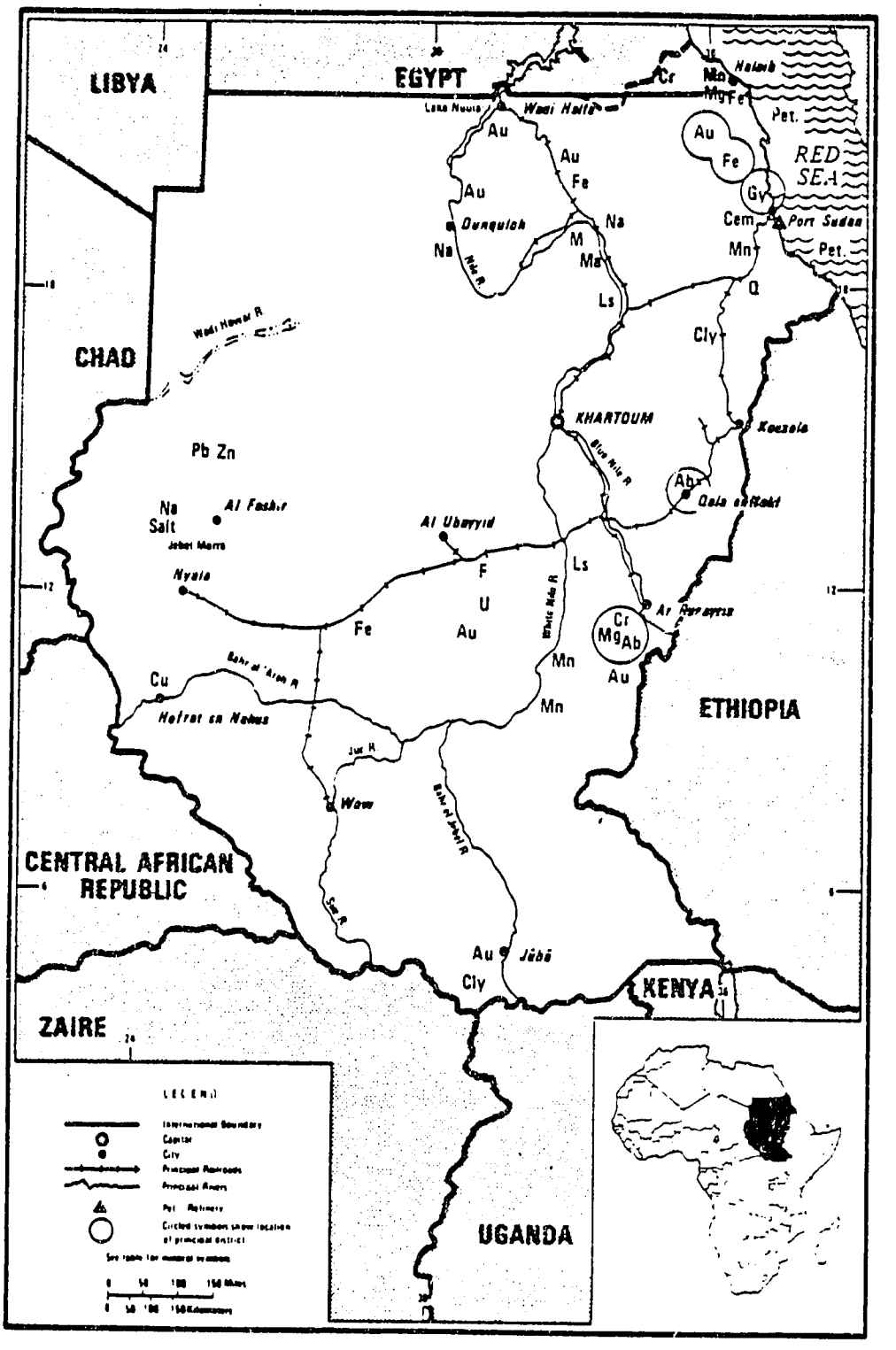

Figure 3.2. Major Occurrences of Minerals

Source: U.S. Bureau of Mines. 1976.

in 1980, which is expected to produce about 12,840 barrels per day. Several other companies are still searching in the region (Europa 1981).

Gold. Sudan has been a source of gold for several thousand years. It is known to occur in a great many localities scattered throughout the country, but deposits are small. Peak production in recent decades appears to have occurred around 1960, when over 2,000 ounces were produced annually. Production had fallen to under 1,000 ounces annually by the mid 1960s and more recent data is unavailable.

Copper. Copper deposits are also widespread, but as of the early 1970s, only one deposit was known to be large enough for economic exploitation. The Hofrat en-Nahas Mine in southwestern Darfur exploits this deposit, but production figures are not available. Estimates of copper ore reserves made in the late 1960s varied widely, from one million to 400 million tons.

Lead and Zinc. Lead is known to occur in several areas, including Darfur, while zinc was known only in the Darfur Mountains as of the early 1970s.

Iron. Iron ore deposits occur in a number of areas, notably the Red Sea hills. The Fodikwan deposit may contain reserves of from 239,000 to six million tons, with iron contents ranging from 45 to 70 percent. Fodikwan was the major working mine in the early 1970s, but other deposits may be much larger. For example, Jebel Abu Tulu, Kordofan, may contain total reserves of nearly 36 million tons of ore with 55 to 65 percent iron. The Sufaya deposits, which are currently worked, contain an estimated seven to eight million tons (approximately 60 percent iron). Sudan produced about 28,500 tons of iron ore in 1965.

Manganese. Major deposits known in the early 1970s were clustered in the northeast along the seacoast and in the Red Sea hills, although some deposits are scattered in other areas of the country. Reserves are generally thought to be small, although figures are unavailable. Peak production apparently occurred in the late 1950s, with 7,000 to 9,000 tons annually. By 1965 production was down to 500 tons.

Chrome. Probably the most important mineral currently exploited, chromite ore is nearly all exported. The major deposits are in the Ingessana Hills on the Ethiopian border. Approximately 30 tons were produced in 1965, and about 20 tons in 1974.

Other Metals include molybdenum, tungsten, arsenic, magnesite, uranium, columbium, titanium, barium, aluminum, and silver. There is not yet any indication that any of these are present in sufficient quantity to allow economic exploitation.

Non-Metallic Minerals currently exploited include gypsum, salt, talc, and sulphur, as well as a number of building materials such as limestone and clay.

3.1.3 Minerals Policy

Because minerals are such an insignificant contributor to the national economy, and prospects for future development are uncertain, very little discussion of Sudan's mineral policy is readily available. U.S. Bureau of Mines (1976) contains the following brief discussion of Sudan's mineral industry organization:

Sudan has demonstrated an interest in attracting foreign investment through more liberalized investment incentives provided by the Industrial Investment Acts of 1972 and 1974. Under the 1972 Act, all minerals and quarried materials found in Sudan belong to the State, which has exclusive right to dispose of them. The Mines and Quarries Board issues licenses for prospecting and mining, the terms of which are negotiable. Under agreements with oil-prospecting companies signed in October 1975, 70 percent of any oil production is to belong to the Government for a five-year period.

3.1.4 Energy [8]

Commercial energy consumption in Sudan accounted for nearly 23 percent of all energy consumed in

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[8] Sources: Europa. 1981.
U.N. 1981.
U.S. AID. 1981b.
U.S. Bureau of Mines. 1976.

1979/80. About 98 percent of this commercial energy demand is met by oil. At present, oil must be imported, but domestically produced oil may eventually be able to supply 30 to 40 percent of demand. One million tons of crude oil were imported and refined in the Port Sudan refinery in 1979/80, and another 200,000 tons of processed oil were also imported. Oil consumption has been increasing by 6.3 percent annually since the later half of the 1970s.

Electric power contributed two percent of total commercial consumption in 1979/80. A total of 892 G.w.h. was generated; 233 G.w.h. was thermally produced by 17 stations, and 659 G.w.h. was hydroelectrically generated by three stations. Table 3.3 indicates installed capacity. Sudan's current capacity is considered inadequate for current needs and is a major constraint on industrial productivity and growth. The government plans to double electrical capacity by 1983, a target well ahead of the annual 10.5 percent growth of the later 1970s. Section 3.2.4 discusses hydroelectric development further in the context of surface water management.

Non-commercial energy, primarily in the form of woodfuel, agricultural crop residue, and animate power, contributed just over 73 percent to total estimated energy consumption in 1979/80. The vast majority of this was fuel wood (69.13% of total energy usage), followed by charcoal (5.99%). Crop residue, animal refuse, and animate power together accounted for 2.22 percent of total energy use. Table 3.4 indicates that most fuelwood usage is in residential contexts. Section 3.4.2 contains further discussion of fuelwood and charcoal. Sudan also conducts an active solar energy research program, and hopes for solar energy to make a significant contribution to some energy needs by the beginning of the 21st century.

Table 3.3. National Grids and Thermal and Hydro Stations Installed Capacity and Energy Created in 1979 - 1980

National Grids and Electricity Stations	Installed Capacity MW	Energy Generated 1979 - 80 G.W.h.		
		Hydro	Thermal	Total
Blue Nile Grid	229.3	637.5	110.7	748.2
Eastern Grid	20.4	21.3	—	21.3
Dueim	0.9	—	3.7	3.7
Kassala	5.1	—	5.6	5.6
Atbara	13.0	—	21.4	21.4
Dongolla	0.4	—	1.2	1.2
Shendi	1.2	—	4.3	4.3
Port Sudan	14.1	—	32.9	32.9
Malakal	0.9	—	1.0	1.0
Wau	0.9	—	1.0	1.0
Juba	6.0	—	36.8	36.8
El Obied	5.1	—	5.3	5.3
Umronba	1.3	—	2.8	2.8
El Fashir	1.3	—	2.5	2.5
Nyala	0.9	—	3.9	3.9
TOTAL	300.9	658.8	233.2	892.0

Source: U.N. 1981.

Table 3.4. Total Energy Consumption, 1979 - 1980

Type of Energy	Units	Quantity available locally for energy	Quantity imported 1,000 tons	Cost 1,000 £S	% of total cost	Oil equivalent 1,000 tons	% of total energy used	% of commercial energy	Per capital E. Cons Kg. Oil	Per capital Cost £S	Distribution among economical sectors % Residential & service	Electricity	Industry	Transport	Agriculture
COMMERCIAL															
Oil I	1,000 tons	-----	1,202	128,609	70.82	1,106.0	21.63	98.0	61.44	6.661	4.0	6.4	15.7	55.5	18.4
Electricity															
i. Hydro	G.W.H.	658.8	-----	-----	-----	50.8	1.00	1.47	1.04	-----	-----	-----	-----	-----	-----
ii. Thermal Oil	G.W.H.	213.2	-----	-----	-----	(16.5)*	-----	0.48	-----	-----	-----	-----	-----	-----	-----
iii. Thermal Biomass	G.W.H.	20.0	-----	-----	-----	1.7	0.03	0.05	0.09	-----	-----	-----	-----	-----	-----
Total Electricity		892.0	-----	53,000	29.18	69.0	1.03	2.00	3.83	2.700	47.4	-----	49.6	-----	3.00
Total Commercial		892.0	1,202	181,689	100.00	1,158.2	22.66	100.00	65.27	9.361	7.2	6.3	18.4	54.5	13.6
NON-COMMERCIAL									% of Non-Com. H						
Biomass															
i. Wood Fuel															
Firewood	1,000 tons	1,065.0	-----	6,000	11.10	3,534.0	69.13	-----	196.43	0.333	98.0	-----	2.0	-----	-----
Charcoal	1,000 tons	550.0	-----	33,000	61.05	306.0	5.99	-----	17.00	1.833	100.0	-----	-----	-----	-----
Total Wood Fuel		11,200	-----	39,000	72.15	3,840.0	75.12	97.15	213.43	2.166	99.0	-----	1.0	-----	-----
ii. Agri-Residue															
Corp. Residue	1,000 tons	120.0	-----	15	0.03	40.0	0.78	-----	2.22	-----	75.0	25.0	-----	-----	-----
Animal Refuse	1,000 tons	50.0	-----	12	0.02	30.0	0.59	-----	1.66	-----	100.0	-----	-----	-----	-----
Total Agr. Residue		170.0	-----	27	0.05	70.0	1.37	1.75	3.88	0.002	86.0	14.0	-----	-----	-----
Animate	Million H.P. hour	750.0	-----	15,000	27.84	43.5	0.85	1.10	2.41	0.833	25.0	-----	-----	30.0	45.0
Total Non-Commercial		-----	-----	54,027	100.00	3,953.5	77.34	-----	219.72	3.001	97.534	0.002	0.014	0.008	0.005
Grand Total		-----	1,202	262,689	-----	5,112.0	100.00	-----	282.29	12.362	77.2	2.5	4.1	11.9	4.3

*Included in Oil

G.D.P. (1979-1980) £S.179.4 Per Capita, Total = S.3198.9 millions

All energy consumption per capital £S.of G.D.P. (Kilogram Oil equivalent) $= \frac{5112 \text{ (1,000 Tons)}}{3198.9 \text{ (millions)}} = 1.60$

Commercial energy consumption per capital £.S.of G.D.P. (Kilogram Oil equivalent) $= \frac{1158.5}{1198.9} = 0.36$

Non-Commercial energy consumption per capital £S.of G.D.P. (Kilogram Oil equivalent) $= \frac{3953.5}{1198.9} = 1.24$

Source: Adapted from U.N. 1981.

3.2 Water Resources

3.2.1 Surface Water 9/

Potential evapotranspiration (cf Appendix I, Figure 3) greatly exceeds rainfall throughout Sudan except in the extreme south. Values range from 828 mm annually at Nagishot near the Uganda border to 1,907 mm annually at Kassala, but exceed 1,450 mm in most areas. Accordingly nearly all of Sudan suffers an annual water deficit (cf Appendix I, Figure 4), and the perennial surface water originates outside the country.

Rivers. The Nile and its tributaries are, of course, the most prominent surface water feature of Sudan, and the majority of the country lies within the Nile drainage basin (Figure 3.3). The river has two main tributaries, the White and the Blue Niles (Figures 3.4 a & b). The White Nile originates in the lakes of equatorial Africa, and drops rapidly, reaching the Sudanese border at Nimule. In the first 168 km in Sudan, the river continues to drop 180 m until it reaches Juba. The Bahr al-Jabal, as the Nile is known in the south, then merges into the Sudd, a giant papyrus swamp covering much of the southern provinces. The Bahr al-Jabal discharges about 29 billion cubic m annually into the swamps, but loses nearly half (14 billion cubic m) to evaporation before it reemerges.

On the northern fringes of the Sudd, two important tributaries join the river, after which it is called the White Nile. The Bahr al-Ghazal drains southwestern Sudan and discharges an average 14 billion cubic m annually into the Sudd. Nearly the entire supply is lost to evaporation, and the Bahr al-Ghazal actually contributes only about 500 million cubic m to the White Nile. The Sobat River, which rises in Ethiopia, joins the Nile from the east near Malakal, where its contribution is 13.7 billion cubic m annually. Daily discharge

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9 Sources: Balek. 1977
Berry. 1968.
Bannage. 1980.
FAO-UNDP. 1968
Newhouse. 1939.
Waterbury. 1979.

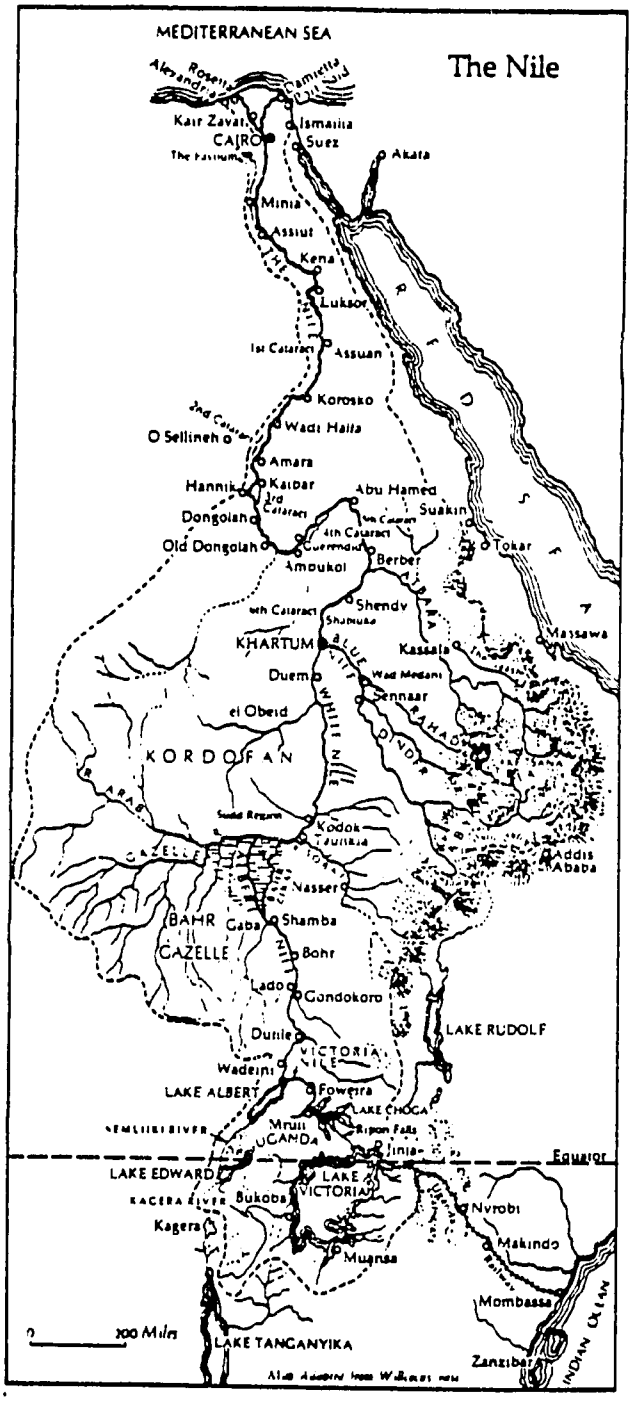

Figure 3.3. The Nile Basin

Source: Waterbury. 1979.

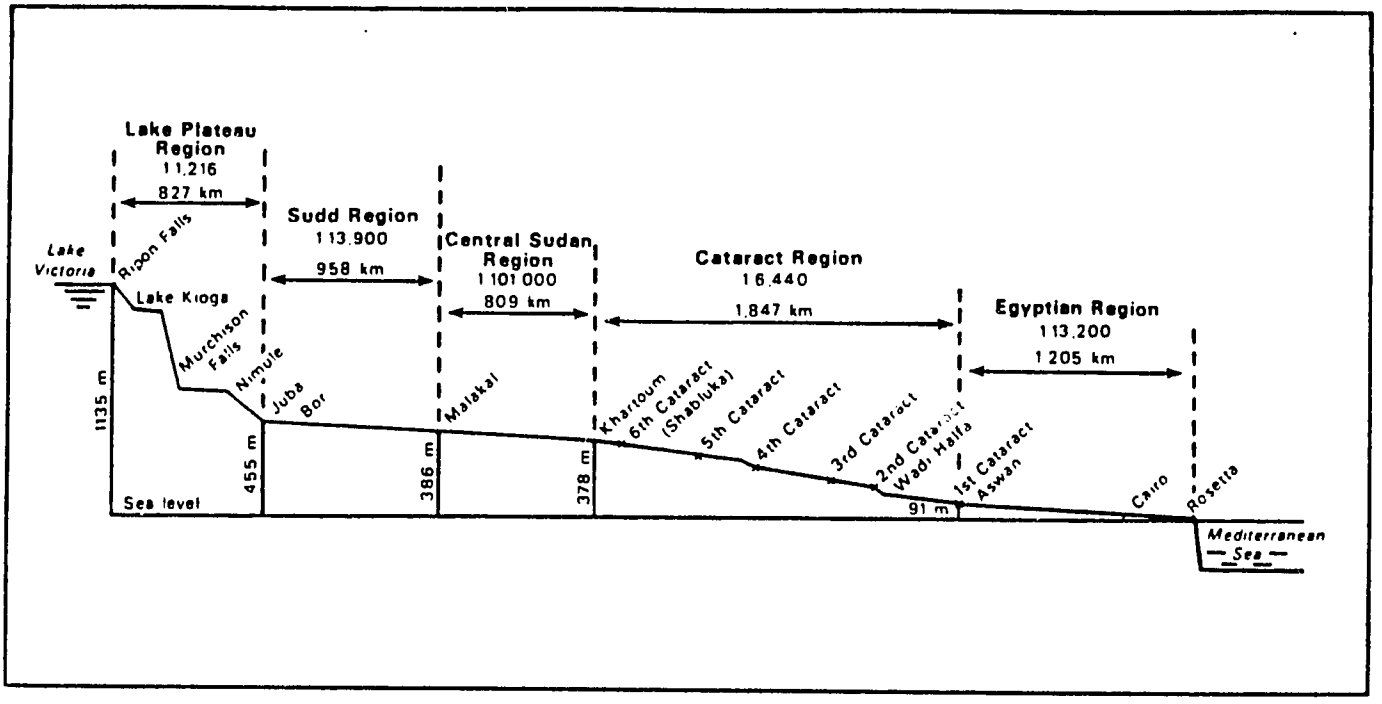

Figure 3.4a. Slope of the Nile from Lake Victoria to the Mediterranean

Source: Waterbury. 1979.

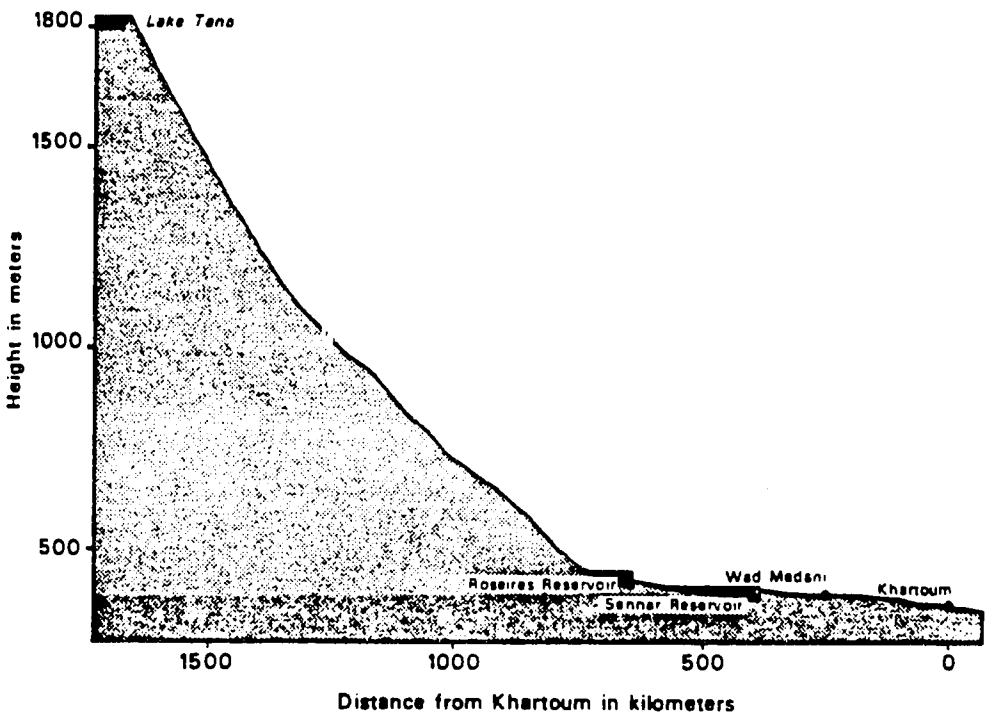

Figure 3.4b. Longitudinal Profile of the Blue Nile

Source: Waterbury. 1979.

fluctuates widely from eight million cubic m in April to 66 million cubic m in November. Total water losses to the swamps of southeastern Sudan reach about eight billion cubic m annually.

From the Sobat, the White Nile flows northward and for 800 km receives no additional sources of water. Total annual average flow at the Jebel Aulia Dam, just south of Khartoum, is 30.9 billion cubic m. Flow ranges from 54 million cubic m per day in April to 114 million cubic m per day in November.

At Khartoum the Blue Nile joins the river, which afterwards is known simply as the Nile. The principal source of the Blue Nile is Lake Tana in Ethiopia, but two other tributaries to the Blue Nile also rise in Ethiopia and flow through Blue Nile Province before joining the river north of Sennar. Annual average discharge of the Dinder is about three billion cubic m, flowing mostly from June to December. The Rahad, which flows mostly from July through November, supplies 1.09 billion cubic m annually. The discharge of the Blue Nile at Khartoum is about 50.7 billion cubic m annually, with flows fluctuating between 11 million cubic m per day in April to 535 million cubic m per day in August.

At Atbara, the Atbara River supplies an additional 12 billion cubic m annually, mostly from June to December. No other significant tributaries enter the Nile, although occasional flash floods in the usually dry wadis may reach the river. Table 3.5 summarizes the water balance of the Nile basin, and Appendix IV contains additional data on the river system in Sudan.

Wadis. A number of seasonal watercourses do not drain to the Nile. Some of the most notable are the Gash, Baraka, and several in Darfur. The Gash rises in Ethiopia, enters Sudan at Kassala, and is lost in the desert north of Kassala. Total annual flow varies between 200 to 800 million cubic m. The Baraka also rises in Ethiopia, but drains to the Red Sea south of Suwakin. Flow estimates are not available, but irrigation utilization suggests that the Baraka flow is similar to that of the Gash.

The Jebel Marra region of Darfur receives from 600 to 1,000 mm rainfall annually, and a number of

Table 3.5. Water Balance of Nile Basin

River	Location	Dr. area	Precipitation	Runoff	Evapotranspiration	Runoff coef.	Water yield	Mean annual discharge
Unit		km^2	mm	mm	mm	%	$l/s/km^2$	m^3/s
Victoria Nile	Ripon Falls	269,000	1302	81	1221	0.06	2.6	699
Semliki	above confluence with Victoria Nile	22,500	1395	88	1307	0.06	2.8	63
Albert Nile	below Albert Lake	281,500	1309	85	1224	0.06	2.7	762
Interbasin	Albert Lake-Mongalla	184,500	1228	20	1208	0.02	0.6	111
White Nile	Mongalla	466,000	1277	60	1217	0.05	1.9	874
Interbasin	Mongalla-Sobat	438,800	900	−38	938	—	−1.2	−511
White Nile	above Sobat	904,800	1094	12	1082	0.01	0.4	362
Sobat	mouth	187,200	1081	71	1010	0.07	2.3	431
White Nile	below Sobat	1092,000	1091	22	1061	0.02	0.7	793
Interbasin	Sobat-Blue Nile	343,000	500	0	500	0.00	0.0	0
White Nile	above Blue Nile	1435,000	710	16	694	0.02	0.5	793
Blue Nile	confluence with W. Nile	324,530	1082	158	924	0.15	5.0	1727
Nile	below confluence with Blue Nile	1759,530	778	43	735	0.06	1.4	2420
Interbasin	confluence-Aswan	79,470	1080	97	983	0.09	3.0	244
Nile	Aswan	1839,000	790	45	745	0.06	1.4	2664
Interbasin	Aswan-mouth	1042,000	7	−18	25	—	−0.6	71
Nile	mouth	2881,000	506	28	479	0.06	0.9	2593

Source: Balek. 1977.

seasonally flowing wadis fan out in all directions from the highlands. Total annual discharge of these wadis has been estimated at 75 million cubic m in the piedmont zone and 255 million cubic m in the lower valleys (Bannage 1980). However, other sources indicate somewhat larger flood flows (FAO-UNDP 1968; Table 3.6).

Other wadis are scattered throughout the country. The government has established gauging stations on 44 of these wadis, and estimates a combined annual flow in these 44 wadis of around 756 million cubic m.

Swamps. 10/ Much of southern Sudan is covered by swamps, usually all grouped together and called the Sudd (Figure 3.5). Balek (1977), however, distinguishes several swamps (Table 3.7), without apparently covering all swampy areas in southern Sudan. He lists Bahr al-Jabal/Bahr al-Ghazal swamp as the largest in Africa. The entire area is flat and featureless, and can be divided into permanent swamp (about 10,000 sq km on the Bahr al-Jabal), seasonally flooded swamp, and some dry ridges rising a few meters above highest flood levels. The water entering the southern swamps is greatly slowed and spread widely, which drastically increases surface evaporation. Water losses by the Bahr al-Jabal average half of the flow entering the Sudd (Table 3.8).

---

[10] Sources: Balek. 1977.
Newhouse. 1939.
Rzoska. 1974.

Table 3.6. Summary of Measured Flood Discharges in Jebel Marra Area

River	Station	Catchment area	1963		1964		1965		1966	
		km²	*10⁶m³*	*mm*	*10⁶m³*	*mm*	*10⁶m³*	*mm*	*10⁶m³*	*mm*
Wadi Toro	Dam site	765	—	—	70	90	21.1	28	9.5	12
Wadi Bala		34	—	—	—	—	1.7	50	1.3	38
Wadi Nyertete	Nyertete	81	—	—	10.7	132	4.2	52	4.2	52
Wadi Golol	Dam site	120	—	—	—	—	6.65	55	5.45	46
Wadi Gendi	Kalckitting	146	—	—	—	—	—	—	3.5	24
Wadi Aribo	[1] Zalingei	1 300	—	—	160	123	77	59	52	40
Wadi Azum	Adjakari	7 385	214	29	240	33	109	15	111	15
Wadi Barei	[1] Murnei	11 650	—	—	227	19.5	102	9	(130)	(11)
Wadi Azum	Dereisa	22 605	—	—	—	—	193	9	286	13
Wadi Debarei	[1] Talanga	2 920	—	—	23	5.9	5.5	1.4	4.8	1.2
Wadi Saleh	[1] Anjikotti	2 800	—	—	(250)	89	70	25	44	16

NOTE: Figures in parentheses are provisional estimates. [1] Stations with float measurements only; results are very approximate.

Source: FAO-UNDP. 1968.

Table 3.7. Area of Main Swamps

Swamp	Area (km^2)
Bahr al-Jabal/ Bahr al-Ghazal	64,000
Kenamuke/ Kabonen	13.955
Lotagipi (partially in Kenya)	12,937
Albert Nile Swamp	5,200
(area east of Malakal not noted)	

Source: Balek. 1977.

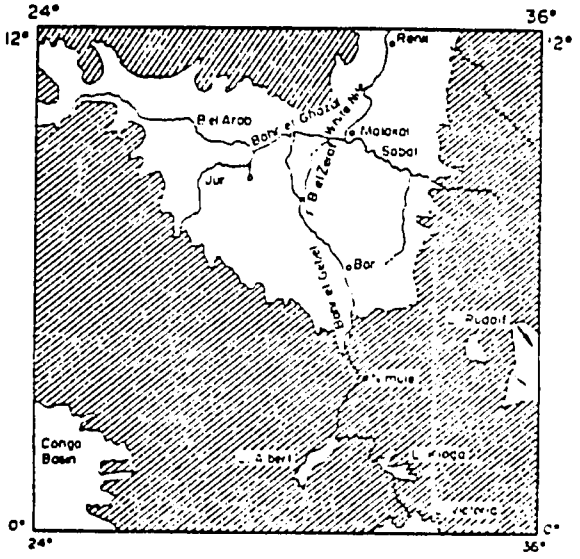

Figure 3.5. Map Showing the Upper Nile Swamp Depression

(Shaded area = above 500 m)

Source: Rzoska. 1974.

Table 3.8. Losses in the Swamps

3 1/2 months' lag

Discharges in billions of cubic meters per annum

(Feb. to Jan. at Mongalla; June to May at Malakal)

Year	Mongalla Discharges	Swamps Discharges	Losses
1905–06	35·9	12·8	23·1
1906–07	39·3	13·7	25·6
1907–08	35·1	13·4	21·7
1908–09	29·6	14·8	14·8
1909–10	31·9	16·3	15·6
1910–11	30·1	14·1	16·0
1911–12	24·8	13·2	11·6
1912–13	23·2	13·4	9·8
1913–14	23·2	13·4	9·8
1914–15	25·9	13·9	12·0
1915–16	27·8	13·2	14·6
1916–17	39·3	16·4	22·9
1917–18	57·7	18·4	39·3
1918–19	44·7	19·6	25·1
1919–20	30·6	16·0	14·6
1920–21	24·9	12·5	12·4
1921–22	16·1	11·1	5·0
1922–23	15·2	10·4	4·8
1923–24	20·1	11·5	8·6
1924–25	20·3	12·9	7·4
1925–26	18·7	12·1	6·6
1926–27	25·8	12·8	13·0
1927–28	25·6	13·2	12·4
1928–29	26·4	13·9	12·5
1929–30	21·1	13·5	7·6
1930–31	23·2	13·5	9·7
1931–32	29·4	14·1	15·3
1932–33	32·9	14·9	18·0
1933–34	30·2	16·2	14·0
1934–35	25·8	15·3	10·5
Mean:	28·50	14·02	14·48

1905–22: Swamp discharge = White Nile at Malakal minus Sobat minus Ghazal.
1923–35: Swamp discharge = Zeraf + White Nile at Abu Tong minus Ghazal.

Source: Newhouse. 1939.

3.2.2 Ground Water 11/

In general, the Nubian Formation is the best aquifer in Sudan. These sandstones contain non-flowing artesian water which is usually of better quality than most other aquifers in the country. Recharge in the west is thought to come from the Ennedi (in Chad) and Darfur highlands. In the east, infiltration from the Nile is mainly responsible for recharge although south of Khartoum soils are too clayey for any significant infiltration. The Umm Ruwaba Formation in the southern half of Sudan also contains significant storage. However, due to poor stratification of the sediments in the Umm Ruwaba, permeable layers are often interspersed with impervious clays. In addition, water quality is often poor. Figure 3.6 indicates water level in Kordofan, which contains both Nubian and Umm Ruwaba Formations.

The Gezira Formation, mostly geologically recent unconsolidated clays, silts, sands, and gravels which overly Nubian sandstone, is the major aquifer of the Gezira. Figures 3.7 and 3.8 show water levels and well yields in the Gezira region. Additional data on groundwater appears in Appendix IV.

3.2.3 Water Quality 12/

Extensive surface water quality data is not readily available, although several government

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[11]Sources: Bannaga. 1980.
el-Boushi. 1972.
FAO-UNDP. 1968.
Ishag. 1965.
Iskander. 1967.
Iskandar. 1972.
Saeed. 1968.
U.N. Dept. of Economic and Social Affairs. 1973.
Whiteman. 1971.

[12]Sources: Bannaga. 1980.
el-Boushi. 1972.
Boutros. 1972.
Buursink. 1971.
Jahn. 1977.
Karkanis. 1966.
Rzoska. 1974.
Saeed. 1968.
Whiteman. 1971.

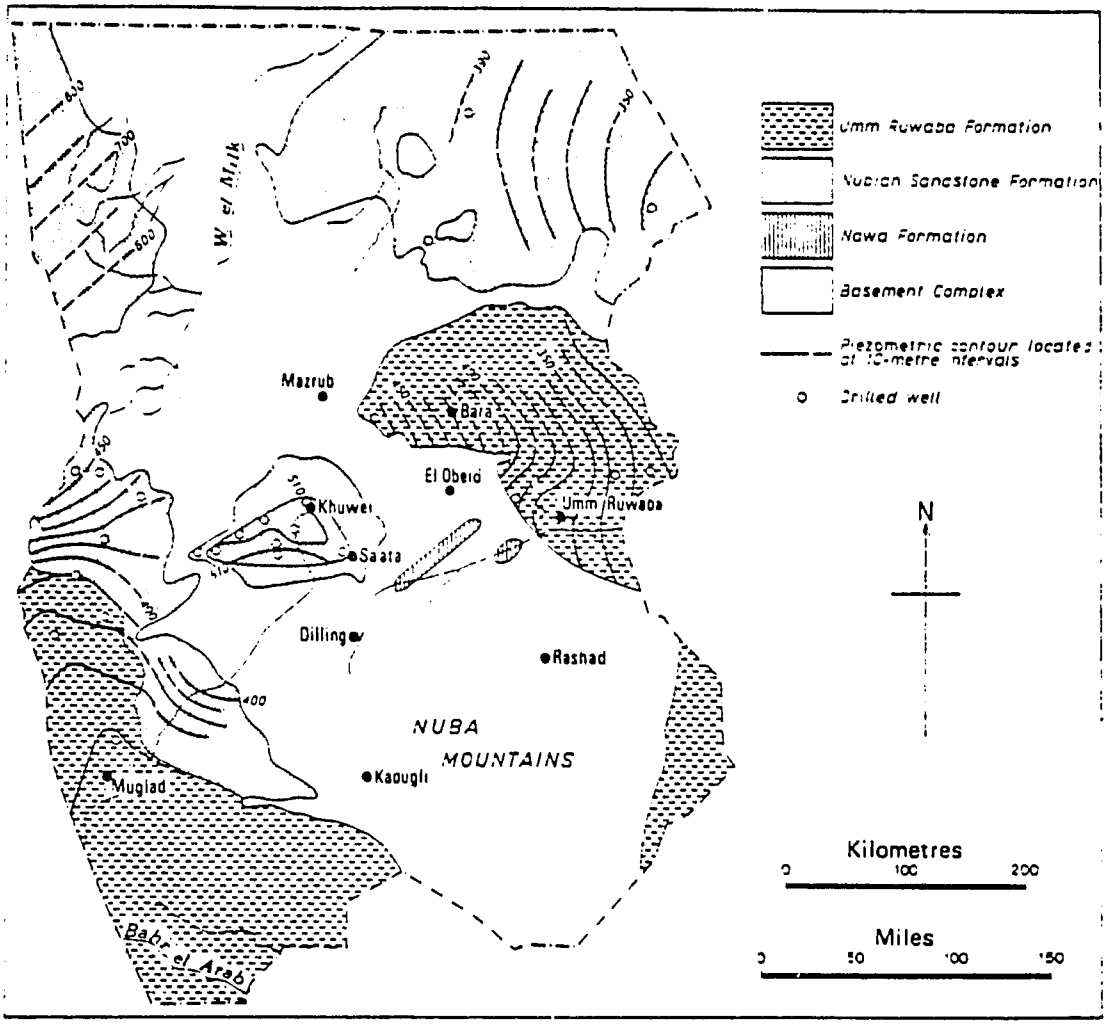

Figure 3.6. Standing Water-Level Contour Map and Formations, Kordofan

Source: Whiteman. 1971.

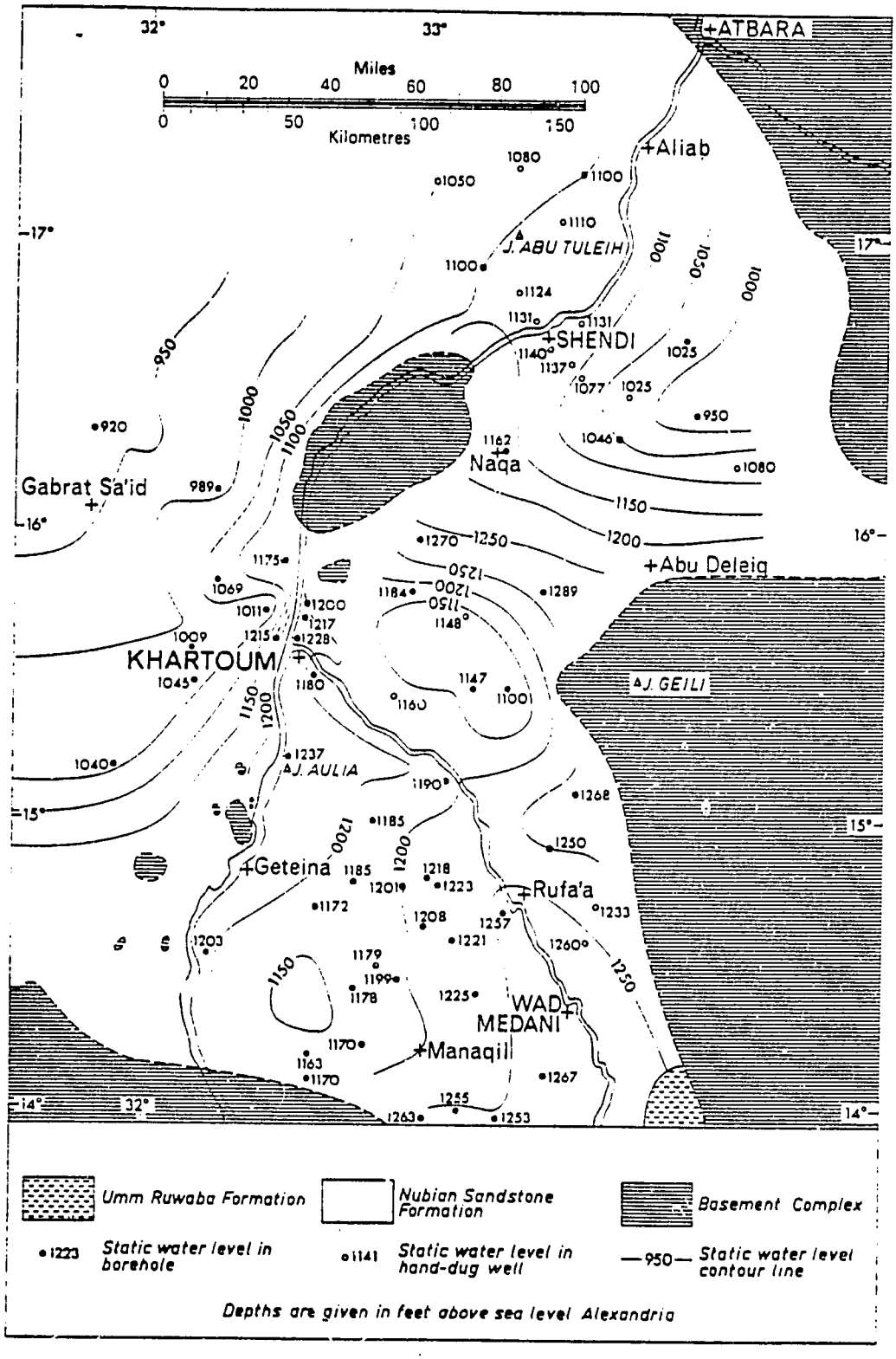

Figure 3.7. Standing Water-Level Contour Map, Gezira-Khartoum-Shendi Region

Source: Whiteman. 1971.

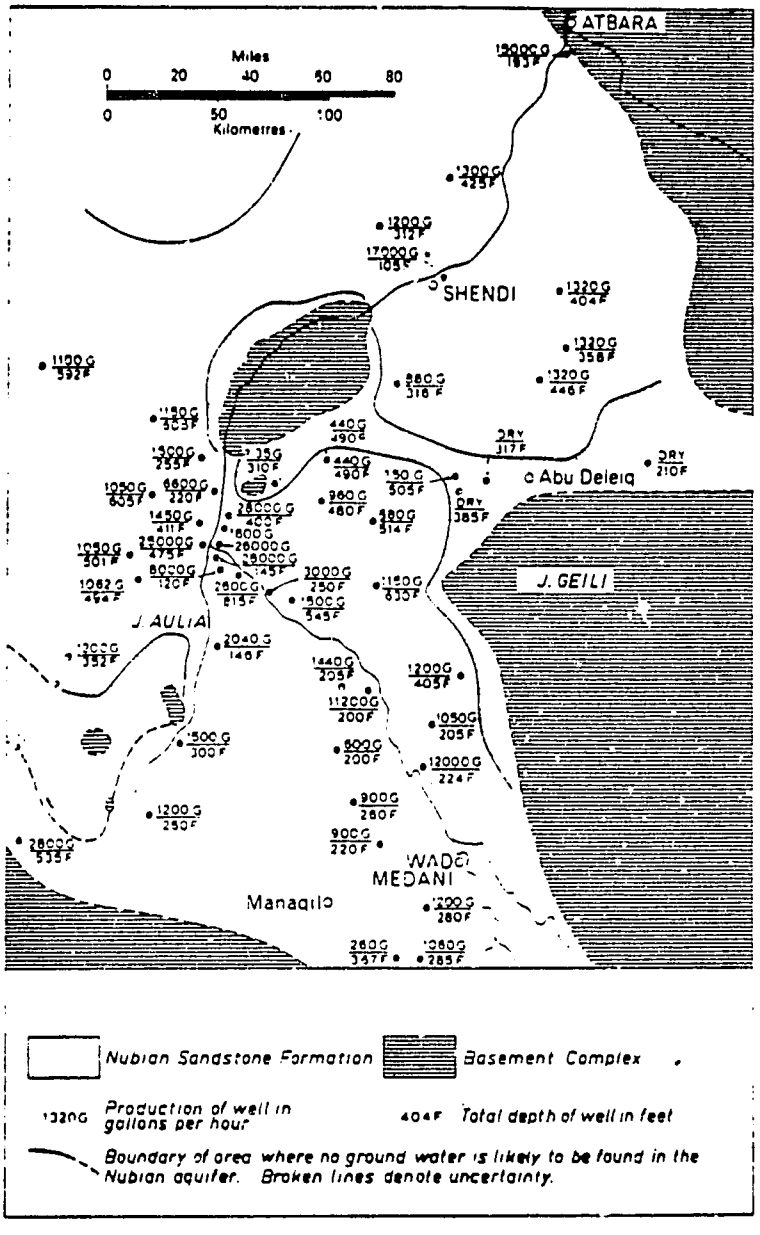

Figure 3.8. Approximate Yields and Total Depth, Nubian Sandstone Formation Wells, Gezira-Khartoum-Shendi Areas

Source: Whiteman. 1971.

agencies sporadically collect data. The suspended sediment load, as well as the dissolved solids, can also vary greatly by season. During the flood season, the Blue Nile in particular becomes extremely brown and turbid. At peak flood in August the river commonly carries as much as 8,000 mg/l in suspended solids, compared to less than 100 mg/l during the dry season. A few measurements have recorded even higher levels (50,800 mg/l in 1974), but these are uncommon. The Gash River in Kassala Province similarly carries a silt load of 8,000 to 16,000 mg/l during peak flood season. Figure 3.9 indicates the fluctuation in silt load carried by the Nile. The annual total is estimated to be around 100 million tons. Dissolved solid load is indicated by Table 3.9. Water quality in the Sudd area is indicated by Table 3.10 and Appendix IV, Table 8.

Groundwater quality is generally best in the Nubian Sandstone aquifers. Soluble salts range from 200 to 500 ppm on the average. Salinity levels in the Umm Ruwaba Formations average 400 to 640 ppm. Figures 3.10, 3.11 and Table 3.11 indicate groundwater quality in Kordofan, the Gezira, and the Gash River Basin, respectively. Appendix IV contains additional water quality data.

3.2.4 Water Use and Management [13]

The vast majority of water used in Sudan is surface water. Little data is available on water usage away from the Nile, but at any rate, the Nile supplies water requirements for a large proportion of the population. Table 3.12 indicates that on the Nile, agricultural demands accounted for 13,692 million cubic m in 1975, compared to only 275 million cubic m for industrial and household use.

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[13] Sources: Allan. 1948.
Bannaga. 1980.
el-Bushra and el-Sammani. 1977.
Jahn. 1977.
Lebon. 1967.
Muller. 1976.
Osman and el-Hag. 1972.
Thimm. 1979.
Simpson. 1970.
Sudan. 1975.
U.S. AID. 1981a.
Waterbury. 1979.

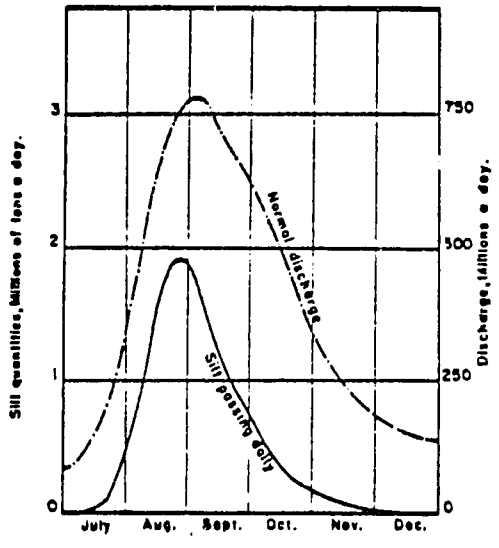

Figure 3.9. Suspended Load of the Nile at Wadi Halfa

Source: Buursink. 1971.

Table 3.9. Chemical Composition of the Dissolved Load of the Nile System

River	Location	Date sampled	Parts per million										Author
			Dissolved solids	Ca	Mg	Na	K	HCO_3	SO_4	Cl	NO_3	SiO_4	
Blue Nile	Wad Medani	1936-37	—	24.4	5.3	9.9	—	—	9.4	—	—	—	Greene H. and Snow O. W., 1939
	Khartoum	1904-07	—	20.2	7.1	7.5	2.0	—	6.3	2.4	—	19.5	Beam W. in: Greene H. and Snow O. W., 1939
	?	?	184	23.8	6	7.1	1.7	108.6	7.3	2.8	0.14	26.7	Livingstone D. A., 1963
White Nile	Khartoum	?	249	17.4	5.2	30.7	11.8	149.2	0.44	8	0.44	25.6	Livingstone D. A., 1963
Nile	Giza	1924-26	—	25.1	7	—	—	102	9	11.6	.003	14.1	Livingstone D. A., 1963
	Cairo	1933-36	167	23	9	20	—	127	10	12	—	21	Hurst H. E., 1952
	Cairo	1957-58	152–181	22–25.3	8–9	15–22	4	55–66	13–14.5	7.5–15.4	—	—	Abdel Bar in: Hasaan F. M. H., 1967

Source: Buursink. 1971.

Table 3.10. Limnological Characteristics of Standing Waters of the Swamp Region

Site area (km²)	Date	Depth (m) approx.	Transparency (m)	Conductivity (μmho/cm)	pH	Alkalinity (10^{-4} N)	Oxygen mg/l	Oxygen Satn (%)	Cl^- (mg/l)	PO_4-P (mg/l)
Shambe lagoon	June 1954	2·2	0·37	—	8·0	31·7	6·0	76	-	0·063
	Feb. 1964		1·10	—	6·95	—	2·62	34	—	—
	May 1964		0·85	—	7·05	—	2·4	33	—	—
Lagoon R.P. 12	Jan. 1949	1·2	—	—	—	—	6·15–8·45	76–108	—	—
0·8	Jan. 1954	1·3	0·28–33	—	8·1–8·3	31·4	8·5–10·2	105–125	14	0·01
Lake No *c.* 30	Jan. 1949	2·0	—	—	7·25	—	6·1–7·15	78–98	—	—
	Dec. 1953		47–55	200	8·4	25·9	8·0	102	10	0·013
	June 1954		—	—	8·2	21·4	7·1	90	—	0·06
	Dec. 1960		—	250	—	—	—	—	—	—
	Feb. 1964		100	—	7·65	—	6·90	89	—	—
	May 1964		95	—	8·0	—	8·14	120	—	—
Lake Ambadi *c.* 15 open water	Jan. 1954	2·5	2·50	40–55	6·4–7·2	25·4	8·0	95	—	—
Khor Perboi 1·0	Jan. 1949	2·2	2·00	—	—	—	1·8–7·15	23–92	—	—
Khor Atar *c.* 5·0	Jan. 1949	3·0	—	—	—	—	6·9	85	—	—
	Feb. 1954		0·25–62	—	8·6	29	11·5	140	6·5	—
	Apr. 1964		0·45	—	8·0	—	6·88	95	—	—

Source: Rzoska. 1974.

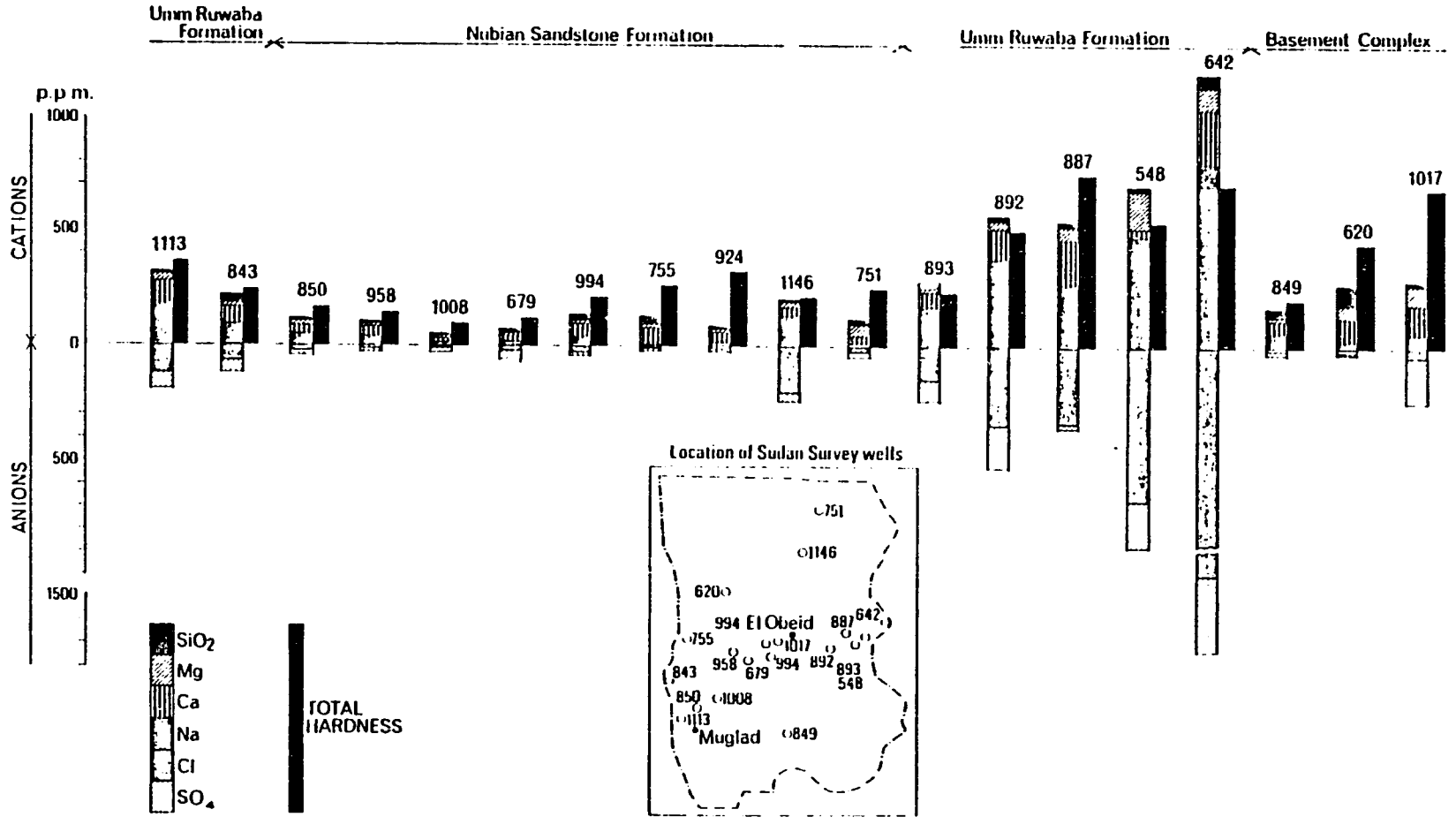

Figure 3.10. Chemical Properties of Groundwater, Kordofan

Source: Whiteman. 1971.

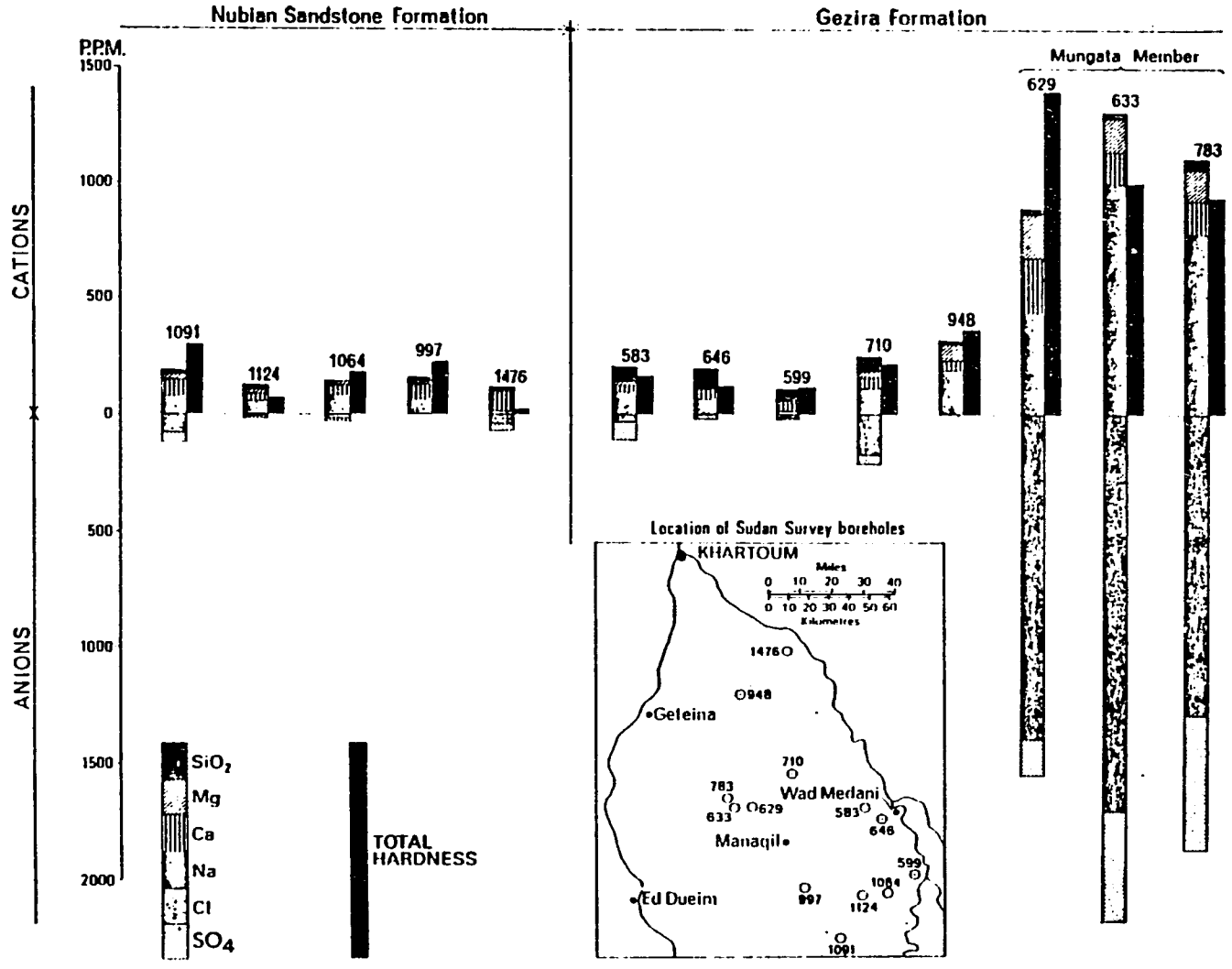

Figure 3.11. Chemical Properties of Groundwater, El-Gezira

Source: Whiteman. 1971.

Table 3.11. Chemical Analyses of Some Groundwater Samples from the Gash Basin

Well No.	Location	pH	Total Dis-solved Solids ppm.	Hardness as $CaCO_3$ ppm.	Calcium Ca^{++} ppm.	Magnesium Mg^{++} ppm.	Sodium Na^{+} ppm.	Silicate as SiO_2 ppm.	Sulphate ppm.	Nitrate ppm.	Chloride ppm.	Fluoride ppm.
277	Police Garage	7.8	228	90	36	20	-	25	25	2.4	25	-
292	Halab Area	7.8	222	100	26	17	-	-	nil	2.7	23	-
497	Gash Board Water Yard	7.5	260	90	36	24	40	35	18	2.0	14	0.24
602	Halab Area	8.3	220	80	20	10	50	30	10	nil	20	0.60
606	Halanga Area	8.0	180	130	35	10	30	-	nil	nil	10	0.50
644	Halab Area	7.6	260	150	40	12	50	40	nil	0.58	20	0.40
1095	Nersery	8.2	220	156	30	20	36	20	10	1.8	12	0.40
1135	Nersery	8.3	196	92	21	10	35	18	10	1.6	10	0.52
1834	Garb El Gash	7.4	220	130	35	10	50	20	50	nil	25	0.64
1836	El Gash East	8.3	200	90	25	10	40	10	35	nil	25	0.32

Source: Saeed. 1968.

Table 3.12. Water Supply and Demand from the Nile, 1975-76 and 1985-86 (bill. m^3)

Supply	1975-76	1985-86
Acquired rights	20.5	20.5
Jonglei, Phase I	—	-2.4
Total	20.5	22.9
Demand		
Agriculture	13.692	27.151
Conveyance loss 10%	1.369	2.715
Household & industrial	275	550
Storage Losses		
Jebel Auliya	1.000	1.000
Sennar/Roseires	.700	1.000 (after heightening of Roseires)
Khashm al-Girba	.190	.190
TOTAL	17.226	32.606
SURPLUS/DEFICIT	+3.274	-9.706

Source: Waterbury. 1978.

Sudan is constrained by its obligations under a 1959 treaty with Egypt to withdraw no more than 18.5 billion cubic m as measured in the flow at Aswan. (This is equivalent to 20.5 billion cubic m measured upstream at Sennar and Malakal.) Because of this, Sudan is expected to run into a deficit by the mid-1980s.

Tables 3.13 and 3.14 indicate total irrigated area and water consumption. Table 3.14 also indicates the major irrigation types in Sudan, and shows that gravity irrigation is most prevalent. The two major gravity irrigation schemes are the Gezira and the Khashm el-Girba (Figure 3.12).

Large scale irrigation began in the Gezira after the completion of the Sennar Dam, although some smaller scale development had taken place earlier. Irrigation expansion was rapid and the ceiling on water use under a 1929 agreement with Egypt was soon reached. The 1959 treaty increased Sudan's share of Nile waters however, and the Managil extension was added to the Gezira scheme. The Khashm el-Gibra scheme on the Atbara was conceived earlier, but the dam was actually completed in 1964. Many nomads were settled on the newly reclaimed land, but the emphasis was resettlement of people displaced in the Wadi Halfa region by the creation of Lake Nasser.

Pump irrigation schemes refer primarily to water pumped from the Nile system. No single pump scheme approaches the major gravity irrigation projects in area, but in aggregate pump irrigation accounts for about one third of Sudan's irrigated area. Flush irrigation (sometimes called spate irrigation in other regions) is practiced primarily on the Gash River and in the Tokar delta of the Baraka River. The annual flood waters are diverted to fields, which receive only one heavy watering. The contribution to Sudan's total irrigated area is only 2.6 percent, but it is practically the only irrigation method in many local areas.

Basin irrigation is practiced primarily in the northern reaches of the Sudanese Nile. When the annual flood arrives, water is channeled to the fields. It remains standing on the fields until the river level begins to fall, and is then drained. Two traditional water lifting devices are also still used in many areas along the Nile

Table 3.13. Irrigated Crop Production Schemes in the Nile System

Sector	Area 1000 feddans	Water consumption millions m^3
Blue Nile		
Downstream Sennar	164	976
Gezira-Managil	2,052	7,598
Pump Schemes Upstream Sennar	452	1,595
Rahad, Phase I*	300	1,139
Evaporation, Sennar Reservoir		669
White Nile		
Pump Schemes incl. Melut Asalaya, Kenana*	620	2,840
Main Nile		
Pump Schemes, downstream Khartoum	420	1,603
Atbara		
Khashm al-Girba	372	1,700
Evaporation Khashm al-Girba Reservoir		139
TOTAL	4,380	18,259

*Projects still partially under execution. Note that no estimates are made for storage losses at Jebel Auliya and Roseires Reservoirs.

Source: Waterbury. 1979.

Table 3.14. Existing Irrigation Schemes

Irrigation method	Schemes	Net commanded area (feddans)	% of Total	Source of water
Gravity	Gezira	1,114,000	26.5	Blue Nile
	Managil	946,000	22.5	Blue Nile
	Rahad (stage 1)	150,000	3.6	Blue Nile
	New Halfa	390,000	9.2	Atbarah
	Sub-total	2,600,000	61.8	
Pump	Kenana	40,000	1.0	White Nile
	Hagar Asalaya	18,000	0.4	White Nile
	Abu Na'ama	30,000	0.7	Blue Nile
	Es Suki	85,000	2.0	Blue Nile
	NW Sennar	49,000	1.2	Blue Nile
	Hurga-Nurel Din	22,000	0.5	Blue Nile
	Guneid	85,000	2.0	Blue Nile
	Nationalized schemes	435,000	10.3	White Nile
	(805,000 f)	270,000	6.4	Blue Nile
		100,000 1/	2.3	Main Nile
	Private schemes 2/	63,000	1.5	Blue Nile
	Private schemes	235,000	5.6	Main Nile
	Sub-total	1,432,000	34.0	
Flush	Gash delta	50,000	1.2	Gash R.
	Tokar delta	60,000	1.4	Baraka R.
	Sub-total	110,000	2.6	
Basin	North. Prov. Sch.	50,000	1.2	Main Nile
Tubewell	Sag el Na'am	3,000	0.1	Groundwater
	Private schemes	15,000	0.3	Groundwater
	Sub-total	18,000	0.4	
Grand Total		4,165,000		

1/ 35,000 f. were already Government schemes.
2/ Uncertain, estimate given (+ or - 5%).
3/ Estimate (+ or - 20%).

Source: U.S. AID. 1980a

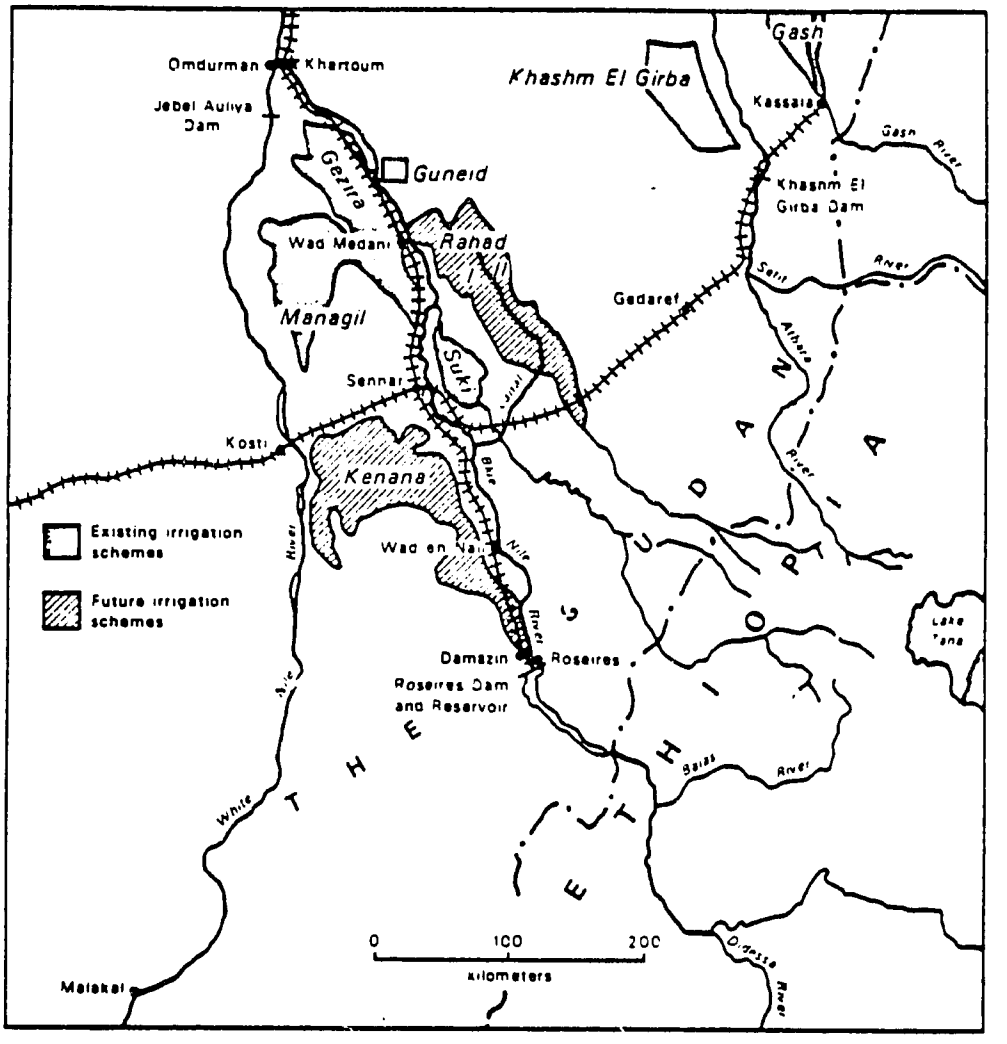

Figure 3.12. Major Irrigation Schemes

Source: Waterbury. 1979.

(Table 3.15). The saqiya, a water wheel, and shadouf, a long lifting pole with a bag or petrol tin on the end, are also occasionally used to lift groundwater. Tubewells have also become important in many parts of western Sudan.

Rural domestic water requirements are estimated in Table 3.16. Nile water is used near the river, and villagers have several traditional methods of purification (cf Jahn 1977). Away from the Nile system, some 800 small catchment ponds had been constructed and 4,000 wells sunk by the mid to late 1970s. Urban water use is noted in Table 3.17. Most urban areas, except for Khartoum, do not have any extensive water system, and conditions are similar to those in rural areas. There is very little industry in Sudan, but even what exists has been constrained by the lack of a water delivery system.

Sudan's major water development efforts are partially directed toward building a network of dams, both to store irrigation water and to provide hydroelectric power. Major current and planned dams are indicated in Table 3.18. Other smaller dams are also planned in a number of areas on the upper Nile. A second focus of water development is the construction of major canals through the Sudd. It is anticipated that faster passage through the swamps and less spreading will greatly reduce evaporation. The current Jonglei Canal (Figure 3.13) is expected to provide a net water benefit to Sudan of about 2.4 billion cubic m when completed. The proposed Machar scheme (the Machar swamps are just north of the Sobat) would provide Sudan with another 2.0 billion cubic m annually.

3.3 Soils and Agricultural Land Use

3.3.1 Soils [14]

The UNESCO-FAO soil map includes Sudan on its Africa sheets (UNESCO-FAO 1977). Nearly 100

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[14] Sources: Buursink. 1971.
FAO-UNDP. 1968.
Greene. 1948.
el-Tom. 1970.
UNESCO-FAO. 1977.

Table 3.15. Shadouf and Saqiya Outputs

Shadouf	Cubic metres per hour	Remarks
One man	3	The maximum lift for one Shadouf is about 2.5 metres.
Two men	5	
High-lift Sagia		
Lift 6 - 8 metres	9	The draught animals for both type of sagia may be either camels or bulls (oxen).
Lift 4 - 6 metres	12	
Lift 2 - 4 metres	15	
Lift 1 - 2 metres	24	
Low-lift Sagia		
One draft animal	40	The lift does not in practice much exceed 1.5 metres.
Two draft animals	80	

Source: Osman and el-Hag. 1972.

Table 3.16. Minimum Annual Water Requirements for Human and Animal Populations in Rural Areas, 1975

Kind	Daily requirements in gallons per head	Annual requirements in m^3 per head	Total population in millions	Total annual water requirements in million m^3
Humans	4	7.2	12	86.4
Camels	2	3.6	3.6	13.0
Cattle	6	10.8	13.3	144.6
Donkeys, horses & mules	4	7.2	2.5	18.0
Sheep	2	3.6	12.2	44.2
Goats	2	3.6	8.0	28.8
Total				335.0

Source: el-Bushra and el-Sammani. 1977.

Table 3.17. Water Consumption in Selected Towns, 1974-75

Town	Population size	Rank	Consumption of water in m^3 per day	Consumption of water in liters per head per day
Khartoum	350,000	1	76,500	219
Omdurman	300,000	2	35,500	118
Kh. North	150,000	3	22,500	150
P. Sudan	135,000	4	15,000	111
Wad Medani	112,000	5	13,000	116
Kassala	100,000	6	6,000	60
El-Obeid	92,000	7	6,000	65
Kosti	67,000	8	8,000	119
El Gedaref	66,000	9	5,000	76
Atbara	64,000	10	12,000	188
Nyala	63,000	11	4,000	63
Juba	57,000	12	6,000	105
El-Fasher	55,000	13	4,000	73
Wau	53,000	14	4,500	85
El-Geneina	39,000	15	750	19
Malakal	37,000	16	2,800	76
Sennar	33,000	17	4,500	136
En Nahud	28,000	18	1,060	38
Ed Dueim	27,000	19	4,500	167
New Halfa	24,000	20	4,500	188

Source: el-Bushra and el-Sammani. 1977.

Table 3.18 Major Dams

Site	Completed	Area km^2	Capacity 10^9 m^3	Hydroelectric capacity MW		
				Installed	Short term	Long term
Blue Nile						
Roseiris Dam	1966	290	3.0	90	120	
Sennar Dam	1925	160	.9	15	15	
White Nile						
Jebel Aulia Dam	1937	600	3.5		25	
Bahral Jabal						
Nimuli-Juba Reach	P*				100	400
Main Nile						
Sabaloka Gorge	P				107	
Fifth Cataract	P					250
Fourth Cataract	P					250
Dal and Third Cataract	P					200
Atbara						
Khashm el-Gibra Dam	1966	150	1.2	13		
Upper Atbara	P				20	

*P = Planned

Sources: Bannaga. 1980.
Waterbury. 1979.

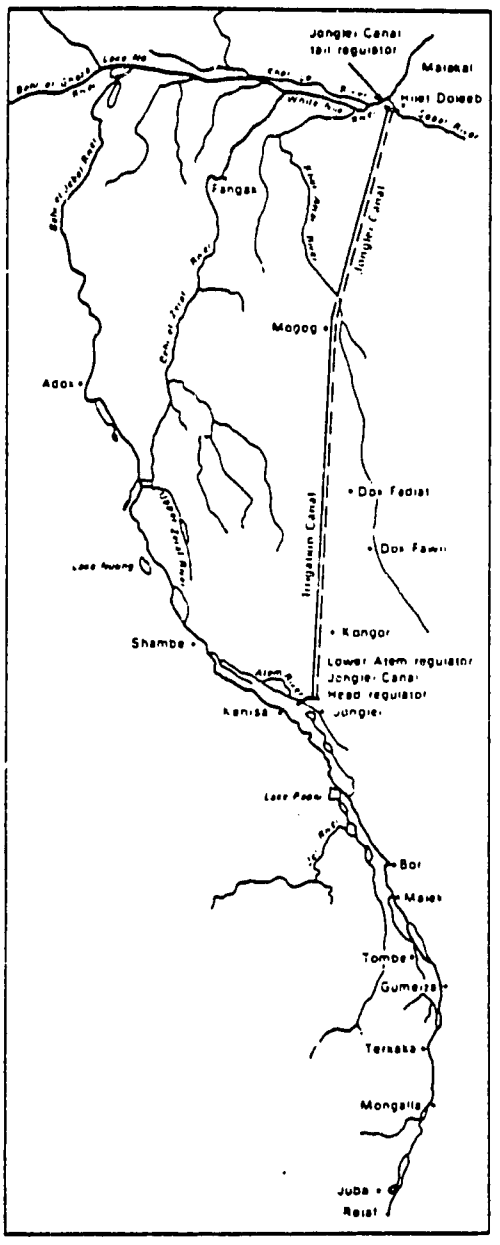

Figure 3.13. Jonglei Canal

Source: Waterbury. 1979.

categories are distinguished within Sudan, which may be broken down into the following broad categories:

Yermosols cover vast areas of the Libyan and Nubian Deserts in the north (Figure 3.14, Table 3.19). Such soils are usually not suitable for either traditional or modern agriculture. Neither are they particularly productive for livestock pastures. Even when water can be made available, agricultural development is limited by stony, lithic, or petrocalcic soils, salt crusts, and the presence of shifting dunes.

Lithosols in various associations are found along the southern fringes of the Libyan Desert, throughout the Jebel Marra and Jebel Nuba areas, and in the Red Sea Hills. Agricultural potential is also very limited because of dissected topography with steep slopes, and by the rockiness and stoniness of the substratum.

Regosols are found scattered throughout Sudan. Eutric regosols occur in and on the fringes of the Libyan Desert, in a bank along the west bank of the central Nile, and in the southern Red Sea Hills and fringes of the Ethiopian highlands. They are also the most common associate with lithosols. Eutric regosols are generally not suitable for agriculture, but do usually produce sufficient pasture to serve as winter ranges for nomadic herds, except in extremely arid areas. Dystric regosols, found in the Bahr al-Ghazal region, are extremely acid, but can sometimes support a few crops such as cassava.

Xerosols occur in a band across Sudan south of the northern deserts. Although occasionally used for growing a few cereal crops, in most cases they are utilized as grazing land. Xerosols with deep profiles and medium texture (uncommon in Sudan) can be developed with irrigation, but usually the soils contain impermeable petrocalcic or argillic B horizons that prevent drainage.

Arensols are found throughout west central Sudan in the provinces of Darfur and Kardofan. All are subclassified as either cambic or luvic, and generally occur in level or undulating terrain. These arenosols are generally poor in organic carbon, nitrogen, exchangeable bases and P_2O_5, and are rarely utilized for cultivation, except where

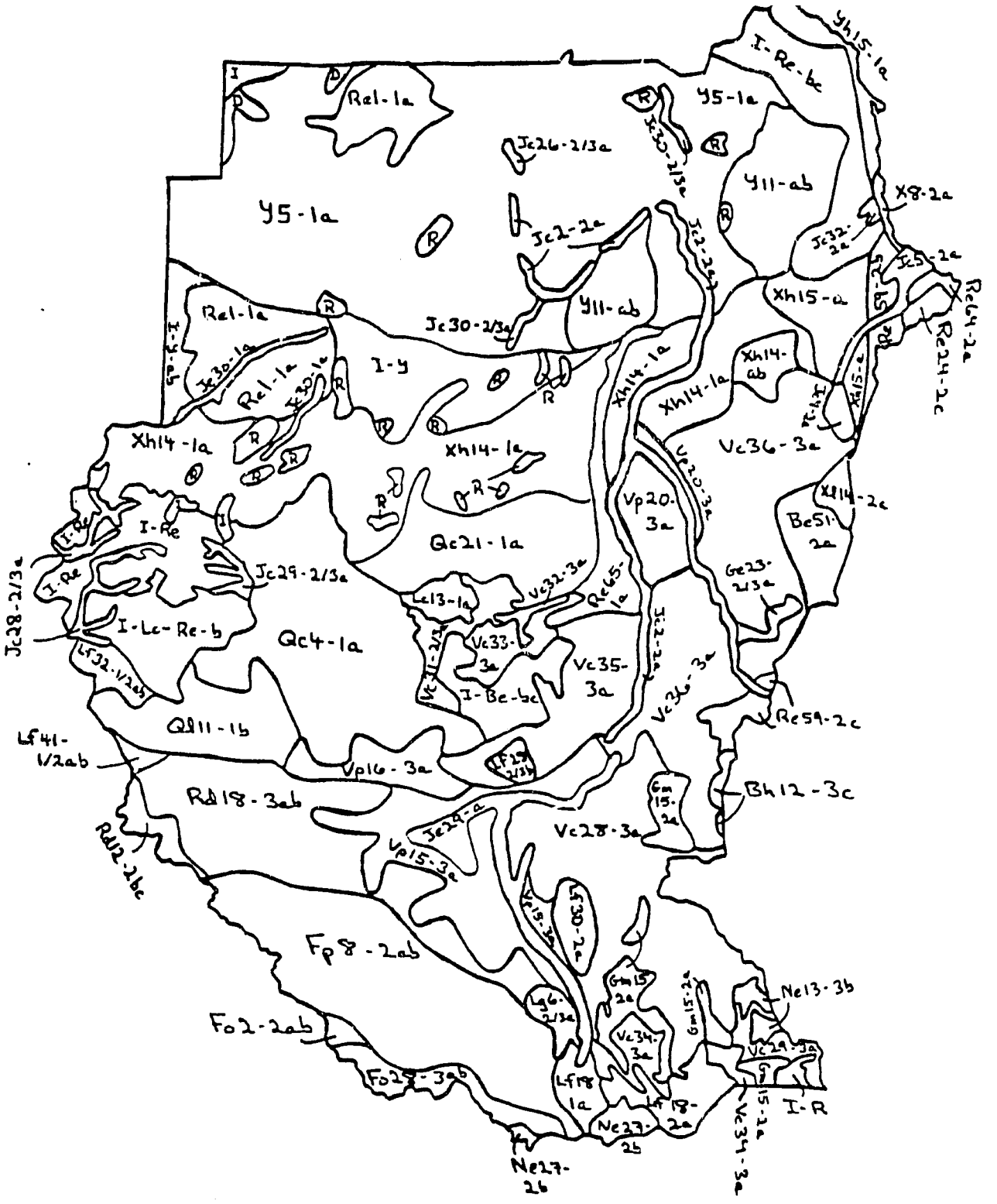

Figure 3.14. Soils

See Table 3.19 for key.

Source: Adapted from UNESCO-FAO. 1977.

Table 3.19 Soils in Sudan

	Associated soils (>20%)	Inclusions (<20%)	Phase	Approx. Area in Sudan (1,000 ha)	Region
Bc8-2b*	Be, I			139	Jebel Marra
Bc9-2b*	Vc			160	Jebel Marra
Bd31-2c*		Bh	Lithic	61	Southern Red Sea Hills
Be9-3c*	Lc	Vp		54	Southern Ethiopian border
Be45-2a*	Th			173	Jebel Marra
Be51-2a	Bc, Vc	Xk, Zo, Jc		1,961	Ethiopian border north of Blue Nile
Bh12-3c	Ao	Jd	Lithic	211	Ethiopian border north of Sobat R.
Fo2-2ab	Qf		Petric	340	Southwest border
Fo28-3ab	Gd			1,723	Southern border
Fo48-2ab*	Fp	Ap, Vc		41	Southern border
Fo50-2a*		Ap, Vp		14	Southern border
Fp8-2ab	Af, Rd	Gd, I, Jd	Petric	13,436	Western Equitoria
Gd5-2a*	Jd			82	Western Equitoria
Ge23-213a	Gm, Vp			343	Dinder, Rahad Rivers
Gm15-2a	Je, Oe	Ge, Vc		3,194	Southeastern swamps
I				476	Scattered Darfur
I			Rock debris	384	Libyan border
I-Bc-Tv-213bc*				532	Jebel Marra
I-Be-bc				2,515	Jabal Nuba
I-Lc-Re-b			Stony	3,310	Jebel Marra
I-R				269	Southeast border
I-R-bc*			Stony	146	Southern border
I-Rd*				306	Western Darfur
I-Rd-So*				68	Western Darfur
I-Re				3,643	Jebel Marra
I-Re-b*			Stony	48	
I-Re-bc			Rock debris	5,818	Red Sea Hills

Table 3.19 Soils in Sudan (continued)

	Associated soils (20%)	Inclusions (20%)	Phase	Approx. Area in Sudan (1,000 ha)	Region
I-y			Stony/ Shifting sands	5,471	Northern Kordofan
I-y-ab			Stony	411	Libyan Desert
I-y-ab			Shifting sands	890	Libyan Desert
Jc2-2a	Gc	Z		2,573	Nile Valley
Jc4-2a	V			387	Gash R. Basin
Jc5-2a	X	Re, Zo	Saline	741	Tokar Delta
Jc26-2/3a	Gc, Gm		Saline	85	Northern Nile Valley
Jc28-2/3a	Lo, Vc			771	Jebel Marra wadis
Jc29-2/3a	Vc			445	Jebel Marra wadis
Jc30-1a	Vc, Zo			506	Wadis in northern Darfur
Jc30-2/3a	Vc, Zo			252	Wadis in northern desert
Jc32-2a	Zo		Saline	85	Wadis in Red Sea Hills
Je23-a*	Vc			68	Upper Blue Nile
Je29-a	Ge, Gm	Vc		2,613	Southern Nile Valley
Lc13-1a	Qc	Bc, Bv		822	Central Kordofan
Lf18-1a	Re		Petric	1,009	Southern highlands
Lf18-2a	Re		Lithic	1,699	Southern highlands
Lf28-2/3b	Lf, Lg	Bc		496	West of Malakal
Lf30-2a	Lg			1,054	Southern swamps
Lf32-1/2ab		I	Petroferric	901	Western Darfur
Lf41-1/2ab	Lg, I		Petric	316	C.A.R. border
Lg6-2/3a	Lf, Vc	Ge, Oe		758	Just northwest of Juba
Ne13-3b	Vp	Be, I, Lp		534	Southeast border with Ethiopia
Ne27-2b	Nh, Rd	I		833	Southern border

Table 3.19 Soils in Sudan (continued)

	Associated soils (20%)	Inclusions (20%)	Phase	Approx. Area in Sudan (1,000 ha)	Region
Qc4-1a	Ql			14,001	Darfur, Kordofan
Qc15-1a*	Re	S, A		258	Western Darfur
Qc17-1a*	S, Ws			54	Western Darfur
Qc21-1a	Ql, Re	Ge, Lk, So		6,742	Central Kordofan
Q111-1b	Re			2,263	Southern Darfur
Q122-1a*	Lf			173	Southern swamps
Q123-1a*	I, Je			75	Western Darfur
Q124-1a*	Lf	G		2,267	Southern Darfur
Rd12-2bc	Bf, I			792	C.A.R. border
Rd18-3ab	I, Lg	Gd, Jd	Petrolithic	11,061	Bahr al-Gazal, Bahr al-Arab region
Re1-1a				173	Northern Darfur
Re1-1a			Shifting sands	8,217	Northern desert
Re16-b*	Je			3	
Re24-2c	I		Lithic	272	Southern Red Sea Hills
Re59-2b		I, Je	Lithic	1,098	Southern Red Sea Hills
Re59-2c		I, Je	Lithic	785	Ethiopian border near Blue Nile
Re64-2a		Zg, Jt		336	Southern Red Sea Coast
Re65-1a	Qc			2,590	Just west of Central Nile
Vc1-2/3a*				37	Southern Darfur
Vc13-3a*	Bv			65	Western Darfur
Vc14-3a*	Re		Stony	116	Western Darfur
Vc26-3a*		Jc, So, Zo		37	Southeast border
Vc28-3a		Je, Ge, Oe		11,792	Jonglei Prov.
Vc29-3a	Ao		Stony	982	Southeast border
Vc31-2/3a	Lo, So	Lc		1,665	Central Kordofan
Vc32-3a	Ge, Je			197	Central Kordoran
Vc33-3a		Ge		1,533	Jabal Nuba

Table 3.19 Soils in Sudan (continued)

	Associated soils (20%)	Inclusions (20%)	Phase	Approx. Area in Sudan (1,000 ha)	Region
Vc34-3a	Ge	Lf, Re		1,570	Southeastern swamps
Vc35-3a	Be, Vp	Lo		5,128	West of White Nile
Vc36-3a	Vp	X, G		17,229	Between Niles, east of Blue Nile
Vp7-3a*	Ge			136	Western Sudd
Vp10-3a*	Bv			14	Western Darfur
Vp15-3a	Oe, Gm	Je		6,800	Sudd
Vp16-31	Qc, Re			2,039	Western Sudd
Vp20-3a	Vc		Sodic	2,736	Gezira
Vp24-2a*	Ws			258	Northern Darfur
X8-2a	Re, Zo			204	Red Sea Hills
Xh14-ab	Re	Vc, Yt	Shifting sands	1,067	Atbara River
Xh14-1a	Re	Vc, Yt	Stony	21,242	Band across country north of Khartoum
Xh15-a	Jc, Xk		Stony	3,028	West of Red Sea Hills
X114-2a	Vc			591	South of Kassala
Y5-1a	I, Re		Stony	45,468	Northern deserts
Y11-ab	I, J	R, Yy, Z	Stony	7,850	Northern deserts
Yh15-1a	Re, Yk		Saline	1,227	Red Sea Coast
Rock debris or desert detritus				2,844	Scattered in north
Dunes or shifting sands				408	Northern borders

Textural Class	Slope Class
1 coarse	a level to gently undulating
2 medium	b rolling to hilly
3 fine	c strongly dissected to mountainous

Note on interpretation: In the example Lf41-1/2ab (on the C.A.R. border) Lf refers to soil type Ferric Luvisol. The number immediately following the soil type (41) is an arbitrary classification for tabulation purposes on the UNESCO-FAO map. It aids in looking up associated soils and inclusions. Numbers following the hyphen (1/2) refer to textural class (coarse to medium). Small letters at the end (ab) refer to slope class.

Interpretations of Symbols

Soil Types

A	Acrisols
Af	Ferric Acrisols
Ao	Orthic Acrisols
Ap	Plinthic Acrisols
Bc	Chromic Cambisol
Bd	Dystric Cambisols
Be	Eutric Cambisols
Bf	Ferralic Cambisols
Bh	Humic Cambisols
Bv	Vertic Cambisols
D	Dunes or Shifting Sands
Fo	Orthic Ferralsols
Fp	Plinthic Ferralsols
G	Gleysols
Gc	not defined in source
Gd	Dystric Gleysols
Ge	Eutric Gleysols
Gm	Millic Gleysols
I	Lithosols
J	Fluvisols
Jc	Calcaric Fluvisols
Jd	Dystric Fluvisols
Je	Eutric Fluvisols
Jt	Thikonic Fluvisols
Lc	Chromic Luvisols
Lf	Ferric Luvisols
Lg	Gleyic Luvisols
Lk	Calcic Luvisols
Lo	Orthic Luvisols
Lp	Plinthic Luvisols
Ne	Eutric Nitosols
Nh	Humic Nitosols
Oc	not defined in source
Oe	Eutric Histosols
Qc	Cambic Arenosols
Qf	Ferralic Arenosols
Ql	Luvic Arenosols
R (on Figure)	Rock debris or desert detritis
R (on Table)	Regosols
Rd	Dystric Regosols
Re	Eutric Regosols
S	Solonetz
So	Orthic Solonetz
Th	Humic Andosols
Tv	Vitric Andosols
V	Vertisols
Vc	Chromic Vertisols
Vp	Pellic Vertisols
Ws	Solodic Planosols
X	Xerosols
Xh	Haplic Xerosols
Xk	Calcic Xerosols
Xl	Luvic Xerosols
Y	Yermosols
Yh	Haplic Yermosols
Yk	Calcic Yermosols
Yt	Takyric Yermosols
Yy	Gypsic Yermosols
Z	Solonchaks
Zg	Gleyic Solonchaks
Zo	Orthic Solonchaks

they border valleys. They do support savanna vegetation and extensive animal husbandry.

Vertisols are probably the most widespread soils in Sudan, occurring throughout the eastern part of the country south of the northern desert. Vertisols are very heavy and difficult to work by traditional methods, so that they are more often used for livestock raising. With proper attention to drainage however, irrigation development can make vertisols fairly productive.

Fluvisols are found throughout the Nile valley as well as in major wadis throughout the country. With irrigation they are well suited for cultivation. They are well endowed with exchangable bases and with total P_2O_5. The adsorbing complex is sometimes mildly saturated with sodium, but is offset by extensive organic matter. Salinity can become a problem without proper management.

Ferralsols are found in Western Equitoria; subdivided into plinthic and orthic categories. They have low adsorbing complex and are often highly desaturated and possess no mineral reserve. Fertility is limited, and their main use and potential is for grazing.

Gleysols are found in the swamps of southern Sudan, luvisols are found along the southern border and scattered in Kordofan and Darfur. Cambisols occur in the fringes of the Ethiopian highlands along the eastern border, and nitosols in the highlands along the southern border.

Table 3.19 lists all the Sudanese soils which are distinguished by UNESCO-FAO (1977), and soil profiles of some areas may be found in Appendix V.

3.3.2 Agriculture [15]

Nearly 292 million feddans, or almost half of Sudan's surface are classified as suitable for agriculture in Waterbury (1979; Table 3.20). Many other sources give about 200 million feddans as cultivable. Only about eight percent of this cultivable land (less if Waterbury's figures are accepted) is currently utilized for agriculture. About 17 million feddans were under cultivation by 1980. However, because a large proportion of these cultivated lands depend upon rainfall, the amount actually cultivated in any particular year can vary greatly due to fluctuations in precipitation. The 1970 figures in Table 3.20, for example, are taken during a particularly bad year when total acreage had declined. Irrigated acreage does not fluctuate much, but has shown steady increases. By 1980, about 4.5 million feddans were irrigated.

The major crop in Sudan in terms of total production and acreage planted is sorghum (Table 3.21). Sorghum (durra) has traditionally been the country's staple cereal, and most farmers prefer to grow some in order to avoid having to buy it with cash. Irrigated sorghum may typically yield around 430 kg per feddan, but only about 500,000 of the total six million feddans were being irrigated by 1980. Yields of non-irrigated sorghum are not available, but Table 3.22 indicates they may be between 16 and 26 percent of irrigated yields, depending on rainfall.

Wheat has traditionally been grown along the Nile north of Khartoum. Most was under basin flooding,

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[15] Sources: Europa. 1981.
FAO-UNDP. 1968.
Hale. 1966.
Lebon. 1967.
Lee. 1970.
MEED. 1977.
Nelson et al. 1973.
Simpson. 1970.
Thimm. 1979.
Tothill. 1948.
U.S. AID. 1981a.
U.S. AID. 1981b.
Waterbury. 1979.

Table 3.20. Present and Proposed Land Use in the Sudan

(in 1,000 feddans)

Distribution of surface	1970		1985	
	1,000 Feddans	% of total	1,000 Feddans	% of total
Total Surface Area of the Sudan	596,383	100		
Not suited for agriculture;				
total:	304,595	51		
of which water courses	(30,895)			
swamp, desert	(273,700)			
Suitable for agriculture				
total.	291,788	49		
of which forests	(212,335)	(35.7)	(202,594)	(34.1)
permanent pasture	(54,400)	(9.1)	(49,520)	(8.3)
arable land	(25,053)	(4.2)	(39,674)	(6.6)
Arable land breakdown				
Irrigated	3,218	.54	4,438	.7
Nonirrigated	21,835	3.66	35,236	5.9
Area harvested				
Irrigated	2,348	.39	3,548	.6
Nonirrigated	8,734	1.47	15,856	2.65
Cropping intensity				
Total		44%		49%
Irrigated		73		80
Nonirrigated		40		44

Source: Waterbury. 1979.

Table 3.21. Principal Crops

(1,000 metric tons)

	1977	1978	1979
Wheat	301	317	266
Maize	43	46	50*
Millet	515	557	370
Sorghum (Durra)	2,200	2,400	1,070
Rice	9	6	20*
Sugar cane	1,549	1,650*	1,700*
Potatoes	22*	25*	25*
Sweet potatoes	40*	40*	41*
Cassava (Manioc)	115*	110*	110*
Other roots and tubers	113*	115*	113*
Onions	20*	20*	20*
Water melons	85*	85*	85*
Dry beans	3*	3	3*
Dry broad beans	20*	20†	21*
Chick-peas	3*	3*	3*
Other pulses	54*	54*	55*
Oranges and tangerines	44*	45*	45*
Lemons and limes	36*	36*	37*
Grapefruit	53*	53*	53*
Mangoes	61*	61*	61*
Dates	106*	110*	110*
Bananas	83*	83*	83*
Groundnuts (in shell)	1,000†	830	1,110†
Seed cotton	392	643†	361†
Cottonseed	256	420	230†
Cotton lint	136	223	131†
Sesame seed	245	226	210†
Castor beans	7	10*	10*
Tomatoes	143*	145*	145*
Pumpkins, etc.	57*	58*	58*
Aubergines	76*	76*	76*
Melons	10*	10*	10*

* FAO estimate. † Unofficial estimate.

Source: Europa. 1981.

Table 3.22. Trends in Total Area, Production and Yield of Main Crops

	Total Area (1000 feddans)	Total Production (1000 metric tons)	Average Yields (kg/feddan)
Rainfed			
1965/66-1969/70 (5 yr. average)	6,729	1,731	257
1972-73	10,498	1,948	186
1973-74	11,064	2,135	193
1974-75 (est)	11,563	2,856	247
Irrigated			
1965/66-1969/70	1,685	1,657	983
1972-73	1,994	2,385	1,196
1973-74	2,210	2,565	1,161
1974-75 (est)	2,480	3,165	1,276
Flooded			
1965/66-1969/70	123	46	374
1972-73	149	54	362
1973-74	144	45	312
1974-75 (est)	181	55	303

Source: adapted from Waterbury. 1979.

but pumps have been increasingly utilized. Consumption patterns have been changing in favor of wheat, and it is now also an important commercial crop, particularly in the Gezira and Khashm al-Girba schemes. Yields have generally been fairly low; averages have varied between 400 to 650 kg/feddan over the past decade, except in irrigated areas.

Cotton is the most important crop from an economic viewpoint. Sudan produces three types of cotton. Most important is long staple cotton, which accounted for about 70 percent of total acreage up to 1974/75. Long staple cotton is grown mainly in government irrigation schemes in the Gezira (about 75% of production), and in the Gash and Tokar delta areas. Short staple cotton accounted for about 12 percent of cotton production, and medium staple (which is often classified with short staple) for about 18 percent. These are occasionally grown on pump schemes along the Nile, but usually are found on rainfed land in Kordofan and the Equitoria area. Much is consumed locally rather than exported. Total acreage was about 1.2 million feddans until 1975, but fell to about one million afterwards, as policies stressing more food production were implemented. Within the last few years, however, there has been renewed interest in increasing production again.

Groundnuts are nearly all grown on rainfed land, although the small proportion of irrigated groundnut area (500,000 feddans) accounts for about one-fourth of production. About two-thirds of production is exported.

Sugar has also become important. In 1981 Sudan officially opened one of the world's largest sugar processing complexes, and was planning several smaller plants which should be already operating. The government hopes eventually to completely supply through domestic production the 400,000 ton annual demand for sugar. Sugar cane is primarily grown in the Gezira area on government irrigation schemes.

Traditional Agriculture. According to Nelson et al. (1973), who are followed here, cultivation techniques in Sudan vary widely according to differences in physical environment and culture.

Along the Nile in the north, where modern irrigation development is more limited, the old

traditional forms of irrigation survive. Most of the cultivated land along the river is perennially irrigated, either by natural flood, by diesel pumps, or by shaduf or saqiyya irrigation. North of 14° N cultivation is generally impossible without irrigation of some kind. Unlike the perennially irrigated land farther south, however, the irrigated land in the desert Nile economy was producing chiefly for subsistence rather than for commercial use in the 1960s.

The area most readily irrigated by traditional shaduf or saqiyya is the alluvium terrace, or natural level, at the river edge. As the longest cultivated and most valuable land, ownership has been greatly fragmented through Islamic inheritance law, and is now subdivided into minute holdings. Alluvial terrace that is well above the level of the highest floods was formerly beyond reach of irrigation but can now be irrigated by means of diesel pumps. Pump projects have proliferated along the desert Nile region since the 1950s, and more are planned. Slightly lower alluvial areas, or basins, are divided into much larger units of holding and cultivation than the older saqiyya lands and usually have but one crop a year, whereas the saqiyya lands have an elaborate succession of crops. Some alluvial land also forms part of the Nile channel but is exposed during the low-water season; this is known as seluka land.

Date palms are very numerous along the Nile in this region, declining in number and date yield toward the south. However, they are so little cared for by the inhabitants as scarcely to qualify as a cultivated crop. The doum palm also springs up naturally on the cultivated lands in this region and is used both in subsistence and in commerce. The nuts are used for carving buttons and other ivory substitutes, and leaves and trunks are used for matting and building.

For the most part, traditional cultivation is rain-fed cultivation. Before the inauguration of large-scale cotton growing, much of the grain was produced in the Gezira area. Since the 1940s, however, most of the country's food crops are grown away from the Nile by rain-fed cultivation. Rain cropping without irrigation is generally most important south of about 14° N.

The traditional forms of rain-fed cultivation are practiced largely in the central clay plains, the goz regions, the Ironstone Plateau, and the flood plain (Figure 3.15). The flood plain proper is used chiefly for grazing after the waters retreat; but there are villages of sedentary cultivators on higher ground in parts of the southern clay plains. Shifting cultivation, in the sense of shifting village location, is for the most part practiced only in the southern provinces. Even there, a village is abandoned only after all the surrounding fields have been exhausted, perhaps after ten or twenty years. The predominant form of sedentary land use in the central economic region is that of rotating fields within walking distance of the permanent village, use of a field being resumed after the land has rested for several years.

The principal crops in the central economic regions are the drought-resistant durra sorghum and dukhn, or bulrush millet, along with sesame and beans. Maize is grown where sufficient moisture is available. In the southern provinces eleusine millet and cassava are also commonly grown, and the climate and soils permit a far greater variety of supplementary crops. Within the central regions the Nuba Hills and the Jabal Marrah, with their silt-depositing streams and more varied temperatures, form separate economies with a greater range of crops, including some temperate-zone crops.

The chief granary of the country in the early 1960s was the eastern portion of the central clay plains. Settlement here, as in the goz sands, tends to be more dense along the railway line, which coincides roughly with the area of higher rainfall. Cultivated land has been expanded in this area by the promotion of rainland mechanization projects, but traditional cultivation has also been assisted by the excavation of reservoirs by the government. The prevalent land-use system is rotation with unimproved grazing, and hariq (the burning of grassland for cultivation) is widely practiced.

Hariq cultivation is practiced extensively in Kordofan, Blue Nile, Kassala, and Upper Nile provinces, in areas of well-watered clays, wherever almost pure stands of certain dense grasses occur. A thick mat of coarse dead grass

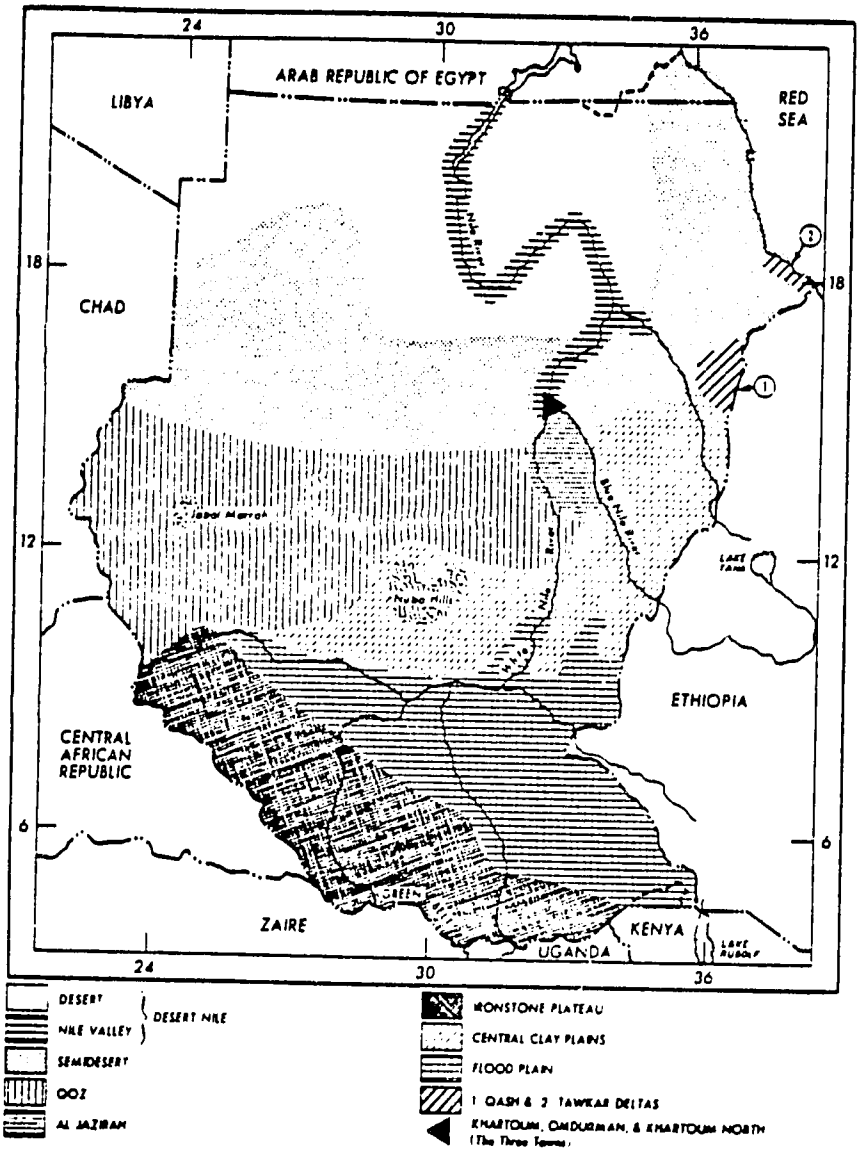

Figure 3.15. Economic Regions of Sudan

Source: Nelson et al. 1973.

is allowed to accumulate for two to four years, protected by fire lanes, and is then fired after the first rains have fallen and the grass seed has germinated. The burning enriches the soil and destroys the young seedlings.

Other distinct cultivation practices prevail among the Nuba and among the Fur of the Jabal Marrah area. A government-sponsored cash-cropping scheme for the growing of cotton has been operating in the Nuba Hills for some years, and an elaborate regional development scheme is under preparation for the Jabal Marrah. The lowland Fur raise durra, dukhn, groundnuts (peanuts), maize (corn), sesame, and bamia (okra) as well as cash crps, such as tobacco, wheat, and barley. The upland Fur have a long tradition of terrace agriculture and practice traditional irrigation from the streams from considerable distances to water their fruit orchards and barley fields. The Nuba also once maintained an extensive system of terrace agriculture on the hills, and are sedentary cultivators by tradition.

Most of the flood-plain economic region is ill suited to cultivation, but the Nilotic inhabitants maintain their permanent cultivating villages from May to October on the areas of high ground or on the edge of the adjoining Ironstone Plateau. The lands are prepared for crop cultivation by cutting and burning the grass during the dry season.

Except along the northern edge, the prevailing form of land use in the Ironstone Plateau economic region is defined as shifting cultivation. This pattern may, however, be merging into simple land rotation in many places, especially where an economy of land abundance has given way to denser population. Along the northern edge of the plateau the Dinka cultivate during the summer months, and the land use is the Nilotic type of land rotation with grazing.

The highest incidence of shifting cultivation is in the western part of Equatoria Province, between Yei and Yambio, an area of closed savanna woodland. It is also practiced in the western part of Bahr al-Ghazal Province, which is very sparsely populated.

The stable crop in most of the area is durra sorghum, but an indication of the potential for

diversification offered by the climate and soil is suggested by a partial list of other crops: eleusine millet, cassava, maize, groundnuts, sesame, sweet potatoes, pulses, dukhn, cotton, tobacco, cucurbits, chilies, mangoes, bananas, yams, papaya, tomatoes, pineapples, rice, coffee, castor beans, and shea nuts.

Commercial agriculture has largely been developed through government efforts in public projects, and has been more or less synonymous with irrigation development and cotton growing. Since the 1960s increasing areas or rotation periods of other crops--notable groundnuts and other oilseeds, but also cane sugar and forage crops--have been added to the major improvement schemes, and allotments of acreage for food grains such as durra have always been used to attract tenants. Groundnuts are the most profitable of the alternative crops and provide the advantage of leguminous rotation with cotton to restore soils. Both existing and proposed areas of irrigated agriculture, however, are often reserved for cotton since it is the most profitable exportable cash crop.

The Gash and Tokar desert deltas were the first areas in the country to be exploited for systematic growing of a commercial cotton crop. The idea was introduced and flood control canals on the Gash River were built between 1924 and 1926. The Baraka River at the Tokar delta has never been harnessed by definite channels and regulators, as it is judged that the local duststorms would make maintenance too costly; natural flood irrigation continues to be used there. Gash and Tokar consist of intermittently cultivated, flush-irrigated cropland, in contrast to the perennially cultivated, gravity-irrigated cropland of the Gezira and associated schemes.

The extensive tableland of the Gezira slopes gently toward the north and west, permitting natural gravity irrigation from the dam at Sannar. The land is very flat, so that it is easily reached by a small canal system and minor distributory channels; and it consists of cracking clays well suited for irrigation.

Conceived in 1904, with cropping actually beginning in 1925, the Gezira Scheme and its Manaqil extension were still accounting for much of the aggregate output of the modern agricultural

sector by 1970: 60 percent of the cotton and about 50 percent of the wheat. They even accounted for a sizable portion of more traditional crops: 12 percent of the year's output of durra and 30 percent of the lubia crop, for example (lubia is a forage bean).

Private irrigation schemes using diesel pumps began to develop in Khartoum Province in the 1920s, raising crops to supply the Three Towns--Khartoum, Omdurman, and Khartoum North--with dairy products, fruits, and vegetables. The completion of the Jabal al-Awlia Dam in 1937 permitted acceleration of the development of local pump schemes. However, it also caused the annual flooding of a large area of tribal grazing and cultivation land, extending upstream for some 180 miles. The riverine tribes involved had to be compensated by the construction of seven pump schemes known as the alternative livelihood pump schemes, which were financed partly by a payment from the Egyptian government. Although the tribesmen had considerable difficulty in adapting themselves to this enforced change in their way of life, the schemes eventually came to produce large surpluses of cotton and durra.

Schemes were stimulated by the high cotton profits during the worldwide boom in the 1950s; in the five years from 1953 to 1958 the total area under cotton of private estates in Blue Nile and Upper Nile provinces increased from 91,000 feddans to 197,000 feddans.

Sharp drops in cotton prices in 1959 led to the failure of many private schemes and drastic cutbacks in new development. Because of the high rate of failures and for other policy reasons, the government in 1968 decided that it would gradually take over ownership and operation of the private pump-irrigated estates. A new body, the Agricultural Reform Corporation, was created for this purpose. The larger estates were taken over in 1968, and thereafter the private pump schemes along the White Nile were brought under the control of the corporation as their leases expired. In May 1970 the remaining leases were revoked, and the land involved was placed under the corporation. By the time the 1970/71 crop was planted, therefore, the government had assumed a monopolistic position in cotton growing.

Sudan has also pursued the establishment of large mechanized areas throughout the zone where rainfall is sufficient, but particularly in Kordofan and Kassala, where much short staple cotton is grown.

3.4 Vegetation

3.4.1 Native Flora [16]

Detailed discussions of vegetation may be found for various Sudan regions as follows: the Northern Nile valley (Frankenberg 1979); Khartoum Province (Halwagy 1961 and 1962; Obeid and Mahmoud n.d. and 1971; Mahmoud and Obeid 1971); Blue Nile Province (Bunting and Lea 1962) Kordofan and Darfur (Wickens and Collier 1971); and Darfur alone (Wickens 1976). Comprehensive summaries of the whole country may be found in Andrews (1948), and Bari (1968), from whom the following summary is taken.

Vegetation in Sudan may be divided into five main zones (compare Figure 3.16).

Desert Zone (located north of 17° N and excluding the Red Sea Hills): Annual rainfall less than 2 inches (50 mm). No vegetation except for what could be found in Bayuda and Atbai deserts. A few ephemeral herbs and grasses grow after the scanty rain and form the "gizzu".

Semi Desert Zone (located between 14°-17° north, including the Red Sea Hills): The vegetation is made up mainly of annual or perennial grasses and herbs with or without woody vegetation. According to soil types and amount of rain this zone is subdivided into 5 subzones named according to the dominant species in the area or the type of soil.

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[16] Sources: Andrews. 1948.
Bari. 1968.
Bunting and Lea. 1962.
Frankenberg. 1979.
Halwagy. 1961.
Halwagy. 1962.
Mahmoud and Obeid. 1971.
Obeid and Mahmoud. n.d.
Obeid and Mahmoud. 1971.
Wickens. 1976.
Wickens and Collier. 1971.

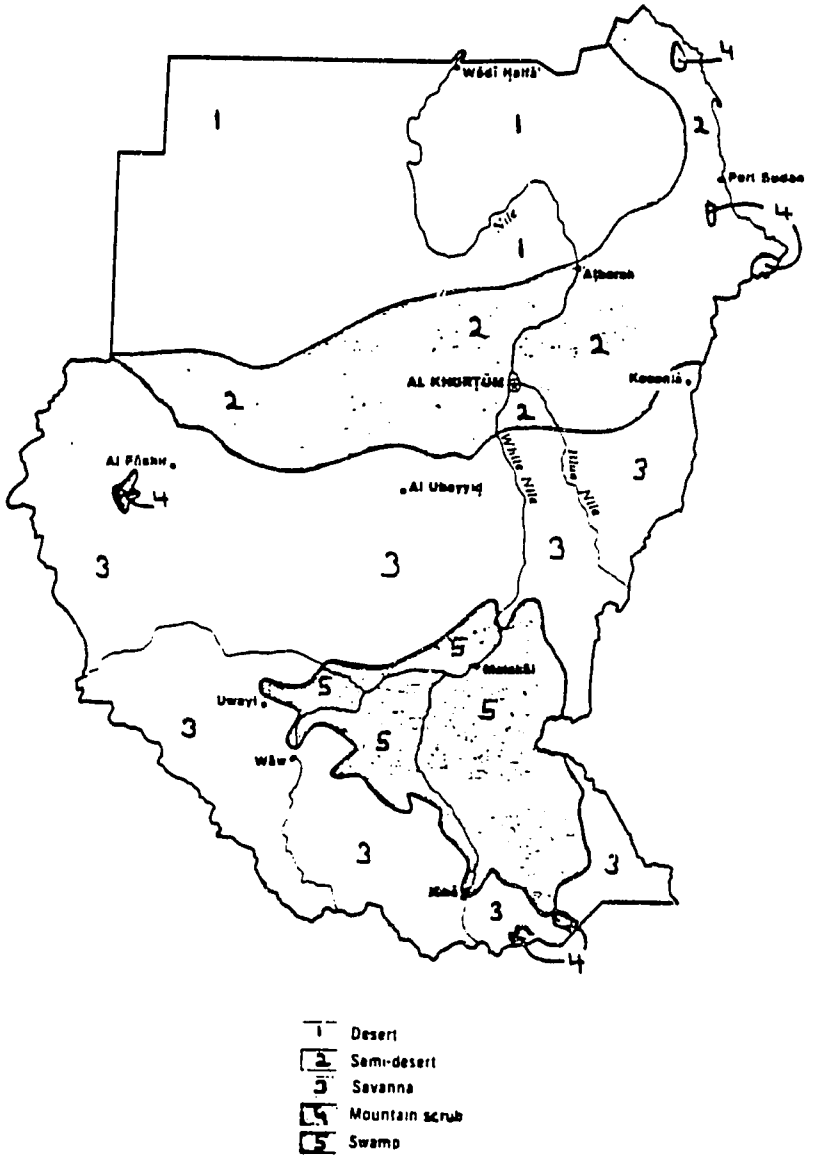

Figure 3.16. Vegetation Zones

Source: Available from U.S. GPO, 78031 3-71.

1. Acacia tortilis - Maerua crassifolia Desert Scrub, found mainly in the east, forms about 78,000 sq km of the total area.

2. Acacia mellifera - Commiphora Desert Scrub, found mainly in the west.

3. Semi Desert Grassland on Sand (in the west), a vegetation of mixed grasses and herbs alternating with Acacia-Commiphora desert scrub plus a few trees along "khor" beds and drainage lines.

4. Semi Desert Grassland on Clay (in the east), a vegetation of mixed grasses and herbs with trees along water courses. The Butana, which lies between the Blue Nile and Atbara, is a typical area (16,000 sq km).

5. Acacia glaucophylla - Acacia etbaica Desert Scrub, found in the Red Sea Hills (8000 sq km).

Woodland Savanna Zone (monsoon rainfall ranging between 300-1500 mm): Here, because of the presence of tall grass, fires play an important role in determining the climax vegetation. Most plants are fire resistant and the vegetation is of mixed grass and bushes with or without trees. According to the amount of rain Low Rainfall and High Rainfall Savanna types are found.

(a) Low Rainfall Woodland Savanna has a vegetation of thorny low stature trees (acacias), thickets of Acacia mellifera, few broad-leaved deciduous trees, few herbs, few perennials and some annuals. This type of vegetation is found mainly in Central Sudan. In East Central Sudan, where dark cracking clays occur, either Acacia mellifera thornland associated with Commiphora africana (102,000 sq km), Boscia senegalensis on hill sides, or Acacia mellifera-Commiphera desert scrub are found. On dry areas Acacia mellifera could be found as pure stands. On wetter areas A. seyal-Balanites savanna (105,000 sq km) alternating with grass areas occur and A. seyal is dominant throughout. On more wet areas A. Senegal is dominant (48,000 sq km). On lowlands A. camplyacantha is common while on areas liable to flooding A. fistula and A. drepanolobium are widespread.

In West Central Sudan, where sandy soils predominate, the following savanna types occur: A. senegal; Combretum cordofanum-Dalbergia-Albizzia sericocephala (30,000 sq km); and Terminalia-Sclerocarya-Anogeissus schimperi mixed deciduous woodland (19,000 sq km).

(b) High Rainfall Woodland Savanna is a vegetation of mixed deciduous woodland of anogeissus-Khaya senegalensis and Isoberlinia (106,000 sq km).

Flood Zone: According to the amount of water, three types of vegetation may be distinguished, with a total area of 116,000 sq km.

(a) Highland (rarely flooded). On sandy soils the vegetation is mainly palm type. Hyphaene thebaica is generally dominant, Borassus aethiopum locally dominant, few acacias with A. sieberiana most common. On clay soils A. seyal-Balanites savanna type occurs.

(b) Intermediate (flooded during the rainy season). The vegetation is mostly grassland with Hyparrhenia rufa and Setaria incrassata as dominant with few areas of A. seyal-Balanites savanna.

(c) Swamps, either permanent (13,500 sq km) in areas flooded by rain, rivers and inland "khors" where the most dominant species is Cyperus papyrus, or seasonal with Echinochloa stagnina, E. pyramidalis usually dominant. Other common swamp species are: Phragmites communis, Hyparrhenia rufa, Vetiveria nigritana, Pistia stratiotes, Ipomoea aquatica and recently Eichhornia crassipes which is very widespread.

Montane Zone: Areas with high altitudes where the vegetation changes with height.

Immatong Mts. and Dongotona Mts.: Podocarpus milanjianus (50 sq km) is dominant. At 5500-7000 ft. Olea hochstetteri, O. welwitschii and Syzygium-aff. S. gerrardii, which forms pure stands, are dominant. Other common species are Protea gaguedi, Hagenia abyssinica, Acacia xiphocarpa, Albizia gummifera and Maesa lanceolata.

Didinga Mts: Podocarpus, Juniperus procera and Olea chrysophylla are dominant.

Red Sea Hills: Juniperus procera, confined to Korora Hills and Olea chrysophylla on Jebel Elba.

Jebel Marra: Open grassland with areas dominated by Olea laperrini and Acacia albida.

Miscellaneous. One should mention, besides the main zones, the Gallery forests (150 sq km) which are a type of rain forests with Khaya grandifolia, Cola cordifolia, Erythrophleum guineense. Mitragyna stipulosa and Syzygium guineense as common species. Also, rainforests (20 sq km) with Celtis zenkeri, Chrysophyllum albidum, Mildbraediodendron excelsum and Entandrophragma angolense. Lastly, Acacia nilotica and A. arabica found as pure forests in areas, N. of Lat. 10°, flooded annually by the Nile.

Some additional data may be found in Appendix VI.

3.4.2 Forestry and Wood Use 17/

Figures on the total amount of forested land are inconsistent, at least partially because of differing definitions currently used. Waterbury (1979) indicates that 212,335,000 feddans of land classified as suitable for agriculture is actually forested (cf Table 3.20). This corresponds fairly well with the 200 to 220 million feddans that several other sources classify as forest (e.g. Bayoumi n.d.; U.S. AID. 1981a), and represents around 36 percent of Sudan's surface area. About 2.5 to 3.0 million feddans are designated as protected Forest Reserve Estates, which are government owned. The majority of wood utilized from Sudan's forests is for fire wood (Table 3.23). Another major use of forests is in gum Arabic production (Table 3.24).

Fuelwood and Charcoal. As noted in Section 3.1.4, the majority of energy consumed in Sudan is from

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[17] Sources: Anon. n.d.
Bayoumi. n.d.
Europa. 1981.
U.N. 1981.
U.S. AID. 1981a.

Table 3.23. Roundwood Removals

('000 cubic metres, all non-coniferous)

	1972	1973	1974	1975	1976	1977	1978
Sawlogs, veneer logs and logs for sleepers	88	90	60	93	30	35	41
Other industrial wood*	1,190	1,254	1,295	1,319	1,361	1,405	1,450
Fuel wood	19,800	18,700	20,250	20,925	25,245	27,002	27,502
TOTAL	21,078	20,044	21,605	22,337	26,636	28,442	28,993

* FAO estimate.

Source: Europa. 1981.

Table 3.24. Gum Arabic Production

(tons)

	1972/73	1973/74	1974/75	1975/76
Gum kashab	32,418	32,410	19,697	43,030
Gum talh	2,649	3,804	1,107	888
TOTAL	35,067	36,214	20,804	43,918

Source: Europa. 1981.

wood or charcoal. Total wood consumed in 1979-80 was an estimated 10.65 million tons, and charcoal accounted for an additional 550,000 tons. Nearly all firewood was obtained from natural forests and desert scrub. Fuelwood plantations contributed about 1.3 percent of total requirements. Table 3.25 presents data on current and projected fuelwood demand.

3.4.3 Range Use and Livestock 18/

Much of Sudan's surface area is more suited to livestock grazing than to cultivation. Cattle, sheep, goats, and camels are all herded in various combinations by the nomadic groups of the country, who account for approximately 11 percent of the population. In addition, settled people often keep some animals. Total herd size is over 17 million for cattle and sheep, over 12 million goats, and 2.5 million camels (Table 3.26). Generally camels are found in the more arid north, while cattle are the main grazing animal in central and southern areas. Few figures on carrying capacity or stocking rates on rangeland are available.

3.5 Fauna and Conservation Measures

3.5.1 Zoogeography of Native Terrestrial Fauna 19/

The fauna of Sudan belongs to the Ethiopian zoogeographical region. This region encompasses all of Africa except the northern part between the Mediterranean from Morocco to Egypt. It also includes the southern part of Arabia. Because Sudan lies near the northern extremity of the Ethiopian zoogeographical region, its fauna shares affinities with that of southern Europe, which is part of the Palearctic Region, and with the fauna of the Oriental Region of southern Asia and India.

The diversity of the vertebrate fauna in Sudan, particularly mammals and birds, is surprisingly great. This is due to several factors, including

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[18] Sources: Europa. 1981
Khogali. 1979.
Nelson et al. 1973.

[19] Sources: Happold. 1967a.
Hallwagy. 1962.
Wilson. 1979, 1980.

Table 3.25. Fuel Wood Supply/Demand Analysis in Sudan up to the Year 2000

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
YEAR	POPULATION In millions																		
	URBAN POPULATION	RURAL POPULATION	TOTAL POPULATION	PER CAPITA CONSUMPTION OF FIRE WOOD - Kg	PER CAPITA CONSUMPTION OF CHAR COAL	TOTAL CONSUMPTION OF FIRE WOOD- MILLION TONS	TOTAL CONSUMPTION OF CHAR COAL - MILLION TONS	WOOD EQUIVALENT OF CHAR COAL - MILLION TONS	TOTAL CONSUMPTION OF WOOD FUEL - MILLION TONS	ALTERNATIVE FUEL SUBSTITUTION %	NET WOOD FUEL CONSUMPTION MILLION TONS	AREA OF NATURAL FORESTS MILLION HECTARS	POTENTIAL OF WOOD FUEL PRODUCTION FROM NATURAL FORESTS - MILLION TONS	AREA OF FORESTS PLANTATION - IN HECTARS	POTENTIAL OF WOOD FUEL PRODUCTION FROM PLANTATION IN MILLION TONS	TOTAL POTENTIAL WOOD FUEL PRODUCTION IN MILLION TONS	DEFICIT IN TOTAL WOOD FUEL NEEDED IN MILLION TONS	AREA OF PLANTATIONS REQUIRED IN MILLION HECTARS	PROGRAM OF ANNUAL PLANTATIONS - IN MILLION HECTARS
1979	2.5	15.0	17.5	594	29.7	10.4	0.52	3.0	13.4	–	13.4	40	17.2	135000	0.13	17.33	–	–	–
1981	2.7	16.8	18.5	589	31.3	10.9	0.58	3.3	14.2	–	14.2	39	16.8	148000	0.14	16.94	–	–	–
1985	3.0	19.2	22.2	548	27.5	12.2	0.61	3.5	15.7	–	15.7	37	15.9	161000	0.16	16.05	–	–	–
1990	3.4	21.8	25.2	548	27.5	13.8	0.69	4.0	17.8	5	16.9	35	15.0	181000	0.17	15.17	2.63	0.66	0.12
2000	4.5	28.0	32.5	549	27.0	17.7	0.88	5.0	22.7	10	19.4	30	12.9	206000	0.20	13.10	9.60	2.40	

Source: U.N. 1981.

Table 3.26. Livestock and Livestock Products

LIVESTOCK
('000 head, year ending September)

	1977	1978	1979
Cattle	15,892	15,905	17,300
Sheep	15,248	17,358	17,200
Goats	11,592	12,088	12,200
Pigs*	8	8	8
Horses*	20	20	20
Asses*	675	678	680
Camels	2,813	2,408	2,500
Chickens*	24,000	25,000	26,000

* FAO estimate.

LIVESTOCK PRODUCTS
(FAO estimates, '000 metric tons)

	1977	1978	1979
Beef and veal	180	188	195
Mutton and lamb	72	73	77
Goats' meat	38	40	42
Poultry meat	14	15	16
Other meat	78	78	78
Cows' milk	885	900	925
Sheep's milk	121	123	122
Goats' milk	370	370	380
Butter and ghee	11.4	11.7	11.9
Cheese	50.5	52.1	53.6
Hen eggs	26.1	29.6	24.0
Wool: greasy	15.0	15.0	15.0
clean	6.2	6.2	6.2
Cattle hides	25.2	26.3	27.3
Sheep skins	10.3	10.5	11.0
Goat skins	7.2	7.6	8.0

Source: Europa. 1981.

1) the broad range of habitats found within Sudan's borders, 2) its very large north-south latitudinal span, and 3) its proximity in the south, to the east African refugia, which is historically one of the two most important centers of species diversity within the Ethiopian Region.

Because of the great latitudinal span of Sudan (about 4° N to 23° N) and marked differences in climate, the vertebrate fauna of arid northern Sudan differs sharply from that of the humid southernmost part of the country. For example, characteristic mammals of the desert-like or rocky regions of the north included, at least formerly, Barbary Sheep (Ammotragus lervia, Addax nasomaculatus), and Scimitar-horned Oryx (Oryx dammah). Characteristic species of the south probably included Cheetah (Acinonyx jubatus), Giraffe (Giraffe camelopardalis camelopardalis), Hippopotamus (Hippopotamus amphibius), Warthog (Phacochoerus aethiopicus), and African Elephant (Loxodonta africana). Many species whose distributional center lies in eastern equatorial Africa, in fact, reach their northernmost range in the forest or grassland and savanna zones of central and northern Sudan. Similarly, many species characteristically associated with the arid zones of northern Africa reach their southern and easternmost limits in northern Sudan.

3.5.2 Mammals

There is a large body of literature dealing with the mammals of Sudan. Specific works treating Sudan, or a portion of the country, or a particular taxonomic group include, Carlisle and Koss (1970), Hashim and Nimir (1977), Happold (1966a, 1967a, 1967b), Ghobrial and Hodieb (1973), Nimir and Hakim (1979), Mackenzie (1954), Owen (1953), Setzer (1965), Watson (1975), and Wilson (1980). Surveys dealing with the combined region of Ethiopia, Somalia and Sudan include Brocklehurst (1931) and Van Rosen (1953). General works on the African continent, which include Sudan, are Dorst and Dandelot (1970) and Meester and Setzer (1971-1977). In addition there are several general works that cover east Africa and also have information relevant to Sudan.

Setzer (1965) lists 159 species of mammals, excluding bats (Chiroptera) in Sudan (Appendix VII), and Happold (1967b) adds many additional species to the list. Unfortunately, during the

last several decades human and domestic livestock populations have increased rapidly in Sudan. This has resulted in more intensive land use, and at least as far as herbivores are concerned, has resulted in a drastic reduction in the numbers of many species. In the north both the addax and oryx have suffered sharp reductions in numbers, especially since 1950. These reductions are believed to be a direct result of increased numbers of domestic livestock. Their plight has also been made worse by a lack of rainfall during the last quarter century. This has caused the virtual disappearance of the "gizu", an ephemeral winter vegetation that occurs as far north as 17° N and provides valuable, if temporary grazing.

The U.S. Department of Interior (1980) lists 11 endangered or threatened mammals in Sudan (Table 3.27). Three of these are not shown on the IUCN (1978) list. IUCN lists 12 species, 5 of which are not listed by the U.S. Department of Interior (Table 3.27) bringing the total to 15. It is likely that even this combined total does not adequately reflect the serious deterioration of wildlife in Sudan. For example, Nimir and Hakim (1979) state that the wildlife conservation in northern Sudan is very inadequate and that wildlife habitats are deteriorating at an alarming rate. They indicate that competition with other land-uses is affecting many wildlife habitats. Several species, such as Oryx, Addax, Addra Gazelle (Gazella dama), Sommering Gazelle (Gazelle someringi), and Leopard (Panthera pardus) are threatened with extinction in Sudan. Two of these species, the Addra and Sommering Gazelle, do not appear on either the IUCN or the U.S. Department of Interior lists, despite the fact they are threatened with extinction according to Nimir and Hakim (1979). IUCN data on listed mammals and reptiles is given in Appendix VII.

Wilson (1980) provides a recent and valuable review of the distribution and status of larger mammals in northern Darfur Province. This region covers some 250,000 sq km and includes habitats ranging from desert to dry broadleaf deciduous woodland. More than half of the area receives less than 100 mm of rainfall per year, and about 90 percent receives less than 400 mm and may be classified as arid. As might be expected, the results of the review are not encouraging. Of the 31 species of larger mammals for which there are

Table 3.27. Vertebrates Listed by the IUCN RED DATA BOOKS and the U.S. Department of Interior

Scientific Name	Common Name	Status	
		IUCN	U.S. Dept. Interior
MAMMALS			
Manis temminckii	Scaly Anteater		E
Equus asinus	African Wild Ass	X	E
Acinonyx jubatus	Cheeta	X	T
Dugong dugong	Dugong		E
Loxodonta africana	African Elephant	X	E
Gazella leptoceros	Slender-horned Gazelle	X	E
Addax nasomaculatus	Addax	X	
Oryx dammah	Scimitar-horned Oryx	X	
Alcelaphus buselaphus tora	Tora Hartebeest	X	E
Panthera pardus	Leopard	X	E
Cerathotherium simum cottoni	Northern White Rhinoceros	X	E
Diceros bicomis	Black Rhinoceros	X	
Equus grevyi	Grevy's Zebra		T
Pan troglodytes	Chimpanzee	X	
Lycaon pictus	African Wild Dog	X	
BIRDS			
Falco peregrinus	Eurasian Peregrine Falcon		E
REPTILES			
Crocodylus niloticus	Nile Crocodile	V	E
AMPHIBIANS			
None			
FISH			
None			

X = listed (status not given); V = vulnerable; T = threatened; E = endangered

definite records in northern Darfur, only six were seen in an aerial survey in late 1976. A small number of others still survive. According to Wilson (1980) the status of four species are of international concern because they are near extinction in northern Darfur. These are the Scimitar-horned Oryx, Addax, Barbary Sheep, and Addra or Dama Gazelle. Of these only small numbers of Addax and Dama Gazelle are certain to still occur. Wilson attributes the drastic decline in wildlife numbers, and restriction of their ranges, as much to competition with increasing human and domestic livestock numbers, as to hunting pressures. The estimated numbers of livestock in the province are indeed staggering: according to Watson (1977 in Wilson 1980) almost 1 million cattle, 1.5 million sheep, 1.2 million goats, 226,000 camels, 150,000 donkeys, and 40,000 horses! Large carnivors, according to Wilson (1980), have suffered greatest declines as a result of systematic hunting during the 1940s and early 1950s.

Data from Wilson's (1980) review are summarized in Table 3.28. During the November 1976 aerial survey of northern Darfur, only five species were seen, Patas monkey (Erythrocebus patas), Jackel, and three species of Gazelle, including Dorcas (Gazella dorcas), Addra (Gazella dama), and Red-fronted Gazelle. The survey estimated 24 Addra, 7,423 Dorcas, and 3,492 Red-fronted Gazelle. In contrast to the very impoverished fauna of Northern Darfur, 18 species of large herbivores were seen in the more wooded southern Darfur Province during an aerial survey carried out at approximately the same time. An average biomass estimate of 28 kilograms per square kilometer in Southern Darfur Province is more than 28 times that of Northern Darfur Province. Unfortunately there are few early records that quantitatively document animal numbers in Northern Darfur Province. Almost certainly, numbers there were never very great, although prior to the 1950s when human presence increased markedly, populations must have been far higher than today.

The prognosis for wildlife in Northern Darfur Province is bleak, according to Wilson (1980). Continual human presence and increasing domestic animal populations will cause even further reductions to the low numbers of range species still surviving. Unless reserves are set aside

Table 3.28. Status of Selected Large Mammals of Northern Darfur Province

Lion	Fairly numerous as recently as 1940s.
Leopard	Probably fairly common formerly; isolated records to 1950.
Cheetah	Widely scattered records.
Spotted Hyaena	Still occur; no precise information.
Striped Hyaena	Still occur; no precise information.
Common Jackal	Probably occurs; no further information.
Fennec Fox	Recorded; no further information.
Ruppell's Fox	Recorded; no further information.
African Hunting Dog	Once widespread and common, scattered records through 1930s, 1940s and early 1950s.
Elephant	Records confusing; no records in last 3-4 decades.
Giraffe	A few records in 1940s and in 1950.
Greater Kudu	Scattered records.
West African Korrigum	Scarce; reported at least to 1951.
Red-fronted Gazelle	Still fairly common.
Dorcas	Still fairly common.
Addra	Formerly widespread; now very rare.
Barbary Sheep	Fairly common in 1900; scattered records; rare.
Buffalo	One record 1945.
Lelwel Hartebeest	"Great Numbers" (1947); now?
Roan Antelope	Fair number probably.

Table 3.28 continued

Scimitar-horned Oryz	Now threatened or extinct.
Addax	Now threatened.
Waterbuck	Occurs in western Darfur (Wilson 1979).
Bushbuck	No definite records but possible (See Wilson 1980).
Hippopotamus	No definite records but possible (See Wilson 1980).
Oribi	No definite records but possible (See Wilson 1980).
Warthog	Certainly present formerly. No recent records.
Grimm's Duiker	Certainly present formerly. No recent records.
Baboons	One reference to 200 in 1938; probably formerly common and widespread.
Patas Monkey	Few references in literature; formerly probably common.
Aardvark	One record (Shaw 1936 in Wilson 1980).
Porcupine	One record (Shaw 1936 in Wilson 1980).
White Rhinoceros	No modern records but probably occurred. Excavated bones indicate presence within Recent Period.
Nubian Ass	No modern records but probably occurred. Excavated bones indicate presence within Recent Period.

Source: Wilson. 1980.

and adequately protected both from hunting and from encroachment by domestic livestock and human interference (an unlikely event), there will probably be no large range wildlife in Northern Darfur Province by the end of the century. In fact, Wilson believes that with the exception of a few especially favorable areas such as the Jebel Marra uplands (for Kudu) and the catchment of the Wadi Howar (for a few gazelle), wildlife will not even last that long.

The status and distribution of wild mammals in Southern Darfur Province were reviewed by Wilson in 1979. Compared to Northern Darfur Province, this province is smaller (160,000 sq km), and somewhat less arid (400-900 mm). The results of the review, which included on-site investigations, are similar to those found in Northern Darfur Province. Of the 49 large mammals discussed, most have undergone a severe reduction in numbers and have suffered severe contractions in range during the last 75 years. However, only a few species that were previously in the province have become extinct. As in Northern Darfur, the decline is attributed to the indirect effect of man and his domestic animals causing habitat destruction. The only major exceptions to this are the elephant and giraffe which have suffered from poaching and traditional hunting respectively, and the large carnivores which were systematically exterminated as a means of protecting livestock. Wilson summarizes by stating that because of the continuing influence of large numbers of domestic animals, further reductions in the numbers and range of wildlife can be expected.

The only other province in Sudan for which information on the mammalian fauna is available is Khartoum Province. Happold's (1967a) work on this province is now somewhat out of date, although there are few other publications on mammals of Khartoum Province. All species reported by Happold were definitely reported during the period 1963-1966 and it is significant that there is only one large species, the Dorcas Gazelle. All other species are bats, rodents such as rats and mice, and small carnivors such as foxes, weasels and mongooses. These are species that would be expected to coexist with man, or at least be tolerant of him. The gazelle, the only species that requires significant open and undisturbed areas, was considered to be "very rare" (Happold

1967a). Increased human population, shooting, and degraded habitat are the factors listed as contributing to their decline. According to Happold (1967a) a few gazelle still occurred in the western part of the province.

Information is not available on the status and distribution of mammals in other Sudanese provinces, although results of these three reviews suggested that serious declines in population of larger mammals are likely over much of Sudan. Data to be discussed under National Parks (Section 3.5.6) may suggest that more larger mammals survive in southern Sudan than in the northern region.

3.5.3 Birds

There is a considerable body of literature on birds of Sudan, and of regions adjacent to Sudan. Early works on Sudan birds include the following: Note on a collection of birds from the Sudan (Phillips 1913), A List of the birds of the Anglo-Egyptian Sudan (Sclater and Praed 1919-1928), and Catalogue of Sudan Birds (Bowen 1926). Recent works include Macdonald and Cave (1948) and Cave and Macdonald (1955). The latter titled Birds of Sudan, is the most exhaustive to date on Sudan birds. Publications useful in portions of Sudan include, those of Shelly (1872), Jackson and Sclater (1938), Etchecopar and Hue (1967), Urban and Brown (1971) and Williams and Arlott (1981). Continent-wide volumes that include relevant information on birds in Sudan include Bannerman (1930-1951), Hall and Moreau (1970), MacWorth-Praed and Grant (1950-1970), Moreau (1966) and Snow (1978).

The U.S. Department of Interior (1980) lists only one endangered species in Sudan, the Eurasian Peregrine Falcon (Falco peregrinus peregrinus). No Sudanese species are listed by the IUCN Red Data Book (1969) on birds although information from the updated 1979 edition was not available. As in many parts of the world larger species such as waterfowl, waders, raptors and game species are often sensitive to human pressures and should be monitored closely. No recent information on any of these groups, or others such as Ostrich (Struthio camelus), bustards (Otididae), or hornbills (Bucerotidae) was available.

3.5.4 Reptiles and Amphibians

The Nile Crocodile (Crocodylus niloticus) is the only species listed by the IUCN Red Data Book (1975). It is classified as vulnerable. No Sudanese reptiles or amphibians are listed by the U.S. Department of Interior's 1980 list. Relevant information on the status and distribution of the Nile Crocodile can be found in Appendix VII.

3.5.5 Fish and Invertebrate Fauna

No fish that occur in Sudan are listed by the IUCN Red Data Book (1969) or the U.S. Department of Interior (1980), although information in the Red Data Book is rather out-of-date. It is also likely that because of the large extent of the Nile River watershed drainage system in Sudan, the status and distribution of Sudan's ichthyofauna is still incompletely surveyed. The effects of increased human and domestic livestock populations on fish in Sudan is unknown.

The World Wildlife Fund (Oryx 1973; p. 161-162) has begun an urgent compaign in an attempt to divert sportsmen and fishermen from activities that damage the coral reefs, ranging from mechanized spear-fishing to underwater photography. The Cambridge Starfish Research Group has described the damage that is being done in the Red Sea, and especially by tourist divers based at Port Sudan. According to Oryx (1973; p. 162)....

"Fish are killed purely for fun, with enormous wastage, and the reefs denuded. They point, too, to some serious but not immediately obvious effects, as for example the ignorant killing of the inedible (because poisonous) puffer fish Arothron hispidus. Quite tame and so an easy prey, the puffer fish is however an important member of the reef community in that it is a predator of the invasive and destructive crown-of-thorns starfish Acanthaster planci, which has killed off large coral reefs in many parts of the world, including the Red Sea. By destroying this predator spear-fishing is contributing to the destruction of the coral. Shell and coral collecting for souvenirs are also damaging--the Group's report describes 37 coral colonies seen drying on the Red Sea Hotel veranda in Port Sudan; collected by nine sport divers they represented

10-20 years of growth. The Group urges the Sudan Government to ban all these activities in the Sudanese Red Sea. As in the Seychelles, where the Government has done this, the result could be a positive encouragement to tourism. It might at least ensure that the coral reefs and their fish were still there for the tourists of the future who are certain to come in increasing numbers."

Because of its economic importance and long association with civilization, the Nile River and its fish and invertebrate fauna have been the subject of considerable investigation. The most important modern ecological document is the Jonglei Investigation Team Report of 1954 (Anon. 1954). This study reported on the probable impact of the Equatorial Nile Project on the ecology of the Upper Nile swamps. Other studies that treat fish, invertebrates or plankton in Sudan include: Cloudsley-Thompson (1964), Mahdi (1973), Green et al. (1979) and Beshir and El-Moghraby (1980). Most are of a technical or highly specialized nature and do not contribute information that is readily useful to this environmental profile.

3.5.6 National Parks and Existing Legislation

Sudan today has three national parks and fifteen game reserves (Cloudsley-Thompson 1973; see Appendix VII). There are also a number of sanctuaries and forest reserves where hunting is prohibited. Unfortunately, present legislation on wildlife and national parks in the Sudan is not adequate to preserve what remains. The Wild Animal Ordinance of 1935, amended in 1971, is the basic legislation under which the wildlife administration operates. This ordinance provides that national parks, game sanctuaries and game preserves may be set aside, and prohibits hunting in national parks and game sanctuaries. Hunting is permitted in game reserves by special permit from the Director of Wildlife Administration.

Conservation in all protected areas in Sudan is unsatisfactory, and enforcement of game laws is inadequate. Some game reserves and sanctuaries are no longer worthy of their name because all game animals have disappeared from them and their natural habitat has been destroyed (Nimir and Kahim 1979).

A new wildlife and national parks legislation was drafted in 1974 but has not yet become law. This proposed ordinance would establish better

guidelines for parks and protected areas. It would also permit a new national park to be established in the Radon area of Southern Darfur. Unfortunately, it does not improve the situation of game reserves and sanctuaries.

The Wildlife Administration is the governmental body that oversees the management of wildlife and parks, and enforcement of the Wild Animals Ordinance of 1935. It is primarily a licensing and policing body. Little progress has been made toward organizing the wildlife department as a technical, natural-resource-conserving body concerned with management of habitats and animal populations (Nimir and Hakim 1979).

The Wildlife Administration currently has 80 game officers and inspectors; few have scientific training in game management. There are also 214 game scouts in the Wildlife Administration. All have had military training and some introduction to the Wildlife Animal Ordinance; none have had formal scientific training. According to Nimir and Hakim (1979) the Wildlife Administration lacks adequate transportation and equipment to perform its function.

3.5.7 Conservation Status of Game Reserves and Game Sanctuaries

The status of the game reserves in Sudan is uncertain. Information was available on three reserves in northern Sudan, the Rahad Game Reserve, Sabloka Game Reserve, and Tokar Game Reserve (Nimir and Hakim 1979). The Rahad Game Reserve has been extensively settled by humans; its trees have been cut and it is believed that most of its wild animals have disappeared.

The Sabloka Game Reserve was established primarily for the protection of wild sheep (Ammotragus lervia) but it is believed none exist there now. Tokar Game Reserve is reported to be deteriorating but little informaion was given by Nimir and Hakim (1979).

Problems in the game reserves stem from many sources, but most can be traced to a lack of funds and poor administration. There is no patrolling system to guard the game reserves, and because of vast distances, poor roads, and lack of transport, attempts to survey or patrol are impossible. Some

game reserves have not been visited by any representative of the Wildlife Administration during the last five years (Nimir and Hakim 1979).

The status of game protection in game sanctuaries is little better than for the reserves. There are no protective measures, signs are not maintained and there is much evidence of deterioration of the environment. Serious damage is reported in the Erkowit Sanctuary, Sinkat-Erkowit Road Sanctuary, and Omdurman Gordon's Tree Sanctuary. Desert regions of Northern Kordofan and Northern Darfur still contain some wildlife; for example the Dorcas Gazelle and ostrich occur in small numbers throughout the region, and the Red-fronted Dama Gazelle is present in many localities. The presence of Barbary Sheep is now very local.

In the Red Sea Hills the Nubian Ibey is found in many localities. Dorcas Gazelle and ostrich are scattered along the Red Sea coastal plains (Nimir and Hakim 1979). Large numbers of Dorcas Gazelle are also still reported in areas from the extensive deserts west of Omdurman through the north to the Nile Province's southern boundaries. Jebel el-Dair, south of el-Rahad in Northern Kordofan, has a good population of Greater Kudu, but this population is subject to poaching and the habitat is deteriorating as a result of tree cutting and pasture burning.

3.5.8 Problems in Sudan's National Parks

Dinder National Park covers 7,120 sq km (2,750 sq miles) and lies 406 km (315 miles) south-east from Khartoum, near the Ethiopian border in Blue Nile Province. Its fine assemblage of game includes elephant (during the rains), hippopotamus, giraffe, buffalo, roan antelope, waterbuck, tiang, greater kudu, red-fronted and Soemmering's gazelle, reedbuck, bushbuck, oribi, duiker, Salt's dikdik, warthog, bush pig, lion, leopard, cheetah, hyaena, wild dog, grivet and red hussar monkeys, and baboon. The status of tora and lelwel hartebeest is uncertain. It has been decided not to reintroduce hippopotamus as poachers would be the only gainers (Cloudsley-Thompson 1973).

Dinder National is the only national park in northern Sudan. In terms of economic, aesthetic and scientific value it holds great potential. Unfortunately, during the wet season many animals

migrate to wet-season ranges outside of the park. Currently, the expansion of unlicensed agriculture into areas adjacent to the park has created problems in wildlife management. A 400,000 ha farm north of Jebel el-Gerri is expected to have serious impact on the animals because it is diminishing the area of wet-season habitat (Nimir and Hakim 1979).

Nimir and Hakim (1979) maintain that during the last six years upon which they report, there has been a significant decline in the population of Tiang (Dam liscus korrigum) and waterbuck (Kobus defassa), amounting to 60 percent and 25 percent respectively. They claim the declines are due to mechanized agriculture on wet-season ranges, and livestock trespassing into the park during the dry season. In addition, the food competition between livestock and wildlife and trespassing in the park has caused outbreaks of rinderpest (1972) and anthrax (1974) among the wild animals (Nimir and Hakim 1979). In addition, stage two construction of the Rahad Canal to transport water from the Roseires Dam to the Rahad River is expected to block the migration route of the Dinder Park animals. The Sudan government has been advised of this problem.

Southern National Park, coversing 16,835 sq km (6,500 sq miles) in Bahrel-Ghazal Province, comprises mainly wooded country and the animals include elephant, white rhinoceros, hippopotamus, giraffe, buffalo, giant eland, roan antelope, waterbuck, tiang, lelwel hartebeest, reedbuck, bushbuck, oribi, duiker, warthog, lion, leopard, serval, hyaena and wild dog (Cloudsley-Thompson 1973). No additional data is available on development in this park.

The following account of Sudan National Parks is taken from Cloudsley-Thompson (1973). Some additional information can be found in Appendix VII.

"Nimule National Park, 260 sq km (100 sq miles) on the Uganda frontier in Equatoria Province, is famous for its enormous herds of elephant. White rhinoceros, hippopotamus, buffalo, Uganda kob, and waterbuck are very common. Smaller species, such as bushbuck, lelwel hartebeest, oribi, duiker, warthog, hyrax, and baboon, are less plentiful, but the aggregation of bigger game is remarkable.

This superb park lies in an ideal setting between mountains on the west and the Nile, with the Fula Rapids, on the east, where, for a distance of nearly a kilometre, the great river hurls itself through a gap not more than 30 metres wide. Since 1961, owing to the rebellion in the south, Nimule has not been accessible to visitors. The game scouts were withdrawn two years later, after which the park had no supervision. According to unconfirmed reports, however, the rebels did not greatly interfere with the game; indeed, the army is likely to have been a far greater menace in this respect. On the other hand, there was no control of poachers from Uganda, although these may have been deterred by the danger of operating so close to the scene of armed conflict.

The Southern National Park is even more remote than Nimule. It has only a skeleton staff and has not been developed in any way. Nearly all the efforts of the Ministry of Animal Resources and of the Tourist Department are being directed towards Dinder National Park. When my wife and I first went there in 1961 the only other name in the visitors' book was that of Professor K.N.G. McLeay who had been in 1959. By contrast, in 1971, 265 visitors used the park accommodation. There are even plans to build an hotel at Galegu, just inside the northern boundary of the park, but these will probably not be realised in the near future. At present, accommodation for visitors is limited to some well constructed straw huts with electric light; meals are served in a pleasant dining room, and showers have been installed and latrines dug. An airstrip permits a twice-weekly schedule by Sudan Airways, and there is an excellent rest camp at Guweisi, where the railway crosses the Dinder river, 155 km (96 miles) north.

Dinder is completely inaccessible during the rains and the park is open to visitors and staff for only four or five months of the year. Poaching is consequently a great problem. In 1970, several waterholes were poisoned by local poachers--possibly as a protest against the Government decision to abandon the Rahad canal scheme which, they hoped, would bring wealth--and many animals died. The project to build a canal from the Roseires dam on the Blue Nile to the Rahad river, which would cut the game migration routes between dry season and wet season ranges, and could be disastrous, was opposed by both the Game

Department and Sudanese members of the Department of Zoology in Khartoum University. A new pumping plant at es-Suki, further north on the Blue Nile, was started this year. The future of the park must inevitably remain in jeopardy while an economically hard pressed government invariably gives priority to irrigation schemes without considering the long-term interests of the country.

In an article on the future of wildlife in the Sudan in Oryx, December 1966, Dr. D.C.D. Happold outlined some of the many problems facing the staff of the Game Department, but he did not give credit for what these sorely pressed officers have actually managed to achieve, despite lack of government support. Nor did he mention that what makes Dinder outstanding amoung the national parks of eastern Africa is not so much the rich fauna as the wealth and beauty of the forests, where chalky white Acacia fistula are interspersed with the red ochre of A. seyal, with groves of dom palms, wild fig trees alive with grivet monkeys or baboons, and guinea fowl calling all round."

3.5.9 Future of Sudan's Wildlife

The following summary is taken from Cloudsley-Thompson (1973).

"Outside the parks and reserves, the traveler does not see much wildlife in the Sudan, apart from the occasional monkey, gazelle, waterbuck (whose meat is said not to be good eating) and ostrich; that is, unless he makes a special effort to go to the best places. Except for hunters, few people bother to do so since game can normally be seen so much more easily inside the parks, especially Dinder.

The extent to which the game of the Sudan has been destroyed during the last century is amply documented, the result of human activities which are likewise responsible for an extremely rapid expansion of desert. Bird life is still surprisingly rich, although a sharp decline in the numbers of cattle egrets of recent years may be associated with the increased use of insecticides, especially in the Gezira. In general, however, agricultural development seems to be less harmful to birds than to mammals (other than rodents) and the construction of reservoirs is beneficial to aquatic species such as pelicans.

The future of Sudan's wildlife depends on how long it takes to build up a profitable tourist trade. This, in turn, depends on the establishment of stable government, the relaxation of immigration formalities, competitive costs and the provision of facilities. These objectives will probably take many years to achieve.

The national parks and game reserves of the Sudan are still relatively inaccessible. They preserve a wild aspect and the game is not unnaturally tame. They cannot hope ever to compete for the massive tourist trade of East Africa. But they have a potential appeal to the more adventurous traveller who is prepared to stand considerable discomfort and innumerable frustrations to see a part of Africa that is, as yet, little affected by modern civilisation."

4.0 Major Environmental Problems

4.1 Desertification

Desertification is one of Sudan's most pressing problems. The debate still continues on whether desertification is primarily a natural phenomenon or caused by man. There is, however, general agreement that man's activities have some impact, even if just to aggravate the problem. At any rate, the desert has shifted southward at a rate of five to ten km per year in Sudan, as indicated by shifts in vegetation belts. The shift can be well illustrated in the area of Wadi el-Milk in northern Kordofan. Research in 1958 showed that the boundary between the desert and the Acacia mellifera-Commiphora scrub occurred where the wadi turned to the northeast near el-Ain. By 1976, Wadi el-Milk left the scrub zone 110 km south of the el-Ain escarpment (Sudan 1976).

According to U.S. AID (1981a), substantial agricultural land is being lost. Sheet and gully erosion are widespread, and approximately 240,000 ha in northern Sudan are affected by salinity problems. About 1.2 million ha of land are cleared annually; 800,000 ha for mechanized crop production and 400,000 ha for traditional agricultural and forest products. Current rainfed mechanized agricultural techniques generally require land abandonment after five years, while only within forest reserves (0.5% of total land area) are good forest practices observed. Overgrazing is common and 500,000 to 800,000 sq km are burned each year, removing about 300 million tons of foliage; nomadic tribes annually uproot millions of acacia trees for firewood. Such pervasive deforestation has caused substantial erosion and reduced water retention capability along many water courses in central Sudan.

Desertification is the environmental problem receiving the most attention from the Sudanese National Research Council's Committee for the Environment. The problem has been under study for several years, and a Program of Desert Encroachment Control and Rehabilitation (DECARP) was prepared in 1976 by a team of specialists from the Ministry of Agriculture's General Administration for Natural Resources and from the National Council for Research working in collaboration with the United Nations Environment Program and the Food and Agriculture Organization. This study (Sudan 1976) contains a detailed discussion of factors behind desertification as well as the phenomenon's impact, and is followed here.

4.1.1 Factors Behind Desertification

The major destructive features of human activities leading to noticeable change in aridity and desert areas are: overgrazing; over and irrational cultivation; wood cutting and deforestation; uprooting shrubs; lowering of the water table due to increased water use; and burning of grasslands, forests and scrub. Observations show that damage is steadily increasng, which is not surprising in view of the present practice of land use in the Sudan. There is generally no regional integration between pastoral and agricultural activities and the same area could be used for both purposes. Some nomadic tribes are involved in cultivation, some cultivators in pastoralism, and all are competing for resources. Some major areas of land misuse are noted in Figure 4.1.

Cultivation in marginal areas during periods of higher than normal rainfall is especially dangerous and perhaps the main cause of desertification. When dry years follow a wet year, ploughed soil or soil from which the sparse cover of natural plants has been eliminated by cultivation is subject to wind and water erosion. The fine clays and silts are carried away as dust, and sand drifts into dunes.

This desertification *in situ* from intensive agricultural activities that rapidly exhaust soil fertility and binding properties is the real danger on the fringes of the desert, not the southward advance of sands.

Systems of cultivation may also contribute to desertification. For example, in the past, *Acacia senegal* gum gardens formed parts of extensive areas over which there was a well defined rotational cultivation - bush fallow system. The cycle was started by cleaning a gum garden in order to grow crops like millet, sesame, groundnuts, hemp and melons. The older gum trees were cut down to kill the stumps, but younger trees and seedlings were pruned back close to the ground so as to keep them alive throughout the 4-6 years of cultivation. The resulting coppice shoots were cut back during weeding operations, but new growth continued even during the early months of the dry season.

LAND MISUSE IN SUDAN

1 Overstocking on semiarid grazing by camel owning tribes.

2 Overcultivation on Gedaref Ridge and vicinity.

3 Overcultivation and overgrazing of Blue and White Nile Riverain zones.

4 Overcultivation and local overgrazing of central sand zone, El Fasher region and Dar Masalit.

5 Eroded upland and pediment soils of Nuba Mountains.

6 Grazing losses by fire on tribal lands of Hawazma and Aulad Himeid.

7 Overstocking and grazing losses by fire in Beqqara and Raqaba Catena.

8 Overstocking of riverain zone of Bahr el Arab.

9 Overstocking and overcultivation on "high" land of Nilotes.

10 Erosion and degradation of high savanna by overcultivation and fire in the Green Belt, Western Equatoria Province.

—.—.—.—.—.—	Country Boundary
- - - - - -	Original Province Boundaries
▬▬▬▬▬	Railway
~~	Rivers
~ ~ ~ ~ ~	Non-Perennial Rivers
o	Towns
.....	Limits Low Woodland - Savanna
	Scale: 1 : 8,000,000

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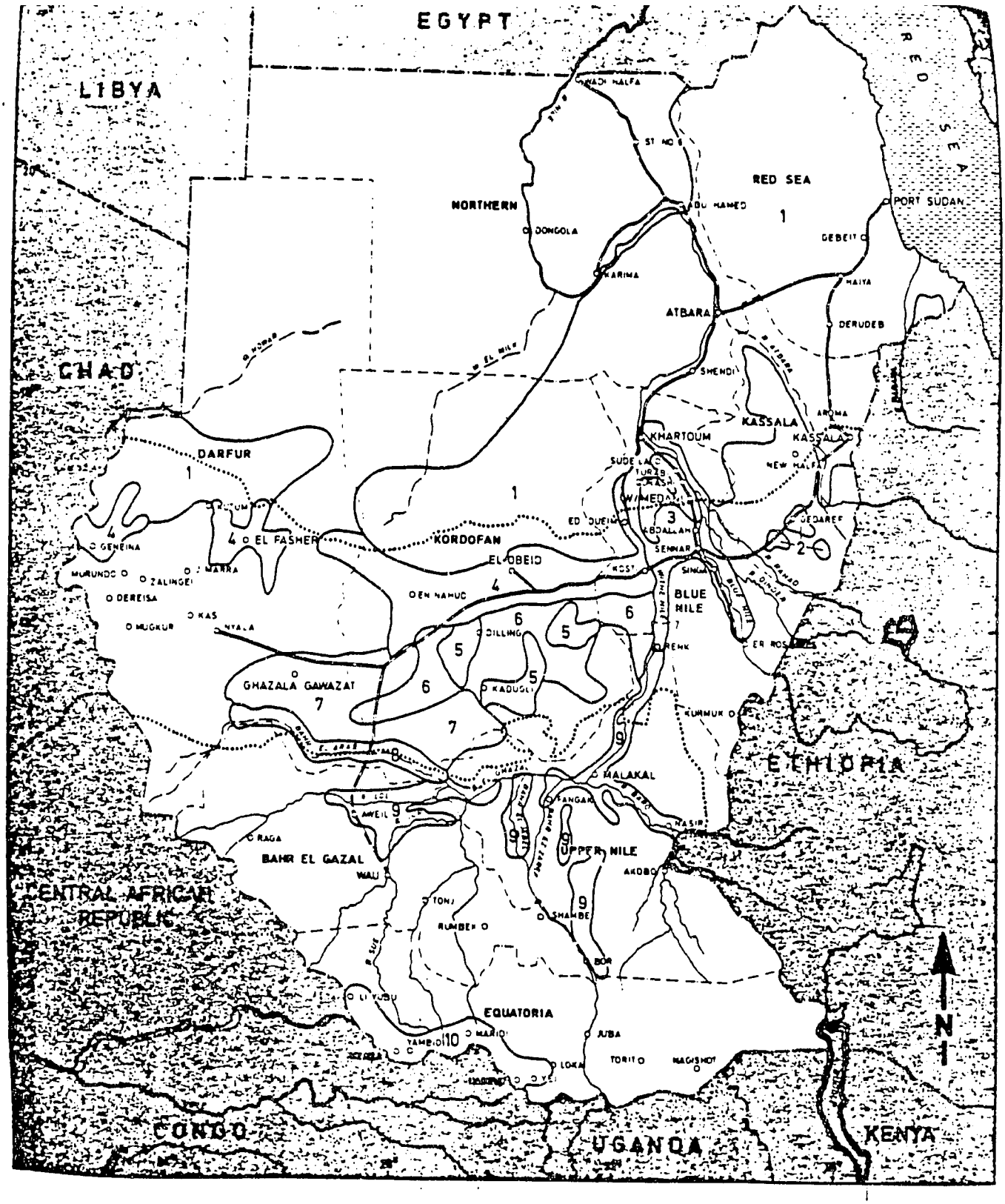

Figure 4.1. Land Misuse in Sudan

Source: Verhoeven. 1975.

This went on throughout the crop cultivation cycle, after which the land was left to revert to bush fallow. The new gum gardens, attaining their maximum yield in 7-10 years, were cleared again for cultivation after 10-15 years. However, with the increase in population, the rotation periods have become shorter in order to meet increased demand and to provide more income from exportable cash crops. Such crops are given preference to gum gardens as they take less time to produce and, in years of good rain, give more income per unit area than that anticipated from gum gardens. Hence, over-cutting of gum trees for cultivation and firewood and overcultivation has caused deterioration of the vegetation cover followed by sand movement, soil deterioration and desert.

The normal system of cultivation includes one or more years of fallow which contributes to overcultivation by expanding the area ploughed. Worse, however, is the trend towards year after year cultivation which provides no environmental protection at all.

Overpopulation and overcultivation also cause the lowering of water tables which is a critical factor in desert encroachment in the Sudan. This situation can come about through the pumping of ground water for drinking or irrigation purposes or the demming or diversion of water courses. The indiscriminate and unregulated installation of a large number of tube wells throughout the Sahel region is triggering an advancement of the desert onto agricultural lands. Better planned water development programs are required so that agricultural field improvements through irrigation are not offset by land losses to advancing sand.

The cutting of wood by pastoralists and cultivators also is a major cause of desert encroachment in the Sudan. Vegetation is harvested for feed, to build homes and enclosures for animals, and for fuel. With brush or tree cover eliminated, the micro-climate is invariably more arid, the dry season more accentuated, and there is a probable - but not yet demonstrated - reduction in total rainfall. Nomads alone may uproot at least 548 million acacia shrubs annually for cooking (Sudan 1977).

While some overgrazing has undoubtedly occurred in the Sudan for centuries, it has only become

widescale and acute during the past few decades (Table 4.1).

In Kordofan, the livestock population increased nearly four-fold from 1957 to 1966 and there have been further increases since. This rapid increase in livestock numbers has broken down the dynamic equilibrium that once existed between livestock and the natural grazing resources. This leads to rapid devegetation, removal of soil cover, and increased wind and water erosion with consequent reduction in human and livestock carrying capacity of the land. In one area surveyed, the actual stocking rate during certain seasons reached eight times the estimated carrying capacity of the range (Table 4.2).

Fire is also an influential factor causing desertification in the Sudan. In addition to destroying potential forage, fire induces remarkable changes in the botanical composition of the predominent vegetation formations and individual plant communities. Desirable perennial grasses which are susceptible to repeated burning are being replaced by less desirable fire-resistant annual species. As a result, 60 percent of the floristic composition is already annual, a manifestation of desertification. In many cases, burning is intentional with the idea that it increases grass palatability. In others, it is accidental and is usually associated with clearing land for cultivation by the use of fire, which often escapes (Table 4.3).

4.1.2 Effects of Desertification

Food production has declined and is declining on the cultivated lands within the Programme Area (mainly northern Darfur and northern Kordofan) because of soil deterioration associated with desertification. Data in Table 4.4 indicate that the acreage needed to produce 73,000 tons of groundnuts in 1978 was almost five times larger than in 1961. Also, the decrease of sesame production was approximately in the proportion of 20 to 1 during the same period. In terms of productivity, sesame producers have lost during twelve years 19 feddans out of 20, and groundnut producers have lost four feddans out of five.

Dura (sorghum) production has declined from 424 kg/feddan in 1961 to 191 kg/feddan in 1973 (Table 4.5). Maize and dukhn (millet) yields have

Table 4.1. Number of Livestock in the Sudan for Selected Years

Type	1924	1964	1974
Cattle	1,500,000	10,000,000	12,897,720
Camels	418,000	2,000,000	3,090,000
Sheep	1,966,800	10,000,000	11,484,000
Goats	1,840,000	7,000,000	8,794,000

Source: Khogali. 1979.

Table 4.2. Sustained-Yield Carrying Capacity and the Number of Livestock at Areas of Animal Concentration at Dar Rezeigat, 1975

Season	Livestock units at sustained production level	Observed livestock units
July and October/November	180,000	1,440,000
August-October	180,000	640,000
December	180,000	600,000
January	209,000	600,000
February-June	209,000	280,000

Source: Khogali. 1979.

Table 4.3. Estimates of Total Dry Forage Removed from Range Due to Seasonal Burning

PROVINCE	Total area (Feddans)	Forage Production (ton/feddan)	Total forage (tons)	% of seasonal burning	Total forage removed (tons)
Kordofan	74,835,200	1.5	112,252,800	30	33,75,840
Darfur	109,856,000	2.0	218,712,000	30	65,613,600
Kassala	63,134,000	0.5	31,567,000	20	6,313,400
Northern Province	-	-	-	-	-
Blue Nile.....	35,072,000	1.0	35,072,000	15	5,260,800
Khartoum	5,184,000	0.5	2,592,000	10	205,200
Upper Nile.....	16,761,600	4.0	67,045,400	35	23,466,240
Bahr el Gazal...	40,819,200	5.0	204,096,000	40	81,638,400
Equatoria	39,833.600	5.0	119,168,000	45	89,625,600
TOTAL	385,495,600		870,506,200		307,892,380

Source: Sudan. 1977.

Table 4.4. Groundnut and Sesame Production of the Kordofan Province 1961/73

	Groundnuts			Sesame		
Year	Total area cropped (feddans)	Total production (m. tons)	Av. yield (m. tons/ feddan)	Total area cropped (feddans)	Total production (m. tons)	Av. yield (m. tons/ feddan)
1961	184,000	73,000	0.400	112,000	38,000	0.339
1964	200,000	59,777	0.297	299,200	30,719	0.102
1967	211,200	45,657	0.216	362,000	31,560	0.083
1970	300,000	69,728	0.232	450,000	43,268	0.097
1973	810,000	73,690	0.090	778,940	14,722	0.019

Source: Sudan. 1976.

Table 4.5 Area, Production, and Average Yield of Crops in Kordofan Province, 1951/73

Year	Dura (Sorghum)			Dughon (Millet)			Maize		
	Total area cropped (feddans)	Total production m. tons	Av. yield kg/feddan	Total area cropped (feddans)	Total production m. tons	Av. yield kg/feddan	Total area cropped (feddans)	Total production m. tons	Av. yield kg/feddan
1961	508,700	215,800	424	192,200	104,000	542			
1962	418,000	158,000	378	302,000	12,000	401			
1963	481,000	171,000	356	175,000	41,000	234	3,000	1,000	333
1964	529,000	184,000	348	449,000	81,000	180	2,000	1,000	500
1965	486,000	158,000	325	451,000	115,000	255	4,000	1,000	250
1966	502,000	153,000	305	453,000	93,000	205	4,000	1,000	250
1967	389,000	82,000	211	433,000	81,000	187	15,000	4,000	267
1968	468,000	145,000	310	509,000	93,000	183	14,000	4,000	286
1969	484,000	113,000	233	506,000	70,000	138	15,000	2,000	133
1970	923,000	310,000	336	666,000	128,000	192	29,000	5,000	172
1971	936,000	234,000	250	751,000	148,000	197	40,000	10,000	250
1972	968,000	244,000	252	1,189,000	195,000	164	17,000	3,000	176
1973	1,048,000	200,000	191	1,592,000	113,000	71	13,000	2,000	154

Source: Sudan. 1976.

declined from 333 kg and 542 kg to 154 kg and 71 kg/feddan respectively during the same period. The reduction in yields was at a proportion of about 8 to 1 during the twelve year period. Since food crop production is so quickly decreasing, the region is on the verge of disaster and there are signs of progressive abandonment of agriculture in many areas.

Meat and milk production is only a fraction of the area's potential. While percent offtake is slightly higher for sheep (about 15%), it is only about 6 to 8 percent for cattle. Sudan has the potential to be self sufficient in meat production and at the same time supply other countries. Yet, it is hardly meeting local and national demands.

Declining Wood and Gum Production. In 1974, extensive dying off of *Commiphora africana* occurred in the Sodiri area. In most of the *Acacia tortilis* - *Commiphora* belt there was a selective death of *Commiphora* species and the belt is gradually changing into a pure *Acacia tortilis* zone characteristic of areas further north. Also, in the area between Umm Bader and Mazrub, along latitude 14°N, extensive death of *Acacia senegal* was observed. The northern limit of this species appears to be shifting south over wide areas and *Acacia senegal* is being replaced by *Leptadenia pyrotechnica*, especially on relatively loose sandy areas.

Sudan is the world's major producer of gum Arabic, which is extracted from *Acacia senegal*. The product amounts to about eight to nine percent of the value of the country's total exports. The death of these trees over large areas has not only adversely affected Sudan's foreign exchange balance, but has also reduced the supply for worldwide use.

Sand Movement and Dunes. A reconnaissence team of the National Council for Research and assisted by the UNEP/UNESCO in November 1975 documented the advance of sand from the extensive Libyan desert and the Jebel Abyan plateau which is being blown southward on a broad front by the steady northern winds. The team reported that striking evidence of the large-scale southward drift of sand is the covering of the bed of the Wadi Howar by loose sand over its whole length. The area in the immediate vicinity of the Wadi Howar, and the

Wadi Howar itself has become sandy desert, except where some of the old Acacia tortilis trees are still standing.

In several Northern Kordofan areas, sand encroachment has moved rapidly ahead of the southern boundary of the desert and loose sand is accumulating over the formerly consolidated sandy clay soils. Shallow sand encroachment appears to have killed all the vegetation as far south as 13°N, except the trees Acacia tortilis and Salanites aegyptiaca and a small number of dune-adapted shrubs.

The UNEP/UNESCO ecologist in describing desert encroachment in the northern Nile Valley, stated: "From about 50 km north of Khartoum, the Nile flows through the arid zone and is surrounded by almost total desert. A discontinuous narrow band of irrigated alluvial soil along the Nile is cultivated and is very productive. This alluvial area includes the Kerma Depression, a former depression, a former course of the river lying to the north of Dongola and to the east of the Nile. The surrounding desert areas are beyond all reasonable hope of rehabilitation because of the climate and the loss of top soil. The alluvial strip along the river and in the nearby depressions is being steadily reduced by the encroachment of the drifting sand from the north and the east. Settlement and agriculture are limited by the extent of the alluvial soil, by the capacity (and authority) to irrigate it from the river, the capacity to irrigate from boreholes and, finally, the extent of sand encroachment. The latter limiting factor is becoming increasingly serious."

The team noted that the whole length of the Nile between Dalgo and Karima, the greater part of the east-west loop, is subject to serious sand encroachment along the north-facing bank. Over long stretches, sand dunes have reached the river and have oblitorated cultivation and extensive settlement. In other areas, moving sand dunes are in the process of covering agricultural land and villages. The reconnaissance team visited the Kerma Depression Land Reclamation Scheme where large areas of agricultural land on alluvial soil have been abandoned due to sand accumulation with an average depth of only 7 cm.

Wildlife. Wildlife, once abundant in desert and semi-arid areas, is slowly vanishing because of deterioration in the wildlife habitats and continuous hunting. The above mentioned team reported small herds of dorcas gazelle in the Wadi Howar, but along the 220 km of the course of the Wadi that were searched, no signs of oryx or addax were seen. Also, no signs of oryx were seen in the vicinity of Nukhoila and el-Atkon Oases or in the desert to the west of them.

The Kababish and Camel Rezeiquat nomads stated that the addax had not been seen in the vicinity of the Wadi Howar for about 15 years. The oryx were thought to be present in small numbers, but the team found no one who had seen any since 1973. It appears that many of the former wildlife species are now extinct in the area and those that remain are highly endangered.

4.2 Soil Salinization

El-Karouri (1979) has summarized salinization problems in Sudan as follows here.

With the rapid expansion of irrigated agriculture, the question of soil salinity is becoming more and more urgent, not only for putting naturally salt-affected lands under cultivation, but also for maintaining the productivity of existing irrigated areas. At present, the total area of irrigated land in the Sudan comprises about 1.6 million ha but there are several new irrigation projects under construction. These could increase the total irrigated area to perhaps 4 million ha. Thus in the near future problems of soil salinity are likely to be encountered on a larger scale.

Work on soil salinity in the Gezira area may be traced back to the turn of the century, when it was established that there were potential salinity and alkalinity hazards associated with the Gezira Scheme. Many workers expressed concern about the possible deterioration of the soils of the Gezira, the first and largest irrigation enterprise in the Sudan, when it was put under irrigation. Some advocated the installation of a sub-soil drainage system if the rapid deterioration of the Gezira soils was to be avoided. This view was not accepted by all because of the poor permeability of the soil and the restricted lateral movement of water, which are prerequisites for an efficient drainage system. However, because of the high-quality irrigation water

with its low salt content (less than 200 ppm) and high Ca:Na ratio, as well as inclusion of long fallows in the rotation during which salts moving to the surface can be washed down by rains, in addition to growing salt-tolerant crops such as cotton, no visible signs of soil deterioration have been observed in the Gezira Scheme.

Although no signs of soil deterioration were detected, efforts were directed towards improving the inherent properties of the Gezira soils, particularly soil permeability. In the 1930s gypsum was used in reclaiming Gezira sodic soils, but leaching following gypsum application was insufficient to effect any profound change in soil productivity. Attempts at using sodium accumulators (Atriplex spp.) also failed to significantly lower sodium levels in the soil, quite apart from its depletion of plant nutrients, particularly nitrogen.

Unlike central Sudan and the Gezira area, the soils of northern Sudan are affected to a greater degree by soil salinity, particularly from Khartoum northwards along both banks of the Nile. The area affected by salinity in the Sudan can only be estimated, since few systematic surveys have been made. However, the areas which are potentially irrigable but where salinity is the main limiting factor for its development cover more than 200,000 ha.

The soils of the two northern provinces are derived largely from the alluvial deposits of the Nile mixed with some nonalluvial sands from the Nubian Sandstone. They are divided into two main groups, soils of the Recent Flood Plain and soils of the High Terraces. Soils of the Recent Flood Plain, which are a mixture of entisols and vertisols, include the Gerif and Gureir (local names) and the basin soils.

The Gerif soils are distributed along both banks of the Nile and contain high amounts of silt of fairly recent origin. Crops are grown without irrigation, after subsidence of the annual flood. The moisture-release curve of these soils indicates that plants could utilize most of the moisture in the profile.

The Gureir soils, which occur near the river bank and adjacent to the Gerif soils, are subject to flooding by moderately high flows. They are similar to Gerif soils in many aspects, but have a finer texture. They are rich free-working alluvial loams and, when irrigated, are one of the most productive soils in the Sudan.

The soils of the basins are alluvial deposits which vary greatly in age and nature. It is believed that the basins are the remains of former channels of the Nile. They are flooded only at very high flood stages. Basin soils are characterized by a high clay content, low salinity, and occasionally by high sodicity.

Most of the soils of the Recent Flood Plain, particularly the Gerif and Gureir soils, are fully exploited for agricultural production, and any envisaged agricultural development in the two northern provinces will depend mainly on the utilization of High Terrace soils. Besides some of the topographic and physical drawbacks, the main factors limiting the development of High Terrace soils are salinity and sodicity.

High Terrace soils occur on the landward side of the Recent Flood Plain. They could be classed as aridisols which have a weak structure and a texture which varies from sandy loams to sandy clays. Table 4.6 demonstrates considerable variation in salt content and composition, not only between different sites but also with depth, reflecting the diversity of parent materials within any one profile. Electric conductivity (EC) and exchangeable sodium percentage (ESP) values range between 0.2 and 49.5 mmhos/cm and between 1 and 100 respectively. Sodium is by far the dominant cation, and the dominant anions are chloride and sulphate. Therefore, the main salts are generally sodium sulphate or sodium chloride.

Little information is available on the reclamation of High Terrace soils. However, experience at the Gezira and other work have revealed that fine-textured soils are difficult to reclaim. On the other hand, it is expected that light-textured High Terrace soils can be reclaimed fairly easily. Preliminary investigations pertaining to the use of gypsum as an ameliorant on light-textured High Terrace soils have indicated its effectiveness in improving the permeability of these soils. Table 4.7 compares EC and ESP from two sites of High Terrace soils, one from virgin land and the other from a plot cultivated and irrigated from a surface well. It shows the effect of irrigation on leaching the salts and reducing the level of exchangeable sodium. One cannot, however, overlook the importance of carrying out more intensified studies and pilot projects before embarking on large-scale project developments.

Similarly the area south of Khartoum between the Blue and the White Nile and extending as far south as the northwest boundary of the Gezira Scheme is predominantly saline and/or sodic. The total area is estimated at 81,000 ha. Due to salinity problems this area has never

Table 4.6. Chemical Analyses of Saturation Extract in High Terrace Soils

Sample No.	Depth (cm)	pH paste	EC mmhos/cm	Soluble cations and anions meq/l							ESP
				Na	K	Ca	Mg	Cl	SO_4	HCO_3	
1	0–30	8.0	0.8	7.7	0.1	0.9	0.6	3.9	3.0	1.4	11.0
	30–60	8.1	1.3	12.8	0.1	0.8	0.2	5.8	3.5	0.5	20.0
	60–90	8.1	5.4	63.5	0.4	4.0	2.3	52.0	12.0	4.1	34.0
	90–120	8.2	4.5	48.0	0.2	3.1	0.9	28.0	21.0	2.5	33.0
2	0–30	7.6	18.5	56.0	1.6	156.0	12.0	57.0	150.0	1.1	7.2
	30–60	7.5	20.1	51.0	0.5	175.0	1.0	64.0	160.0	0.8	6.3
	60–90	7.5	10.6	42.0	0.2	68.0	4.0	40.0	75.0	1.0	8.4
	90–120	7.6	7.3	35.0	0.2	35.0	0.2	28.5	32.0	1.3	11.9
3	0–30	8.1	0.9	15.0	0.3	2.8	0.7	0.7	8.6	2.2	14.0
	30–60	8.1	1.4	13.0	0.1	0.8	0.2	0.4	7.6	4.2	17.5
	60–90	7.9	5.4	39.0	0.1	2.0	0.6	2.0	60.0	1.4	12.8
	90–120	7.5	17.6	80.0	0.3	9.0	82.0	95.0	95.0	1.2	11.9

Source: el-Karouri. 1979.

Table 4.7. EC and ESP of Virgin and Cultivated Plots

Soil depth (cm)	EC mmhos/cm		ESP	
	Virgin	Cultivated	Virgin	Cultivated
0–30	27.0	3.0	62	2
30–60	18.5	6.0	28	12
60–90	5.9	3.5	12	10

Source: el-Karouri. 1979.

been utilized agriculturally in any form except for a short-lived animal fattening scheme which was established in an area of 4,000 ha. Low productivity of the land was one of the factors that contributed to its failure. Soil and land classification studies undertaken in the area have confirmed that most of the soils are unsuitable for development and that the two limitations of these soils are salinity and sodicity. Four main soil types have been identified.

Esailat Sodic Series. These constitute about 46 percent of the surveyed area. The clay content is variable, ranging from 13 to 51 percent. The soil matrix is calcareous throughout. In the top layer salinity is light to moderate and electric conductivity ranges from 0.5 to 6 mmhos/cm. The subsoil is more affected by salinity, and EC ranges from 4 to 30 mmhos/cm. Similarly, ESP varies with depth and ranges from 8 to 71, with the lower values being associated with the surface horizons.

Eilafun Series. This is a brown clayey soil that forms deep cracks when dry, and surface cracks are common but often covered with a thick surface mulch. Clay content varies from 25 to 61 percent. The occurrence of soluble salts and exchangeable sodium is rather variable. EC ranges from 0.5 to 17 mmhos/cm, and the ESP from 4 to 42. Both EC and ESP are generally lower in the upper layers, but are present in moderate to high amounts lower down.

Gureir Series. This has a loamy texture, with the clay content ranging from 15 to 39 percent. Excess amounts of exchangeable sodium are contained in the lower horizons. Soluble salts content is low at the top of the profile but is moderate to high at greater depths. EC ranges from 1 to 16 mmhos/cm, and ESP from 15 to 43.

Bageir Series. This has a light texture, with a clay content that ranges from 9 to 36 percent. Generally it is non-saline but sodic. EC ranges from 0.5 to 6 mmhos/cm and ESP from 11 to 68. The lower values are those of the surface horizons. The chemical analyses of four profiles representative of the four soil types (Table 4.8, a-d) show the magnitude of salinity and sodicity in the area.

Recently the Ministry of Agriculture, Food, and Natural Resources in the Sudan has recognized the need for applied research in the field of soil salinity in order to permit the development of the area south of Khartoum. Thus the Soba Research Station for soil salinity studies was established. The programme of work at this station

Table 4.8. Chemical Analyses of Four Soil Types South of Khartoum

A. Esailat Series

Depth (cm)	pH paste	EC mmhos/cm	CEC meq/100g	Exch. cations meq/100 g				Soluble ions meq/l sat. extract								ESP
				Na	K	Ca	Mg	Na	K	Ca	Mg	Cl	SO_4	HCO_3	CO_3	
0–35	8.9	2.9	38	22	0.8			28		0.9	0.3	11.3		3.0	0.6	56.3
35–90	8.5	5.1	50	22	0.9			61		4.0	0.9	16.4		2.0	0.4	43.1
90–120	8.8	3.2	38	20	0.7			33		2.0	0.5	12.8		2.2	0.5	51.6

B. Eilafun Series

Depth (cm)	pH paste	EC mmhos/cm	CEC meq/100g	Exch. cations meq/100 g				Soluble ions meq/l sat. extract								ESP
				Na	K	Ca	Mg	Na	K	Ca	Mg	Cl	SO_4	HCO_3	CO_3	
0–5	8.6	0.6	54	8.0	1.2			7.4		0.4	0.4	1.1		2.5	1.0	15.6
5–45	8.6	0.8	57	14.0	1.1			9.0		0.8	0.2	2.1		1.9	1.3	24.5
45–65	8.3	6.7	56	16.0	1.0			75.4		14.2	7.1	24.0		0.8	0.5	28.2
65–105	8.0	7.4	43	14.0	1.0			80.0		29.8	1.9	27.2		0.7	0.0	32.3
105–135	8.0	5.8	43	12.8	0.9			61.0		9.4	4.9	24.7		0.6	0.5	30.0

C. Gureir Series

Depth (cm)	pH paste	EC mmhos/cm	CEC meq/100g	Exch. cations meq/100 g				Soluble ions meq/l sat. extract								ESP
				Na	K	Ca	Mg	Na	K	Ca	Mg	Cl	SO_4	HCO_3	CO_3	
0–15	8.7	1.2	34	5.0	0.6			10.0		0.8	0.4	1.9		1.3	1.4	14.7
15–35	8.3	16.3	34	13.5	0.4			136.0		21.4	5.5	26.5		0.9	0.5	40.0
35–60	8.5	8.2	35	15.0	0.3			87.2		9.6	2.9	72.8		0.5	0.6	43.0
60–90	8.5	6.5	27	8.3	0.3			68.0		5.9	1.3	55.6		0.7	0.6	30.7
90–120	8.7	3.4	14	4.3	0.2			33.0		1.6	1.6	30.0		0.6	0.6	30.7

D. Bageir Series

Depth (cm)	pH paste	EC mmhos/cm	CEC meq/100g	Exch. cations meq/100 g				Soluble ions meq/l sat. extract								ESP
				Na	K	Ca	Mg	Na	K	Ca	Mg	Cl	SO_4	HCO_3	CO_3	
0–5	8.4	0.6	19	2.1	0.6			6.0		1.0	0.4	1.2		3.0	0.5	11.0
5–20	9.0	1.4	43	24.0	0.9			14.0		1.3	0.3	3.4		4.0	1.2	56.0
20–55	8.6	5.7	36	24.3	0.8			71.2		3.3	0.4	8.6		2.4	0.8	67.5
55–95	8.7	2.8	29	19.0	0.5			28.0		1.6	0.8	7.0		2.0	0.9	65.5
	9.0	2.3	9	11.5	0.4			30.0		0.7	0.3	5.9		2.5	1.3	128.0

Source: el-Karouri. 1978.

covers a wide range of research pertaining to the field of saline and sodic soils reclamation, such as the assessment of leaching and drainage requirements, water needs of crops, use of organic and chemical ameliorants, establishment of a salt-tolerance index, economics of reclamation and management, etc.

Although only a short time has elapsed since the establishment of Soba Research Station in 1974, some useful findings have been made. In a four-year experiment chemical and organic ameliorants were compared using wheat, maize, fodder sorghum, beans, and broad-beans as indicator crops. Resulting crop yield indicated the superiority of farmyard manure to gypsum and green manure. Although gypsum improved the soil physical properties (increased hydraulic conductivity and reduced mechanical resistance and crust strength) and increased seedling emergence, it did not result in any substantial increase in crop yield.

In a series of experiments more than 25 crops were screened for salinity tolerance under field conditions. The yields of these crops were found to range from 20 to 70 percent of the normal productivity of non-saline soils in the region. The magnitude of the reduction in yield depended on the type of crop and its level of tolerance to salts. The crops that gave fairly moderate yields were beetroot, radishes, cucumbers, onions, fodder sorghum, alfalfa, sunflowers, safflower, soybeans, etc. On the other hand, peas, beans, broad beans, lentils, lupins, watermelons and jojoba performed rather poorly.

Cultural practices and management could modify to a great extent the performance of crops grown on saline soils. It has been found that planting on ridges or beds increases seedling emergence and plant populations significantly, particularly in areas where crust formation is a hindrance to seedling emergence.

4.3 Public Health Issues

Health issues in Sudan may be divided for convenience into several categories. Development of surface water resources, particularly irrigation networks, may cause the spread of certain diseases such as malaria and bilharzia. Rural areas, and occasionally sections of urban areas as well, often lack elementary water or sewage treatment facilities. Housing is often inadequate and crowded. In some areas of the country, an influx of refugees has exacerbated the difficulties in improving health standards. Major problems include:

Water borne disease. 20/ The implementation of major irrigation projects has usually been accompanied by increases in incidence of malaria and schistosomiasis. The Rahad irrigation scheme (east bank of the Rahad River), for example, lies within a hyper-endemic malaria zone where malaria was originally transmitted primarily during the rainy season. Peaks in transmission still occur during the rainy season, but transmission now occurs throughout the year. A similar pattern has been found in the Gezira/Managil schemes. Plasmodium falciparum is by far the predominant parasite species. In 1975 malaria outbreak reached epidemic proportions in the Gezira (parasite rate in children aged 0-9 years was 19.7%). Emergency measures had reduced this rate to 5.2 percent by the following year, and improvement continued through 1978.

Similarly, schistosomiasis has increased, both because of the expansion of the vector's favored environment and because of the labor influxes to irrigation development areas. These migrants may bring the disease from other areas. The effects of bilharzia are severe throughout the entire Gezira area and incidence of the disease is increasing. Hospital admissions for schistosomiasis at the provincial hospital increased rapidly during the mid 1970s, and in 1978, half of the patients in the general ward were bilharzia cases.

Over 33,000 cases were diagnosed in the Province during 1977 but the prevalence is estimated to be from 50 to 70 percent in the Scheme. One of the occupational groups most severely affected is the men who clear weeds from the canals and the disease probably affects most of the labor force in the Gezira, causing disability and even death. Table 4.9 shows the prevalence rate of the parasite S. mansoni in a sample of Gezira residents, while Table 4.10 notes the main vectors and parasites.

Water Supply. The availability of an adequate supply of uncontaminated water is vital to the health of any population. U.S. AID (1980) estimated that in 1975, about 43 percent of rural inhabitants and 96 percent of urban inhabitants (total Sudan 50%) had access to safe water. U.S. AID (1978), however, stated that the supply of water remains inadequate or hardly existent in many

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20 Sources: Anonymous. 1978?
Bannaga and Pickford. 1979.
Waziri. 1978.

Table 4.9 Prevalence Rate of *S. mansoni* Infection in the Gezira

Age	Male		Female	
	No. examined	Percent	No. examined	Percent
0-4	120	8.3	128	2.3
5-9	163	45.4	177	45.2
10-14	160	76.3	137	79.6
15-19	65	82.2	121	79.3
20-24	25	68.0	81	51.9
25-29	27	55.8	72	45.8
30-34	25	64.0	67	44.8
35-39	27	51.7	56	48.2
40-44	31	32.3	38	21.1

Source: Waziri. 1978.

Table 4.10 Snail Species and Parasites in the Gezira

Snail	Parasite	Relative Frequency
Biomphalaria pfeifferi	*S. mansoni*	Abundant
B. sudanixa	*S. mansoni*	Common
B. alexandria	*S. mansoni*	Common
Bulinus truncatus	*S. haematobium*	Abundant
B. Forskalii	non-transmitter	Common
Lymnaea natalensis	*Fasciola hepatica*	
Cleopatra ferruginea	non-transmitter	
Melanoides tuberculata	non-transmitter	

Sources: Anonymous. 1978?
Waziri. 1978.

low income residential areas. In the three cities area water supply in 1978 was provided by four treatment plants with a capacity of about 116,000 cubic m/day. Average usage in 1977/78 was less than 95,000 cubic m/day. Problems of blockage, pressure lapses, and inadequate maintenance are common in all urban areas.

Sanitation. According to U.S. AID (1981a) only Khartoum and Khartoum North have a central sewage system. Khartoum's treatment plant capacity of three million gallons per day (MGD) was far below usage of 6 MGD in 1978 (U.S. AID 1978). The plant provides service to less than 30 percent of the city's population. The Khartoum North plant had a capacity greater than usage in 1978, but only 15 to 20 percent of housing units were connected. Houses in both cities, as well as in Omdurman, which are not connected, usually utilize septic tanks. Much of the low-income housing, however, has no sewage provisions, particularly in shanty town areas. Maintenance of drainage systems, usually covered ditches, is often poor, resulting in blockage and flooding problems. Garbage collection is usually available only to some of the middle or upper income areas. In low-income areas garbage is often dumped in the center of the neighborhood.

Housing. Housing is detailed in U.S. AID (1978), and summarized in U.S. AID (1981a), which follows here.

Over 13 million people, or 75 percent of Sudan's population, are estimated to be living in rural areas. Of these, 4.4 million people live in permanent houses made with local materials such as mud, timber, and straw, and another 8.6 million people are either nomads with portable light-weight shelters or seasonal migrants living in houses built for temporary occupancy. Because of the differing and sometimes ambiguous definitions of "household", the average occupancy per house may vary from 5-10 people.

Housing density is very low in a typical rural village settlement. Cattle herdsmen cluster a number of huts around fenced areas where they keep their cattle. Farming communities have a tendency to build shelters at the edge of their farmland, where cattle areas and huts are placed side by side.

The design and materials used for rural housing vary depending upon local raw material availability. In the northern and western parts of the country, the rural shelters are made mostly with mud and have thatched or straw roofs and walls plastered with manure. In the southern region, the circular one-room house, called a

toukal, has mud or straw walls and a conical, layered straw roof. This type of unit requires constant maintenance and creates a fire hazard.

Proximity to a water supply, whether from a river, spring, or man-made well, is the most important factor in choosing a site for permanent settlement. Sanitary waste does not present a significant problem in rural areas, due to low residential densities. In general, rural housing meets the basic needs of rural residents and improvement of housing and services is given low priority compared to housing in the major urban areas.

According to the 1973 census, the "average household" in urban areas had 5.4 persons living in two rooms. Forty-three percent of dwelling units had only one room, and 40 percent of those households with 5-6 members lived in only one room.

Only a small portion of urban houses were built of "permanent materials"; 4.7 percent of homes had walls of brick or stone, and 12.7 percent of homes had roofs of zinc sheets or concrete. Walls of mud were used in 47.4 percent of homes. However, the combination of mud walls and baladi roofs was by far the predominant housing type throughout urban areas of Sudan; 30.9 percent of homes were of this type. In addition to the traditional building materials, the most commonly used building materials for housing construction are bricks, cement, lime, lumber, and reinforced steel bars. Tables 4.11 and 4.12 indicate building materials and housing characteristics according to the 1973 census.

Refugees. According to U.S. AID (1981a), one of the most immediate issues in Sudan is the estimated 450,000 refugees who have sought a haven there. Refugees have been entering Sudan since the mid-1960s from Zaire, Ethiopia, Uganda, and Chad. In coordination with the United Nations High Commission for Refugees (UNHCR) and World Food Program (WFP), the Government of Sudan has consistently accepted refugees on a humanitarian basis and has attempted to assist in settling them away from the borders. Such efforts have often been at the expense of applying the same financial and human resources to address the needs of its own citizens. The strain on Sudanese resources (food, housing, medicine, transportation, education, etc.) has been pushed even further in the past year with another large influx of refugees fleeing from the most recent fighting in Ethiopia. To avoid greater social and economic tensions between refugees and local populations, Sudan has adopted a new policy aimed at integrating the refugees into the

Table 4.11. Urban Building Materials, 1973

Wall Material	Roof Material: Baladi	Wood	Zinc Sheet*	Con-crete	Other	Total
Grass	.4		.1		18.0	18.5
Brick	4.6	4.7	6.5	1.4	1.4	18.6
Mud	30.9	2.6	1.8		12.1	47.4
Stones	.1	.2	.8	.5	.5	2.1
Wood	.1	4.1	.1		.2	4.4
Muddy Brick	2.0	.2	.3		.4	2.9
Other	.3	.3	.9	.3	4.2	6.1
Total	38.4	12.1	10.5	2.2	36.8	100.0

* Permanent material

Source: U.S. AID. 1981a.

Table 4.12. Housing Characteristics from 1973 Census

	Sudan Urban	Khartoum 3 Cities	Port Sudan	El Obeid	Juba
Total number of dwelling units	471,490	132,726	29,143	15,783	9,836
Average number of rooms	2.0	2.2	1.7	2.3	1.6
Percent with only one room	43	39	55	38	66
Persons per household	5.4	5.9	4.5	5.6	5.4
Persons per room	2.7	2.7	2.7	2.4	3.4

Source: U.S. AID. 1981a.

country's long-range development plans. The government now believes that refugee resettlement must be done in concert with general economic development and must emphasize production-oriented activities. If this program is successful, the energy and resources currently being experded on the refugees might be available to address some of the environmental and development-related problems, which in the meantime hinder self-sufficiency for all of Sudan.

Refugees in the urban areas, particularly Khartoum, Kassala, and Port Sudan, live in crowded squatters' huts. These single-room huts, with no access to water or sanitation facilities, often hold as many as four families. The government's solution is to move the refugees into organized settlements outside the towns. Understanding that many refugees who came from an urban background do not want to live in rural areas, Sudan hopes to provide vocational training so they can get urban jobs later.

Sudan has set up several successful refugee resettlement villages where each family is given a small plot of land to farm. However, at the present most refugees in Sudan live in poor conditions. Temporary shelters (tents, tarpaulins, plastic sheeting) are common and many people must walk several miles for firewood and water. Generally, these relief camps have no storage facilities, so each family receives a two-week supply of food, soap, and cooking oil at a time. However, Sudan is making progress in alleviating these conditions.

4.4 Water Hyacinth and Other Weeds

The water hyacinth (Eicheria crassipes) problem is summarized in U.S. AID (1981a), which is followed here.

The unchecked outbreak of water hyacinth in the Nile has been called "one of the environmental disasters of the century." The water hyacinth is a South American plant, first seen in the Upper Nile region in 1958. By 1962, the plant had succeeded in infesting the whole stretch of the White Nile from Juba to the Jebel Aulia Dam as well as other rivers and lakes (Figure 4.2). In the period of April to October, vast amounts of water hyacinth plants drift north toward the Jebel Aulia Dam where they accumulate, completely covering the water surface. During this period wind and water current action compress them into a thick carpet that people can walk on.

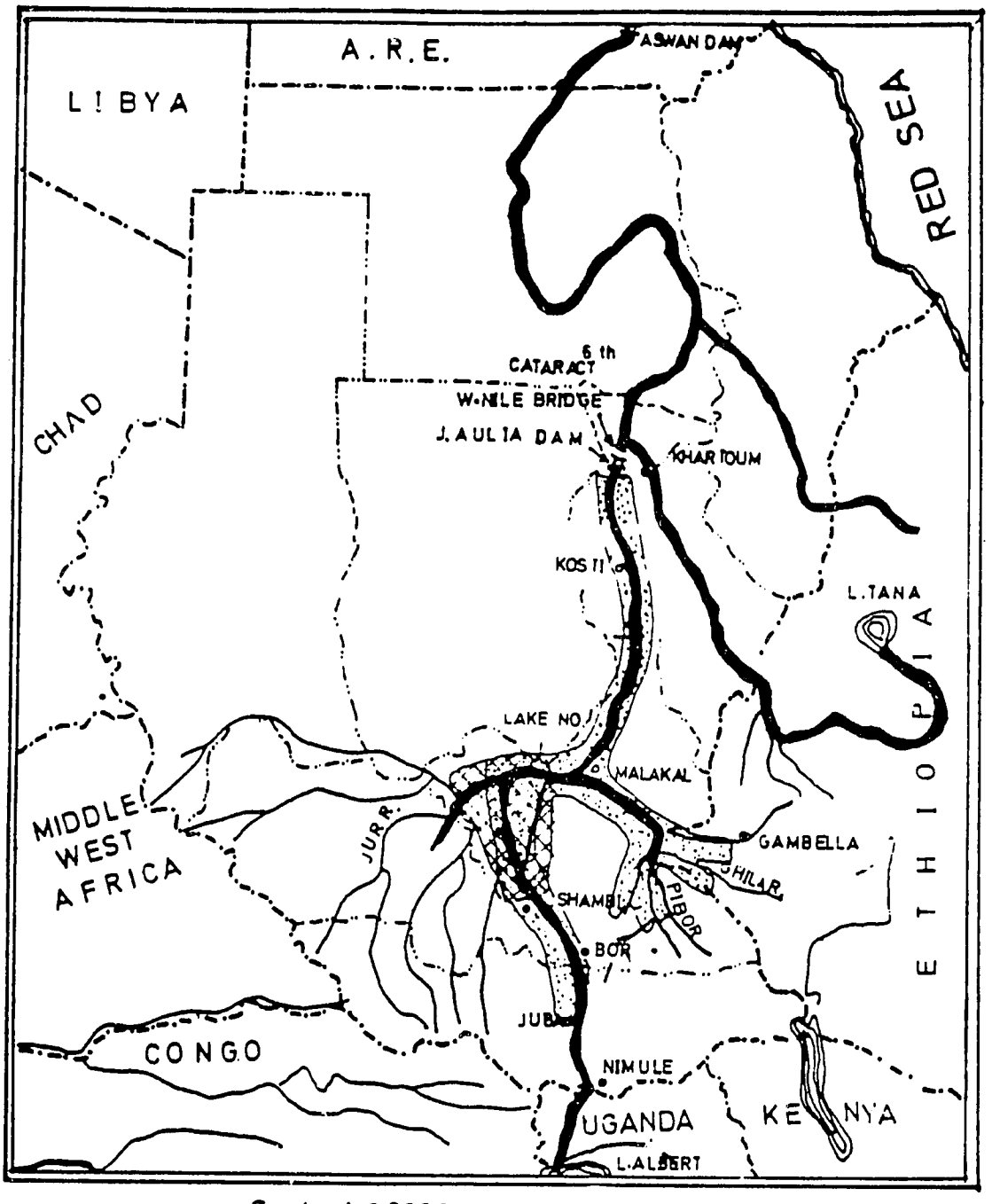

Figure 4.2. Areas of Water Hyacinth Infestation

Source: Sudan and USA. 1975.

The accumulation of water hyacinth on the Nile has caused a water loss of up to seven billion cubic meters per year, or one-tenth the normal yield of the river. Besides reducing the water supply, water hyacinth blocks irrigation pump inlets and canals, hydroelectric power plants, and water supply channels for settlements. Difficulties in water transport such as damage to boats, delays in service, and increased fuel consumption have been reported. Fishing along the river banks has become difficult or impossible since many side channels are completely choked up. Water hyacinth also provides good breeding sites for mosquitos (causing an increased incidence of malaria) and freshwater snails, which are intermediate hosts for the parasite that causes schistosomiasis.

The Sudanese government has launched a control program to limit the spread of the plant at a cost of US $2.5 million per year. However, researchers have expressed concern over the limitations and dangers of using herbicides. Efforts made in South America by a team of entomologists to select insects that live on and destroy water hyacinth are being investigated. These and a number of other possible control programs are discussed in Sudan and USA (1975).

Hamdoun and Babiker (1972) discuss weeds which impede cultivation. Typha angustifolia, another water weed, often establishes itself in drains, and can completely block them. Ishaemum afrum and Sorghum sp. infestation is very serious in some fields, particularly in the Kashm el-Girba scheme. Other major problem weeds include Striga hermonthica, Cyprus rotundus, and Cynodon dactylon.

4.5 Pest Infestations

A number of infestations are briefly mentioned in U.S. AID (1981a):

Migratory Locusts. In 1930 migratory locusts appeared in the Sudan for the first time since 1899. Between 1930 and 1940 they returned every year and caused heavy damage to crops. In 1968, migratory locusts appeared in the eastern Sudan, where they ate 1,214 ha. of sugarcane.

Red Locusts. Sudan is on the very northern edge of the red locust's range. The only record of the red locust having penetrated into Sudan was in 1937 when a swarm appeared and travelled north as far as 17° N, near Atbarah.

Desert Locusts. The coastal region of the Sudan is part of the desert locust breeding zone along the Red Sea and the Gulf of Aden. Kassala Province in particular has been hard hit by all four of this century's major desert locust plagues. There was significant desert locust damage in the Sudan in 1967, but the plague did not last beyond 1969, largely due to control efforts by the Desert Locust Control Organization/East Africa (DLCO/EA). DLCO/EA was also responsible for controlling the plague of 1978-79, when desert locusts in Sudan were restricted to the coastal area, and no major damage was reported.

Testse Flies. Tsetse flies are endemic in southern Sudan. A government control problem exists, but most people living in this area have adapted by not keeping cattle.

During the summer of 1980 a serious Quelea bird infestation was reported by the Sudan Ministry of Agriculture. DLCO/EA assisted in a spraying operation in the southern, central, and eastern parts of the country.

Further discussion may also be found in Abdel-Nur (1972); Allam (1972); and el-Amin (1972).

4.6 Flooding

Clary and McKelvey (1978) and U.S. AID (1981a) have summarized flooding problems in Sudan as follows here:

"Floods are an annual and generally welcome event which provides water for drinking and irrigation. However, every three or four years major flooding occurs that causes structural and agricultural damage. In 1975 extensive flooding in central and eastern Sudan inundated more than 66 million ha, destroying approximately 7,000 homes and leaving 100,000 people homeless. In 1978 flood waters caused severe damage in Gezira, White Nile, Northern Nile, and Kassala provinces. Some 200 villages were badly damaged and up to 80 were totally destroyed. There was heavy water damage to the Gezira Scheme irrigation system and an undetermined quantity of crops and livestock were lost. The total dollar value of the damage was estimated at $25 million by the Government of Sudan."

4.7 Miscellaneous

Rodger (1972) discusses dust problems, and notes that dust may so reduce visibility at Khartoum that somtimes

the airport must close. Machinery and electronic equipment wears much faster in an environment with high levels of dust. Respiratory problems are also more prevalent in such environments. Workers in some industries are particularly susceptible; for example, workers in mines and quarries, or in some factories such as sugarcane refineries. The level of industrial air pollution, however, is very low in Sudan because of the lack of extensive industrial development.

Pollution by pesticides is somewhat of a problem, according to Mohamed (1972). About 85 percent of pesticides used in Sudan are allocated toward controlling cotton pests, but some are used to control the Quelea bird and other agricultural pests. In addition, insecticides are used in residential areas to control malaria. Mohamed presents data which indicates that a small number of people and domestic animals have died because of accidental poisoning (five humans near Kasti in 1970).

Hamdoun and Babiker (1972) briefly discuss herbicide pollution, and note that many crops have suffered from soils that had previously been treated. Detailed data on the problem, however, are not available.

Literature Cited

Abdel Nur, O.M. 1972. The Insect Problem in the Sudan. In: Man-Environment-Development. Proceedings of the Arab Regional Symposium on Environmental Aspects of Development in the Arab Countries, Khartoum, February 1972. Cairo: Arab League Educational, Cultural, and Scientific Organization (ALESCO). pp. 335-339.

Ahmed, O. 1972. Iron Ores of the Sudan and the Possibility of their Development or Industrialization. In: Man-Environment-Development. Proceedings of the Arab Regional Symposium on Environmental Aspects of Development in the Arab Countries, Khartoum, February 1972. Cairo: Arab League Educational, Cultural, and Scientific Organization (ALESCO). pp. 303-309.

Allam, T.M.H. 1972. The Grasshopper Problem in the Sudan. In: Man-Environment-Development. Proceedings of the Arab Regional Symposium on Environmental Aspects of Development in the Arab Countries, Khartoum, February 1972. Cairo: Arab League Educational, Cultural, and Scientific Organization (ALESCO). pp. 340-343.

Allan, W.N. 1948. Irrigation in the Sudan. In: Agriculture in the Sudan (J.D. Tothill, ed.). London: Oxford University Press. pp. 593-632.

el-Amin, el-T.M. 1972. Insect Pests and Human Environment. In: Man-Environment-Development. Proceedings of the Arab Regional Symposium on Environmental Aspects of Development in the Arab Countries, Khartoum, February 1972. Cairo: Arab League Educational, Cultural, and Scientific Organization (ALESCO). pp. 231-241.

Andrews, F.W. 1948. The Vegetation of the Sudan. In: Agriculture in the Sudan (C.M.G. Tothill, ed.). London: Oxford University Press. pp. 32-61.

Anon. n.d. National Progress Report on Forestry, Sudan, Period 1975-1977. Place of publication unknown. Mimeographed Manuscript. 14 pp.

-----. 1978? Plan of Operations for a Comprehensive Approach to the Prevention and Control of Water Associated Diseases in the Irrigated Schemes, Gezira Province, Sudan. Place of publication unknown. Mimeographed Manuscript. 38 pp.

Balek, J. 1977. Hydrology and Water Resources in Tropical Africa. Amsterdam: Elsevier. 208 pp.

Bannaga, I.Y. 1980. Water Resources of the Sudan. In: The First Arab Symposium on Water Resources, November 1978, Vol. 2: Water Legislation. Damascus: Arab Center for the Studies of Arid Zones and Dry Lands. pp. 54-87.

Bannaga, S. el-D.I. and J. Pickford. 1979. Water-Health Relationships in el-Obeid an Example from an Urban Semi-Arid Area in Western Sudan. In: Proceedings of the Khartoum Workshop on Arid Lands Management, University of Khartoum - United Nations University, 22-26 October 1978. (J.A. Mabbutt, ed.). Tokyo: United Nations University. pp.65-70.

Bannerman, D.A. 1930-1951. The Birds of West and Equatorical Africa. 8 vols. Edinburgh and London.

Bari, E.A. 1968. Sudan. In: Conservation of vegetation in Africa South of the Sahara. Proceedings of a Symposium held at the 6th Plenary meeting of the "Association pour l'Etude Taxonomique de la Flore d'Afrique Tropicale" (AETFAT) in Uppsala, Sept. 1966. (I. Hedberg & O. Hedberg, eds.). Uppsala: Almquist & Wiksells Boktryckeri AB. pp. 59-64.

Bayoumi, A.A. n.d. Forestry and Rural Development: Some Examples from the Sudan. Place of publication unknown. Mimeographed Manuscript. 5 pp.

Berry, L. and A.J. Whiteman. 1968. The Nile in the Sudan. Geographical Journal 134(1):1-37.

Beshir, M. el-M. and el-Moghraby, A.I. 1980. Ecological Studies on the Sudanese Nile System. Water Supply and Management 4(1/2):25-28.

el-Boushi, I.M. 1972. The Shallow Ground Water of the Gezira Formation at Khartoum and the Northern Gezira Area, Sudan. In: Man-Environment-Development. Proceedings of the Arab Regional Symposium on Environmental Aspects of Development in the Arab Countries, Khartoum, February 1972. Cairo: Arab League Educational, Cultural, and Scientific Organization (ALESCO). pp. 288-300.

Boutros, J.Z. 1972. Water Quality in the Sudan. In: Man-Environment-Development. Proceedings of the Arab Regional Symposium on Environmental Aspects of Development in the Arab Countries, Khartoum, February 1972. Cairo: Arab League Educational, Cultural, and Scientific Organization (ALESCO). pp. 365-370.

Bowen, W.W. 1926. Catalogue of Sudan Birds. Sudan Gov. Mus. Nat. Hist. Publ. No. 1.

Brocklehurst, H.S. 1931. Game Animals of the Sudan. London: Gurney and Jackson.

Bunting, A.H. and J.D. Lea. 1962. The Soils and Vegetation of the Fung, East Central Sudan. Journal of Ecology 50(3):529-558.

el-Bushra, el-S. 1979. Some Demographic Indicators for Khartoum Conurbation, Sudan. Middle Eastern Studies 15(3):295-309.

el-Bushra, el-S. and M.O. el-Sammani. 1977. Urban and Rural Water Supplies in the Sudan. Ekistics 43(254):36-42.

Buursink, J. 1971. Soils of Central Sudan. Utrecht: Grafisch Bedrijf Schotanus & Jens Utrecht N.V. 248 pp.

Carlisle, D.B. and G.G. Koss. 1970. Food and water requirements of the dorcas gazelle in the Sudan. Mammalia 32:249-256.

Cave, F.O. and J.D. MacDonald. 1955. Birds of the Sudan. Edinburgh & London: Oliver and Boyd.

Clary, R. and M. McKelvey. 1978. Sudan Floods--Trip Report, July 30-August 18, 1978. Place of publication unknown. Xeroxed manuscript. ii + 2 pp.

Cloudsley-Thompson, J.L. 1964. Guide to the natural history of Khartoum Province. Part I: Desert Invertebrates of Khartoum Province. Reprinted from Sudan Notes and Records 45:1-11.

-----. 1973. Development in the Sudan Parks. Oryx 12:49-52.

Dorst, J. and P. Dandelot. 1970. A Field Guide to the Larger Mammals of Africa. London: Collins.

Etchecopar, R.D. and F. Hue. 1967. The Birds of North Africa. Oliver and Boyd. 612 pp.

Europa Publications, Ltd. 1981. The Middle East and North Africa 1981-82. London: Europa. pp. 688-725.

FAO-UNDP. 1968. Land and Water Resources Survey in the Jebel Marra Area, the Sudan. Final Report. Rome: FAO. ix + 70 pp. + maps.

Frankenberg, P. 1979. Zur Vegetation des Niltals zwischen der Mittelmeerküste und Khartoum -- Ein Beitrag zu dem Problem Steppe/Savanne. Die Erde 110(2-3):127-133.

Ghobrial, L.I. and A.S.K. Hodieb. 1973. Climate and seasonal variations in the breeding of the desert Jerboa (Jaculus jaculus) in the Sudan. J. Reprod. Fert. Suppl. 19:221-233.

Green, J., A.I. el-Moghraby and O.M.M. Ali. 1979. Biological observations on the crater lakes of Jebel Marra, Sudan. J. of Zooology 189(4):493-502.

Greene, H. 1948. Soils of the Anglo-Egyptian Sudan. In: Agriculture in the Sudan (J.D. Tothill, ed.) London: Oxford University Press. pp. 144-175.

Hale, G.A. 1966. Cultivation Terraces in Western Darfur, Sudan: A Study in an Agricultural Form and Practice. University of California, Los Angeles, Ph.D. Dissertation. xv + 207 pp.

Hall, B.P. and R.E. Moreau. 1970. An Atlas of Speciation in African Passerine Birds. London, British Museum.

Halwagy, R. 1961. The Vegetation of the Semi-Desert North East of Khartoum, Sudan. Oikos 12(1):87-110.

-----. 1962. The Incidence of the Biotic Factor in Northern Sudan. Oikos 13(1):97-117.

Hamdoun, A.M. and A.G.T. Babiker. 1972a. Persistence of Some Soil-Acting Herbicides in the Sudan. In: Man-Environment-Development. Proceedings of the Arab Regional Symposium on Environmental Aspects of Development in the Arab Countries, Khartoum, February 1972. Cairo: Arab League Educational, Cultural, and Scientific Organization (ALESCO). pp. 356-363.

-----. 1972b. Some weed problems of the Sudan and their Control. In: Man-Environment-Development. Proceedings of the Arab Regional Symposium on Environmental Aspects of Development in the Arab Countries, Khartoum, February 1972. Cairo: Arab League Educational, Cultural, and Scientific Organization (ALESCO). pp. 242-250.

Happold, D.C.D. 1966. Breeding periods of rodents in the Northern Sudan. Revue Zool. Bot. Afr. 74:357-363.

-----. 1967a. Guide to the natural history of Khartoum Province. Mammals. Reprinted from Sudan Notes and Records 1967, 48:1-22.

-----. 1967b. Additional information on the mammalian fauna of the Sudan. Mammalia 31:605-609.

Hashim, I.M. and M.B. Nimir. 1977. Population Trend Counts of Tiang, Waterbuck and Roan Antelope in Dinder National Park. Submitted for publication.

Hasseeb, M.A., H.H. Erwa, A.M. Nasr and M.A. Amin. 1972. Review of Endemic and Infectious Diseases in Sudan: I General Survey; II Diarrhoeal Diseases; III Malaria; IV Schistosomiasis. In: Man-Environment-Development. Proceedings of the Arab Regional Symposium on Environmental Aspects of Development in the Arab Countries, Khartoum, February 1972. Cairo: Arab League Educational, Cultural, and Scientific Organization (ALESCO). pp. 93-127.

Heinritz, G. 1981a. Beobachtungen zur Land-Stadt-Wanderung in Khartoum/Sudan. Geographische Zeitschrift 69(4):267-285.

-----. 1981b. Zum Wanderungsverhalten der Westerner in der Republik Sudan. Erdkunde 35(1):54-65.

Iskander, W. 1967. An Appraisal of Ground Water Resources of Zalengei Area, Darfur Province, Sudan. University of Arizona, Tucson, Arizona, Masters Thesis. x + 101 pp. + maps.

-----. 1972. Ground Water in the Sudan. In: Man-Environment-Development. Proceedings of the Arab Regional Symposium on Environmental Aspects of Development in the Arab Countries, Khartoum, February 1972. Cairo: Arab League Educational, Cultural, and Scientific Organization (ALESCO). pp. 281-286.

Ishag, A.H. 1965. A Quantitative Study of the Potential Recharge to Principal Aquifers in Kordofan Province of Western Sudan. University of Arizona, Tucson, Arizona, Masters Thesis. viii + 54 pp.

International Union for the Conservation of Nature and Natural Resources (IUCN). 1966. Red Data Book, Vol. 2: Aves. Morges, Switzerland: IUCN.

-----. 1969. Red Data Book, Vol. 4: Pisces. Morges, Switzerland: IUCN.

-----. 1971. U.N. List of National Parks and Equivalent Reserves, 2nd ed. Brussels: IUCN. 601 pp.

-----. 1975. Red Data Book, Vol. 3: Amphibia and Reptilia. Morges, Switzerland: IUCN.

-----. 1978. Red Data Book, Vol. 1: Mammalia. Morges, Switzerland: IUCN.

Jackson, F.J. and W.L. Sclater. 1938. The Birds of Kenya Colony and the Uganda Protectorate. Vol. 1 and 2. London and Edinburgh.

Jahn, S. al-A. 1977. Traditional Methods of Water Purification in the Riverain Sudan in Relation to Geographic and Socio-Economic Conditions. Erdkunde 31(2):120-130.

Johnson, H. and J. Johnson. 1977. Environmental Policies in Developing Countries. Beiträge zur Umweltgestaltung, Heft A 27. Berlin: Erich Schmidt Verlag.

Karkanis, B.G. 1966. Hydro Chemical Facies of Ground Water in the Western Provinces of Sudan. University of Arizona, Tucson, Arizona, Masters Thesis. viii + 63 pp.

el-Karouri, M.O.H. 1979. Effect of Soil Salinity on the Productivity of Arid Lands, with Special Reference to the Sudan. In: Proceedings of the Khartoum Workshop on Arid Lands Management, University of Khartoum - United Nations University, 22-26 October 1978. (J.A. Mabbutt, ed.). Tokyo: United Nations University. pp. 49-54.

Khogali, M.M. 1979. Nomads and Their Sedentarization in the Sudan. In: Proceedings of the Khartoum Workshop on Arid Lands Management, University of Khartoum - United Nations University, 22-26 October 1978. (J.A. Mabbutt, ed.) Tokyo: United Nations University. pp. 55-59.

Lebon, J.H.G. 1967. The Land and Water Use Survey of North-Central Kordofan (1961-66). Geographical Journal 134(4):546-550.

Lee, D.R. 1970. The Location of Land Use Types: The Nile Valley in northern Sudan. Economic Geography 46(1):53-62.

MacDonald, J.D. and F.O. Cave. 1948. Recent additions to the Sudan check-list of birds. Ibis 90:240-251.

MacKenzie, P.Z. 1954. Catalogue of Wild Mammals of the Sudan occurring in the Natural Orders Artiodactyla and Perissodactyla. Publs. Sudan Govt. Mus. Nat. Hist., No. 4:1-21.

MacWorth-Praed, C.W. and C.H.B. Grant. 1950-1958. Birds of East and Northeast Africa. Vol. I and II. London: Longman Group Limited.

-----. 1962-1963. Birds of the Southern third of Africa. Vols. I and II.

-----. 1970-1973. Birds of Westcentral and Western Africa. Vols. I and II.

Mahdi, M.A. 1973. Studies on factors affecting survival of Nile Fish in the Sudan. I. The effect of hydrogen ion concentration. Marine Biol. 18(2):89-98.

Mahmoud, A. and M. Obeid. 1971. Ecological Studies in the Vegetation of the Sudan I: General Features of the Vegetation of Khartoum Province. Vegetatio 23(3-4):153-176.

Meester, J. and H.W. Setzer, eds. 1971-77. The Mammals of Africa: An Identification Manual. Washington, D.C.: Smithsonian Institute.

Middle East Economic Digest (MEED). 1977. Sudan: A MEED Special Report. London: MEED. 20 pp.

Mohamed, el-S el-B. 1972. Pesticides and Pollution of Human Environment in the Sudan. In: Man-Environment-Development. Proceedings of the Arab Regional Symposium on Environmental Aspects of Development in the Arab Countries, Khartoum, February 1972. Cairo: Arab League Educational, Cultural, and Scientific Organization (ALESCO). pp. 350-355.

Moreau, R.E. 1966. The Bird Faunas of Africa and its Islands. New York: Academic Press. 424 pp.

Muller, M. 1976. Experts Cling to Water Myths. New Scientist 70(1006):692-693.

Nelson, H.D. et al. 1973. Area Handbook for the Democratic Republic of Sudan. Washington, D.C.: U.S. GPO. xiv + 351 pp. (DA Pam 550-27)

Newhouse, F. 1939. The Training of the Upper Nile. London: Sir Isaac Pitman & Sons, Ltd. 102 pp.

Nimir, M.B. and S.A.R. Hakim. 1979. Wildlife conservation in the arid zone of the Sudan. Proceedings of the Khartoum Workshop on Arid Lands Management. The United Nations University.

Obeid, M. and A. Mahmoud. n.d. Guide to the Natural History of Khartoum Province, Part IV: The Vegetation of Khartoum Province. Khartoum: University of Khartoum.

Board for Arid Zone Research. 27 pp. (Reprinted from Sudan Notes and Records 5D)

-----. 1971. Ecological Studies in the Vegetation of the Sudan II: The Ecological Relationships of the Vegetation of Khartoum Province. Vegetatio 23(3-4):177-198.

O'Conner, A.M. 1978. The Geography of Tropical African Development. 2nd ed. Oxford, England: Pergamon Press. xviii + 229 pp.

Oliver, J. 1965. Guide to the Natural History of Khartoum Province, Part II: The Climate of Khartoum Province. Khartoum: University of Khartoum, Board for Arid Zone Research. 40 pp. (Reprinted from Sudan Notes and Records 46, 1965)

-----. 1969. Problems of Determining Evapotranspiration in the Semi-Arid Tropics Illustrated with Reference to the Sudan. Journal of Tropical Geography 28:64-74.

Osman, M.S. and H.E. el-Hag. 1972. Irrigation Practices and their Development in the Sudan. In: Man-Environment-Development. Proceedings of the Arab Regional Symposium on Environmental Aspects of Development in the Arab Countries, Khartoum, February 1972. Cairo: Arab League Educational, Cultural, and Scientific Organization (ALESCO). pp. 201-220.

Owen, J.S. 1953. Field Guide to Sudanese Rodents. Sudan Notes and Records 34:104-113.

Phillips, J.C. 1913. Notes on a collection of birds from the Sudan. Bull. Mus. Comp. Zool. Harv. 58:1-27.

Rodger, L.A.F. 1972. The Problem of Dust in the Environment with particular Reference to the Sudan. In: Man-Environment-Development. Proceedings of the Arab Regional Symposium on Environmental Aspects of Development in the Arab Countries, Khartoum, February 1972. Cairo: Arab League Educational, Cultural, and Scientific Organization (ALESCO). pp. 326-334.

Von Rosen, B. 1953. Game Animals of Ethiopia. Swedish-Ethiopian Company. Addis Ababa.

Rzoska, J. 1974. The Upper Nile Swamps, a Tropical Wetland Study. Freshwater Biology 4(1):1-30.

Saeed, el-T.M. 1968. Ground Water Appraisal of the Gash River Basin at Kassala, Kassala Province, Sudan. University of Arizona, Tucson, Arizona, Masters Thesis. x + 84 pp. + maps.

Sclater, W.L. and C.M. Praed. 1919-1920. A list of the birds of the Anglo-Egyptian Sudan (parts 3 and 4). Ibis 11(1):628-707; 11(2):781-855.

Setzer, H.W. 1965. Mammals of the Anglo-Egyptian Sudan. Proc. U.S. Nat. Mus. 106:447-587.

Shelley, G.E. 1872. Handbook to the Birds of Egypt. London: John van Voorst, Paternoster Row. 342 pp.

Simpson, I.G. 1970. New Approaches to Irrigated Farming in the Sudan: Organization and Management. Land Economics 46(3):287-296.

Snow, D.W., ed. 1978. An Atlas of Speciation in African non-Passerine Birds. London: British Mus. 390 pp.

Sudan. Executive Organization for the Development Projects in Jonglei Area. 1975. Jonglei Project (Phase One). Khartoum: Ministry of Culture and Information. 114 pp.

Sudan. National Council for Research-Agricultural Research Council, and USA, National Academy of Sciences. 1975. Aquatic Weed Management: Some Prospects for the Sudan and the Nile Basin. Report of a Workshop held November 1975, Khartoum, Sudan. Khartoum: National Council for Research, Agricultural Research Council. 57 pp.

Sudan. Ministry of Agriculture, Food, and Natural Resources. 1976. Sudan's Desert Encroachment Control and Rehabilitation Programme (DECARP). Part I: Background Information. Part II: Proposed Action Programme, Strategies, Organizational Structure and Projects. Khartoum: Ministry of Agriculture, Food, and Natural Resources. x + 86 pp.; vii + 183 pp.

Sudan. 1977. The Sudan Experience in the Field of Desert Encroachment Control and Rehabilitation. U.N. Conference on Desertification. Country Paper of the Government of the Democratic Republic of the Sudan. Mimeographed Manuscript. 27 pp.

Thimm, H.-U. 1979. Development Projects in the Sudan: An Analysis of their Reports with Implications for Research and Training in Arid Land Management. Tokyo: The United Nations University. i + 59 pp.

el-Tom, M.A. 1969. A Statistical Analysis of the Rainfall over the Sudan. Geographical Journal 135 (3):378-387.

el-Tom, O.A.M. 1970. Mineralogical Characterization of Vertisols of the Sudan Gezira. University of Arizona, Tucson, Arizona, Masters Thesis. ix + 77 pp.

Tothill, C.M.G., ed. 1948. Agriculture in the Sudan. London: Oxford University Press. xviii + 974 pp. + maps.

United Nations. 1981. United Nations Conference on New and Renewable Sources of Energy, Nairobi, Kenya, 10-21 August 1981. National Report Submitted by the Sudan. iii + 34 pp. (A/CONF/100/NR/11)

United Nations, Department of Economic and Social Affairs. 1973. Groundwater in Africa. New York: U.N. ST/ECA/147. iv + 170 pp.

UNESCO-FAO. 1977. Soil Map of the World. Vol. VI: Africa. Paris: UNESCO. xiv + 299 pp. + maps.

Urban, E.K. and L.U. Brown. 1971. A checklist of the birds of Ethiopia. Addis Ababa. Haile Selassie I University.

U.S. AID. 1976. Health Sector Report - Sudan. Washington, D.C.: U.S. AID (manuscript). 22 p.

-----. 1978. Sudan Shelter Sector Asse sment. Washington, D.C.: U.S. AID, Office of Housing. Varied paging.

-----. 1980. All Data Currently Available on Sudan. Washington, D.C.: U.S. AID, DS/DIU/ESDS, 12/23/80. (Computer Data Base, in House Access)

-----. 1981a. East Africa: A Regional Profile. Washington, D.C.: U.S. AID, Office of U.S. Foreign Disaster Assistance. xv + 322 pp.

-----. 1981b. Sudan: Country Development Strategy Statement, FY 83. Washington, D.C.: U.S. AID. iv + 64 pp.

U.S. Bureau of Mines. 1976. Mineral Industries of Africa. Washington, D.C.: U.S. Department of the Interior. 115 pp.

U.S. Department of Agriculture. 1980. Indices of Agricultural Production in Africa and the Near East, 1970-1979. Washington, D.C.: USDA Economics, Statistics, and Cooperatives Service. Statistical Bulletin No. 637. i + 54 pp.

U.S. Department of the Interior. Fish and Wildlife Service. 1980. List of endangered and threatened wildlife and plants. Federal Register 45(99):33768-33781. (Tues, 20 May 1980, Part II.)

Verhoeven, H. 1975. Problem in the Development of the Savanna Belt of Sudan. Paper No. 13, I.S.S.S. Commissions I, IV, V, and VI Meeting on Savannah soils of Africa and their Management, Tema, Ghana, Nov. 1975. Mimeographed Manuscript. 8 pp. + maps.

Waterbury, J. 1979. Hydropolitics of the Nile Valley. Syracuse, New York: Syracuse University Press. xii + 301 pp.

Watson. 1975. Livestock Census in Northern Sudan. Unpublished report submitted to the Govt. of Sudan.

Waziri, H.A. 1978. Health Impact Observed on the Population of Gezira Scheme (Sudan). Agenda Item No. 5.3, Seminar on the Prevention and Control of Vector-Borne Disease in Water Resources Development Projects, Alexandria/Khartoum, March-April 1978. Alexandria: WHO, Regional Office for the Eastern Mediterranean. Mimeographed Manuscript. 6 pp.

Whiteman, A.J. 1971. The Geology of the Sudan Republic. Oxford: Clarendon Press. xiv + 290 pp. + pl.

Wickens, G.E. 1976. The Flora of Jebel Marra (Sudan Reublic) and its Geographical Affinities. London: Her Majesty's Stationary Office (Royal Botanic Gardens, Kew: Kew Bulletin Additional Series V). vii + 368 pp.

Wickens, G.E. and F.W. Collier. 1971. Some Vegetation Patterns in the Republic of the Sudan. Geoderma 6(1):43-59.

Williams, J.G. and N. Arlott. 1981. A Field Guide to the Birds of East Africa. London: Collins. 415 pp.

Wilson, R.T. 1979. Wildlife in southern Darfur, Sudan: Distribution and status at present and in the recent past. Mammalia 43(3):323-338.

-----. 1980. Wildlife in northern Darfur, Sudan: A review of its distribution and status in the recent past and at present. Biol. Conservation 17(2):85-101.

World Bank. 1980. World Tables, 2nd ed. Baltimore: The Johns Hopkins University Press. 474 pp.

-----. 1981. World Development Report 1981. Washington, D.C.: World Bank. viii + 192 pp.

World Wildlife Fund. 1973. The Underwater Massacre. Oryx 12(2):161-162.

Appendix I

Geography and Climate

Figure 1. Physical Features

Figure 2. Rainfall and Moisture Regions

Table 1. Average Monthly Rainfall

Table 2. Average Number of Raindays During the Rainy Season

Table 3. Frequency of Rain Days and Heaviest Daily Falls

Table 4. Variability of Annual Rainfall

Table 5. Average Monthly Solar Radiation at Khartoum

Figure 3. Annual Potential Evapotranspiration

Table 6. Average Annual Water Balance

Table 7. Mean Relative Humidities

Figure 4. Annual Water Deficits

Table 8. Resultant Wind Directions and Steadiness, Khartoum

Table 9. Frequency of Haboobs at Khartoum Airport

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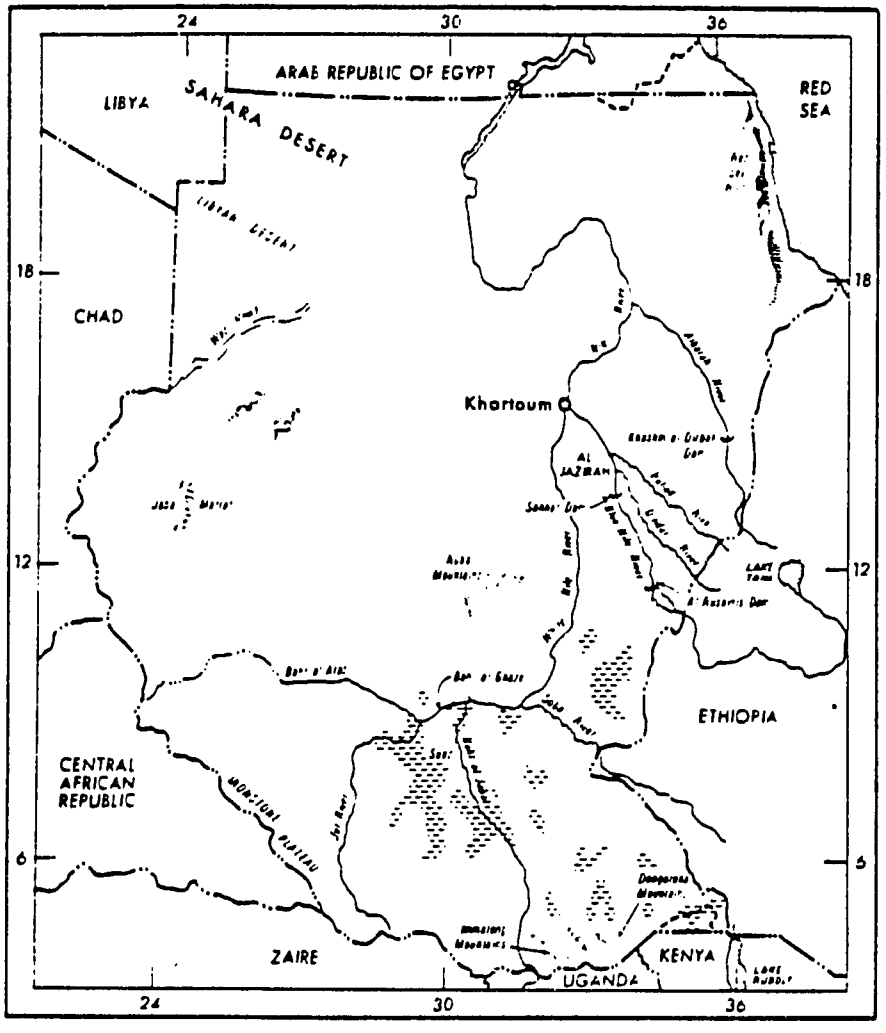

Figure 1. Physical Features

Source: Nelson et al. 1973.

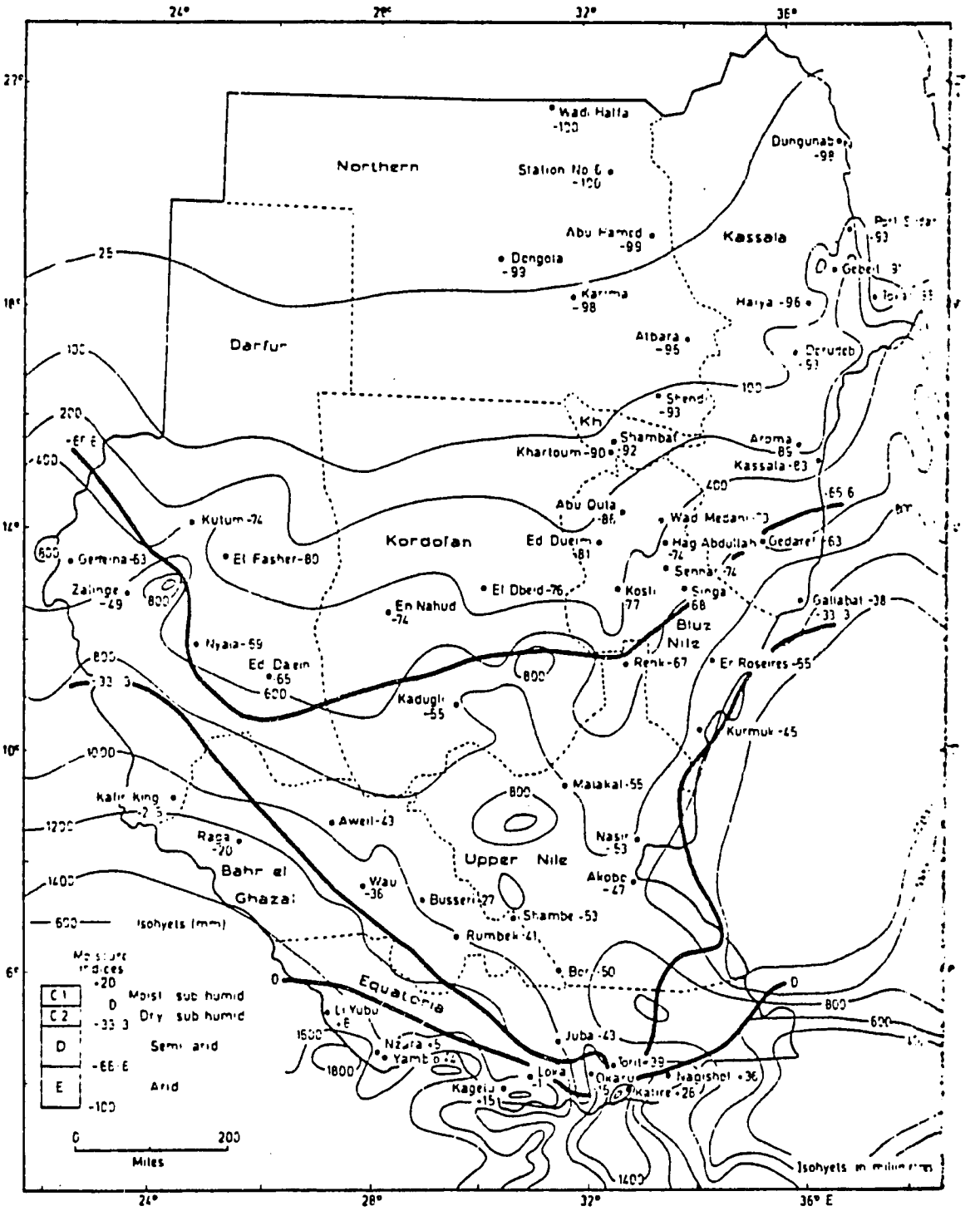

Figure 2. Rainfall and Moisture Regions

Source: Oliver. 1969.

Table 1. Average Monthly Rainfall

Month / Station	J	F	M	A	M	J	J	A	S	O	N	D
Atbara . .	0	0	0	1	4	1	20	38	7	1	0	0
Shendi . . .	0	0	t	1	3	2	43	64	20	3	0	0
Khartoum .	0	t	t	1	5	7	48	72	27	4	t	0
Wad Medani	0	0	t	2	20	34	123	138	60	16	0	0
Sennar . . .	0	t	1	4	29	47	146	170	63	21	t	0
Singa . . .	0	0	t	4	26	73	171	198	95	28	1	t
Roseires . .	0	t	1	11	58	126	166	221	152	36	5	0

Source: Buursink. 1971.

Table 2. Average Number of Raindays (≥10mm) during the Rainy Season

Month / Station	May	June	July	August	September	October
Atbara	0	0	1	1	0	0
Shendi	0	0	1	2	1	0
Khartoum	0	0	1	3	1	0
Wad Medani	1	1	4	5	2	0
Sennar	1	2	5	6	3	1
Singa	1	2	5	7	3	1
Roseires	2	4	5	7	5	3

Source: Buursink. 1971.

Table 3. Frequency of Rain Days and Heaviest Daily Falls (1931-60)

STATION	MEAN RAINFALL (mm.)	MEAN NO. OF RAIN DAYS	FALLS ≥ 1.0mm.		FALLS ≥ 10.0mm.		HEAVIEST DAILY RAINFALL (mm.)
			NO. OF RAIN DAYS	PERCENT OF ALL RAIN DAYS	NO. OF RAIN DAYS	PERCENT OF ALL RAIN DAYS	
Abu Hamed	17	3.5	3.0	86	0.6	17	52.5
Karima	38	6.0	4.8	80	1.1	18	60.0
Port Sudan	110	15.6	12.8	82	1.3	8	111.5
Tokar	88	14.3	12.5	87	2.4	17	90.0
Atbara	72	10.6	9.0	85	2.0	19	98.1
Shendi	136	10.9	10.9	100	4.1	45	55.0
Khartoum Airport	164	21.3	19.7	92	5.3	25	79.9
Kassala	341	33.5	30.4	91	11.0	33	95.5
El Fasher	287	34.3	31.8	93	9.1	27	93.0
El Obeid	418	41.6	36.7	88	13.8	33	96.7
El Geneina	549	57.6	52.5	91	19.0	33	87.4
Wad Medani	373	42.9	38.1	89	12.5	29	79.6
Kosti	406	42.1	38.7	92	12.5	31	193.0
Er Roseires	776	71.4	68.8	96	26.9	38	116.4
Aweil	948	69.3	69.0	99	30.0	43	163.7
Malakal	783	78.0	69.8	90	23.4	30	176.1
Tonj	1014	72.9	72.7	100	33.0	45	107.7
Bor	860	74.8	71.2	95	27.4	37	140.0
Yambio	1512	122.6	119.1	97	48.8	40	121.0
Juba	982	102.9	93.1	91	30.6	30	110.8
Torit	994	96.1	93.2	97	32.3	34	108.0
Nagishot	1161	105.3	104.2	99	43.7	42	75.0

Source: Oliver. 1969.

Table 4. Variability of Annual Rainfall

STATION	ANNUAL MEAN (mm.)	ANNUAL MEDIAN (mm.)	STANDARD DEVIATION (mm.)	COEFFICIENT OF VARIATION (Per Cent)
Abu Hamed	19	7	30	158
Zeidab	70	63	56	71
Sallom	85	79	59	69
Tokar	90	80	52	58
Atbara	74	67	46	67
Khartoum (Shambat)	144	143	77	53
Kassala	327	333	87	27
El Fasher	303	301	128	42
El Obeid	388	369	107	28
Wad Medani	381	361	105	28
Ed Dueim	332	329	87	26
Er Roseires	803	773	133	17
Malakal	817	775	166	20
Bor	858	827	169	20
Wau	1127	1080	173	15
Juba	971	975	179	18
Torit	989	965	133	13
Nimule	1188	1211	170	14
Yambio	1418	1438	231	16

Source: Oliver. 1969.

Table 5. Average Monthly Solar Radiation (cals/cm^2/day) at Khartoum

J	F	M	A	M	J	J	A	S	O	N	D
470	518	564	581	570	537	522	524	518	489	473	445

Source: Buursink. 1971.

Table 6. Average Daily Temperature (^{o}C)

Month / Station	J	F	M	A	M	J	J	A	S	O	N	D
Atbara . . .	22.6	23.5	26.7	30.7	33.7	35.0	33.7	32.9	33.9	32.0	27.5	24.1
Shendi . . .	23.1	23.6	27.1	30.5	33.5	35.0	33.1	32.2	33.2	31.6	27.9	23.8
Khartoum .	23.7	24.7	27.9	31.5	33.7	34.1	31.7	33.4	32.0	32.3	28.2	24.9
Wad Medani	24.1	25.1	28.1	31.1	32.4	32.1	29.3	27.7	28.8	30.1	27.4	24.7
Sennar . . .	23.0	26.0	28.9	31.5	32.2	31.2	28.3	27.1	28.0	29.7	28.3	28.7
Singa . . .	25.9	26.9	29.7	32.1	32.1	30.5	27.9	26.7	27.7	29.4	28.7	26.7
Roseires . .	26.3	27.5	29.8	32.1	30.7	28.5	26.7	26.1	26.7	28.0	27.7	26.6

Source: Buursink. 1971.

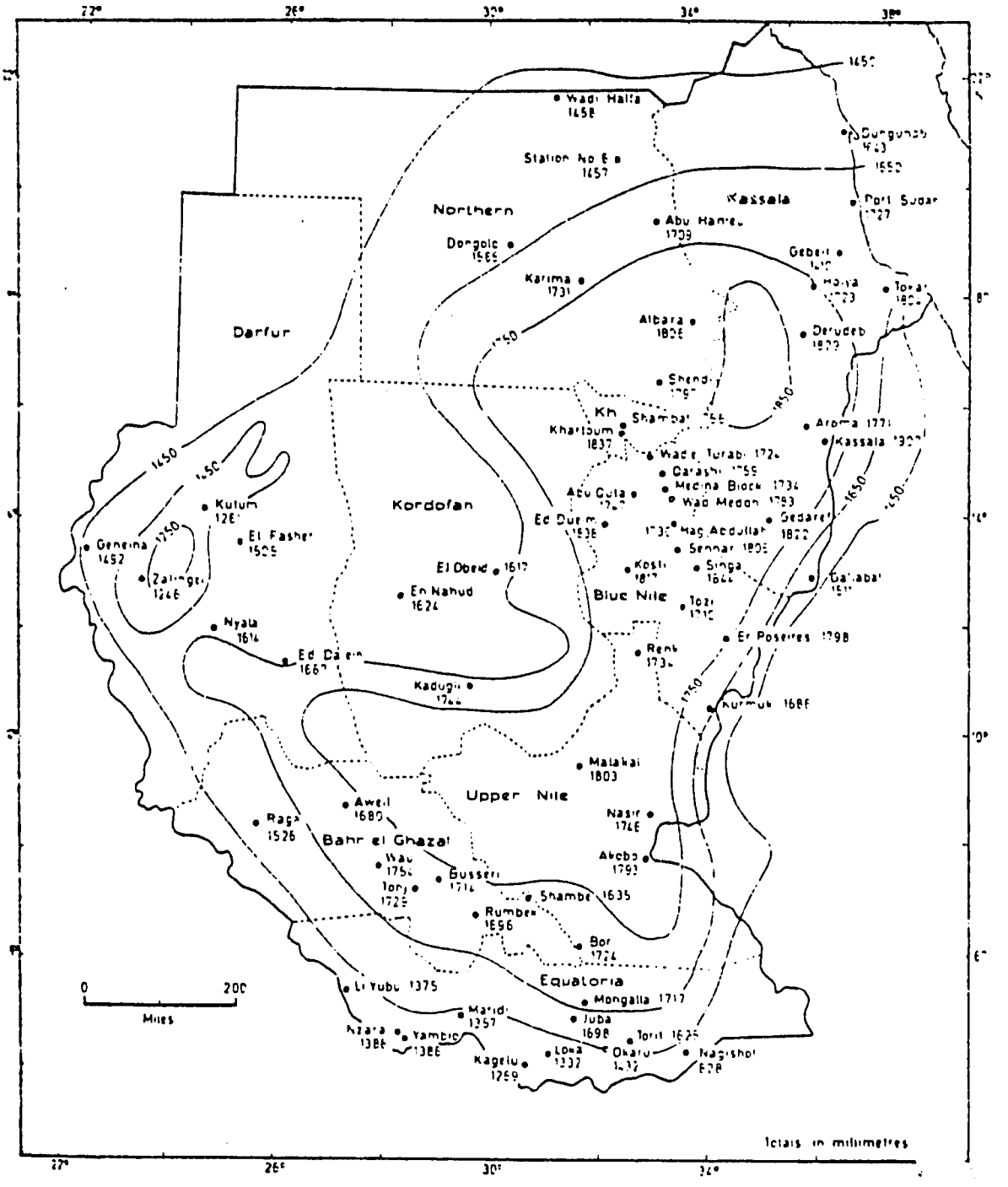

Figure 3. Annual Potential Evapotranspiration

Source: Oliver. 1969.

Table 7. Average Annual Water Balance (mm)

Station	Open-water evaporation	Potential evapo-transpiration	Rainfall	Water deficit
Atbara	3120	1806	72	1733
Shendi	—	1797	136	1661
Khartoum	2555	1837	164	1656
Wad Medani	2810	1783	373	1402
Sennar	2519	1806	481	1337
Singa	2171	1844	596	1254
Roseires	1916	1798	776	996

Source: Buursink. 1971.

Table 8. Mean Relative Humidities, 1931-1960

	Khartoum (30 years)				Jebel Aulia (10 years)		
	0800	1400	2000	1600	0800	1400	2000
				(1901-21)			
January ..	36	20	27	15	53	34	45
February ..	29	16	22	13	45	28	39
March ..	23	13	18	8	41	26	34
April ..	20	12	18	7	38	24	34
May ..	27	15	22	11	37	24	31
June ..	38	18	25	16	47	26	34
July ..	58	31	41	23	63	37	47
August ..	68	41	53	30	73	49	63
September ..	56	30	41	25	64	40	51
October ..	38	20	29	17	50	31	44
November ..	34	20	28	16	50	32	45
December ..	38	22	29	18	56	38	50
Year ..	39	21	29	16	51	32	43

Source: Oliver. 1965.

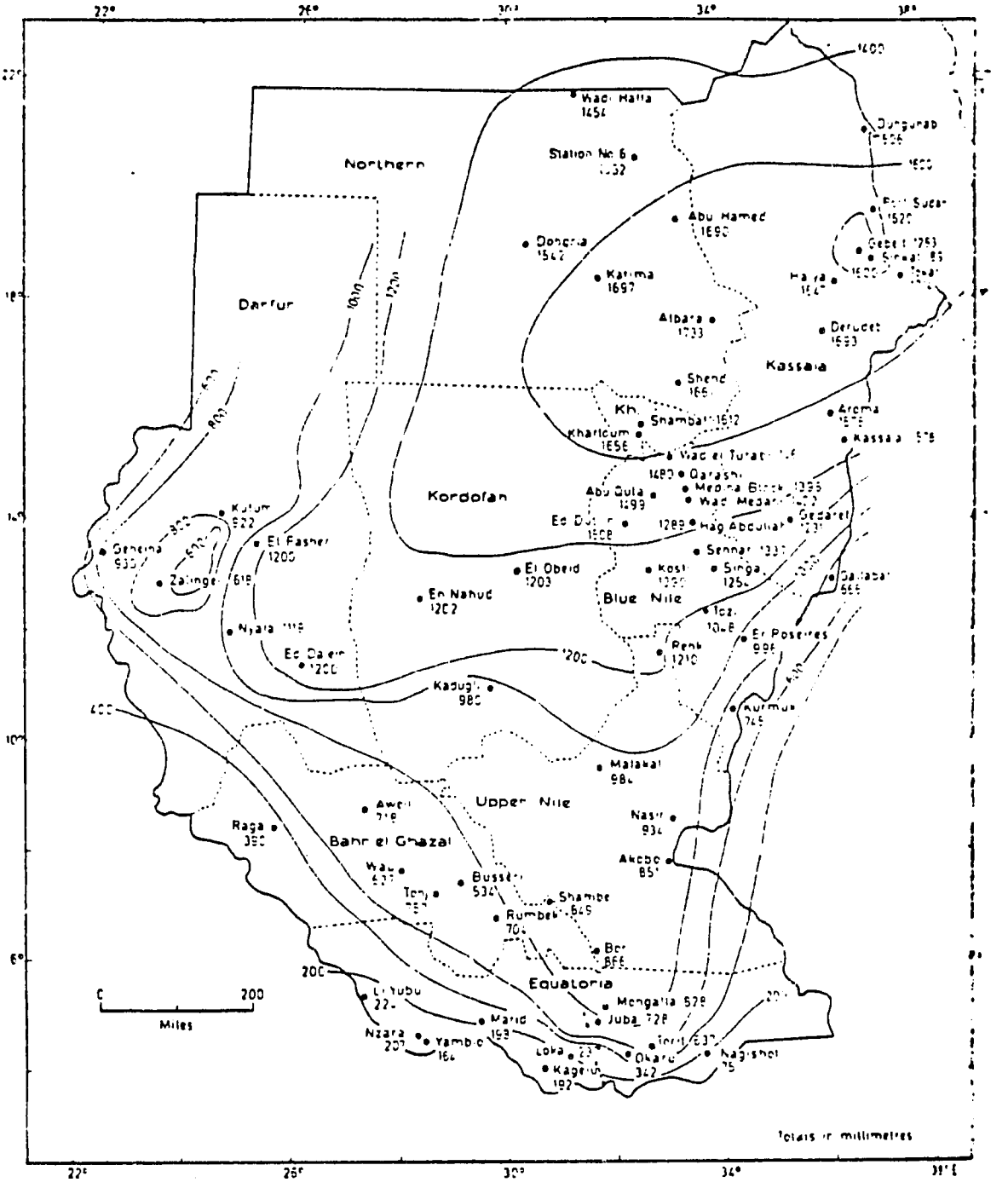

Figure 4. Annual Water Deficits

Source: Oliver. 1969.

Table 9. Resultant Wind Directions and Steadiness, Khartoum (1901-1916)

	Result. Directions from True N.				Relative Steadiness per cen.			
	0800 hours	1400 hours	2000 hours	Daily Mean	0800 hours	1400 hours	2000 hours	Mean
January ..	8	17	5	10	89	87	92	89
February ..	12	18	7	12	87	85	89	87
March ..	21	18	13	17	8[illegible]	80	82	82
April ..	31	20	6	18	72	66	68	68
May ..	33	15	7	16	23	33	37	31
June ..	209	231	197	212	54	28	28	36
July ..	204	224	211	213	77	68	66	70
August ..	208	222	208	212	78	66	58	67
September ..	212	218	186	204	48	30	42	37
October ..	11	35	20	23	26	33	31	29
November ..	16	14	7	12	84	72	80	78
December ..	12	15	5	10	91	85	92	91
Year ..	7	6	0	4				

Source: Oliver. 1965.

Table 10. Frequency of Haboobs* at Khartoum Airport (1916-1929 and 1949-1955)

	Total Number of Haboobs		Average Number of Days with Haboobs 1949–55	Maximum Number of Days with Haboobs in any year 1949–55
	(a) 1916–1929	(b) 1949–1955		
April ..	18	2	0.3	1
May ..	48	20	2.7	5
June ..	82	20	2.6	6
July ..	64	28	3.7	7
August ..	32	14	2.0	4
September ..	35	11	1.6	3
October ..	10	5	0.5	2
Total ..	289	100		

*violent dust storms

Source: Oliver. 1965.

Appendix II

Population and Public Health

Table 1. Miscellaneous Demographic Features

Figure 1. Provincial Boundaries, 1976

Table 2. Population, Urbanization, and Growth by Province

Table 3. Population by Nationality

Figure 2. Age and Sex Structure

Table 4. Provincial Distribution of Principal Languages

Figure 3. Use of Arabic Language

Figure 4. Predominant Patterns of Social Organization

Table 5. Schistosomiasis - Cases and Deaths

Table 6. Incidence of Diarrhoeal Diseases

Table 7. Incidence of Pulmonary Tuberculosis and Cerebro-Spinal Meningitis

Table 8. Small Pox, Hepatitis, Kala Azar

Table 9. Health Care Personnel and Facilities

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Table 1. Miscellaneous Demographic Features

Population	18,340,000	mid 1980
Density per sq. km.	7.0	1977
Density per sq. km. arable land	55.0	1978
Growth	3.0	1969-79
Crude birth rate (per 1000)	46.0	1979
Crude death rate (per 1000)	18.0	1978
Life expectancy at birth (years)	48.6	1973
Average daily caloric consumption	2247	1976
(% of estimated requirement)	(93%)	(1977)
Population per practicing physician	9857	1976
Percent literate	20	1975
Per capita GNP (U.S. $)[1]	370	1979
Total labor force (1000)	4443.0	1973
% of women in labor force	10.6	1975
% of labor force in agriculture[1]	78	1979

Sources: U.S. AID. 1980.
[1]World Bank. 1981.

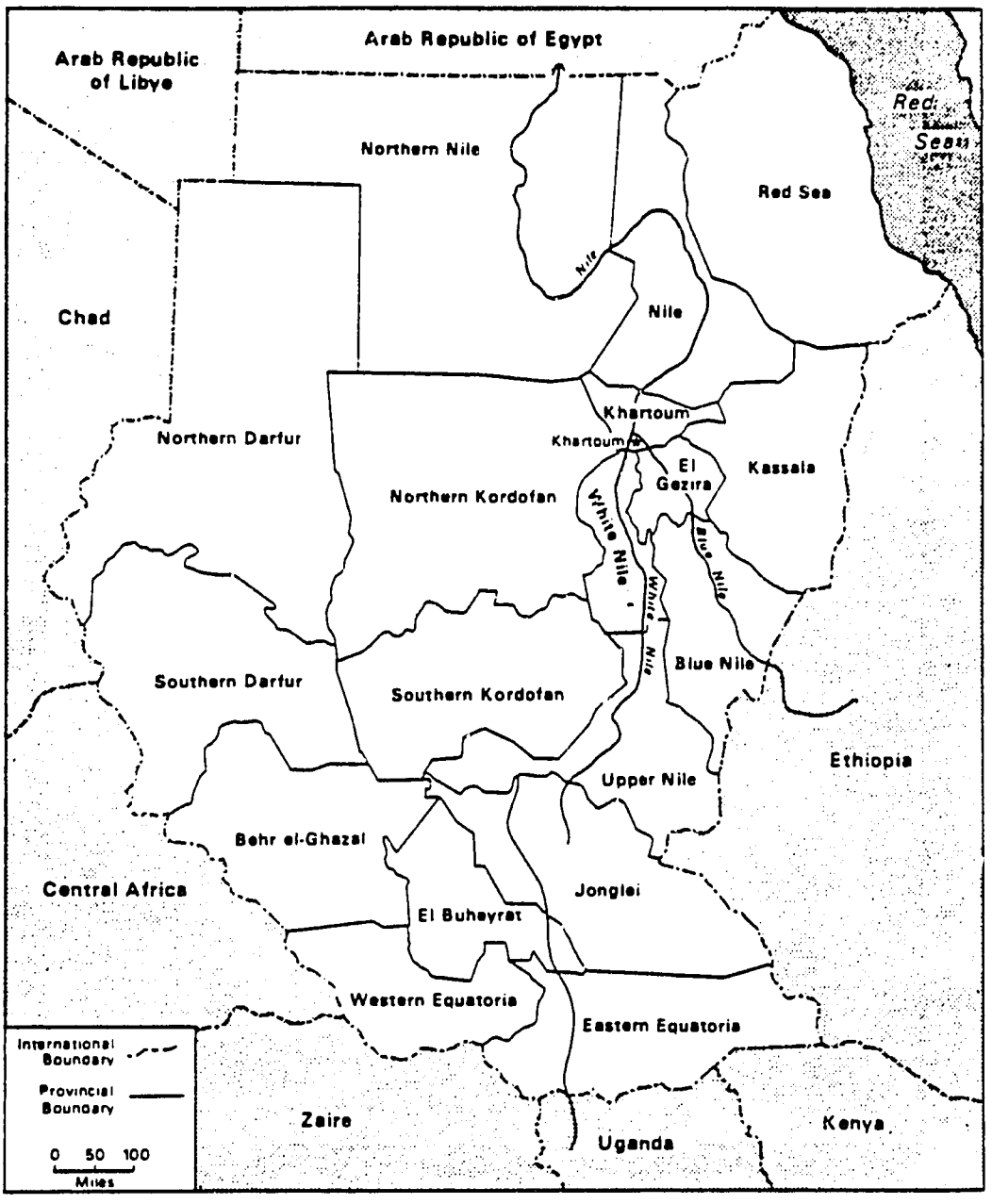

Figure 1. Provincial Boundaries, 1976

Source: Waterbury. 1979.

Table 2. Population, Urbanization and Growth by Province

	1973 Population (000's)	Annual Growth Since 55/56	1973 Urban Population[1] (000's)	Annual Growth Since 55/56	Percent Urban[1] 1955-56	1964-66	1973-74
Northern Provinces							
Red Sea, Kassala	1,547	2.8%	326	6.0%	12.1%	14.5%	21.6%
Nile, Northern	958	.5	64	3.2	4.2	4.9	6.9
Khartoum	1,146	4.7	600	6.6	50.2	57.4	71.9
Gezira, White & Blue Nile	3,740	3.2	260	5.3	5.0	5.7	7.1
North & South Kordofan	2,202	1.3	120	3.1	3.9	3.4	5.7
North & South Darfur	2,140	2.7	177	6.5	4.3	6.5	8.5
Total Northern	11,733	2.6%	1,747	5.8%	8.4%	NA	14.9%
Southern Provinces							
Upper Nile, Junglei	836	-.4	37	7.7	1.1	1.6	4.9
Buheyrat, Bahr el Ghazal	1,397	2.0	53	11.1	.8	1.2	4.0
West & East Equatoria	792	-.7	57	9.7	1.2	1.7	7.9
Total Southern	3,025	.5%	147	9.6%	1.0%	NA	4.9%
Total Sudan	14,758	2.1%	1,894	6.0%	6.4%	8.3%	12.8%

[1]Urban population is here defined as resident population in urban centers which had 20,000 inhabitants or more in 1973.

Source: U.S. AID. 1978.

Table 3. Population by Nationality (1973 Census)

	Khartoum	Omdurman	Khartoum North	Greater Khartoum	Port Sudan	El Obeid	Juba
Egypt	2,936	3,482	558	6,976	315	146	6
Chad	1,656	2,149	717	4,522	211	58	1
Zaire	128	10	4	142	3	1	1,019
Ethiopia	1,500	486	454	2,440	302	28	2
Nigeria	4,404	1,092	131	5,627	1,566	860	5
Other Africa	481	552	[illegible]	1,062	47	12	41
Total Africa	11,105	7,771	1,893	20,769	2,444	1,105	1,074
Yemen	283	518	439	1,240	305	6	-
India	142	483	3	628	456	-	6
Other Middle East/Asia	619	64	31	714	130	6	17
Total Middle East/Asia	1,044	1,065	473	2,582	891	12	23
Greece	392	10	13	415	21	17	35
Other Europe	857	60	76	993	75	30	15
Total Europe	1,249	70	89	1,408	96	47	50
Other	87	1	3	91	1	2	18
TOTAL FOREIGN	13,485	8,907	2,458	24,850	3,432	1,166	1,165
TOTAL SUDANESE	320,418	290,490	148,311	759,219	129,444	88,886	55,572
NOT STATED	3	2	220	225	1	21	--
TOTAL	333,906	299,399	150,989	784,294	132,877	90,073	56,737

Source: U.S. AID. 1978.

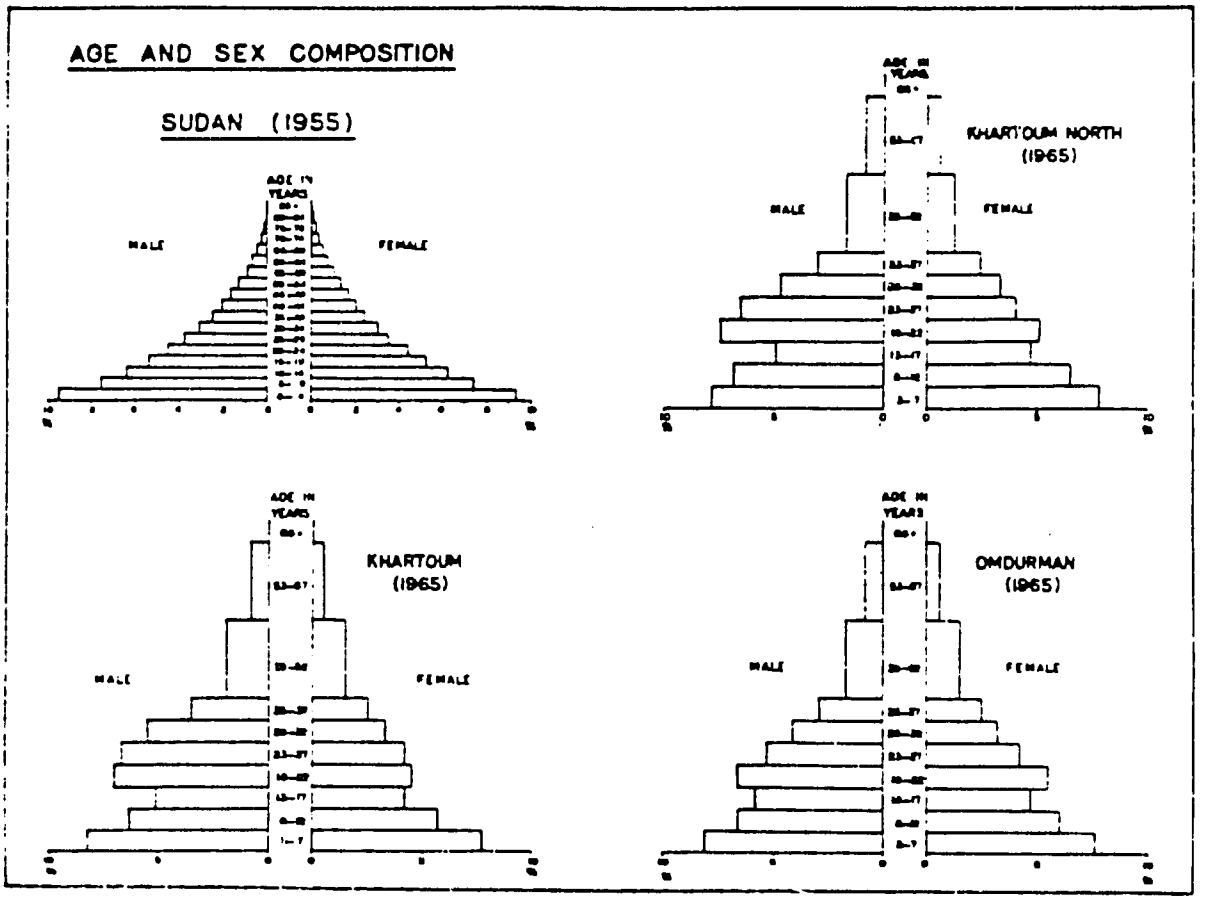

Figure 2. Age and Sex Structure

Source: el-Bushra. 1979.

Table 4. Provincial Distribution of Principal Languages, 1955/56 Census (in percent)

Language	Bahr al Ghazal	Blue Nile	Darfur	Equatoria	Kassala	Khartoum	Kordofan	Northern	Upper Nile
Arabic	0.9	86.4	54.5	0.6	36.3	96.9	68.0	81.0	1.7
Beja	....	....	....	....	50.2	....	....	....	....
Nuba	....	0.2	0.1	....	0.4	0.4	26.8	....	....
Darfurian	0.1	0.1	41.7	....	0.5	....	0.4	....	....
West African[1]	....	7.9	2.5	....	11.1	0.8	2.7	0.1	0.1
Nubian	....	....	....	....	0.2	0.2	....	18.9	....
Fung	....	4.8	....	....	0.6	....	....	....	1.6
Zande	0.4	....	....	23.8	....	....	....	....	....
Bongo-Baka	1.5	....	0.6	3.0	....	....	....	....	....
Ndogo-Sere	2.9	....	....	2.5	....	....	....	....	....
Moru-Madi	....	....	0.6	10.2	....	....	0.1	....	0.1
Dinka	87.4	....	....	0.3	....	0.1	1.8	....	25.4
Nuer	....	....	....	....	....	....	....	....	52.2
Luo	4.8	0.4	....	4.9	....	....	0.1	....	13.8
Lango[2]	0.1	....	....	31.3	....	....	....	....	....

[1] Includes a variety of related languages of countries west of Sudan.

[2] Includes Bari, Lotuko and Toposa.

Source: Nelson, et al. 1973.

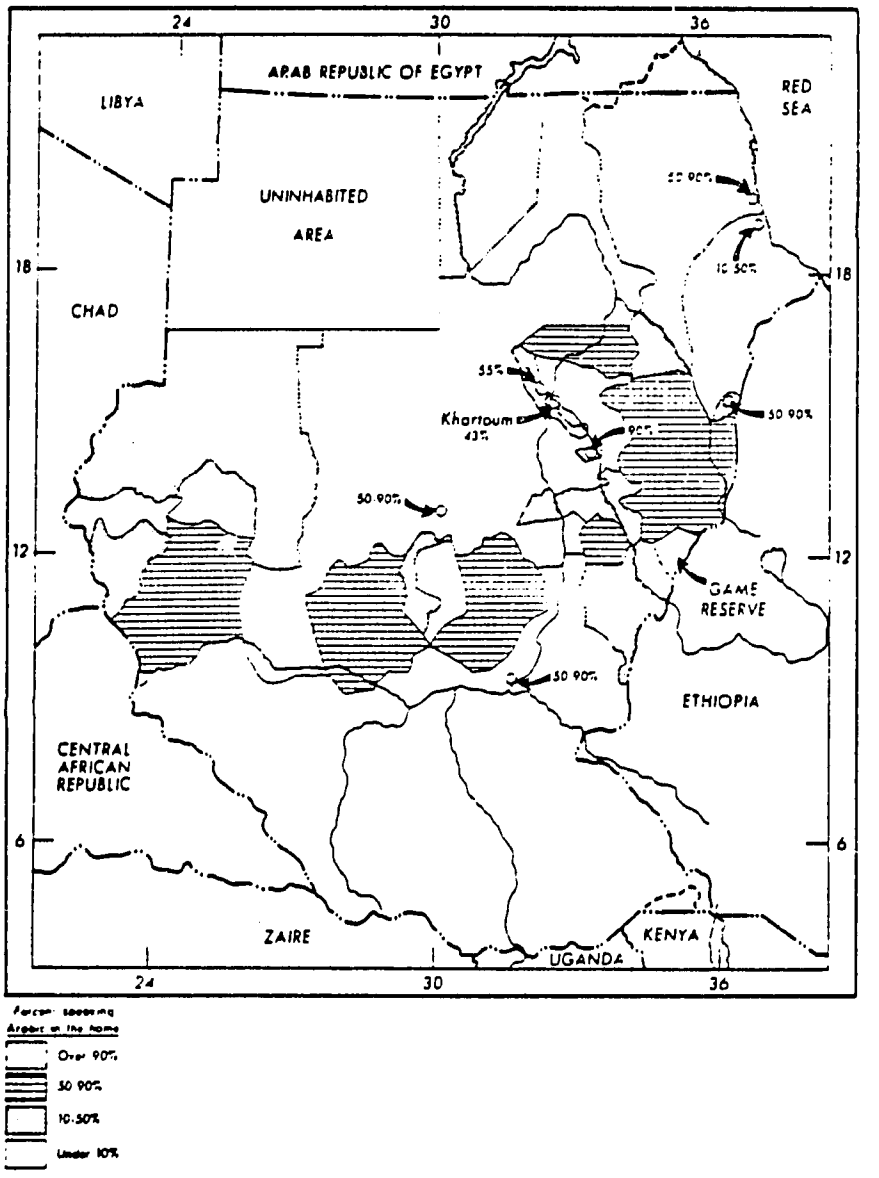

Figure 3. Use of Arabic Language, 1972

Source: Nelson et al. 1973.

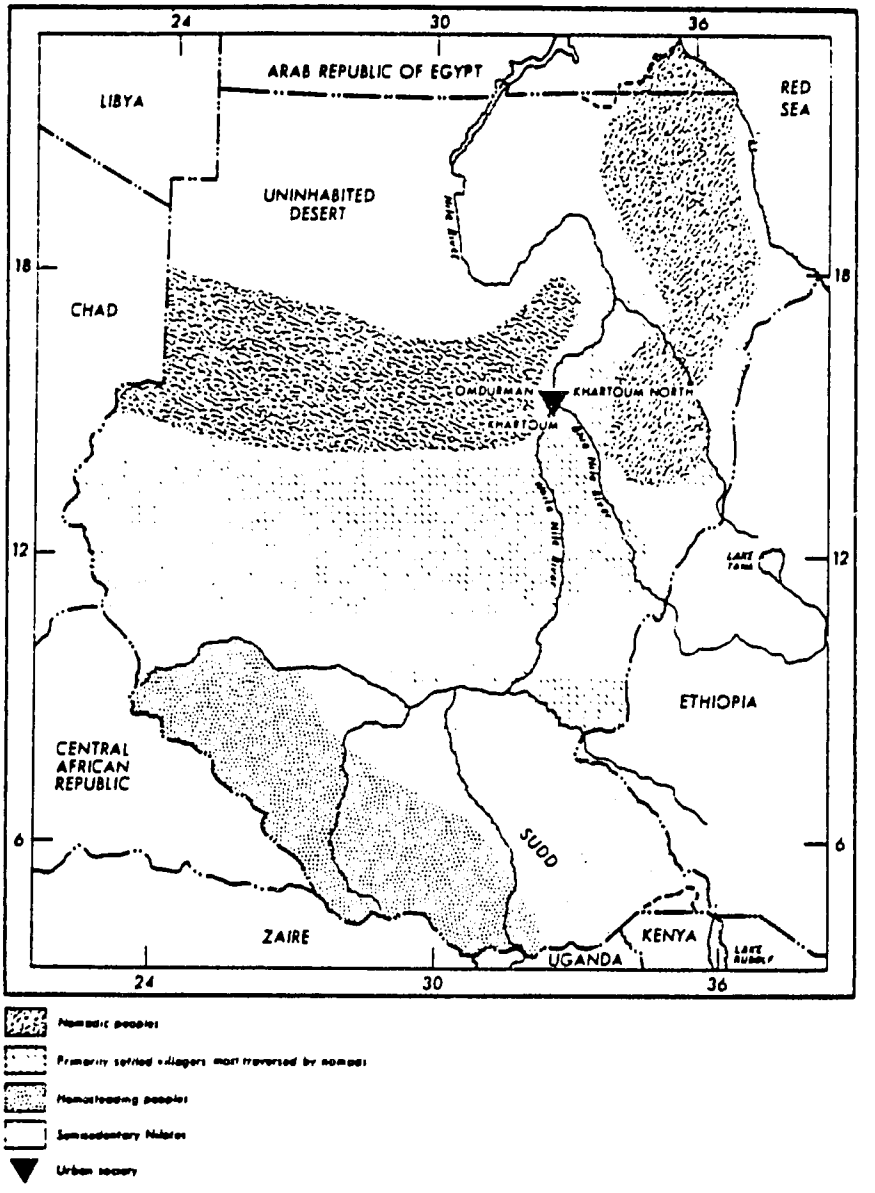

Figure 4. Predominant Patterns of Social Organization

Source: Nelson et al. 1973.

Table 5. Schistosomiasis - Cases and Deaths

Years	Blue Nile		Darfur		Kordofan		Northern		Kassala		Bahr El Ghazal		Equatoria		Upper Nile		Khartoum		Total	
	Cases	D	Cases	D	Cases	D	Cases	D	Cases	D	Cases	D	Cases	D	Cases	D	Cases	D	Cases	D
1949	6262	24	2028	—	5522	2	3058	3	567	4	417	3	1913	3	117	—	753	—	20637	39
1950/51	10397	25	2707	1	7179	1	30061	—	826	1	547	—	5768	6	172	1	1116	—	58809	55
1951/52	14869	8	3205	2	4793	2	2550	—	389	1	336	1	3121	3	14	—	710	—	29987	17
1952/53	11439	5	4079	—	4913	1	3272	1	440	--	229	1	3801	9	91	—	968	—	29276	17
1953/54	09541	12	3031	—	7271	—	4271	—	555	—	313	1	3835	10	126	1	1782	1	30725	25
1954/55	11468	19	3240	1	9972	—	5314	—	468	1	821	—	3528	2	220	—	2539	—	37570	23
1955/56	13346	6	3780	1	6778	1	3770	1	270	—	386	1	1878	3	125	1	1408	1	55643	15
1956/57	17631	12	3379	1	13376	—	3886	—	154	—	874	1	2962	6	61	—	1740	2	44063	22
1957/58	12862	15	5308	—	12096	—	3673	2	159	—	447	—	3960	4	79	—	3061	—	41645	21
1958/59	12524	14	3545	1	13592	—	5729	—	271	—	423	—	4619	13	63	—	4328	2	45094	30
1959/60	17446	9	3412	—	11020	2	5636	1	119	—	965	4	4165	8	114	—	4566	2	47343	26
1960/61	17910	18	6036	—	10090	—	5121	—	513	1	956	9	5355	8	159	—	6437	6	52877	42
1961/92	16716	14	12833	1	8494	1	5339	—	407	1	529	2	4529	6	186	—	8205	4	57229	29
1962/63	22256	11	11533	1	5744	4	4674	1	751	1	803	1	3770	5	8290	—	6004	—	63825	24
1963/64	23058	12	16294	2	9197	1	3579	2	1432	2	909	—	4120	8	1758	2	7229	5	67556	34
1964/65	42150	17	16023	1	10140	2	2603	3	613	1	343	—	3695	4	1040	—	7029	1	83636	29
1965/66	41783	43	11631	2	14211	1	4078	5	508	—	870	—	2274	2	2846	12	11992	7	90193	72
1966/67	42698	13	15170	—	17843	1	6089	7	922	10	795	—	1923	1	3756	9	10580	3	99776	44
1967/68	46701	34	20071	—	25625	2	7312	3	968	11	1020	1	2298	—	4299	—	9964	—	118258	51
1968/69	49035	—	11786	—	10058	—	4228	—	1016	—	1220	—	1763	—	1547	—	10462	—	92115	—

Source: Hasseeb et al. 1972.

Table 6. Incidence of Diarrhoeal Diseases

Age		Gastro-Enteritis & Other Diarrhoeal Diseases	Bacillary & Amoebic Dysentry	Paratyphoid Fever & Other Salmonella Infections	Typhoid Fever
0—1	M	1,220			
	F	1,818			
2—4	M	16,820			
	F	14,220			
5—14	M	118,220	19,813		1,420
	F	120,000	111,000		1,317
15—44	M	1,820	920,110	6,172	7,208
	F	1,914	980,000	7,914	8,418
45 & OVER	M	1,115	158,000		
	F	1,810	148,000		
TOTAL	M	139,195	1,097,924	6,172	8,628
	F	139,762	1,239,000	7,914	9,735
GRAND TOTAL		278,957	2,336,924	14,088	18,363

Source: Hasseeb et al. 1972.

Table 7a. Incidence of Pulmonary Tuberculosis (per 10,000)

Year	Cases	No. of Cases Admissions per 10,000	Deaths
1960	7864	60	337
1961	8768	67	399
1962	8466	65	403
1963	8635	66	316
1964	7693	59	330
1965	12009	110	305
1966	8194	58	285
1967	9690	59	261
1968	14654	100	950
1969	14654	104	1075
1970	13929	120	1069

Source: Hasseeb et al. 1972.

Table 7b. Incidence of Cerebro-Spinal Meningitis, 1958-1968

Year	Attack Rate per 100,000	Percentage of Admission	Death Ratio For Admission
1958/59	4	73.3	1 : 7
1959/60	59	68.6	1 : 3
1960/61	43	85	1 : 10
1961/62	13	71	1 : 7
1962/63	15	73.6	1 : 11
1963/64	23	88.3	1 : 12
1964/65	16	72.1	1 : 11
1965/66	100	65.9	1 : 26
1966/67	21	65	1 : 17
1967/68	22	85.7	1 : 17

Source: Hasseeb et al. 1972.

Table 8. Small Pox, Hepatitis, Kala Azar

a. Incidence of Small Pox in 1970

Province	Cases	Deaths
Bahr el Ghazal	104	4
Blue Nile	18	1
Equatoria	119	3
Darfur	—	—
Kassala	83	3
Khartoum	246	3
Kordofan	32	—
Northern	9	—
Upper Nile	32	1

Source: Hasseeb et al. 1972.

b. Incidence of Infective Hepatitis

Year	Cases
1963/64	2440
1964/65	7072
1965/66	11771
1966/67	21481
1967/68	9142
1968/69	31059
1969/70	8476
1970/71	10699

Source: Hasseeb et al. 1972.

c. Incidence of Kala Azar

Year	No. of Cases
1961/62	4693
1962/63	2486
1963/64	4206
1964/65	3271
1965/66	5050
1966/67	2019
1967/68	1594
1968/69	1846
1969/70	1267
1970	1823

Source: Hasseeb et al. 1972.

Table 9. Health Care Personnel and Facilities
(mid 1970s)

A. Personnel	
Physicians	1287
Dentists	54
Medical Assistants	1645
Technicians	514
Pharmacists	307
Health Visitors (nurse-midwife)	23
Health Statisticians	50
Dental Technicians	27
Social Workers	4
Nutritionists	19
Senior Public Health Inspector	62
Public Health Inspector	151
Public Health Officers	271
Sanitory Overseers	11,120
Nurses	4,438
Village Mid-wives	??
B. Facilities	
Hospitals	133
Hospital Beds	15,670
Health Centers	144
Dispensaries	634
Dressing Stations	1505
Blood Banks	22
Specialty Hospitals	38
School Health Units	11
Nursing Schools	54
Village Mid-wives Schools	18
Health Visitors Schools	3
Medical Assistant Schools	5
Public Health Laboratories	4
Public Health Offices	225
Endemic Disease Units	3

Source: U.S. AID. 1976.

Appendix III

Economic Characteristics

Table 1. World Bank Economic Data Sheet

Table 2. Agricultural Production

Table 3. Exports of Selected Crops

Table 4. Composition of Labor Force by Sector, Skills

Table 5. Estimated Size and Urban-Rural Composition of Labor Force-1973

Table 6. External Trade

Table 7. Principal Trading Partners

SUDAN

Economic Data Sheet 1 - Population, National Accounts, and Prices

GNP Per Capita - 1977 (US$) 330

	1950	1955	1960	1965	1966	1967	1968	1969	1970	1971
Population										
Total, midyear, thousands	9322.0	10210.0	11256.0	12533.0	12832.0	13136.0	13451.0	13772.0	14100.0	14464.0
GDP by industrial origin										At current factor cost
Agriculture	..	..	294.5	314.6	248.8	276.0	292.8	296.4	355.2	393.4
Mining	..	..	0.4	0.4	2.7	2.9	3.4	2.8	2.9	3.3
Manufacturing	..	..	24.2	38.3	52.9	56.0	60.8	71.0	87.6	90.3
Construction	..	..	32.2	33.6	34.5	31.5	35.6	36.9	40.2	40.4
Electricity, gas, and water	..	..	22.0	24.8	24.0	23.7	24.5	27.0	28.5	29.9
Transport and communications	..	..	38.1	46.3	45.9	45.6	49.5	55.6	87.3	91.2
Trade and finance	..	..	52.5	121.8	151.4	165.0	186.0	194.7	133.8	140.4
Public administration and defense	..	..	40.0	88.7	58.8	67.2	75.4	127.2	133.0	152.9
Other branches	..	..	8.7	9.4	40.0	41.0	43.9	23.7	19.7	20.6
GDP at factor cost	..	..	512.9	658.9	659.8	710.9	771.9	837.3	891.2	962.4
Net indirect taxes	..	17.6	22.6	29.0	29.1	31.3	34.0	36.9	39.3	42.4
GDP at market prices	..	416.6	535.5	687.9	688.9	742.2	805.9	874.2	930.5	1004.8
GDP by industrial origin (constant 1975 prices)										At constant factor cost
Agriculture	..	..	..	..	..	351.7	374.0	407.8	380.4	390.4
Mining[e]	..	..	..	..	..	..	..	..	..	..
Manufacturing	..	..	..	..	..	108.1	116.7	108.3	123.6	134.6
Construction	..	..	..	..	..	70.2	84.3	75.8	63.9	60.9
Electricity, gas, and water	..	..	..	..	..	20.6	26.6	30.3	27.5	31.3
Transport and communications	..	..	..	..	..	80.0	82.9	76.2	101.6	104.1
Trade and finance	..	..	..	..	..	287.6	294.1	341.7	253.8	257.0
Public administration and defense	..	..	..	..	..	141.8	144.4	152.9	192.4	220.7
Other branches	..	..	..	..	..	0.2	..	0.4	..	0.1
GDP at factor cost[g]	..	..	..	..	..	1060.2	1125.0	1193.4	1143.2	1199.1
Net indirect taxes	..	..	..	..	..	..	..	..	..	..
GDP at market prices	592.9	842.0	1012.4	1110.5	1093.7	1060.2	1125.0	1193.4	1143.2	1199.1
Resources and expenditures										At current market prices
GNP	..	415.9	533.7	683.0	683.0	737.4	799.8	867.5	925.3	999.7
Factor payments to abroad (net)	..	-0.7	-1.8	-4.9	-5.9	-4.8	-6.1	-6.7	-5.2	-5.1
GDP	..	416.6	535.5	687.9	688.9	742.2	805.9	874.2	930.5	1004.8
Imports of goods and N.F.S.	..	..	63.1	93.7	103.3	107.2	122.2	108.8	104.9	135.0
Exports of goods and N.F.S.	..	..	65.6	82.3	89.0	93.4	103.4	103.5	115.6	123.4
Total resources	..	400.9	533.0	699.3	703.2	756.0	824.7	879.5	919.8	1016.4
Private consumption	..	364.0	456.1	573.2	534.0	577.8	631.8	681.8	676.5	767.8
General government consumption	..	21.2	30.7	63.2	93.6	105.2	112.1	132.6	147.7	159.0
Gross domestic investment	..	15.7	46.2	62.9	75.6	73.0	80.8	85.1	95.6	89.6
Resources and expenditures (constant 1975 prices)										At constant market prices
GNP	..	840.2	1008.9	1103.4	1084.1	1053.4	1117.0	1183.5	1136.7	1193.0
Factor payments to abroad (net)	..	-1.8	-3.5	-7.1	-9.6	-6.8	-8.0	-9.9	-6.5	-6.1
GDP	592.9	842.0	1012.4	1110.5	1093.7	1060.2	1125.0	1193.4	1143.2	1199.1
Imports of goods and N.F.S.	..	..	171.8	247.9	316.6	249.3	264.2	253.0	218.5	259.6
Exports of goods and N.F.S.	..	..	107.1	126.5	159.6	179.6	198.8	199.0	210.2	195.9
Total resources	..	810.3	1077.1	1231.9	1250.7	1129.9	1210.4	1247.4	1151.5	1262.5
Private consumption	..	735.8	827.3	859.5	725.8	673.9	736.7	791.4	730.5	798.7
General government consumption	..	42.8	101.9	177.3	253.7	250.4	271.9	263.5	267.3	282.4
Gross domestic investment	..	31.7	147.9	195.1	271.2	205.6	201.8	192.5	153.7	181.7
Investment financing										At current market prices
Gross domestic investment	..	15.7	46.2	62.9	75.6	73.0	80.8	85.1	95.6	89.6
Gross national savings (excluding net current transfers from abroad)	..	30.7	46.9	46.6	55.4	54.4	55.9	73.1	101.1	72.9
Net balance of goods and services	..	15.0	0.7	-16.3	-20.2	-18.6	-24.9	-12.0	5.5	-16.7
Gross national savings (including net current transfers from abroad)	..	..	..	..	..	54.9	55.2	72.5	101.2	72.0
Domestic price indexes (1970=100)										
Consumer price (or retail price) index	46.4	68.4	71.7	84.0	85.4	94.9	85.3	96.0	100.0	101.4
Wholesale price index	85.6	85.2	78.5	81.8	84.1	96.3	88.2	95.1	100.0	95.7
Implicit GDP deflator	..	60.8	65.0	76.0	77.4	86.0	88.0	90.0	100.0	102.9
										Sudanese pounds per US dollar
Foreign exchange rate	..	..	0.348	0.348	0.348	0.348	0.348	0.348	0.348	0.348

a. 1980 b. Finance is included in other branches. c. Included in other branches. d. 1970–75. e. Included in manufacturing. f. Statistical discrepancy. g. GDP at market prices. h. 1955–60

Table 1. Continued

1972	1973	1974	1975	1976	1977	1960-80	1960-70	1970-77	
						Average annual growth rate (percent)			
14637.0	15220.0	15812.0	16015.0	16461.0	16919.0	1.9	2.3	2.6	(Total, midyear, thousands)
(millions of Sudanese pounds)						As percentage of GDP			
401.5	436.1	516.4	585.3	640.5	836.7	57.3[a]	45.3	40.4[d]	Agriculture
3.5	3.7	4.1	4.6	11.9	11.6	0.1[a]	0.2	0.3[d]	Mining
84.0	91.3	107.2	136.3	109.0	116.7	4.7[a]	6.9	9.0[d]	Manufacturing
42.7	46.3	61.0	65.0	55.4	63.4	6.3[a]	5.4	4.4[d]	Construction
27.9	30.4	16.6	20.9	43.0	43.6	4.3[a]	3.6	2.3[d]	Electricity, gas, and water
84.7	92.2	74.6	89.4	159.9	167.3	7.4[a]	7.2	7.6[d]	Transport and communications
242.1	263.1	271.5	354.4	246.3[b]	273.4[b]	10.2[a]	16.0	21.1[d]	Trade and finance
152.7	165.9	127.9	151.2	..[c]	..[c]	7.8[a]	10.4	13.3[d]	Public administration and defense
12.6	13.3	12.1	12.9	404.5	455.0	1.7[a]	3.0	1.4[d]	Other branches
1051.9	1142.3	1193.6	1422.0	1672.5	1966.1	100.0[a]	100.0	100.0	GDP at factor cost
46.3	50.3	52.6	88.6	104.4	122.9	4.4[a]	4.4	5.3	Net indirect taxes
1098.2	1192.6	1246.2	1510.6	1776.9	2091.0	104.4[a]	104.4	105.3	GDP at market prices
(millions of Sudanese pounds)						Average annual growth rate (percent)			
413.2	500.1	480.4	585.3	545.3	536.0	..	..	6.2	Agriculture
..	..	..	..	..	..	..	..	..	Mining[e]
135.6	103.6	129.4	160.9	180.7	193.1	..	..	6.6	Manufacturing
71.4	66.9	101.4	73.4	80.7	94.3	..	..	5.7	Construction
26.4	26.9	17.7	21.0	22.0	23.3	..	..	-4.7	Electricity, gas, and water
95.7	101.6	109.3	100.3	105.6	116.1	..	..	1.5	Transport and communications
263.1	293.6	316.3	369.3	396.2	419.3	..	..	8.1	Trade and finance
212.2	213.7	220.9	200.6	201.9	244.2	..	..	1.3	Public administration and defense
..	..	103.3[f]	..	..	..	..	..	..	Other branches
1240.6	1307.0	1476.7	1510.6	1535.4	1626.3	..	..	5.4	GDP at factor cost[g]
..	..	..	..	..	..	..	..	..	Net indirect taxes
1240.6	1307.0	1476.7	1510.6	1535.4	1626.3	5.5	1.3	5.4	GDP at market prices
(millions of Sudanese pounds)						As percentage of GDP			
1091.6	1164.9	1235.6	1491.3	1742.4	2051.7	99.7[h]	99.3	98.8	GNP
-6.4	-7.7	-10.4	-19.5	-34.5	-39.3	-0.3[h]	-0.7	-1.2	Factor payments to abroad (net)
1098.2	1192.6	1246.2	1510.6	1776.9	2091.0	100.0[h]	100.0	100.0	GDP
134.2	195.0	306.6	416.6	454.0	519.5	..	13.8	20.9	Imports of goods and N.F.S.
125.6	172.0	159.5	179.3	242.3	272.3	..	12.5	12.6	Exports of goods and N.F.S.
1106.6	1215.6	1393.5	1750.1	1986.6	2336.2	96.1[h]	101.3	106.1	Total resources
889.5	944.9	983.7	1277.3	1440.5	1764.2	86.1[h]	79.9	80.6	Private consumption
141.0	165.5	180.5	207.6	231.4	255.0	5.5[h]	11.1	13.7	General government consumption
76.1	105.2	229.3	265.0	316.7	319.0	6.5[h]	10.3	13.6	Gross domestic investment
(millions of Sudanese pounds)						Average annual growth rate (percent)			
1233.7	1299.2	1466.0	1491.3	1506.0	1595.4	..	1.3	5.2	GNP
-6.9	-7.6	-12.7	-19.5	-29.4	-30.9	..	..	..	Factor payments to abroad (net)
1240.6	1307.0	1476.7	1510.6	1535.4	1626.3	5.5	1.3	5.4	GDP
220.0	270.6	374.1	416.6	407.0	447.0	..	1.7	12.0	Imports of goods and N.F.S.
167.6	215.0	164.4	179.3	237.3	192.5	..	6.6	-0.1	Exports of goods and N.F.S.
1272.6	1362.6	1686.4	1750.1	1705.1	1880.6	..	0.7	7.5	Total resources
913.5	969.6	1212.9	1277.3	1240.3	1432.3	..	-1.2	10.2	Private consumption
212.2	215.0	204.5	207.6	166.6	202.3	..	12.1	-4.6	General government consumption
147.1	176.2	271.0	265.0	276.2	246.2	..	-1.3	9.5	Gross domestic investment
(millions of Sudanese pounds)						As percentage of GDI			
76.1	105.2	229.3	265.0	316.7	319.0	100.0[h]	100.0	100.0	Gross domestic investment
61.3	74.5	71.6	6.2	70.5	32.5	125.4[h]	80.1	32.6	Gross national savings (excluding net current transfers from abroad)
-14.6	-30.7	-157.7	-256.6	-246.2	-286.5	25.4[h]	-19.9	-67.2	Net balance of goods and services
63.7	75.3	76.6	22.0	77.5	39.5	..	..	35.4	Gross national savings (including net current transfers from abroad
						Average annual growth rate (percent)			
115.0	132.6	167.2	207.2	210.6	246.0	4.5	2.6	15.3	Consumer price (or retail price) index
104.3	120.6	153.7	177.4	..	..	-0.9	2.3	13.5[d]	Wholesale price index
106.7	112.0	103.6	122.9	142.1	158.0	..	3.7	6.3	Implicit GDP deflator
(annual average)									
0.346	0.346	0.346	0.346	0.346	0.348				Foreign exchange rate

Source: World Bank. 1980.

Table 2. Agricultural Production

PRODUCTION BY COMMODITY, VALUE AND INDICES OF TOTAL AGRICULTURAL AND FOOD PRODUCTION, AVERAGE 1961-65, ANNUAL 1970-79

COMMODITY	PRICE WEIGHT	AVERAGE 1961-65	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
	DOLLARS	-1,000 METRIC TONS-										
WHEAT	46	36	115	163	140	152	236	269	264	298	317	150
CORN	42	17	37	25	25	30	49	49	55	53	50	45
MILLET	63	303	460	325	355	368	434	444	403	468	400	557
SORGHUM	47	1,256	1,529	2,153	1,300	1,654	1,702	1,744	2,026	1,900	2,017	2,408
PULSES	97	176	200	200	200	100	71	74	77	80	82	82
CASSAVA	16	120	134	134	134	143	90	92	130	131	131	139
ONIONS	56	50	70	70	70	70	100	29	34	35	34	35
COTTON	655	157	252	237	240	239	223	226	113	156	203	192
COTTONSEED	60	308	472	460	465	465	432	421	210	291	370	286
PEANUTS, IN SHELL	119	256	351	394	515	314	549	931	827	850	1,021	829
SESAME SEED	149	165	297	271	290	245	234	233	230	248	245	220
ORANGES	52	5	7	7	7	7	29	41	42	43	44	22
DATES	98	41	50	50	50	50	92	102	135	106	109	77
BEATS	349	79	110	120	120	120	300	327	350	360	372	375
MILK	60	1,774	1,870	1,880	1,880	1,880	1,350	1,312	1,328	1,376	1,412	1,445
AGGREGATES OF PRODUCTION		-MILLION DOLLARS AT CONSTANT PRICES-										
CROPS		282.4	419.0	431.1	411.3	396.9	415.7	465.1	379.5	417.1	480.4	452.3
LIVESTOCK		134.0	150.6	154.7	154.7	154.7	185.7	192.8	231.9	208.2	214.5	217.5
TOTAL AGRICULTURE		416.4	568.6	585.8	566.0	551.6	601.4	657.9	581.4	625.3	694.9	669.9
TOTAL FOOD		313.8	403.5	430.6	408.8	395.1	455.3	502.9	527.4	523.1	561.9	544.1
INDICES OF PRODUCTION		(1961-65 = 100)										
CROPS		100	149	153	146	141	147	165	134	148	170	160
TOTAL AGRICULTURE		100	137	141	136	132	144	159	140	150	167	161
TOTAL FOOD		100	129	137	130	126	145	162	162	167	179	173
PER CAPITA AGRICULTURE		100	110	110	112	107	114	122	106	111	121	114
PER CAPITA FOOD		100	111	116	107	102	115	126	122	123	130	123
INDEX OF POPULATION 1961-65 POPULATION= 12,080,000		100.0	116.2	119.7	121.7	123.9	126.6	129.4	132.2	135.0	137.9	140.9

Source: USDA. 1980.

Table 3. Exports of Selected Crops

(quantity in 1,000 tons, value in £S millions)

Crop Year	Cotton Q	Cotton V	Dura* Q	Dura* V	Millet Q	Millet V	Groundnuts Q	Groundnuts V	Sesame Q	Sesame V	Gum Arabic Q	Gum Arabic V
1965	117	31	112	2	5	.164	159	9	71	5	58	7.5
1966	143	35	79	1.8	6	.180	108	7	167	6	56	7
1967	172	41	.5	.02	.7	.03	109	6	75	6	52	8
1968	184	48	55	1.1	2	.056	88	5	85	6	51	8
1969	172	49	2	.4	1.2	.037	82	6	112	8	49	9
1970	232	65	2	.6	2.6	.116	69	5	82	9	47	9
1971	241	69	37	1.1	1.7	.077	121	9	86	8	43	8
1972	248	74	55	1.7	5.6	.214	114	9	86	9	44	9
1973	226	81	102	3.1	6	.214	138	13	104	11	36	8
1974	103	58	98	4.8	4	.174	130	18	108	21	31	14
1975	144	66	48	2.4	3	.133	206	34	57	12	15	7

*Dura = sorghum.

Source: Waterbury. 1979.

Table 4. Composition of Labor Force by Sector, Skills

(From 1973 Census; All Numbers in Thousands)

By Economic Activity	Urban		Total Sudan	
Agriculture	140	18%	2,253	65%
Mining and quarrying	1	-	3	-
Manufacturing	90	12	135	4
Electricity, gas and water	19	2	35	1
Construction	38	5	69	2
Wholesale, retail trade, restaurants and hotels	107	14	186	5
Transport, storage and communications	80	11	129	4
Financing, insurance real estate and business services	4	1	4	-
Community, social and personal services	229	30	380	11
Not adequately classified	53	7	259	8
Total	761	100%	3,453	100%
By Skill Type				
Professional, technical and related workers	52	7%	92	3%
Administrative and managerial workers	5	1	12	-
Clerical and related workers	35	5	46	1
Sales workers	77	10	144	4
Service workers	148	19	241	7
Agricultural workers	127	16	2,210	64
Production and related workers	211	28	366	11
Workers not classified by occupation	106	14	342	10
Total	761	100%	3,453	100%
By Employment Status				
Employer	17	2%	98	3%
Self Employed	243	32	1,914	55
Employee	451	60	907	26
Unpaid Family Worker	9	1	325	10
Unpaid Other	1	-	2	-
Unemployed	40	5	207	6
Total	761	100%	3,453	100%
By Marital Status				
Married	254	33%	835	24%
Unmarried	459	60	2,335	68
Widowed	21	3	162	5
Divorced	26	4	120	3
Unknown	1	-	1	-
Total	761	100%	3,453	100%
By Education				
Uneducated	343	45%	2,413	70%
Koranic School	79	10	379	11
Primary School	211	28	479	14
General Secondary	63	8	91	3
High Secondary	42	6	64	2
University	14	2	16	-
Post Graduate	6	1	7	-
Other	2	-	3	-
Unknown	1	-	1	-
Total	761	100%	3,453	100%

Source: U.S. AID. 1978.

Table 5. Estimated Size and Urban-Rural Composition of Labor Force - 1973
(thousands)

	Narrow Concept			Broad Concept		
	Male	Female	Total	Male	Female	Total
Low Estimate						
Urban: Age to 15	51.5	10.9	62.4	64.3	27.3	91.6
Over 15	615.8	48.0	663.8	615.8	60.0	675.8
Total:	667.3	58.9	726.2	680.1	87.3	767.4
Rural: Age to 15	672.8	58.7	731.5	731.3	440.1	1171.4
Over 15	2927.1	323.0	3250.1	2927.1	1937.7	4864.8
Total:	3599.9	381.7	3981.6	3658.4	2377.8	6036.2
TOTAL:	4267.2	440.6	4707.8	4338.5	2465.1	6803.6
High Estimate						
Urban: Age to 15	77.2	27.3	104.5	96.5	54.5	151.0
Over 15	629.8	60.0	689.8	629.8	72.0	701.8
Total	707.0	87.3	794.3	726.3	126.5	852.8
Rural: Age to 15	731.3	146.7	878.0	789.8	586.7	1376.5
Over 15	3022.6	387.5	3410.1	3022.6	2066.9	5089.5
Total	3753.9	534.2	4288.1	3812.4	2653.6	6466.0
TOTAL:	4460.9	621.5	5082.4	4538.7	2780.1	7318.8

Summary of ILO Data shown above

	Percent Urban		Percent Male in Urban Areas		Percent Male Overall	
	Narrow	Broad	Narrow	Broad	Narrow	Broad
Low	15.4%	11.2%	92%	89%	91%	64%
High	15.6%	11.7%	89%	85%	88%	62%

Source: U.S. AID. 1978.

Table 6.

EXTERNAL TRADE
(£S million)

	1971	1972	1973	1974	1975	1976	1977	1978	1979
Imports c.i.f.*	123.7	123.1	151.8	228.4	332.9	341.4	376.5	449.5	477.3
Exports f.o.b.†	115.2	125.5	152.2	122.0	152.5	193.0	230.2	202.3	232.7

* Excluding imports of crude petroleum (£S31,220,000 in 1976).
† Excluding exports of camels (£S2,420,000 in 1971).

PRINCIPAL COMMODITIES
(£S '000)

Imports	1977	1978	1979
Sugar	13,440	18,930	20,470
Tea	6,551	17,398	6,185
Coffee	1,695	5	1,598
Wheat	6,490	8,825	22,007
Textiles	28,232	37,360	26,723
Footwear	160	88	50
Sacks and jute	3,577	4,544	5,300
Fertilizers	3,370	433	5,969
Machinery	125,619	111,955	100,796
Tyres	6,509	9,657	11,173
Petroleum products	44,354	49,953	71,889
Pharmaceuticals	10,156	14,527	10,581
Iron and steel	8,327	8,750	8,759
Transport equipment	39,659	57,510	70,956
Metal manufactures	20,759	32,855	42,217

Exports	1977	1978	1979
Animals	4,538	8,310	7,102
Cotton, long-staple	100,044	71,209	93,658
Cotton, others	31,518	33,723	57,602
Cottonseed } Cottonseed cake and meal }	2,717	1,007	1,635
Sorghum (Durra)	4,767	2,664	13,524
Groundnuts	28,593	20,725	9,956
Groundnut cake and meal	2,927	3,773	4,307
Groundnut oil	3,138	7,479	3,556
Gum arabic	13,007	13,996	18,247
Hides and skins	4,361	3,000	3,680
Sesame seed	16,258	19,152	6,278
Sesame cake and meal	2,182	1,330	1,325
Sesame oil	34	1,225	460

Source: Europa. 1981.

Table 7.

PRINCIPAL TRADING PARTNERS
(£S '000)

	Imports			Exports		
	1977	1978	1979	1977	1978	1979
Belgium	12,486	12,271	10,938	2,517	2,211	2,190
China, People's Republic	10,288	22,349	19,623	19,597	21,032	40,748
Egypt	4,816	9,043	15,228	2,399	12,445	5,179
France	29,710	36,454	33,524	12,993	14,998	8,455
Germany, Federal Republic	44,311	44,126	50,900	16,842	8,813	9,578
India	17,097	21,356	10,993	20,504	7,940	785
Iraq	39,459	33,212	6,899	798	349	49
Italy	16,754	24,573	19,725	26,376	27,159	30,672
Japan	39,989	29,317	30,445	17,960	16,578	16,278
Netherlands	10,795	14,085	8,417	5,829	4,988	3,259
Poland	1,351	1,516	4,274	5,036	4,782	2,950
U.S.S.R.	1,943	830	397	7,948	6,859	10,484
United Kingdom	53,065	71,705	67,772	7,375	4,992	6,315
U.S.A.	24,349	32,686	39,439	5,068	4,642	5,683
Yugoslavia	3,010	4,075	7,470	13,537	12,207	14,545
Total (incl. others)	376,484	449,464	477,318	230,181	202,341	232,667

Source: Europa. 1981.

Appendix IV

Minerals and Water Resources

Table 1. List of minerals and number of occurrences in Sudan

Figure 1. Mineral locality map

Figure 2. Natural yield of the Nile at Aswan

Table 2. Discharges of the Nile and selected branches

Table 3. Percentage of total flow passing salient points

Table 4. Annual discharge of Lake Albert at Mongalla

Table 5. Lag between Mongalla and Malakal of maximum and minimum discharges

Table 6. Assumed open water evaporation and rainfall in the Sudd

Table 7. Geography and hydrology of the main swamp rivers

Table 8. Limnological characteristics of swamp rivers

Table 9. Recharge Estimates and Transmissiblity Calculations in Kordofan

Table 10. Residual Drawdown and Recovery Data for Well No. 1834, Gash River Basin

Table 11. Specific Capacities of Some Wells in Gash River Basin

Figure 3. Reference map of Darfur Kordofan border area (for Table 12)

Table 12. Chemical analysis of groundwater in Darfur and Kordofan

Figure 4. Wells and oases of northern Sudan

Figure 5. Standing water level contour map, el Gezira

Figure 6. Total dissolved solids, ppm map, el Gezira

Figure 7. Proposed Upper Nile Projects

Table 1. List of Minerals and Number of Recorded Occurrences in the Sudan

Minerals and non-metallic minerals	No. in Fig 1	No. of localities
Precious metals		
Gold	1–74	74
Silver	75–76	2
Non-ferrous metals		
Copper	77–108	32
Lead	109–115	7
Zinc	109	1
Tin	116–117	2
Aluminium		
Iron and ferro-alloy metals		
Iron	118–131	14
Manganese	132–159	28
Chrome	160–166	7
Molybdenum	167–169	4
Tungsten	170–173	3
Minor metals		
Arsenic	2	1
Magnesium	174–176	3
Uranium	177–178	2
Columbium	179	1
Titanium	180	1
Barium	181–183	3
Non-metallic minerals and substances		
Clay		
Kaolin	184–185	2
Fluorspar	186	1
Talc	187–189	3
Building stones	190–195	6
Sand and gravel	196–197	2
Cement	198–199	2
Gypsum	200–211	12
Lime	212	[illegible]
Magnesite	213–214	[illegible]
Vermiculite	215–216	2
Wollastonite	217	1
Asbestos	218–219	2
Pumice	220–221	2
Diatomite	222–223	2
Mica	224–228	5
Salt	229–230	2
Natron	231–233	3
Abrasives		
Quartz	234–235	2
Glass sand	236	1
Paints and pigments	237	1
Phosphorite	238	1
Gemstones	239–240	2

Source: Whiteman. 1971.

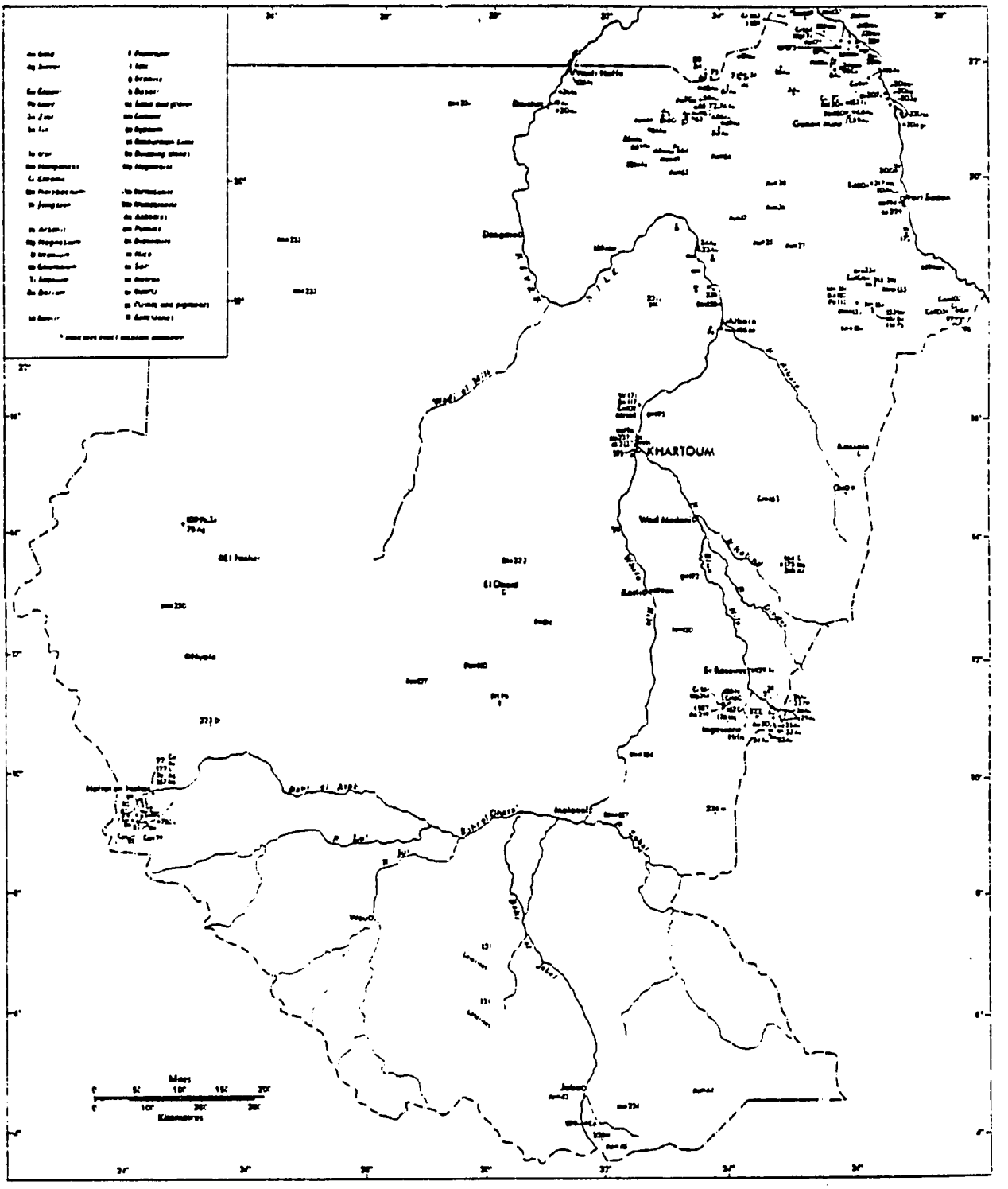

Figure 1. Mineral Locality Map, Sudan

Source: Whiteman. 1971.

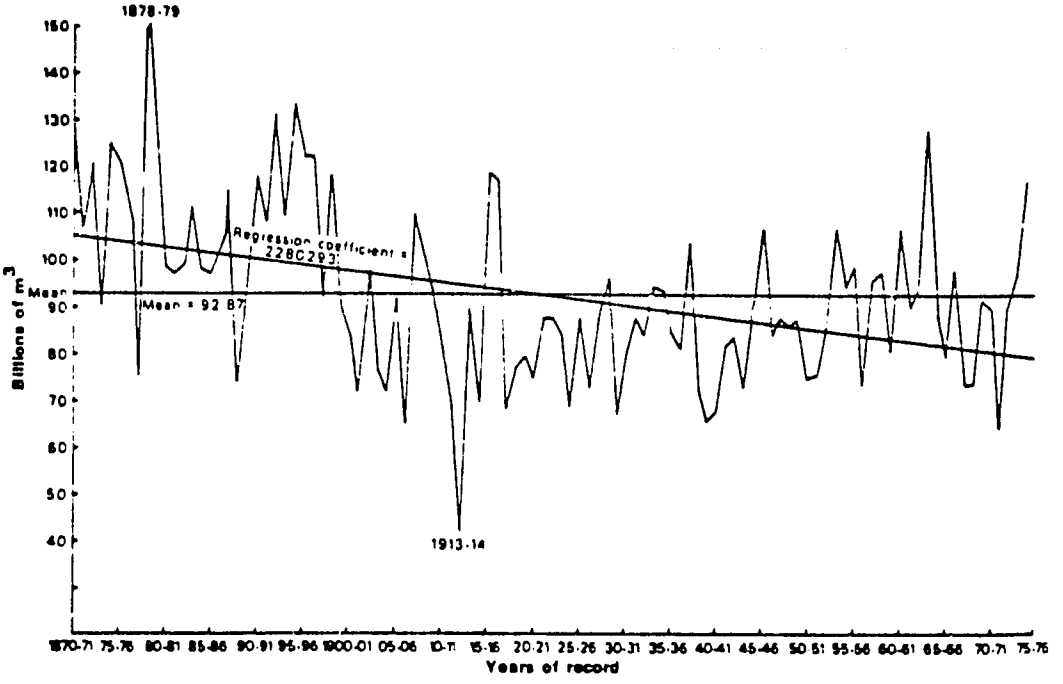

Figure 2. Natural Yield of the Nile at Aswan by Hydrologic Year, 1870/71-1975/76

Source: Waterbury. 1979.

Table 2. Discharges of the Nile and Selected Branches

Site	Period	Annual Totals in Milliards of Cubic Metres			Millions of cubic metres per day (from 10-day means)			
					Mean		Absolute	
		Min.	Mean	Max.	Min.	Max.	Min.	Max.
Lake Albert . .	1908–34	12·0	23·0	45·4	54·7	75·1	27·8	163·8
Bahr el Gebel at Mongalla . .	1905–34	15·3	28·5	55·8	58·6	115·0	26·8	245·0
Bahr el Gebel at Mouth . .	1924–34	8·6	9·4	10·1	23·0	28·0	19·5	29·2
Bahr el Ghazal at Mouth . .	1923–34	0·5	0·6	1·0	0·05	4·3	−1·3	7·8
Bahr el Zeraf at Mouth . .	1908–34	2·5	4·5	9·1	9·4	16·0	4·7	29·2
Swamps Discharge	1905–34	10·4	14·1	20·7	32·7	47·1	20·9	68·1
Sobat River at Mouth . .	1905–34	9·5	13·9	23·1	5·3	73·4	2·2	108·0
White Nile at Malakal . .	1905–34	22·6	28·4	44·4	43·6	114·0	28·3	168·0
Blue Nile at Khartoum. .	1900–34	25·7	53·2	79·2	8·8	607·0	3·7	934.0
Main Nile at Tamaniat . .	1911–34	40·2	77·4	107·0	50·5	649·0	28·7	880·0
River Atbara at Mouth . .	1903–34	4·9	12·4	27·0	Dry	241·0	Dry	547·0
Aswan Natural River . .	1871–1932	45·5	96·2	139·0	47·5	861·0	23·9	124·0

Source: Newhouse. 1939

Table 3. Percentage of Total Flow Passing Salient Points

Site	Percentage of Maximum Supply normally passing Site	
	Summer	Flood
Mongalla	77	12
Bahr el Ghazal at Mouth	3	1
River Sobat at Mouth	14	7
Malakal	73	12
White Nile at Mogren	63	16
Blue Nile at Khartoum	17	70
River Atbara at Mouth	0	20
Main Nile at Atbara	80	100
" " Wadi Halfa	78	95
" " Aswan	100	91
" " Delta Barrage	69	63
Rosetta Branch at Sea	0	40
Damietta Branch at Sea	0	19

Source: Newhouse. 1939.

Table 4. Annual Discharge of Lake Albert at Mongalla
(billions of cubic meters per annum)

Year	Annual Discharge	Year	Annual Discharge
1904	32·6	1918	45·4
1905	29·7	1919	27·2
1906	32·0	1920	21·9
1907	31·0	1921	16·5
1908	25·1	1922	12·0
1909	27·0	1923	13·8
1910	24·8	1924	17·5
1911	20·4	1925	15·6
1912	17·8	1926	18·4
1913	19·3	1927	24·0
1914	19·8	1928	20·2
1915	22·8	1929	17·9
1916	26·1	1930	19·7
1917	44·9	1931	24·4
		1932	27·1
		1933	27·3
		1934	21·8
		Mean 1904–34	24·0

Source: Newhouse. 1939.

Table 5. Lag Between Mongalla and Malakal of Maximum and Minimum Discharges

Year	Mongalla Total Millions m³	Maximum			Minimum		
		Date at Mongalla	Date at Malakal	Interval in 10-day Periods	Date at Mongalla	Date at Malakal	Interval in 10-day Periods
1905	36 200	Nov. 21-31	Jan. 1-10, 1906	4	Mar 21-31	June 11-20	8
1906	38 930	Sept. 11-20	Nov. 21-30	7	Mar. 11-20	May 21-31	7
1907	35 920	Nov. 1-10	Jan. 1-10, 1908	6	Apr. 1-10	July 21-31	11
1908	29 810	Aug. 21-31	Sept. 21-30	3	Apr. 11-20	June 11-20	6
1909	31 910	Sept. 21-30	Feb. 1-10, 1910	13	Mar. 11-20	June 11-20	9
1910	30 390	Sept. 11-20	Jan. 21-31, 1911	13	Apr. 1-10	June 11-20	7
1911	25 270	Sept. 11-20	Dec. 21-31	10	Mar. 1-10	May 1-10	6
1912	33 440	Sept. 11-20	Dec. 21-31	10	Mar. 11-20	June 21-30	10
1913	21 000	July 21-31	Nov. 21-30	12	Mar. 21-31	July 1-10	10
1914	25 520	Nov. 11-20	Jan. 21-31, 1915	7	Apr. 21-30	July 11-20	8
1915	27 880	Oct. 1-10	Jan. 1-10, 1916	9	Mar. 11-20	June 21-30	10
1916	37 890	Sept. 21-30	Dec. 11-20	7	Mar. 11-20 Mar. 21-31	June 11-20	8
1917	55 810	Oct. 1-10	Mar. 11-20, 1918	16	Mar. 21-31 Apr. 1-10	July 11-20	10
1918	47 130	Jan. 1-10	Apr. 1-10	9	Dec. 21-31	May 11-20, 1919	14
1919	31 200	July 21-31	Dec. 11-20	14	Mar. 21-31	Sept. 21-30	18
1920	25 800	Aug. 1-10	Dec. 21-31	14	Mar. 21-31	July 21-31	12
1921	16 020	Oct. 11-20	Dec. 21-31	7	May 1-10	July 1-10	6
1922	15 260	Sept. 1-10	Dec. 21-31	11	Feb. 21-28	June 1-10	10
1923	19 320	Aug. 1-10	Dec. 21-31	14	Mar. 11-20	June 1-10	8
1924	20 450	Nov. 1-10	Jan. 11-20, 1925	7	Mar. 21-31	July 1-10	10
1925	18 870	Nov. 21-30	Jan. 1-10, 1926	4	Mar. 11-20	June 11-30	10
1926	24 850	Aug. 11-20	Feb. 1-10, 1927	17	Mar. 21-31	July 21-31	12
1927	26 030	June 1-10	Aug. 11-20	7	Dec. 21-31	Feb. 21-29	6
1928	26 000	May 21-31	Aug. 11-20	8	Mar. 11-20	May 21-31	7
1929	21 300	May 1-10	Aug. 11-20	10	Apr. 1-10	July 1-10	9
1930	22 700	Nov. 1-10	Jan. 11-20, 1931	7	Feb. 21-28	May 11-20	8
1931	29 000	Sept. 1-10	Jan. 21-31, 1932	14	Feb. 21-28	May 21-31	9
1932	32 600	Aug. 1-10	Jan. 11-20, 1933	16	Feb. 21-29	June 1-10	10
1933	30 600	Sept. 11-20	Dec. 21-31	10	Apr. 21-30	Aug. 1-10	10
1934	26 300	Aug. 21-31	Nov. 21-31	9	Apr. 1-10	Aug. 1-10	12
		Total		295			281
		Mean		9·8			9·4
		General Mean			9·6		

Source: Newhouse. 1939.

Table 6. Assumed Open Water Evaporation and Rainfall in the Sudd (monthly totals in mm.)

Monthly Totals in mm.

Month	Mean Evaporation	Mean Rainfall	Net Evaporation	Weight	Weighted Net Evaporation
Jan.	158	0	158	90	142
Feb.	159	3	156	80	125
March	146	19	127	80	102
April	106	51	55	70	38
May	74	99	− 25	70	− 18
June	55	121	− 66	70	− 46
July	44	148	− 104	80	− 83
Aug.	41	158	− 117	90	− 105
Sept.	46	120	− 74	100	− 74
Oct.	50	77	− 10	100	− 19
Nov.	94	12	− 82	100	82
Dec.	131	3	128	90	115
	1 112	811	301	—	259

Source: Newhouse. 1939.

Table 7. Geography and Hydrology of the Main Swamp Rivers

	White Nile B. el Gebel	Zeraf	Ghazal	Sobat
Origin	Lake Victoria	Swamps at Jonglei	L. Ambadi	Ethiopia and East swamps
Length in km	1000 km on entry 627 km in swamps	About 293 as distinct channel	About 200 from Jur entry into Ambadi	About 200 as joint river
Discharge, mean 1913–1942 (milliard m³)	Swamp head 27 Swamp tail 14·3	Included in Gebel discharge	0·63	13·0
Altitudes and slope (m)	Bor 419 L. No 386 a.s.l. 0·052 m/km	398·4–384·5 0·047 m/km	388·3–386·2 0·008 m/km	About 400–383 0·085 m/km
Current	Bor 1·13 m sec L. No 0·61 m/sec	0·65 m/sec–0·61 m/sec	0·02–0·20 m/sec	Not calculated
Depth	Varying, not exceeding 10 m (Monakov, 1969)	Unknown in detail sites investigated up to 10 m	1·5–4·0 m	No details, site investigated was 10 m

Source: Rzoska. 1974.

Table 8. Limnological Characteristics of Swamp Rivers

A. Bahr el Gabel (Upper White Nile)

Site	Distance from L. Victoria (km)	Date and investigator	pH*	Conductivity (μmho/cm, 20°C)	Transparency (m)	CO_2 (mg/l)	Oxygen (mg/l)	% saturation
Near Bor	980	Talling, June 1954	7·8	—	0·17	3·00	5·10	65
		Talling, December 1954	7·9	270	0·40	2·80	6·20	77
		Gay, March 1958	—	350	—	—	—	—
		Kurdin, Dec.–Jan. 1963/4	7·35	—	0·75	6·00	4·81	61
		Kurdin, Apr.–May 1964	7·25	—	0·65	7·10	3·82	50
Near Shambe	1210	Talling, June 1954	7·2	255	0·53	17·0	0·8	10
		Talling, Dec. 1954	7·05	208	0·53	18·0	3·0	37
		Bishai, Dec. 1960	6·8	250	—	26·0	0·28	3
		Gayed, Dec. 1961	—	250	—	—	—	—
		Kurdin, Dec.–Jan. 1963/4	7·10	—	1·25	9·8	2·30	29
		Kurdin, Apr.–May 1964	7·0	—	1·10	12·4	0·66	9
River Post 70	1283	Chadwick, Apr. 1961	—	340	—	—	—	—
River Post 59	1340	Gayed, Dec. 1961	—	170	—	—	—	—
River Post 30	1480	Gay, March 1958	—	350	—	—	—	—
River Post 12	1583	Pyle, Jan. 1949	—	—	—	—	2·45	43·5
		Talling, Jan. 1954	7·8	—	0·45	—	5·00	64
		Talling, Dec. 1954	7·15	202	0·58	14·5	4·50	55
At Lake No	1633	Talling, Jan. 1954	7·8	—	0·45	—	5·00	65
		Talling, June 1954	7·8	250	0·32	3·8	4·40	56
		Talling, Dec. 1954	7·2	202	0·60	13·0	4·70	57
		Gay, March 1958	—	360	—	—	—	—
		Bishai, Dec. 1960	7·4	550	—	15·0	1·40	17
		Gayed, Dec. 1961	7·1	190	—	—	—	—
		Kurdin, Dec. 1963	7·25	—	1·30	9·60	3·76	45
		Kurdin, April 1964	7·17	—	0·85	9·90	2·43	32
At Khor Atar	1745	Pyle, June 1949	—	—	—	—	3·23	58
		Talling, Feb. 1954	8·2	—	0·40	—	7·2	87
		Talling, June 1954	7·8	—	0·25	3·5	—	—
		Talling, Dec. 1954	7·15	237	0·90	16·0	2·1	24
		Rzóska, Dec. 1956	—	225	—	—	—	—
		Kurdin, Dec. 1963	7·25	—	1·90	10·2	1·85	22
		Kurdin, April 1964	7·35	—	1·10	9·8	2·57	34
At Sobat Mouth	1756	Pyle, Jan. 1949	—	—	—	—	4·7–5·3	45–61
		Talling, Dec. 1953	7·4	—	0·35	—	6·0–6·6	71–75
		Talling, Dec. 1954	6·8	112	—	18·0	3·4	41
		Rzóska, Dec. 1956	—	125	—	—	—	—
		Kurdin, Dec. 1963	6·8	—	0·55	7·0	4·31	52
		Kurdin, April 1964	7·15	—	0·30	3·6	6·20	81

* Temp. (not given) lie between 22–28°C.

Source: Rzoska, 1974.

B. Bahr el Ghazal

Site	Distance from origin of Bahr el Ghazal	Date	pH	Conductivity	Transparency (m)	Oxygen (mg/l)	Oxygen Sat (%)
Entrance of Aut	0	Jan 1956	[illegible]	—	—	—	—
L. Ambouk	[illegible]	Jan 1956	[illegible]	[illegible]	2.50 (to bottom)	[illegible]	[illegible]
						Upper water 7.5-8.0	[illegible]
Aweiong	[illegible]	Jan 1956	[illegible]	—	1.80	[illegible]	[illegible]
Wangkai	[illegible]	Jan 1956	—	—	2.50	—	—
[illegible]	[illegible]	Jan 1956	7.0	[illegible]	1.12	[illegible]	[illegible]
		Apr 1961	[illegible]	[illegible]	—	—	—
		Dec 1962	—	[illegible]	1.60	[illegible]	[illegible]
River Post no. 1	[illegible]	Jan 1956	7.3	—	[illegible]	[illegible]	[illegible]
River Post no. 2	[illegible]	Jan 1956	7.3	—	[illegible]	[illegible]	[illegible]
		Dec 1961	7.3	[illegible]	—	—	—
Mouth of Ghazal at L. Ric	[illegible]	Dec 1953	7.3	—	[illegible]	[illegible]	[illegible]
Lake Ric	—	Dec 1953	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Source: Rzoska, 1974.

C. Bahr el Zeraf and Sobat

Site	Distance from origin (km)	Date	pH	Conductivity	Transparency (m)	Alkalinity (as HCO_3^-)	Oxygen (mg/l)	Oxygen Sat (%)	Cl^- (mg/l)	SiO_2 (mg/l)
Zeraf River										
Zeraf site	[illegible]	Dec 1961	7.3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—
Downstream	[illegible]	Jan 1956	[illegible]	—	—	[illegible]	[illegible]	[illegible]	—	[illegible]
diff site			[illegible]	—	—	[illegible]	[illegible]	[illegible]	—	—
River Post 3	[illegible]	Feb 1956	—	—	[illegible]	—	—	—	—	—
15 km from mouth	[illegible]	Jan 1956	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]
5 km from mouth	[illegible]	Dec 1961	[illegible]	[illegible]	—	—	—	—	—	—
Mouth	[illegible]	Jan 1961	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—
Sobat River										
Nasir Mouth	[illegible]	Dec 1961	—	—	—	—	[illegible]	[illegible]	—	—
		Dec 1955	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Dec 1956	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		Dec 1956	—	[illegible]	—	—	—	—	—	—
		March 1956	—	[illegible]	—	—	—	—	—	—
		June 1961	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—
		Dec 1961	[illegible]	[illegible]	—	—	—	—	—	—
		Feb 1962	[illegible]	—	[illegible]	—	[illegible]	[illegible]	—	—
		May 1962	[illegible]	—	[illegible]	—	[illegible]	[illegible]	—	—

Source: Rzoska, 1974.

Table 9. Recharge Estimates and Transmissibility Calculations in Kordofan

A. Formations in Southwestern Kordofan

Central Kordofan - West Eighelle

Average annual rainfall	= 400 mm/year
Amount of runoff	= 100 mm/year
	= .34 ft/year
Catchment area: 30 miles radius	= 2820 square miles
Volume of runoff = 2820 x 640 x .34	= 6.1×10^5 acre ft/year
$= \frac{6.1 \times 10^5 \times .89}{1000}$	= 543×10^6 gals/day
Percentage of recharge increment from total runoff	= 30%
Total (Q) or volume of recharge	
$= \frac{543 \times 10^6 \times 30}{100}$	= 16.3×10^7 gals/day
	= .25 in/yr or 6 mm/yr
Using the ground water equation	
Q = T I L	
$T = \frac{16.3 \times 10^7 \times 1150}{150 \times 5280 \times 1}$	= 200 000 gals/ft/day

Source: Ishag, 1965.

B. Nubian Aquifer in Northern Kordofan

Average annual rainfall (from Eq. 1)	= 290 mm/year
Amount of runoff	= 50 mm/year
	= .16 ft/year
Catchment area: 20 miles radius	= 1250 square miles
Volume of runoff = 1250 x 640 x .16	= 12.8 x 10^6 acre ft/yr
$= \frac{12.8 \times 10^6 \times .84}{1000}$	= 11.4 x 10^6 gals/day
Percentage of recharge underneath from total runoff	= 60%
Total (Q) or volume of recharge	= 6.8 x 10^6 gals/day
	= .07 cubic or 1.8 mm/yr
Using the ground water equation	
Q = TIL	
$T = \frac{6.8 \times 10^6 \times 3280}{300 \times 3280 \times .1}$	= 151,000 gals/ft/day

Source: Ishag. 1965.

C. Umm Ruwaba Aquifer in Eastern Kordofan

Northern Nuba Mountains - Khor Abu Habil

Average annual rainfall (from Eq. 1)	= 400 mm/year
Amount of runoff	= 200 mm/year
	= .67 ft/year
Catchment area: 30 miles radius	= 2827 square miles
Volume of runoff = 2827 x 640 x .67	= 1.2 x 10^6 acre ft/yr
$= \frac{1.2 \times 10^6 \times .84}{1000}$	= 1040 x 10^6 gals/day
Percentage of recharge underneath from total runoff	= 30%
Total (Q) or volume of recharge	
$= \frac{1040 \times 10^6 \times .31}{100}$	= 32 x 10^6 gals/day
	= .4 cubic or 12 mm/yr
Using the ground water equation	
Q = TIL	
$T = \frac{32 \times 10^6 \times 7280}{300 \times 3280 \times .1}$	= 215,000 gals/ft/day

Source: Ishag. 1965.

Table 10. Residual Drawdown and Recovery Data for Well No. 1834, Gash River Basin

Time Since Pump Test Started (t min.)	Time Since Pump Test Stopped (t' min.)	Ratio t/t'	Depth to Water Level (in ft.)	Residual Drawdown (s') (in ft.)	Calculated Recovery (s-s') (in ft.)	Remarks
600	0	0.00	32.50	4.03	0.00	Static water level is 28.47 ft. Q = 250 gpm.
601	1	601	27.78	3.31	2.92	
602	2	301	29.35	0.48	3.15	
604	4	151	29.18	0.71	3.32	
607	7	86.70	29.16	0.67	3.36	
610	10	61.00	29.09	0.61	3.41	
613	13	47.15	29.00	0.53	3.50	
616	16	38.50	28.93	0.46	3.57	
623	23	27.06	28.83	0.36	3.67	
631	31	20.35	28.68	0.21	3.82	
640	40	16.00	28.66	0.17	3.84	
645	45	14.10	28.60	0.13	3.90	
650	50	13.00	28.57	0.10	3.93	
660	60	11.00	28.56	0.07	3.96	
670	70	9.60	28.51	0.04	3.99	
690	90	8.50	28.49	0.02	4.01	

Source: Saeed. 1968.

Table 11. Specific Capacities of Some Wells in Gash River Basin

Location Area	Owner	Discharge (gpm)	Drawdown Feet	Specific Capacity (gpm/ft.) of drawdown	Transmissivity = Cs x 2000 gpm/ft.
Gerf El Gash B. H. No. 1234	Municipality	250	4.03	61	122,000
Gerf El Gash B. H. No. 1834	Municipality	250	4.50	55.55	111,000
Tukrof West	Mohamed Nider Dunlejak B. H. No. 4	210	2.00	105	210,000
"	Mohamed Nider Dunlejak B. H. No. 8	200	5.00	40.00	80,000
"	Mohed. Osman Nagia	192	16.00	12.00	24,000
"	Abdel Rahim Mahgoub	192	10.00	19.20	38,400
Tukrof	Ibrahim Fad El Mola	192	2.00	96	192,000
"	Mohed. Bakiber Aila	180	10.00	18	36,000

Source: Saeed. 1968.

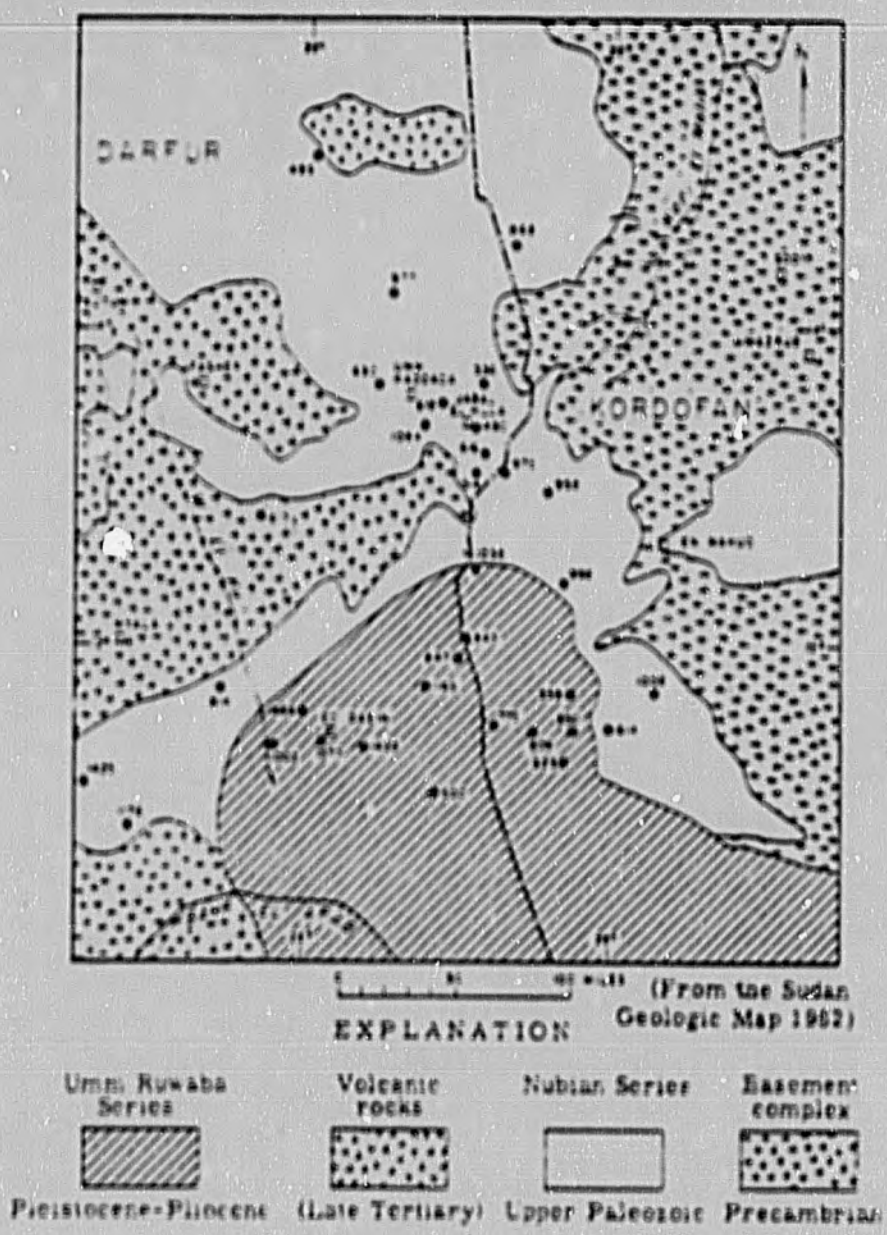

Figure 3. Reference Map of Darfur Kordofan Border Area (for Table 12)

Source: Karkanis. 1966.

Table 12. Chemical Analyses of Groundwater in Darfur and Kordofan

Bore hole Number	690 ppm	699 ppm	506 ppm	514 ppm	536 ppm	551 ppm	611 ppm	615 ppm
Silica	20	24	6	30	20	20	10	50
Calcium	120	60	28	28	60	60	19	64
Magnesium	66	15	10	16	nil	15	25	570
Sodium	-	-	-	-	nil	45	123	2663
Bicarbonate	-	-	-	-	-	182	607	536
Chloride	1164	21	21	121	.5	60	34	6060
Sulphate	1144	2	13	99	nil	30	10	2750
Nitrate	25	0.25	nil	.30	nil	nil	2.9	5.8
Fluoride	1.9	0.44	.96	6.5	nil	.15	0.6	.25
Total dissolved solids	3072	230	235	452	250	330	430	11620
Hardness as $CaCO_3$	60	12	8	90	100	160	150	1300
pH (lab.)	6.8	6.8	7.6	7.3	6.8	7.4	8.2	8.1

Table 12. Continued

Bore hole Number	617 ppm	618 ppm	666 ppm	775 ppm	814 ppm	843 ppm	847 ppm	850 ppm
Silica	20	20	80	60	75	60	30	10
Calcium	10	17	86	33	42	73	54	39
Magnesium	4	4	49	17	6	14	8	14
Sodium	135	24	139	49	53	89	57	66
Bicarbonate	257	64	280	290	256	256	231	232
Chloride	24	26	216	4	16	72	16	32
Sulphate	40	nil	100	20	10	53	50	10
Nitrate	19	.6	23	.5	.7	17.4	1.2	1.5
Fluoride	.4	.6	.8	.5	.2	0.4	.3	.6
Total dissolved solids	450	120	900	260	260	600	400	260
Hardness as $CaCO_3$	60	60	416	150	130	260	166	156
pH (lab.)	7.5	7.8	7.2	8.3	8.4	7.8	7.9	8.3

Table 12. Continued

Data Serial Number	862 ppm	906 ppm	953 ppm	975 ppm	977 ppm	997 ppm	1002 ppm
Silica	15	8	10	15	10	5	10
Calcium	27	25	60	18	13	33	50
Magnesium	9	6	8	8	5	12	21
Sodium	10	30	43	23	27		116
Bicarbonate	127	207	219	109	85	150	207
Chloride	14	2	22	18	14	26	180
Sulphate	10	10	10	10	14	24	125
Nitrate	2.6	.9	.5	.8	1.0	1	12
Fluoride	.5	.2	.9	.6	.6	.7	.5
Total dissolved solids	160	200	260	120	90	220	650
Hardness as $CaCO_3$	104	104	134	80	52	130	252
pH (lab.)	7.2	7.8	8.2	8.1	8.1	8.0	7.9

Table 12. Continued

Data Serial Number	1042 ppm	1131 ppm	1146 ppm	1169 ppm	1176 ppm	1377 ppm	1425 ppm	1428 ppm
Silica	10	9	10	14	60	10	6	22
Calcium	21	45	24	59	69	34	41	65
Magnesium	12	17	26	13	7	10	10	14
Sodium	11	29	66	75	81	47	33	75
Bicarbonate	110	232	171	253	279	267	244	290
Chloride	8	22	92	95	80	10	4	30
Sulphate	15	19	29	32	35	14	10	30
Nitrate	1.3	1	3	3	nil	.5	.7	.7
Fluoride	.3	.7	1	.3	.4	.4	.7	.4
Total dissolved solids	190	260	360	380	390	230	250	460
Hardness as $CaCO_3$	100	150	168	80	208	128	146	218
pH (lab.)	8.3	8.3	8.0	8.0	8.3	8.0	8.3	8.3

Source: Karkamis, 1966.

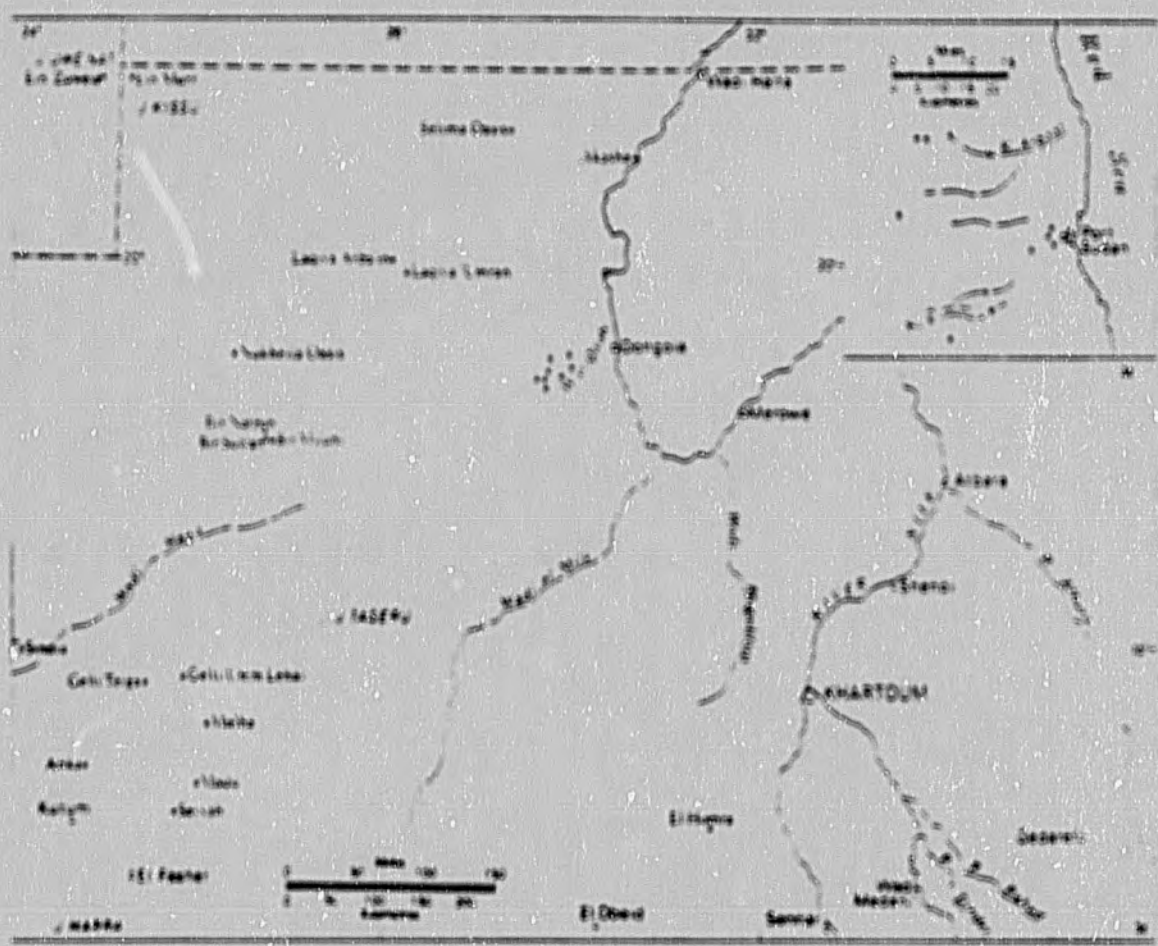

Figure 4. Wells and Oases of the Northern Sudan

Source: Whiteman. 1971.

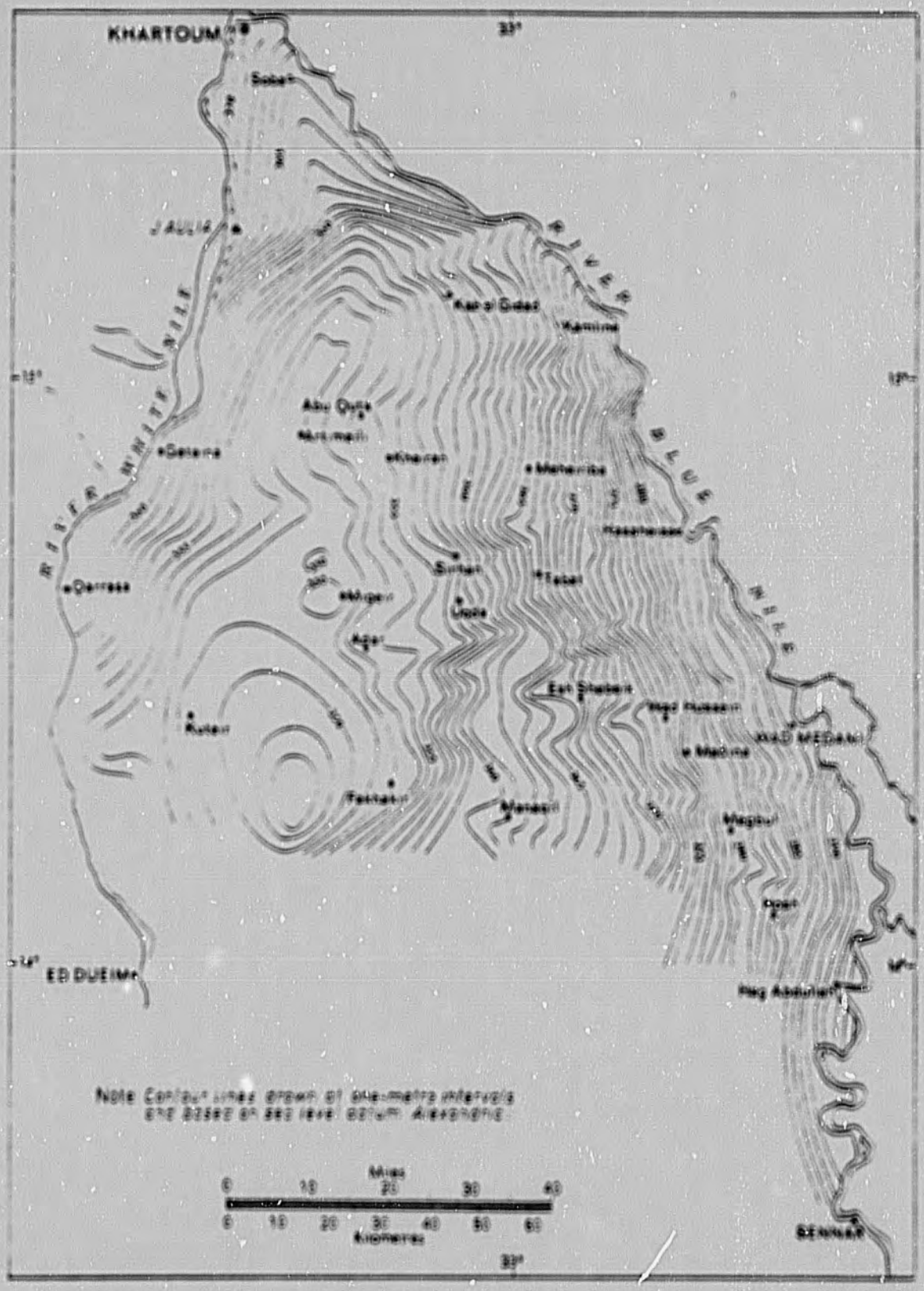

Figure 5. Standing Water-Level Contour Map, El Gezira

Source: Whiteman, 1971.

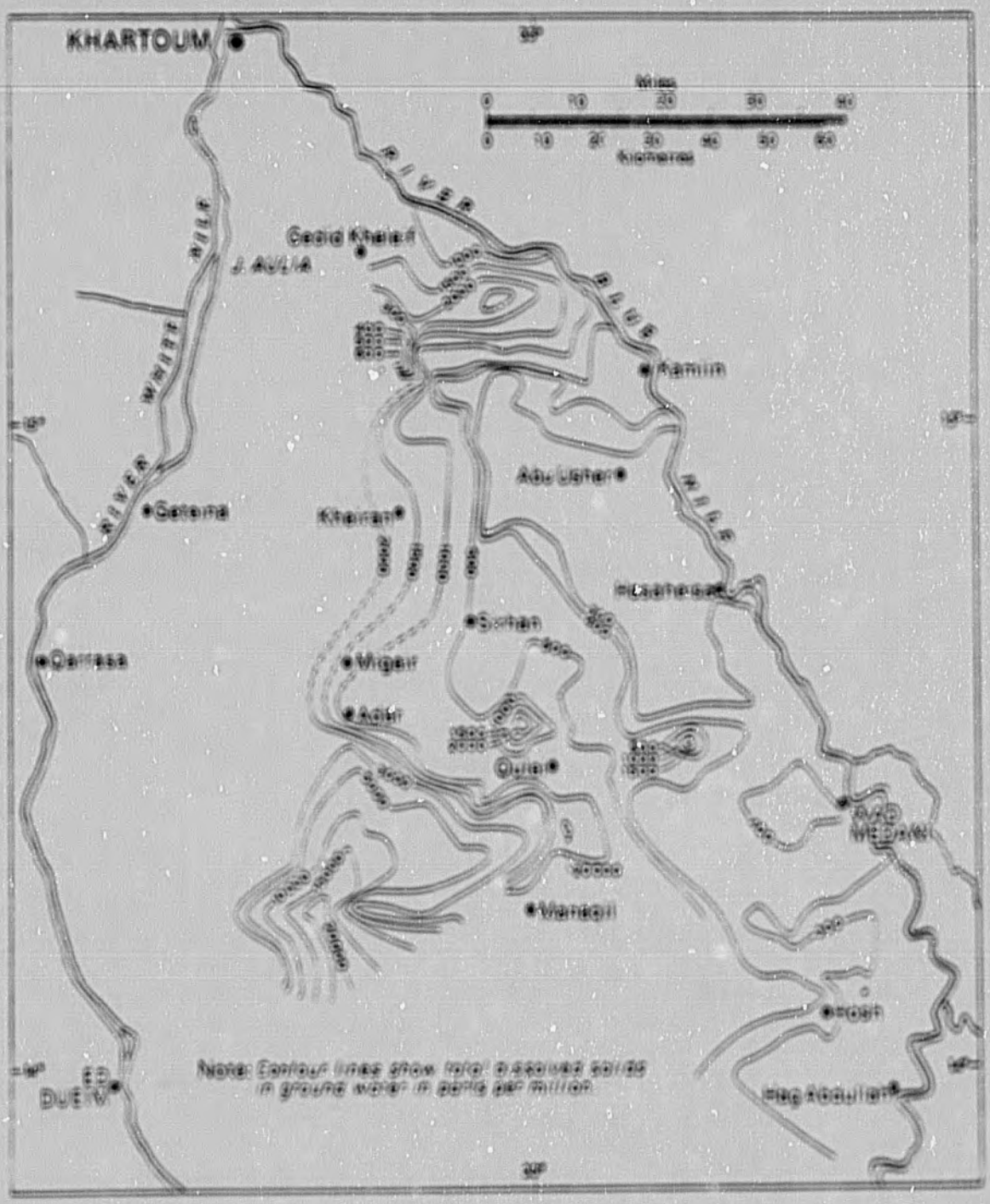

Figure 6. Total Dissolved Solids , El Gezira (P.P.M.)

Source: Whiteman. 1971.

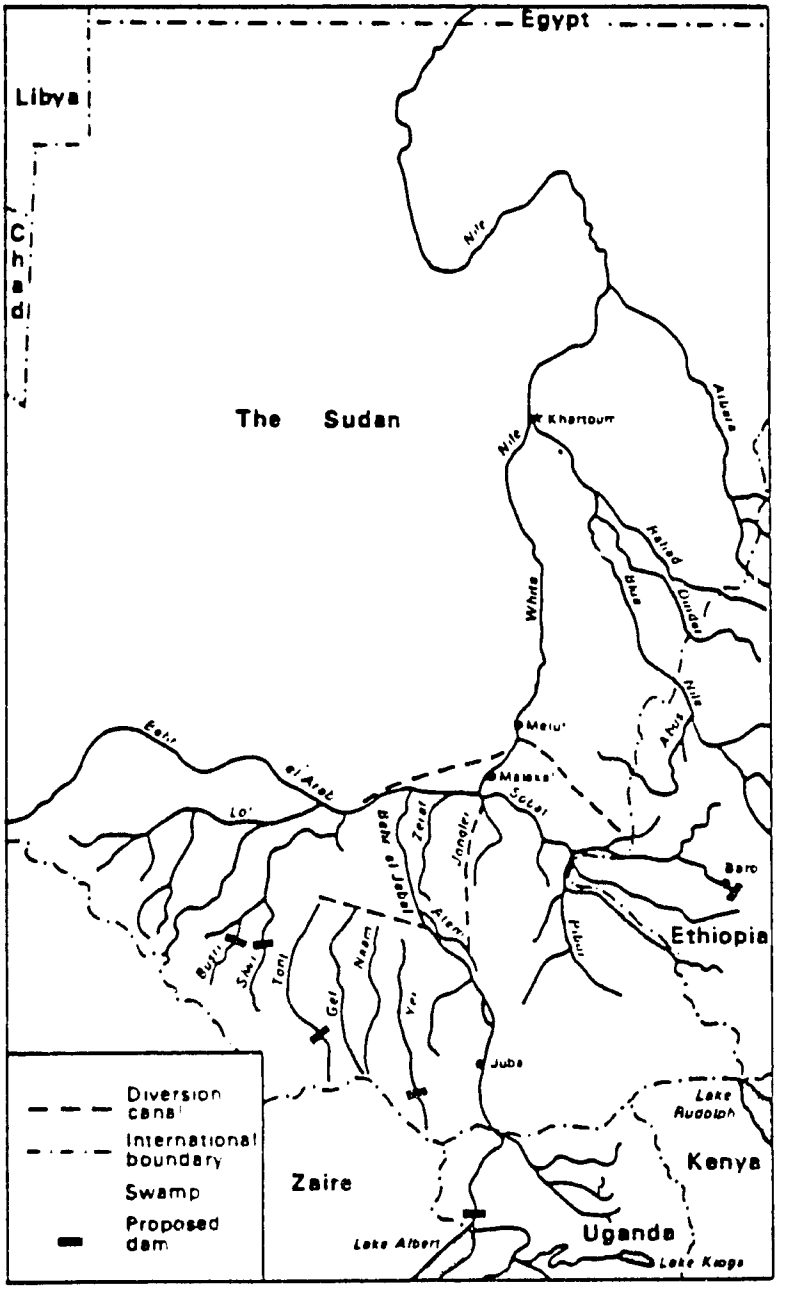

Figure 7. Proposed Upper Nile Projects

Source: Waterbury. 1979.

Appendix V

Soils Data

Table 1. Temperature Data of a Khartoum Soil

Table 2. Soil Moisture Storage at Three Stations

Figure 1. Reference map for location of soil profiles

Table 3. Selected Soil Profiles along Nile

Figure 2. Location of Principal Improvement Schemes, 1971

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Table 1. Temperature Data of a Khartoum Soil

A. Soil Temperature Means in °C, 1958-62

Month / Depth in cm	J	F	M	A	M	J	J	A	S	O	N	D
1	31.0	32.8	37.8	43.2	44.3	44.9	39.5	38.0	40.6	41.1	37.2	32.7
2.5	30.1	31.2	36.2	40.8	42.7	43.4	36.4	36.6	38.7	39.1	35.5	32.0
5	29.3	30.6	35.4	40.3	42.0	42.9	38.3	36.2	38.1	38.4	35.0	31.4
10	29.0	29.7	34.1	38.6	40.4	41.2	37.3	35.5	37.1	37.6	34.2	30.7
20	27.8	28.1	31.7	37.6	37.6	39.2	35.7	34.4	36.0	36.1	33.1	29.9
50	29.0	29.3	31.8	35.2	37.2	38.4	36.5	34.7	35.8	36.1	33.6	30.6
100	30.2	29.8	31.4	34.0	35.9	37.1	36.3	34.6	35.3	35.8	34.4	31.8

Source: Buursink. 1971.

B. Soil Temperature Variation in °C, 1958-62

Depth in cm	Yearly means	Monthly mean		Absolute		Difference
		Highest	Lowest	Maxima	Minima	
air	29.6	33.7	23.7	47.7	5.2	42.5
1	38.5	65.3	20.7	73.0	12.0	61.0
2.5	37.0	56.2	20.5	65.5	12.7	52.8
5	36.5	52.9	20.9	61.0	13.5	47.5
10	35.5	46.6	22.7	50.5	17.2	33.3
20	33.8	40.9	25.4	44.3	22.0	22.3
50	34.0	38.5	28.8	39.8	25.8	14.0
100	33.9	37.2	29.8	38.5	27.9	10.6

Source: Buursink. 1971.

Table 2. Soil Moisture Storage at Three Stations, 1957 (in mm)

Month / Station	J	F	M	A	M	J	J	A	S	O	N	D
Sennar	3	2	1	0	0	0	0	11	9	6	5	4
Singa	7	4	2	1	0	0	4	55	46	29	17	11
Roseires	19	12	4	1	0	0	28	115	127	83	51	32

Source: Buursink. 1971.

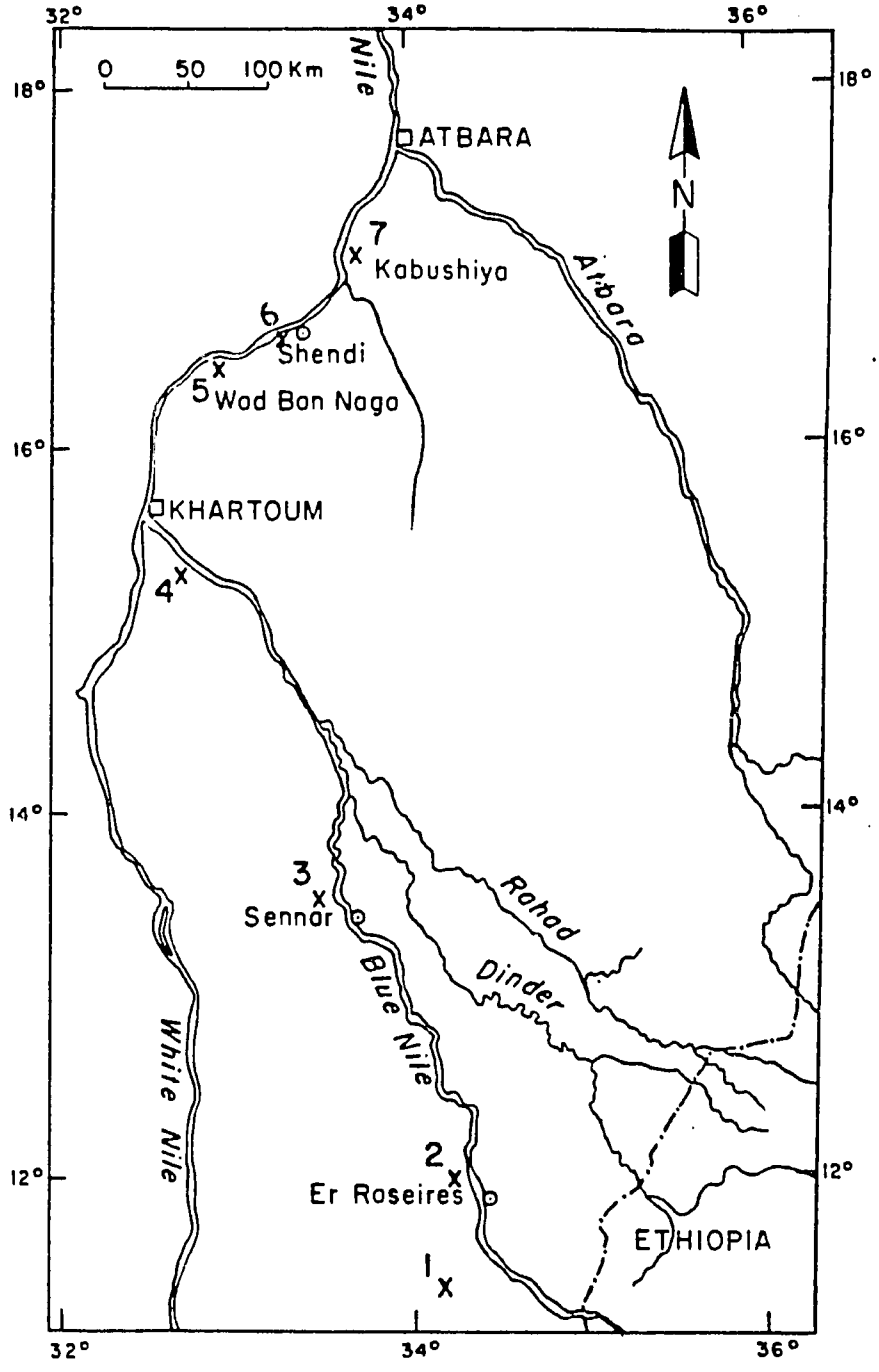


Figure 1. Reference Map for Location of Soil Profiles

Source: Buursink. 1971.

Table 3. Selected Soil Profiles along Nile

Sample	Site	Landform	Vegetation
15	1	Foot of inselberg	Few *Dalbergia melanoxylon*, few *Acacia mellifera*
16	1	Foot of inselberg	Dominant *Acacia mellifera*, very few *Acacia seyal*, very few *Balanites aegyptiaca*
21	2	Nile terrace	Sparse *Hyphaene thebaica*, *Calotropis procera*, and short grass cover
22	2	Nile levee	Few *Balanites aegyptiaca*, *Adansonia digitata*, *Acacia seyal*
32	3	Nile levee	Sparse *Acacia seyal*
33	3	Backswamp	Dryland cultivated
41	4	Nile terrace	Dryland cultivated
42	4	Nile levee	Short grass
51	5	Lower Nile terrace	Desert scrub
67	6	Nile terrace	Sparse *Acacia tortilis*
71A	7	Lower Nile terrace	Sparse grass
77	7	Upper Nile terrace	None

Source: Bursink. 1971.

Laboratory Data Profile No. 15

Depth, cm	Horizon	% >2 mm	Particle size distribution (μ) % sand 2000–200	sand 200–50	silt 50–20	silt 20–2	clay <2	clay 2–0.2	clay <0.2
0– 10	A1	15	30.5	19.8	12.4	8.6	28.7		
10– 25	A2	20	19.3	20.7	7.2	8.7	44.1		
25– 65	Bt	25	18.0	12.3	7.5	8.7	53.5		
65–105	Bt	25	13.9	13.3	6.7	7.8	58.3		
105–150	B2	25	12.0	10.7	7.1	14.7	55.5		
150–190	Cca	11	10.2	9.9	8.3	10.0	61.6		

B.D. (g per cc)	Organic matter C %	Organic matter C/N	$CaCO_3$ equiv %	Gypsum %	pH 1 : 5	Clayminerals Mt	Mi	Vm	Chl	K	Q
	1.33	20	—		6.7	xxxx	x			xx	t
	1.18	22	—		6.8	xxxx	x			xx	t
	0.62	14	—		6.8	xxxx	x			xx	t
			—		6.9	xxxx	x			xx	t
			—		7.0	xxxx	x			xx	t
			3.4		7.9	xxxx	x			xx	t

Cation exch. cap	Extractable cations, meq/100 g Sum	Ca	Mg	K	Na	Exch. Na %	Saturation extract, soluble (meq/l) Ca	Mg	Na	E.C. mmhos per cm
28.1	20.5	13.3	6.7	0.5	t	—				
36.3	25.9	16.2	9.4	0.3	t	—				
37.2	28.1	18.0	9.7	0.4	t	—				
39.0	30.7	19.7	10.5	0.5	t	—				
41.2	33.3	21.6	11.2	0.5	t	—				
46.7	41.2	27.4	13.3	0.5	t	—				

Waterextract 1 : 5, soluble (meq/100 g) cations Ca	Mg	K	Na	Sum	anions Sum	CO_3	HCO_3	Cl	SO_4	NO_3	E.C., mmhos per cm
0.2	0.2	t	t	0.4	0.4	—	0.4	t	t	t	0.1
0.1	0.1	t	0.1	0.3	0.2	—	0.3	t	t	t	0.1
0.1	0.1	t	0.1	0.3	0.1	—	0.1	t	t	t	0.1
0.1	0.1	t	0.1	0.3	0.2	—	0.2	t	t	t	0.1
0.1	0.1	t	0.1	0.3	0.4	—	0.4	t	t	t	0.1
0.4	0.4	t	0.2	1.0	1.2	—	1.2	t	t	t	0.2

Depth, cm	Horizon	% >2 mm	Particle size distribution (μ) % sand 2000-200	sand 200-50	silt 50-20	silt 20-2	clay <2	clay 2-0.2	clay <0.2
0- 15	A11	18	8.6	6.9	9.8	13.7	61.0		
15- 50	A12	16	7.8	7.9	6.2	15.5	62.6		
50- 80	AC?	12	9.5	7.4	6.5	14.8	61.8		
80-110	AC?	8	9.1	6.6	6.6	13.5	64.2		
110-150	AC?	4	6.3	5.3	5.5	14.8	68.1		
150-175	C	—	6.2	5.2	9.5	13.1	66.0		

B.D. (g per cc)	Organic matter C %	Organic matter C/N	$CaCO_3$ equiv. %	Gypsum %	pH 1 : 5	Clayminerals Mt	Mi	Vm	Chl	K	Q
	0.98	32	—		7.0	xxxx				xx	t
	0.73	27	—		6.8	xxxx				xx	t
			—		7.2	xxxx				xx	t
			—		7.4	xxxx				xx	t
			—		7.8	xxxx				xx	t
			—		7.9	xxxx				xx	t

Cation exch. cap.	Extractable cations, meq/100 g Sum	Ca	Mg	K	Na	Exch. Na %	Saturation extract, soluble (meq/l) Ca	Mg	Na	E.C. mmhos per cm
49.0	36.0	16.9	18.6	0.5	t	—				
49.1	36.1	18.2	17.6	0.3	t	—				
49.5	36.8	19.0	17.3	0.2	0.3	0.6				
49.1	39.4	21.3	17.3	0.3	0.5	1.0				
52.4	44.1	24.8	18.3	0.4	0.6	1.2				
56.2	49.7	28.1	20.5	0.4	0.7	1.3				

Water extract 1 : 5, soluble (meq/100 g) cations Ca	Mg	K	Na	Sum	anions Sum	CO_3	HCO_3	Cl	SO_4	NO_3	$E.C._5$ mmhos per cm
0.1	0.2	t	0.1	0.4	0.3	—	0.3	t	t	t	0.1
0.1	0.1	t	0.2	0.4	0.5	—	0.2	0.1	0.2	t	0.1
0.1	0.1	t	0.3	0.5	0.3	—	0.3	t	t	t	0.1
0.1	0.1	t	0.4	0.6	0.6	—	0.5	t	0.1	t	0.1
0.1	0.2	t	0.6	0.9	1.0	—	1.0	t	t	t	0.1
0.2	0.4	t	0.7	1.3	1.3	—	1.3	t	t	t	0.1

Laboratory Data Profile No.21

Depth, cm	Horizon	% >2 mm	Particle size distribution (μ) % sand 2000-200	sand 200-50	silt 50-20	silt 20-2	clay <2	clay 2-0.2	clay <0.2
0- 25	A1	—	1.1	7.0	41.3	23.7	26.9	3.1	23.8
25- 43	C1	—	0.1	8.1	37.7	33.0	27.4	3.7	23.7
43- 70	C2	—	0.1	0.9	38.2	34.4	26.4	3.6	22.8
70-124	C3	—	—	—	27.2	50.0	22.8	2.3	20.5
124-190	C4	—	0.1	0.2	31.1	38.5	30.1	0.8	29.3

Elemental composition

SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O	Loss on ignition	Ba	Co	Mn	Ni	Sr	Zn
weight percentages								ppm					
51.0	14.5	10.8	2.1	6.7	2.6	1.4	8.2	270	32.5	1080	37.0	276	105.0
45.5	15.2	11.1	2.1	6.7	2.6	1.2	8.3	570	32.0	1005	37.0	276	104.0
44.6	15.5	11.3	2.2	6.7	2.6	1.3	7.4	575	47.0	1220	47.0	357	97.5
42.5	15.4	11.3	2.2	7.1	2.5	1.4	7.7	445	45.0	1240	53.5	276	111.5
48.9	15.3	11.1	2.2	6.7	2.4	1.4	7.7	410	31.0	1240	68.5	282	112.0

B.D. (g per cc)	Organic matter C %	Organic matter C/N	$CaCO_3$ equiv. %	Gypsum %	pH 1 : 5	Clayminerals Mt	Mi	Vm	Chl	K	Q
1.34	1.41	13	3.8		8.3	xxxx	t			xx	t
1.32	0.98	13	4.9		8.4	xxxx	t			xx	t
1.47	0.90		3.8		8.5	xxxx	t			xx	t
1.27	0.83		4.6		8.5	xxxx	t			xx	t
1.26	0.62		4.7		8.5	xxxx	t			xx	t

Cation exch. cap.	Extractable cations, meq/100 g Sum	Ca	Mg	K	Na	Exch. Na %	Saturation extract, soluble (meq/1) Ca	Mg	Na	E.C. mmhos per cm
33.8	35.1	28.5	5.2	1.4	t	—				
36.7	39.6	33.3	5.4	0.9	t	—				
36.0	37.5	31.2	5.2	1.1	t	—				
37.7	38.2	31.9	5.6	0.6	0.1	0.3				
36.9	40.4	33.5	5.8	1.1	t	—				

Waterextract 1 : 5, soluble (meq/100 g) cations Ca	Mg	K	Na	Sum	anions Sum	CO_3	HCO_3	Cl	SO_4	NO_3	E.C.$_5$ mmhos per cm
0.7	0.2	t	0.2	1.1	1.2	t	0.8	t	0.4	t	0.3
0.7	0.2	t	0.3	1.2	1.1	t	0.7	t	0.4	t	0.3
0.4	0.1	t	0.1	0.6	0.8	t	0.6	0.2	t	t	0.2
0.4	0.1	t	0.1	0.6	0.6	t	0.6	t	t	t	0.1
0.4	0.1	t	0.1	0.6	0.6	t	0.6	t	t	t	0.2

Depth, cm	Horizon	% >2 mm	Particle size distribution (μ) %, sand 2000–200	sand 200–50	silt 50–20	silt 20–2	clay <2	clay 2–0.2	clay <0.2
0– 18	A1	—	64.9	24.1	4.0	2.2	4.3	1.7	3.1
18– 38	A2	—	61.2	24.4	5.1	0.6	8.7	2.9	5.8
38– 60	Bt1	—	53.2	15.9	4.6	2.3	24.0	1.8	22.2
60– 90	Bt2	—	54.2	14.4	6.6	0.1	24.7	2.2	22.5
90–120	B2	—	53.9	20.6	5.6	2.8	17.1	2.4	14.7
120–150	B2	—	52.4	18.9	5.1	5.7	17.0	1.9	16.0
150–175	C	—	41.7	15.3	5.2	3.5	34.3		
200–250		—	40.6	16.8	4.2	4.7	33.7		

Waterextract 1 : 5, soluble (meq/100 g) cations: Ca	Mg	K	Na	Sum	anions: Sum	CO_3	HCO_3	Cl	SO_4	NO_3	E.C.$_5$ mmhos per cm
t	t	t	0.1	0.1	0.1	t	t	t	0.1	t	0.1
t	t	t	0.1	0.1	0.1	t	t	t	0.1	t	0.1
t	t	t	0.2	0.2	0.3	t	0.1	t	0.2	t	0.1
t	t	t	0.3	0.3	0.5	t	0.2	t	0.3	t	0.1
t	t	t	0.3	0.3	0.4	t	0.2	t	0.2	t	0.1
t	t	t	0.3	0.3	0.5	t	0.2	t	0.3	t	0.1
t	0.1	t	0.5	0.6	1.0	t	0.4	0.2	0.4	t	0.1
0.1	0.1	t	0.8	1.0	0.9	t	0.8	t	0.1	t	0.2

Elemental composition: SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O	Loss on ignition	Ba	Co	Mn	Ni	Sr	Zn
weight percentages								ppm					
82.6	6.6	1.7	0.6	0.7	0.2	1.8	1.0	770	5.5	184	12.0	288	14.5
77.9	6.9	2.2	0.7	0.9	0.3	1.8	1.1	625	14.0	315	12.0	339	17.0
77.7	9.9	3.9	0.7	0.9	0.5	1.4	2.7	425	15.5	220	35.0	359	24.5
74.6	10.6	3.9	0.8	0.8	0.4	1.6	2.7	700	24.0	210	21.5	291	28.5
74.5	9.3	3.7	0.9	0.8	0.4	1.7	2.0	700	24.0	930	26.0	265	24.5
72.1	9.6	4.1	0.9	0.7	0.4	1.7	2.2	480	17.0	610	27.5	240	20.0

B.D. (g per cc)	Organic matter C %	C/N	$CaCO_3$ equiv. %	Gypsum %	pH 1 : 5	Clayminerals Mt	Mi	Vm	Chl	K	Q
1.59	0.24	13	—		6.5	xxxx				x	x
1.62	0.14	12	—		6.2	xxxx				x	x
1.93	0.23	12	—		6.9	xxxx	t			x	t
1.92			—		7.7	xxxx	t			x	t
1.74			—		8.4	xxxx	t			x	t
1.81			—		8.5	xxxx	t			x	t
1.84			—		8.8	xxxx				x	t
			—		8.8	xxxx				x	t

Cation exch. cap.	Extractable cations, meq/100 g: Sum	Ca	Mg	K	Na	Exch. Na %	Saturation extract, soluble (meq/1): Ca	Mg	Na	E.C. mmhos per cm
2.7	1.7	1.1	0.5	0.1	t	—				
4.0	2.8	1.6	1.0	0.2	t	—				
14.6	12.6	8.1	4.0	0.5	t	—				
15.5	12.9	8.1	4.2	0.6	t	—				
9.4	8.5	5.6	2.4	0.5	t	—				
11.5	10.7	7.1	3.0	0.6	t	—				
19.6	17.8	11.8	5.2	0.7	0.1	0.5				
19.6	17.8	12.3	4.7	0.8	t	—				

Depth, cm	Horizon	% >2 mm	Particle size distribution (μ) %, sand 2000–200	sand 200–50	silt 50–20	silt 20–2	clay <2	clay 2–0.2	clay <0.2
0– 12	A1	12	25.8	17.4	14.2	10.8	31.8		
12– 44	Bt	9	23.4	9.7	10.3	14.0	42.6		
44– 85	B2	—	22.8	7.7	11.4	13.9	44.2		
85–123	B2	—	22.8	7.8	10.4	15.6	43.4		
123–175	C	2	20.8	7.1	13.1	10.7	48.3		

B.D. (g per cc)	Organic matter C %	Organic matter C/N	$CaCO_3$ equiv. %	Gypsum %	pH 1 : 5	Clayminerals Mt	Mi	Vm	Chl	K	Q
	1.29	11	4.6		7.7	xxxx				x	t
	0.73	12	3.9		7.9	xxxx				x	t
			4.3	t	7.6	xxxx				x	t
			4.2	0.8	7.2	xxxx				x	t
			1.9		7.6	xxxx				x	t

Cation exch. cap.	Extractable cations, meq/100 g: Sum	Ca	Mg	K	Na	Exch. Na %	Saturation extract, soluble (meq/l): Ca	Mg	Na	E.C. mmhos per cm
27.5	24.4	18.1	3.7	2.3	0.3	1.1				1.5
38.0	31.9	22.7	6.4	0.7	2.1	5.5				2.9
35.4	39.8	26.2	8.7	0.9	4.0	11.3				3.5
36.8	33.2	20.7	7.5	0.4	4.6	12.5				3.8
42.9	36.0	21.3	9.1	0.4	5.2	12.1				2.3

Waterextract 1 : 5, soluble (meq/100 g): cations Ca	Mg	K	Na	Sum	anions Sum	CO_3	HCO_3	Cl	SO_4	NO_3	$E.C._5$ mmhos per cm
0.7	0.4	0.3	0.4	1.8	2.1	—	1.9	t	0.3	t	0.4
0.5	0.4	t	3.3	4.2	4.6	—	3.2	0.9	0.5	t	0.7
1.0	0.7	t	6.1	7.8	7.9	—	3.2	0.9	3.1	0.7	1.4
6.5	3.4	0.1	8.1	18.0	21.5	—	0.8	0.8	18.2	1.7	3.5
0.5	0.4	t	5.4	6.3	6.0	—	0.6	0.6	2.5	1.6	1.4

Depth, cm	Horizon	% >2 mm	Particle size distribution (μ) % sand 2000–200	sand 200–50	silt 50–20	silt 20–2	clay <2	clay 2–0.2	clay <0.2
0– 10	Ap	—	8.8	5.6	5.4	11.9	68.3		
10– 42	A11	—	8.0	4.9	5.0	13.2	68.9		
42– 89	A12 - A11b?	—	8.0	4.4	7.6	12.9	67.1		
89–146	A12b?	—	5.0	3.6	5.5	12.7	73.2		
146–180	AC	0.8	2.8	3.2	8.6	13.5	71.8		

B.D. (g per cc)	Organic matter C %	C/N	$CaCO_3$ equiv. %	Gypsum %	pH 1 : 5	Clayminerals Mt	Mi	Vm	Chl	K	Q
	0.56	20	4.7		8.0	xxxx				xx	t
	0.55	20	3.7		8.0	xxxx				xx	t
	0.54		5.3		8.5	xxxx				xx	t
	0.56		4.4		8.2	xxxx				xx	t
			10.0	0.7	7.6	xxxx				xx	t

Cation exch. cap.	Extractable cations, meq/100 g Sum	Ca	Mg	K	Na	Exch. Na %	Saturation extract, soluble (meq/l) Ca	Mg	Na	E.C. mmhos per cm
70.9	65.3	51.5	10.3	0.9	2.6	3.7				
70.9	64.7	57.8	10.9	0.7	5.3	7.5				
71.4	65.0	44.3	11.6	0.5	8.6	12.0				
72.0	66.3	41.9	15.1	0.4	8.9	12.4				3.0
66.6	63.0	39.4	14.5	0.5	8.6	12.9				4.7

Waterextract 1 : 5, soluble (meq/100 g) cations Ca	Mg	K	Na	Sum	anions Sum	CO_3	HCO_3	Cl	SO_4	NO_3	$E.C._5$ mmhos per cm
0.2	0.1	t	1.4	1.7	1.6	—	1.6	t	t	t	0.2
0.1	0.1	t	1.8	2.0	1.7	—	1.7	t	t	t	0.2
0.1	0.1	t	1.9	2.1	1.9	0.1	1.8	t	t	t	0.3
0.2	0.1	t	4.7	5.0	4.9	—	2.3	1.0	1.6	t	0.9
4.6	2.7	t	9.3	16.6	18.4	—	1.1	0.7	16.6	t	2.6

Laboratory Data Profile No. 41

Depth, cm	Horizon	% >2 mm	Particle size distribution (μ) %: sand 2000–200	sand 200–50	silt 50–20	silt 20–2	clay <2	clay 2–0.2	clay <0.2
0–10	A1	—	14.9	37.6	22.0	8.2	17.3	2.4	14.9
10–55	IIAb	—	3.6	10.8	26.7	26.3	32.6	5.6	27.0
55–105	IIC1	—	0.5	10.2	40.3	19.0	29.7	5.2	24.5
105–175	IIC2	—	0.2	12.4	29.8	21.2	36.4	7.3	29.1

Elemental composition

SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O	Loss on ignition	Ba	Co	Mn	Ni	Sr	Zn
weight percentages								ppm					
64.4	9.5	5.9	1.2	4.4	1.6	1.4	4.1	415	26.5	860	32.0	366	83.5
57.6	14.7	10.1	2.0	6.4	2.4	1.3	6.5	515	26.0	1210	49.5	417	112.0
55.7	15.5	10.4	2.0	6.9	2.5	1.3	6.5	610	35.0	1210	61.0	456	130.5
54.4	16.0	10.7	2.1	6.9	2.5	1.4	6.6	415	37.0	1320	74.5	378	139.0

B.D. (g per cc)	Organic matter C %	Organic matter C/N	$CaCO_3$ equiv %	Gypsum %	pH 1:5	Clayminerals Mt	Mi	Vm	Chl	K	Q
1.41	0.58	12	2.4		8.5	xxxx				xx	t
1.29	0.99	14	2.8		8.4	xxxx				xx	t
1.17	0.69		2.7		8.5	xxxx				xx	t
1.13	0.48		2.6		8.5	xxxx				xx	t

Cation exch cap	Extractable cations, meq/100 g: Sum	Ca	Mg	K	Na	Exch Na	Saturation extract soluble (meq/l): Ca	Mg	Na	E.C. mmhos per cm
16.8	19.0	15.1	2.9	1.0	t	—				
32.0	33.9	28.5	4.9	0.5	t	—				
31.7	34.7	28.9	5.3	0.4	0.1	0.3				
35.6	37.4	31.2	6.0	0.1	0.1	0.3				

Waterextract 1:5, soluble (meq/100 g): cations Ca	Mg	K	Na	Sum	anions Sum	CO_3	HCO_3	Cl	SO_4	NO_3	E.C. mmhos per cm
0.5	0.1	0.1	0.1	0.8	0.7	t	0.6	t	0.1	t	0.2
0.5	0.1	t	0.1	0.7	0.7	t	0.6	t	0.1	t	0.2
0.4	0.1	t	0.2	0.7	0.7	t	0.6	t	0.1	t	0.2
0.4	0.1	t	0.2	0.7	0.9	t	0.6	0.2	0.1	t	0.2

Laboratory Data Profile No. 42

Depth, cm	Horizon	% >2 mm	Particle size distribution (μ) %: sand 2000–200	sand 200–50	silt 50–20	silt 20–2	clay <2	clay 2–0.2	clay <0.2
0–10	A11	6	38.6	32.0	5.1	5.1	19.2	3.0	16.2
10–28	A12	6	34.0	33.4	2.7	4.8	25.4	2.4	22.0
28–55	Bt1	—	33.0	28.2	2.1	4.7	32.0	2.8	29.2
55–83	Bt1	—	32.1	27.7	1.1	6.1	33.0	2.9	30.1
83–99	Bt2	—	34.0	30.0	1.7	5.0	28.7	3.2	25.5
99–160	C	—	38.3	37.7	1.1	4.4	18.5	1.6	16.9

Elemental composition													
SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O	Loss on ignition	Ba	Co	Mn	Ni	Sr	Zn
weight percentages								ppm					
69.8	6.3	3.4	0.8	5.5	1.5	0.8	6.0	190	14.5	1230	27.0	396	35.5
71.0	8.5	3.6	0.8	2.5	0.5	1.3	3.2	225	12.5	655	20.5	775	49.5
72.4	9.3	5.0	1.0	2.2	0.6	1.5	4.1	205	7.0	485	34.0	675	26.0
74.1	9.0	4.7	0.9	4.5	0.6	1.4	5.4	190	10.0	440	30.0	450	43.0
67.5	8.7	4.6	0.9	4.1	0.6	1.3	5.0	220	12.5	530	36.0	324	39.0
71.8	8.5	4.3	0.9			1.3	4.4						

B.D. g per cm³	Organic matter C %	Organic matter C/N	$CaCO_3$ equiv. %	Gypsum %	pH 1:5	Clayminerals Mt	Mi	Vm	Chl	K	Q
1.80	0.18	16	10.2		9.1	xxxx				xx	t
1.71	0.16	12	1.7		9.1	xxxx	t			xx	t
1.83	0.13	16	1.9		9.3	xxxx	t			xx	t
1.88			5.7		9.5	xxxx	t			xx	t
1.90			6.1		9.5	xxxx				xx	t
1.74			6.3		9.6	xxxx				xx	t

Cation exch cap	Extractable cations, meq/100 g: Sum	Ca	Mg	K	Na	Exch. Na %	Saturation extract, soluble (meq/l): Ca	Mg	Na	E.C mmhos per cm
14.1	16.3	14.5	1.2	0.6	t	—				
14.7	17.0	14.6	1.6	0.8	t	—				
19.6	21.9	17.4	2.6	1.9	t	—				
24.3	25.4	20.2	3.3	1.6	0.3	1.2				
22.0	23.2	18.0	3.1	2.0	0.1	0.5				
15.3	17.4	14.1	2.3	0.9	0.1	0.7				

Waterextract 1:5, soluble (meq/100 g)											E.C. mmhos per cm
cations					anions						
Ca	Mg	K	Na	Sum	Sum	CO_3	HCO_3	Cl	SO_4	NO_3	
0.3	t	t	0.1	0.4	0.5	0.1	0.4	t	t	t	0.1
0.4	t	t	0.2	0.6	0.6	t	0.4	0.2	t	t	0.1
0.2	t	0.1	0.6	0.9	0.8	t	0.8	t	t	t	0.2
0.2	t	0.1	0.7	1.0	0.9	0.2	0.7	t	t	t	0.2
0.2	t	0.1	0.7	1.0	0.9	0.2	0.7	t	t	t	0.2
0.2	t	0.1	0.7	1.0	0.9	0.2	0.7	t	t	t	0.2

Laboratory Data Profile No. 51

Depth cm	Horizon	>2 mm	Particle size distribution (<2 mm) %: sand 2000-200	sand 200-50	silt 50-20	silt 20-2	clay <2	clay 2-0.2	clay <0.2
0-11	A1	—	7.7	32.8	16.2	8.1	35.2		
11-26	C1	—	7.3	20.7	14.1	13.1	44.8		
26-46	IIC2	0.6	47.2	42.0	1.6	1.1	8.1		
46-86	IIC3	0.4	11.3	29.2	12	6.7	40.8		
86-110	IIC4	0.6	37.6	50.9	1.1	1.3	8.9		
110-150	IIIC5	0.6	25.2	35.2	4	9.5	25.4		
150-170	IIIC6	0.6	18.5	42.6	7.7	8.5	22.7		

Elemental composition: SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O	Loss on ignition	Ba	Co	Mn	Ni	Sr	Zn
weight percentages								ppm					
								395	25.0	700	39.0	405	120.5
								335	42.0	820	47.5	324	81.0
								355	25.0	350	28.5	312	30.5
								385	21.5	860	51.5	342	50.0
								310	16.5	380	31.0	324	25.0

HD (g per cm³)	Organic matter C %	C/N	$CaCO_3$ equiv. %	Gypsum %	pH 1:5	Clayminerals Mt	Mi	Vm	Chl	K	Q
	0.75	12	0.7		7.3	xxxx				xx	t
	0.38	14	0.4		7.5	xxxx				xx	t
	0.06	13	0.2		7.4	xxxx				xx	t
	0.28		0.4		8.0	xxxx				xx	t
	0.05		0.1		8.6	xxxx				xx	t
	0.10										

Cation exch cap	Extractable cations, meq/100 g: Sum	Ca	Mg	K	Na	Exch. Na %	Saturation extract, soluble (meq/l): Ca	Mg	Na	E.C mmhos per cm
29.2	26.6	21.1	3.6	1.5	0.5	1.7				
41.1	38.3	32.2	4.6	1.1	0.4	1.0				
6.6	6.4	5.3	0.8	0.2	0.1	1.5				
35.4	32.4	24.0	6.1	0.4	1.9	5.1				
6.6	5.7	4.0	1.2	0.1	0.4	6.1				

Waterextract 1:5, soluble (meq/100 g): cations Ca	Mg	K	Na	Sum	anions Sum	CO_3	HCO_3	Cl	SO_4	NO_3	E.C. mmhos per cm
0.4	0.1	0.1	0.1	0.6	1.0	—	0.9	t	0.1	t	0.2
0.3	0.1	0.1	0.1	0.6	0.7	—	0.6	t	0.1	t	0.2
0.2	0.1	t	0.1	0.4	0.6	—	0.4	0.1	0.1	t	0.1
0.1	t	t	0.8	0.9	1.0	—	0.8	0.1	0.1	t	0.2
t	t	t	0.8	0.8	0.8	—	0.6	0.1	0.1	t	0.2

Depth, cm	Horizon	% >2 mm	Particle size distribution (μ) % sand 2000–200	sand 200–50	silt 50–20	silt 20–2	clay <2	clay 2–0.2	clay 0.2
0–16	Bt1	—	29.9	33.7	13.5	2.6	20.3	2.4	16.9
16–46	Bt2	—	22.4	30.3	17.6	7.1	22.6	3.5	19.1
46–86	C1	—	28.8	45.3	12.3	2.3	11.3	1.7	9.6
86–124	C1	9	24.7	44.1	12.0	6.4	12.8	1.9	10.9
124–170	IIC1	—	17.6	27.3	11.9	20.0	23.2	3.8	19.4

Elemental composition													
SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O	Loss on ignition	Ba	Co	Mn	Ni	Sr	Zn
weight percentages								ppm					
73.3	6.7	3.7	0.8	4.9		0.9	5.0						
70.8	7.9	3.2	0.9	5.0		1.0	6.4						
81.9	5.3	2.9	0.7	4.0		0.8	3.7						
75.4	5.0	3.6	0.8	3.7		0.9	3.1						
64.1	9.5	6.0	1.1	4.4		1.1	5.1						

B.D. (g per cc)	Organic matter C %	Organic matter C/N	$CaCO_3$ equiv %	Gypsum %	pH 1:5	Clay minerals Mt	Mi	Vm	Chl	K	Q
1.73	0.12	8	7.1		9.5	xxxx				x	t
1.74	0.10	26	8.7		9.0	xxxx				xx	t
1.91			4.0	0.02	9.3	xxxx				x	t
1.87			2.7	0.02	9.6	xxxx				x	t
1.90			4.2	0.02	9.3	xxxx				x	t

Cation exch cap	Extractable cations, meq/100 g: Sum	Ca	Mg	K	Na	Exch Na %	Saturation extract, soluble (meq/l): Ca	Mg	Na	E.C. mmhos per cm
17.5	18.6	11.0	2.1	0.5	5.0	28.6	3.9	1.0	74.8	9.0
20.6	26.8	10.0	2.8	0.3	9.7	47.1	24.8	12.2	282.6	31.0
12.8	16.3	6.6	1.5	0.2	8.0	62.5	15.1	3.6	208.7	19.6
15.3	17.8	5.0	1.9	0.2	9.8	64.1	8.0	2.5	150.0	13.6
30.4	30.6	7.0	4.5	0.4	18.7	61.5	1.0	0.8	65.2	7.2

Water extract 1:5, soluble (meq/100 g) cations: Ca	Mg	K	Na	Sum	anions: Sum	CO_3	HCO_3	Cl	SO_4	NO_3	E.C. mmhos per cm
0.1	t	t	3.8	3.9	4.1	0.6	0.7	2.5	0.2	0.1	0.8
0.3	0.1	t	14.1	14.5	14.0	0.2	0.9	11.9	0.1	0.9	3.0
0.2	t	t	10.1	10.3	10.1	0.2	0.8	4.2	4.7	0.4	2.0
0.1	t	t	8.0	8.1	7.4	0.3	0.4	3.4	3.2	0.1	1.7
0.1	t	t	8.5	8.6	8.3	0.4	1.4	3.7	2.8	t	1.7

Laboratory Data Profile No. 71A

Depth, cm	Horizon	% >2 mm	Particle size distribution (μ) % sand 2000-200	sand 200-50	silt 50-20	silt 20-2	clay <2	clay 2-0.2	clay <0.2
0-25	A1	—	0.5	6.1	7.6	14.2	71.4	11.6	59.8
25-55	A1	—	0.4	6.1	7.7	14.4	71.4	13.0	58.4
55-90	C1	1	0.6	6.9	8.6	14.2	69.7	11.2	58.5
90-125	C1	1	0.7	8.4	10.8	12.8	67.3	11.2	56.1
125-150	C2	—	1.0	9.1	8.6	13.9	67.4	11.1	56.3

Elemental composition													
SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O	Loss on ignition	Ba	Co	Mn	Ni	Sr	Zn
weight percentages								ppm					
52.6	16.8	9.3	1.2	3.2	1.1	1.3	7.8	305	48.0	1180	42.5	300	102.5
52.7	16.9	9.4	1.5	3.2	1.2	1.4	7.7	245	38.5	1120	32.0	330	93.0
53.4	16.4	9.4	1.5	3.5	1.3	1.2	7.0	295	22.5	1270	82.5	375	80.5
55.7	17.1	9.2	1.6	3.3	1.1	1.2	6.8	295	38.5	1120	72.0	318	98.5
55.7	16.7	9.4	1.6	3.2	1.0	1.2	6.9	515	43.5	960	80.5	1170	82.5

B.D (g per cc)	Organic matter C %	Organic matter C/N	$CaCO_3$ equiv. %	Gypsum %	pH 1:5	Clayminerals Mt	Mi	Vm	Chl	K	Q
	0.36	20	1.2		9.1	xxxx				xx	t
	0.37	19	1.0		9.0	xxxx				xx	t
			0.7	0.1	8.4	xxxx				xx	t
			0.6	1.9	8.2	xxxx	t			xx	t
			1.3	0.1	8.3	xxxx	t			xx	t

Cation exch cap	Extractable cations, meq 100 g Sum	Ca	Mg	K	Na	Exch Na %	Saturation extract, soluble (meq l) Ca	Mg	Na	E.C. mmhos per cm
52.8	53.2	41.3	7.7	1.7	2.5	4.7				
53.7	52.4	33.9	7.9	1.3	9.3	17.3	1.3	0.4	23.9	2.8
52.4	54.6	28.7	7.1	1.6	17.2	32.8	19.8	5.5	117.4	12.8
48.9	55.4	28.2	7.7	1.5	18.0	36.8	25.0	8.7	151.1	15.4
50.5	51.0	16.9	7.9	1.7	24.5	49.0	12.8	6.1	133.7	13.4

Waterextract 1:5, soluble (meq 100 g) cations Ca	Mg	K	Na	Sum	anions Sum	CO_3	HCO_3	Cl	SO_4	NO_3	E.C.$_e$ mmhos per cm
0.1	0.1	t	1.1	1.3	1.1	0.1	0.8	0.1	0.1	t	0.2
0.2	0.1	t	3.2	3.5	3.2	0.1	1.0	1.8	0.3	t	0.7
1.7	0.4	0.1	16.1	18.3	18.4	t	0.4	6.4	11.4	0.2	3.6
8.6	1.9	0.2	28.6	39.5	38.4	t	0.2	6.5	31.6	0.1	5.9
1.5	0.6	0.1	22.8	25.0	24.3	t	0.5	7.0	16.7	0.1	4.4

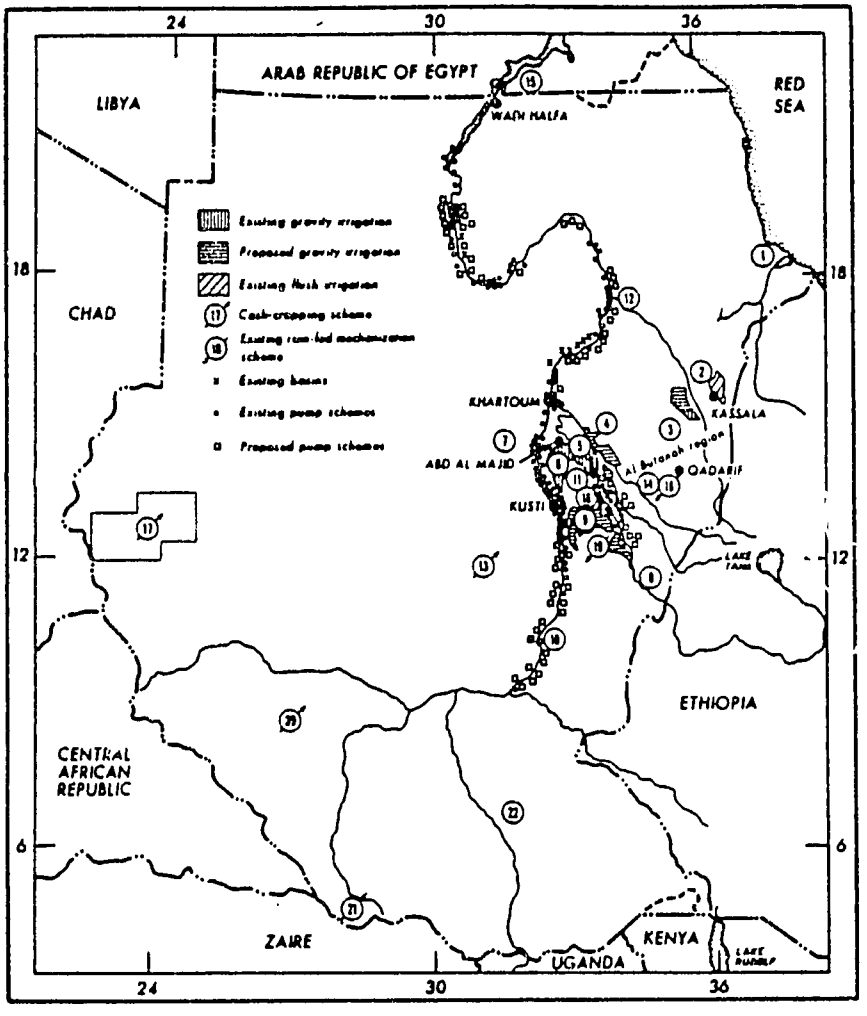
Depth, cm	Horizon	% >2 mm	Particle size distribution (μ) % sand 2000–200	sand 200–50	silt 50–20	silt 20–2	clay <2	clay 2–0.2	clay <0.2
0–15	A1	—	32.0	33.5	4.6	2.6	27.3		
15–55	Bt	9	32.1	29.5	2.5	5.2	30.7		
55–70	IIC1	50	47.3	24.8	3.4	2.5	22.0		
70–120	IIC2	44	34.5	31.9	7.3	3.2	25.1		

Elemental composition													
SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O	Loss on ignition	Ba	Co	Mn	Ni	Sr	Zn
weight percentages								ppm					
				1.4	0.3			600	17.0	1000	45.0	420	40.0
				1.6	0.4			165	14.0	1450	30.0	237	41.5
				1.8	0.4			150	21.5	905	33.5	261	31.0
				41.7	0.4			300	18.5	670	43.5	171	14.5

B.D. (g per cc)	Organic matter C %	Organic matter C/N	$CaCO_3$ equiv. %	Gypsum %	pH 1:5	Clayminerals Mt	Mi	Vm	Chl	K	Q
1.80	0.22	31	0.9		7.2	xxxx	t			x	t
1.90	0.25	31	1.0		7.4	xxxx				xx	t
			1.6		7.0	xxxx	t			xx	t
			51.2	t	7.0	xxxx	t			xx	t

Cation exch cap.	Extractable cations, meq/100 g Sum	Ca	Mg	K	Na	Exch Na %	Saturation extract, soluble (meq/l) Ca	Mg	Na	E.C. mmhos per cm
27.3	26.0	23.1	1.7	0.6	0.6	2.2				
32.5	30.6	27.0	2.1	0.3	1.2	3.7				
22.4	21.2	18.5	2.0	0.1	0.6	2.7				11.2
11.5	12.8	10.9	1.4	0.1	0.4	3.5				9.0

Water extract 1:5, soluble (meq/100 g) cations Ca	Mg	K	Na	Sum	anions Sum	CO_3	HCO_3	Cl	SO_4	NO_3	E.C., mmhos per cm
0.1	t	t	0.2	0.3	0.7	—	0.5	0.1	0.1	t	0.1
0.1	t	t	0.9	1.0	1.2	—	0.5	0.4	0.1	0.2	0.3
1.0	0.2	t	1.6	2.8	3.4	—	0.3	2.0	0.3	0.8	0.9
1.0	0.3	t	1.4	2.7	3.4	-	0.3	1.8	0.8	0.5	0.8



1	Tawkar	12	Az Zaydab
2	Qash	13	Nuba Hills
3	Khashm al Qirbah	14	Rahad East Bank
4	Junayd	15	Lake Nasser
5	Jazirah	16	Suki
6	Manaqil	17	Jabal Marrah
7	Jabal al Awliya	18	Wad al Huri
8	Rusayris	19	Dali and Mazmoun
9	Kinanah	20	Uwayl (rice)
10	Malut	21	Zande
11	Sannar	22	Jonglei Canal

Figure 2. Location of Principal Improvement Schemes, Existing and Proposed, Sudan, 1971

Source: Nelson et al. 1973.

Appendix VI

Vegetation

Figure 1. Vegetation Regions of Sudan

Table 1. Vegetation of Khartoum Province

Figure 2. Vegetation Map of the Fung

Table 2. Check List of the Flora of Tozi Research Farm

Figure 3. Sketch Map of the Vegetation in the Jebel Marra Region

Table 3. Classification of Vegetation in the Jebel Marra Region

Figure 4. Schemic Diagrams of Vegetation in the Jebel Marra Region

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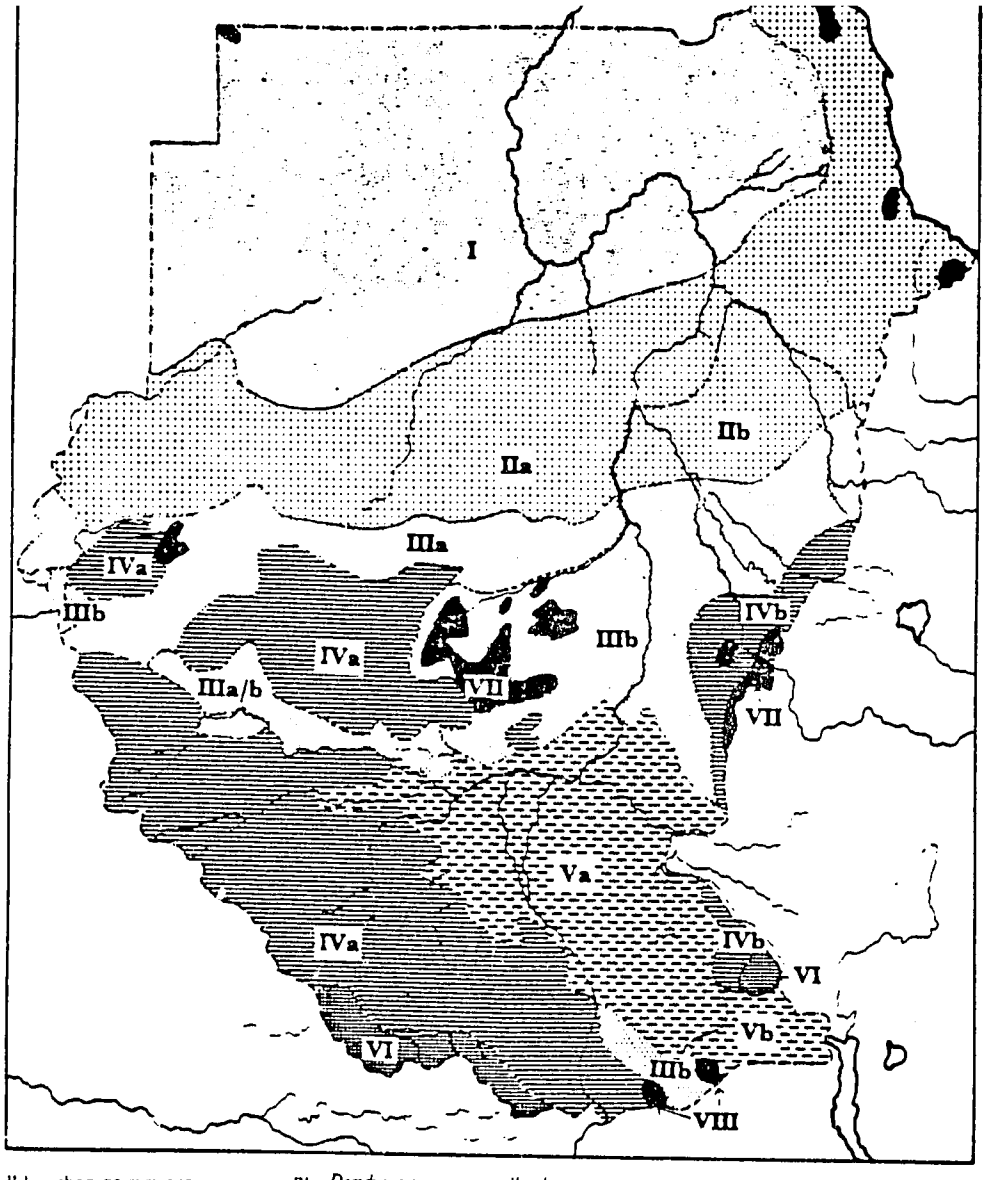


I *Desert:* average rainfall less than 75 mm per annum, and the vegetation, if any, confined to the seasonal watercourses.

II *Semi-desert scrub and grassland*

A *on lithosols:* average rainfall from 75 to 250 mm per annum. Scrub vegetation includes such species as *Acacia tortilis* subsp. *tortilis*, *Leptadenia pyrotechnica*, *Salvadora persica*, with *Aristida* spp. as the dominant grasses; *Panicum turgidum* occurs on the sandy soils.

B *on clay soils:* average rainfall from 75 to 400 mm. Scrub vegetation includes *Acacia mellifera*, *Capparis decidua*, *Ziziphus spina-christi* and *Balanites aegyptiaca* along the drainage lines, with *Schoenefeldia gracilis* and *Sporobolus ioclados* as the dominant grasses.

III *Thorn savanna and scrub*

A *on sandy soils:* average rainfall 280 to 450 mm. *Acacia senegal* is the dominant tree with *Aristida sieberiana* and *Eragrostis* spp. as the dominant grasses.

B *on clay soils:* average rainfall 400 to 800 mm. Pure stands of *Acacia mellifera* scrub occur between 400 and 500 mm with *Acacia seyal* and *Balanites aegyptiaca* dominant in the higher rainfall areas. The major grasses include *Schoenefeldia gracilis*, *Cymbopogon* spp. and *Brachiaria obtusiflora*.

IV *Deciduous savanna woodland*

A *on latosols:* average rainfall 450 to 1300 mm. *Combretum glutinosum*, *Anogeissus leiocarpus*, *Terminalia brownii*, *Albizia amara* subsp. *sericocephala*, *Khaya senegalensis* and *Isoberlinia doka* are the major tree constituents, with *Aristida* spp., *Eragrostis* spp., *Pennisetum* spp. and *Hyparrhenia* spp. among the important grasses.

B *on clay soils:* average rainfall 800 to 1000 mm. The major tree species are *Combretum hartmannianum* and *Anogeissus leiocarpus*, with *Hyparrhenia* spp. as the dominant grasses.

V *Flood region*

A *Swamp and wetland savanna:* average rainfall 800 to 1000 mm. Includes the perennial *Cyperus papyrus* swamps of the 'sudd' and the seasonally flooded 'toich' area with *Hyphaene thebaica*, *Borassus aethiopum*, *Acacia seyal*, *A. sieberiana* and *Balanites aegyptiaca* among the tree species present (see Jonglei Investigation Team, 1954 for further details).

B *Grassland:* average rainfall over 1000 mm. Known as the Toposa area, with *Hyparrhenia* spp., *Setaria* spp., *Chrysopogon plumulosus* = *C. auctorum* var. *quinquepluma*, *Bothriochloa insculpta*, etc., among the more important grasses, with thickets of *Acacia mellifera* also present.

VI *Lowland forest:* average rainfall over 1300 mm. Consisting of small relic forest areas at Lotti, Laboni, Talanga, Azza and Aloma Plateau with *Celtis zenkeri*, *Chrysophyllum albidum*, etc., and also including areas derived from forest with *Albizia zygia*, *Vitex doniana*, *Terminalia glaucescens*, etc.

VII *Hill vegetation:* regarded as isolated areas of savanna and woodland vegetation surviving on hill slopes in areas where similar communities are no longer to be found in the surrounding lowlands.

VIII *Montane vegetation:* upland areas often with temperate and tropical species that are only known from similar upland areas in Africa.

Figure 1. Vegetation Regions of Sudan

Source: Wickens. 1976

Table 1. Vegetation of Khartoum Province

a Floristic Composition of 6 Stands Representing the Western Clayey Desert Plains

b Floristic Composition of 6 Stands Representing the Eastern Sandy Desert Plains

c Floristic Composition of 3 Stands Representing the Gravel Desert

d Floristic Composition of 6 Stands Representing the Khor Terraces

e Schrub Composition of 9 Stands on Khor Terraces

f Floristic Composition of 6 Stands Representing the Jebels (Hills)

r rare
o occasional
c common
a abundant
va very abundant
d dominant

Source: Halwagy. 1961.

Table 1a. Floristic Composition of Six Stands Representing the Western Clayey Desert Plains

							Presence %
Trees and shrubs							
Acacia ehrenbergiana Hayne	d	a	o	c	d	c	100
Capparis decidua (Forsk.) Edgew.	–	o	r	c	c	d	83
Ziziphus spina-christi (L.) Willd.	r	–	–	–	r	r	50
Acacia seyal Del.	–	–	–	la	c	r	50
Leptadenia heterophylla (Del.) Decne.	r	–	–	–	–	r	33
Acacia tortilis (Forsk.) Hayne	–	–	–	–	r	–	17
Acacia raddiana Savi.	–	–	–	–	–	r	17
Undershrubs and herbs							
Chloris prieurii Kunth.	va	va	r	va	o	va	100
Eragrostis pilosa (L.) Beauv.	va	va	o	c	c	va	100
Sporobolus humifusus var. *cordofanus* Stapf ex Massey	a	a	c	va	c	va	100
Dactyloctenium aegyptium (L.) Beauv.	a	va	r	va	c	*	100
Schoenefeldia gracilis Kunth.	c	–	d	va	c	va	83
Trianthemo sedifolia Vis.	–	–	a	o	*	c	67
Aristida adscensionis L.	–	r	c	r	–	*	67
Panicum hygrocharis Steud.	r	r	–	r	–	–	50
Corchorus depressus (L.) Christens.	–	r	–	–	o	r	50
Aristida hordeacea Kunth.	–	–	a	o	–	*	50
Corchorus tridens L.	–	r	–	–	o	–	33
Boerhavia diandra L.	–	r	–	–	–	o	33
Euphorbia granulata Forsk. var. *glabrata* (Gay) Boiss.	–	r	–	–	–	r	33
Cassia senna L.	–	–	c	–	r	–	33
Cyperus rotundus L.	c–la	–	–	–	–	–	17
Cyperus bulbosus Vahl.	–	c–la	–	–	–	–	17
Tribulus terrestris L.	–	r	–	–	–	–	17
Polygala erioptera DC.	–	r	–	–	–	–	17
Eragrostis cilianensis (All) Link ex Vign. Lut.	–	–	–	r	–	–	17
Aristida mutabilis Trin. & Rupr.	–	–	–	–	va	–	17
Panicum turgidum Forsk.	–	–	–	–	c	–	17
Tragus paucispina Hack.	–	–	–	–	r	–	17
Indigofera oblongifolia Forsk.	–	–	–	–	0	–	17
Bergia suffruticosa Fenzl.	–	–	–	–	r	–	17
Psoralea plicata Del.	–	–	–	–	r	–	17
Hibiscus obtusilobus Garcke.	–	–	–	–	r	–	17
Crotalaria saltiana Andr.	–	–	–	–	o	–	17
Sesbania microphylla Harms ex Phillips & Hutch.	–	–	–	–	o	–	17
Solanum dubium Fresen.	–	–	–	–	o	–	17
Sprorobolus glaucifolius (Steud.) Hochst. ex Dur. & Schinz.?	–	–	–	–	lc	–	17

* Species recorded with no indication of frequency.

Table 1b. Floristic Composition of Six Stands Representing the Eastern Sandy Desert Plains

							Presence %
Trees and shrubs							
Acacia tortilis (Forsk.) Hayne	d	d	d	d	o	cod.	100
Acacia raddiana Savi.	a	c	–	c	–	–	50
Capparis decidua (Forsk.) Edgew.	–	c	–	c	d	–	50
Acacia ehrenbergiana Hayne	–	c	o	–	–	cod.	50
Maerua crassifolia Forsk	–	–	o	–	–	–	17
Undershrubs and herbs.							
Schoenefeldia gracilis Kunth	va	va	c	va	va	va	100
Eragrostis pilosa (L.) Beauv	c	a	va	c	c	a	100
Aristida funiculata Trin. & Rupr.	a	a	o	r	c	a	100
Aristida mutabilis Trin. & Rupr	c	o	c	va	va	–	83
Aristida hordeacea Kunth.	c	c	–	o	–	o	67
Sporobolus humifusus var. *cordofanus* Stapf. ex Massey	c	a	–	c	c	–	67
Dactyloctenium aegyptium (L.) Beauv	–	c	c	c	c	–	67
Chloris prienrii Kunth.	–	r	o	r	–	r	67
Trianthema sedifolia Vis	–	o	–	c	c	r	67
Trianthema polyspermia Hochst. ex Oliv.	–	r	r	–	o	c	67
Eragrostis cilianensis (All) Link ex Vign. Lut.	–	r	va	–	–	c	50
Euphorbia granulata Forsk. var. *glabrata* (Gay) Boiss	–	–	r	–	r	–	33
Tragus paucispina Hack	–	–	–	r	o	–	33
Eragrostis tremula Hochst. ex Steud.	–	–	r	–	–	–	17
Corchorus depressus (L.) Christens	–	–	–	–	c	–	17
Boerhavia diffusa L. var. viscosa (Choisy) Cuf	–	–	–	–	c	–	17
Limeum viscosum (non Fenzl) Broun & Massey	–	–	–	–	r	–	17
Indigofera cordifolia Heyne ex Roth.	–	–	–	–	–	r	17
Enneapogon brachystachyus (Jaub. & Spach) Stapf	–	–	–	–	–	r	17

Table 1c. Floristic Composition of Three Stands Representing the Gravel Desert

				Presence %
Herbs				
Enneapogon brachystachyus (Juab. & Spach) Stapf	a	c	a	100
Aristida mutabilis Trin. & Rupr	a	c	a	100
Aristida funiculata Trin. & Rupr	c	c	c	100
Eragrostis cilianensis (All) Link ex Vign. Lut	o	c	r	100
Boerhavia diandra L.	r	c	–	67
Aristida adscensionis L.	–	r	c	67
Indigofera arenaria A. Rich	r	–	r	67
Aristida hirtigluma Steud. ex Trin. & Rupr	a	–	–	33
Eragrostis tremula Hochst. ex Steud.	o	–	–	33
Heliotropium strigosum Willd	r	–	–	33
Tephrosia vicioides A. Rich	r	–	–	33
Cymbopogon excavatus (Hochst.) Stapf.?	r	–	–	33
Schoenefeldia gracilis Kunth	–	c	–	33
Boerhavia diffusa var. *viscosa* (Choisy) Cuf	–	c	–	33
Tragus poucispina Hack	–	o	–	33
Tragus berteronianus Schult	–	–	r	33
Eragrostis pilosa (L.) Beauv	–	–	r	33

Table 1d. Floristic Composition of Six Stands Representing the Khor Terraces

							Presence %
Trees and shrubs							
Acacia nubica Benth.	d	o	d	o	r	d	100
Acacia ehrenbergiana Hayne	c	d	c	o	d	–	83
Capparis decidua (Forsk.) Edgew.	c	r	a	c	o	–	83
Ziziphus spina-christi (L.) Willd.	o	r	c	–	c	–	67
Calotropis procera (Ait.) Ait. f.	–	–	a	r	–	r	50
Acacia tortilis (Forsk.) Hayne	–	a	–	–	–	a	33
Maerua crassifolia Forsk.	–	–	–	r	–	–	17
Undershrubs and herbs							
Schoenefeldia gracilis Kunth.	va	va	c–la	d	va	c	100
Eragrostis pilosa (L.) Beauv.	c–la	a	o	c	a	c	100
Dactyloctenium aegyptium (L.) Beauv.	r	o	c–la	c	r	r	100
Eragrostis cilianensis (All) Link ex Vign. Lut.	c	c	r	–	c	c	83
Aristida hordeacea Kunth.	c	r	r	–	o	c	83
Aristida mutabilis Trin. & Rupr.	r	a	r	–	c	va	83
Aristida adscensionis L.	c	–	c–la	c	c	c	83
Panicum turgidum Forsk.	–	c	c	r	c	c	83
Aristida funiculata Trin. & Rupr.	c	c	–	–	o	a	67
Chloris virgata Sw.	c	–	–	o	va	r	67
Indigofera hochstetteri Bak.	r	r	–	–	r	o	67
Cyperus rotundus L.	–	–	c	la	r	c	67
Corchorus depressus (L.) Christens.	r	–	–	–	o	c–la	50
Solanum dubium Fresen.	c	–	–	o	–	r	50
Boerhavia diandra L.	–	–	–	o	r	r	50
Cenchrus biflorus Roxb.	o	–	–	–	–	o	33
Cassia italica (Mill.) Lam.	o	–	–	r	–	–	33
Sesbania microphylla Harms ex Phillips & Hutch.	r	–	–	o	–	–	33
Tribulus terrestris L.	–	r	r	–	–	–	33
Echinochloa colonum (L.) Link	–	–	–	r	c	–	33
Cymbopogon excavatus (Hochst.) Stapf.?	–	·	–	–	c	c	33
Enneapogon brachystachyus (Jaub. & Spach) Stapf.	–	–	–	–	r	o	33
Dichanthium annulatum (Forsk.) Stapf.	la	–	–	–	–	–	17
Celosia argentea L.	r	–	–	–	–	–	17
Kohautia caespitosa Schnizl.	r	–	–	–	–	–	17
Crotalaria saltiana Andr.	r	–	–	–	–	–	17
Trianthema sedifolia Vis.	–	–	c–la	–	–	–	17
Cassia senna L.	–	–	o	–	–	–	17
Tragus paucispina Hack.	–	–	r	–	–	–	17
Panicum hygrocharis Steud.	–	–	–	c	–	–	17
Ipomoea verticellata Forsk.	–	–	–	c	–	–	17
Digera alternifolia (L.) Aschers.	–	–	–	r	–	–	17
Hibiscus obtusilobus Garcke.	–	–	–	r	–	–	17
Indigofera stenophylla var. *latifolia* A. Rich.?	–	–	–	r	–	–	17
Corchorus tridens L.	–	–	–	–	o	–	17
Euphorbia granulata var. *glabrata* (Gay) Boiss.	–	–	–	–	r	–	17
Indigofera viscosa Lam.	–	–	–	–	r		17
Indigofera cordifolia Heyne ex Roth.	–	·	–	·	r	·	17
Limeum viscosum (non Fenzl) Broun & Massey	–	–	–	–	r	–	17
Boerhavia diffusa var. *viscosa* (Choisy) Cuf.	–	–	–	–	–	o	17
Cenchrus priceurii (Kunth) Maire.	–	–		–	·	o	17
Trianthema crystallina (Forsk.) Vahl.	–	–	–	–	–	o	17
Fagonia parviflora Boiss.	–	–	–	–	–	r	17

Table 1e. The Shrub Composition of Nine Stands on Khor Terraces

	Soil: clayey sand to sandy clay				Presence %	Soil: sand, sometimes slightly loamy					Presence %
Acacia ehrenbergiana	d	d	o	d	100	r	–	–	cod.	o	60
Acacia nubica	c	c	o	c	100	d	–	–	–	d	40
Acacia tortilis	–	–	–	–	0	r	d	d	cod.	a	100
Calotropis procera	a	c	r	–	75	–	–	–	–	–	0
Capparis decidua	a	–	c	c	75	o	–	–	–	r	40
Ziziphus spina-christi	c	a	–	o	75	c	*	–	–	r	60

* species recorded with no indication of frequency.

Table 1f. Floristic Composition of Six Stands Representing the Jebels (Hills)

Shrubs							
Capparis decidua (Forsk.) Edgew.	r	–	r	r	–	–	50
Acacia ehrenbergiana Hayne	–	r	–	r	–	–	33
A. laeta R. Br. ex Benth.	r	–	–	–	–	–	17
Cadaba rotundifolia Forsk.	–	r	–	–	–	–	17
C. farinosa Forsk.	–	–	r	–	–	–	17
Ziziphus spina-christi (L.) Willd.	–	–	–	r	–	–	17
Undershrubs and herbs							
Aristida adscensionis L.	d	d	a	c	c	–	83
Aristida mutabilis Trin. & Rupr.	o	o	a	d	–	a	83
Eragrostis pilosa (L.) Beauv.	c	c	c	c	a	–	83
E. cilianensis (All) Link ex. Vign. Lut.	c	c	c	r	–	o	83
Boerhavia diandra L.	–	o	r	–	r	r	67
Schoenefeldia gracilis Kunth.	o	o	c	–	–	–	50
Panicum turgidum Forsk.	–	r	r	r	–	–	50
Cassia senna L.	r	r	–	–	r	–	50
Aerva tomentosa Forsk.	o	o	–	–	–	–	33
Abutilon fruticosum Guillem. & Perrott.	r	r	–	–	–	–	33
Euphorbia granulata Forsk. var *glabrata* (Gay) Boiss.	r	r	–	–	–	–	33
Solanum dubium Fresen.	r	r	–	–	–	–	33
Aristida hordeacea Kunth.	–	–	r	r	–	–	33
Chloris prieurii Kunth.	–	–	o	–	c	–	33
Enneapogon brachystachyus (Jaub. & Spach) Stapf.	–	–	–	o	–	a	33
Aristida funiculata Trin. & Rupr.	–	–	–	o	–	c	33
Indigofera hochstetteri Bak.	–	–	–	r	r	–	33
Eragrostis tremula Hochst. ex Steud.	–	–	–	–	c	o	33
Blepharis edulis (Forsk.) Pers.	–	–	la	–	–	–	17
Tetrapogon spathaceus (Hochst.) Hack.	–	–	r	–	–	–	17
Citrullus colocynthis (L.) Schrad.	–	–	r	–	–	–	17
Sporobolus humifusus var. *cordofanus* Stapf ex Massey	–	–	r	–	–	–	17
Trianthema crystallina (Forsk.) Vahl.	–	–	r	–	–	–	17
Tragus paucispina Hack.	–	–	–	r	–	–	17
Echinochloa colonum (L.) Link.	–	–	–	–	r	–	17
Cenchrus pennisetiformis Steud. & Hochst.	–	–	–	–	r	–	17
Dactyloctenium aegyptium (L.) Beauv.	–	–	–	–	r	–	17
Aristida hirtigluma Steud. ex Trin. & Rupr.	–	–	–	–	–	a	17
Tephrosia vicioides A. Rich.	–	–	–	–	–	r	17
Indigofera arenaria A. Rich.	–	–	–	–	–	r	17
Heliotropium strigosum Willd.	–	–	–	–	–	r	17
Cymbopogon excavatus (Hochst.) Stapf.?	–	–	–	–	–	r	17

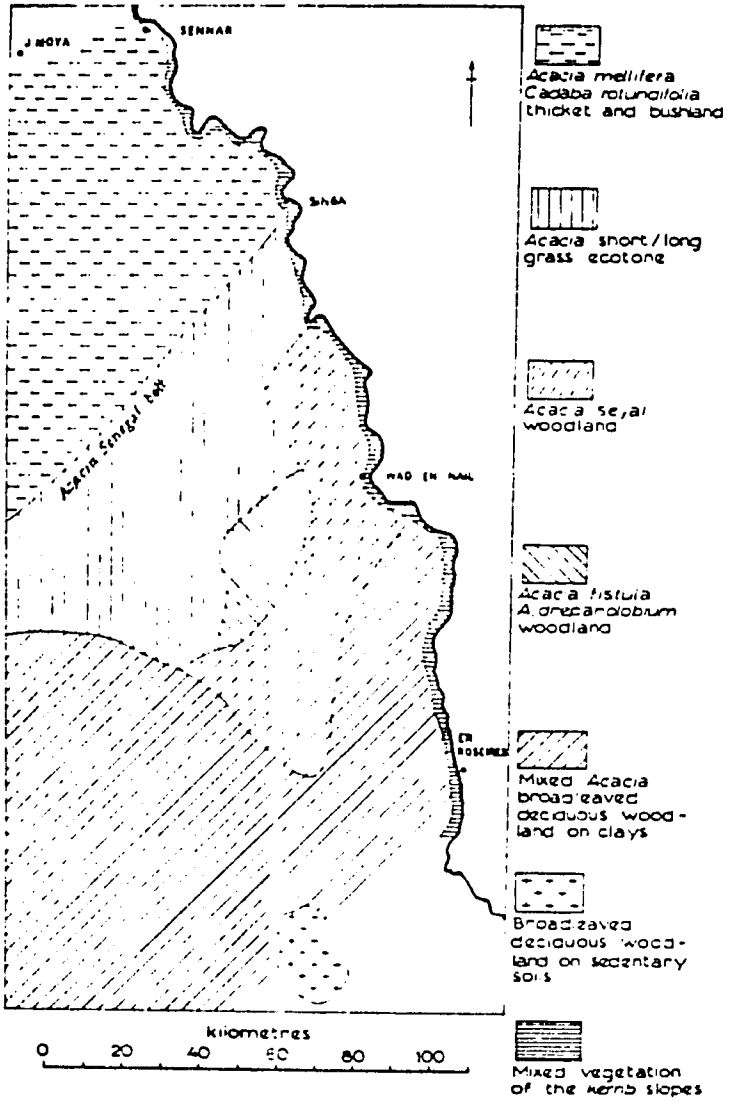


Figure 2. Vegetation Map of the Fung (Scale 1:2,000,000)

Source: Bunting and Lea. 1962.

Table 2. Check List of the Flora of Tozi Research Farm

(15 km east of Wad an Nail)

Trees and Shrubs

Acacia campylacantha Hochst. ex. A. Rich.	Mimosaceae
A. drepanolobium Harms ex Sjöstedt.	Mimosaceae
A. fistula Schweinf.	Mimosaceae
A. mellifera (Vahl) Benth.	Mimosaceae
A. nubica Benth.	Mimosaceae
A. senegal (L.) Willd.	Mimosaceae
A. seyal Del.	Mimosaceae
Adansonia digitata L.	Bombacaceae
Balanites aegyptiaca (L.) Del.	Simaroubaceae
Cadaba farinosa Forsk.	Capparidaceae
C. glandulosa Forsk.	Capparidaceae
Calotropis procera (Ait.) Ait. f.	Asclepiadaceae
Capparis decidua (Forsk.) Edgew	Capparidaceae
Clerodendrum sp. near C hildebrandtii Vatke.	Verbenaceae
Combretum aculeatum Vent.	Combretaceae
C. hartmannianum Schweinf.	Combretaceae
Dichrostachys glomerata (Forsk.) Chiov.	Mimosaceae
Ficus abutilifolia (Miq.) Miq.	Moraceae
Maerua oblongifolia (Forsk.) A. Rich.	Capparidaceae
Ziziphus sp.	Rhamnaceae

Gramineae

Aristida adscensionis L.
A. hordeacea Kunth.
Beckeropsis nubica Fig. et De Not.
Brachiaria deflexa (Schumach.) C. E. Hubbard ex Robyns.
B. lata (Schumach.) C. E. Hubbard.
Chloris gayana Kunth.
C. virgata Sw.
Cymbopogon nervatus (Hochst.) Chiov.
C. proximus (Hochst.) Stapf.
Cynodon dactylon (L.) Pers.
Dactyloctenium aegyptium (L.) Beauv.
Digitaria gazensis Rendle.
Dinebra retroflexa (Vahl) Panz.
Echinochloa colonum (L.) Link.
E. pyramidalis (Lam.) Hitchc. et Chase.
Eleusine indica (L.) Gaertn.
Eragrostis aspera (Jacq.) Nees.
E. cilianensis (All.) Link ex Vign. Lut.
E. tremula Hochst. ex Steud.
Eragrostis nubica (Steud.) Hack. et Stapf ex Hell.
Hyparrhenia atl. H. contrans (Hochst.) Anderss. ex Aschers. et Schweinf.
H. pseudocymbaria (Steud.) Aschers. et Schweinf.
Ischaemum afrum (J. F. Gmel.) Dandy.
Ophiuros papillosus Hochst.
Panicum porphyrrhizos Steud.
Pennisetum polystachion (L.) Schult.
P. ramosum (Hochst.) Aschers. et Schweinf.
P. tetrastachyum K. Schum.
Rottboellia exaltata L.f.
Schima ischaemoides Forsk.
Setaria incrassata (Hochst.) Hack.
S. pallide-fusca (Schumach.) Stapf et Hubbard
S. verticillata (L.) Beauv.
Sorghum purpurensericeum (Hochst.) Aschers. et Schweinf.
Sorghum sp.
Sporobolus humifusus var. cordofanus Stapf ex Massey.
Tetrapogon spathaceus (Hochst.) Hack.
Urochloa trichopus (Hochst.) Stapf.

Table 2. Continued

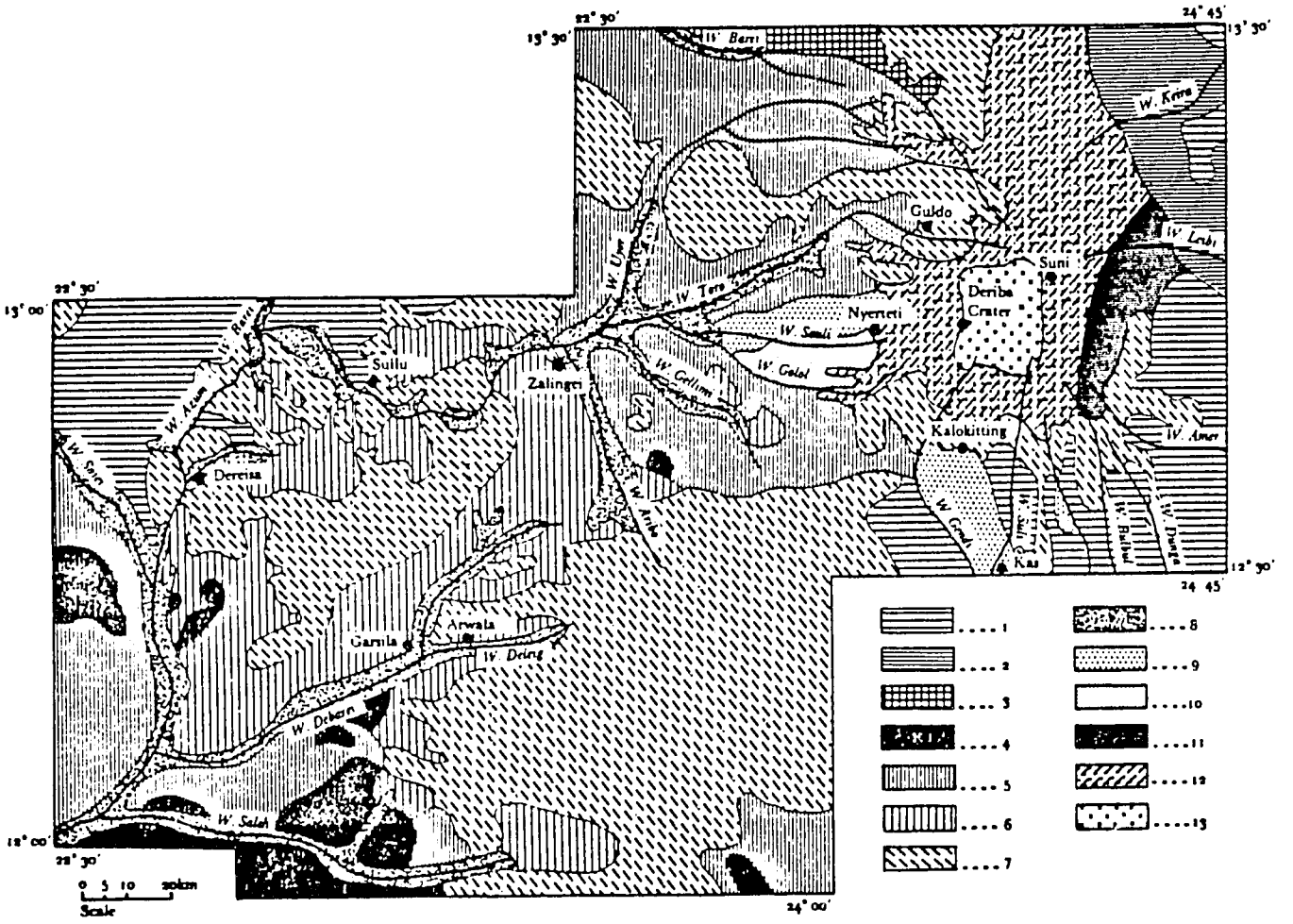
Herbs

Abutilon figarianum Webb.	Malvaceae
Acalypha crenata Hochst. ex A. Rich.	Euphorbiaceae
Alysicarpus glumaceus (Vahl) DC.	Papilionaceae
Amaranthus angustifolius Lam.	Amaranthaceae
Ammania sp. aff. A. acriculata Willd.	Lythraceae
A. baccifera L.	Lythraceae
Aristolochia bracteolata Lam.	Aristolochiaceae
Bergia ammannioides Heyne et Roth.	Elatinaceae
Borreria phyteuma (Schweinf.) Dandy.	Rubiaceae
Caperonia serrata (Turcz.) C. Presl.	Euphorbiaceae
Cassia mimosoides L.	Caesalpiniaceae
C. tora L.	Caesalpiniaceae
Celosia argentea L.	Amaranthaceae
C. trigyna L.	Amaranthaceae
Cephalocroton cordofanus Hochst.	Euphorbiaceae
Chlorophytum? tuberosum (Roxb.) Bak.	Liliaceae
Chrozophora plicata (Vahl) A. Juss. ex Spreng.	Euphorbiaceae
Cleome viscosa L.	Capparidaceae
Clitoria ternatea L.	Papilionaceae
Commelina forskalaei Vahl.	Commelinaceae
Corchorus fascicularis Lam.	Tiliaceae
C. olitorius L.	Tiliaceae
C. tridens L.	Tiliaceae
Coreopsis borianiana Schultz Bip.	Compositae
Crotalaria sp. aff. C. impressa Nees.	Papilionaceae
Cucumis melo L. var. agrestis Naud.	Cucurbitaceae
Cyanotis lanata Benth.	Commelinaceae
Cyperus latifolius Poir.	Cyperaceae
C. longus L.	Cyperaceae
C. tenuispica Steud.	Cyperaceae
Dalechampia sp. ? nov.	Euphorbiaceae
Datura metal L.	Solanaceae
Desmodium dichotomum (Klein) DC.	Papilionaceae
Digera alternifolia (L.) Aschers.	Amaranthaceae
Dolichos daltoni Webb.	Papilionaceae
Eleocharis atropurpurea (Retz.) Kunth.	Cyperaceae
Emilia sp. ? nov. aff. E. coccineae (Sims) G. Don.	Compositae
Eruca sativa Mill.	Cruciferae
Euphorbia aegyptiaca Boiss.	Euphorbiaceae
E. hirta L.	Euphorbiaceae
E. indica Lam.	Euphorbiaceae
Foeniculum vulgare Mill.	Umbelliferae
Gloriosa simplex L.	Liliaceae
Glycine borianii (Schweinf.) Bak.	Papilionaceae
Gynandropsis gynandra (L.) Briq.	Capparidaceae
Hibiscus esculentus L.	Malvaceae
H. rhabdotospermus Gareke.	Malvaceae
Hybanthus enneaspermus (L.) F. Muell.	Violaceae
Indigofera hochstetteri Bak.	Papilionaceae
I. parviflora Heyne ex Wight et Arn.	Papilionaceae
I. subulata Poir.	Papilionaceae
Ipomoea cordofana Choisy.	Convolvulaceae
I. eriocarpa R.Br.	Convolvulaceae
I. repens Lam.	Convolvulaceae
Justicia palustris (Hochst.) T. Anders.	Acanthaceae
Oldenlandia grandiflora (DC.) Hiern	Rubiaceae
Lactuca taraxacifolia (Willd.) Schumach.	Compositae
Leonotis africana (Beauv.) Brig.	Labiatae
Leucas martinicensis (Jacq.) Ait. f.	Labiatae
Melothria maderaspatana (L.) Cogn.	Cucurbitaceae
Momordica tuberosa (Roxb.) Cogn.	Cucurbitaceae
Nesaea ? dodecandra Koehne	Lythraceae
Ocimum basilicum L.	Labiatae
Oxygonum atriplicifolium (Meisn.) Martelli.	Polygonaceae
Pancratium trianthum Herbert.	Amaryllidaceae
Peristrophe bicalyculata (Retz.) Nees.	Acanthaceae
Phaseolus mungo L.	Papilionaceae
Phyllanthus maderaspatensis L.	Euphorbiaceae
P. niruri L.	Euphorbiaceae
Physalis divaricata D. Don.	Solanaceae
Portulaca oleracea L.	Portulacaceae
P. quadrifida L.	Portulacaceae

Table 2. Continued

Rhynchosia minima (L.) DC. var. prostrata Harv.	Papilionaceae
Sclerocarpus africanus Jacq. ex Murr.	Compositae
Sida alba L.	Malvaceae
Solanum incanum L.	Solanaceae
S. nigrum L.	Solanaceae
Stemodia serrata Benth.	Scrophulariaceae
Striga gesneriodes (Willd.) Vatke.	Scrophulariaceae
S. hermonthica (Del.) Benth.	Scrophulariaceae
Striga sp.	Scrophulariaceae
Tenagocharis latifolia (D. Don.) Buchen.	Butomaceae
Tephrosia bracteolata Guillem. et Perrott.	Papilionaceae
T. uniflora Pers.	Papilionaceae
Thunbergia annua Hochst. ex Nees.	Acanthaceae
Tragia ? cannabina L.f. ex Cooke.	Euphorbiaceae
Trianthema pentandra L.	Ficoidaceae
T. portulacastrum L.	Ficoidaceae
Tribulus terrestris L.	Zygophyllaceae
Trichodesma ? africanum (L.) Lehm.	Boraginaceae
Vahlia digyna (Retz.) Kuntze.	Saxifragaceae
Vernonia kotschyana Schultz Bip.	Compositae
V. pauciflora (Willd.) Less.	Compositae
Vicoa leptoclada (Webb) Dandy.	Compositae
Vigna pubigera Bak.	Papilionaceae
V. vexillata (L.) Benth.	Papilionaceae
Withania somnifera (L.) Dunal.	Solanaceae

Source: Bunting and Lea. 1962.



1 *Acacia mellifera – Commiphora africana* on indurated soils
2 *Acacia mellifera* on hill soils of the basement complex
3 *Acacia mellifera – Anogeissus leiocarpus* mosaic on basement complex soils
4 *Acacia seyal – Balanites aegyptiaca* on clay soils
5 *Acacia seyal – Anogeissus leiocarpus* mosaic on basement complex soils
6 *Anogeissus leiocarpus* on basement complex soils
7 *Anogeissus leiocarpus – Boswellia papyrifera* on basement complex hill soils
8 *Acacia albida – Balanites aegyptiaca* on alluvial soils
9 *Acacia albida* on ash piedmont soils
10 *Combretum glutinosum – Terminalia laxiflora* on ash piedmont soils
11 *Acacia mellifera* on volcanic soils of the Jebel Marra massif
12 *Anogeissus leiocarpus* on volcanic soils of the Jebel Marra massif
13 Upland grassland and upland meadow on volcanic soils of the Jebel Marra massif

The following two associations are too small to be mapped:
Acacia senegal – Combretum glutinosum on aeolian sands, 25 km NW of Dereissa
Combretum glutinosum – Guiera senegalensis on Nubian sandstone, 5 km W of Garsila

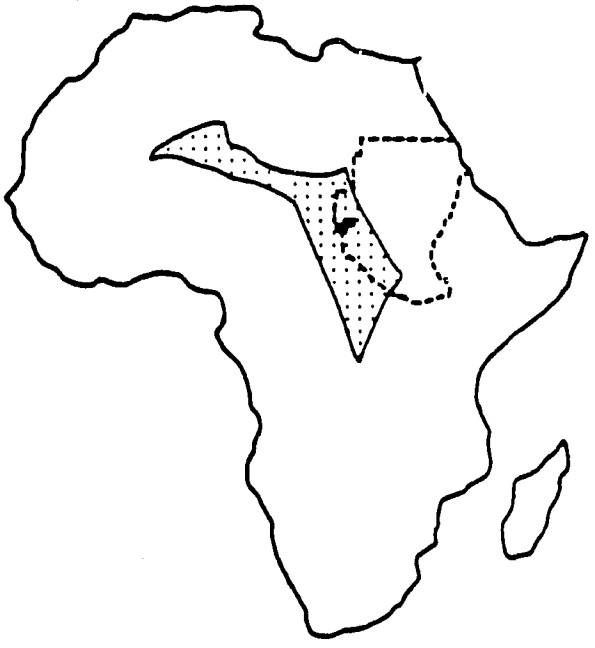


Figure 3. Sketch Map of the Vegetation in the Jebel Marra Region

Source: Wickens. 1976.

Table 3. Classification of Vegetation in the Jebel Marra Region

Formation-type	Formation	Sub-formation	Association
Tropical thornland	Thorn scrub	*Acacia mellifera* thornland	I *Acacia mellifera – Commiphora africana* on indurated soils. II *Acacia mellifera* on hill soils of the basement complex. III *Acacia mellifera* hill thornland on volcanic soils of the Jebel Marra massif.
	Thorn savanna	*Acacia senegal* thorn savanna	I *Acacia senegal – Combretum glutinosum* on aeolian sand.
		Acacia seyal – Balanites thorn savanna	I *Acacia seyal – Balanites* on clay soils. II *Acacia seyal – Anogeissus* on basement complex soil mosaic.
	Thorn woodland	*Acacia albida* thorn woodland	I *Acacia albida* on piedmont ash soils.
		Riparian woodland	I *Acacia albida* on alluvial soils. II *Balanites aegyptiaca* on alluvial soils.
Tropical savanna	Savanna woodland	*Combretum – Albizia – Terminalia* savanna woodland	I *Combretum glutinosum – Guiera senegalensis* on Nubian sandstone soils. II *Combretum glutinosum – Terminalia laxiflora* on piedmont ash soils.
		Anogeissus leiocarpus savanna woodland	I *Anogeissus leiocarpus* on lowland basement complex soils. II *Anogeissus leiocarpus – Boswellia papyrifera* on hill soils of the basement complex. III *Anogeissus leiocarpus* hill savanna on volcanic soils of the Jebel Marra massif.
Tropical forest	Lowland forest	Gallery forest	*Trema-Syzygium* gallery forests of the Jebel Marra massif.
Montane	Afro-montane vegetation	Montane grassland	Upland grassland and upland meadow on volcanic soils of the Jebel Marra massif.

Source: Wickens. 1976.

Figure 4. Schemic Diagrams of Vegetation in the Jebel Marra Region

A. Zalingei Area

B. Transect from Basement Complex to Alluvial Soils at Adjakari, near Zalingei

C. Riparian Vegetation near Nyertete

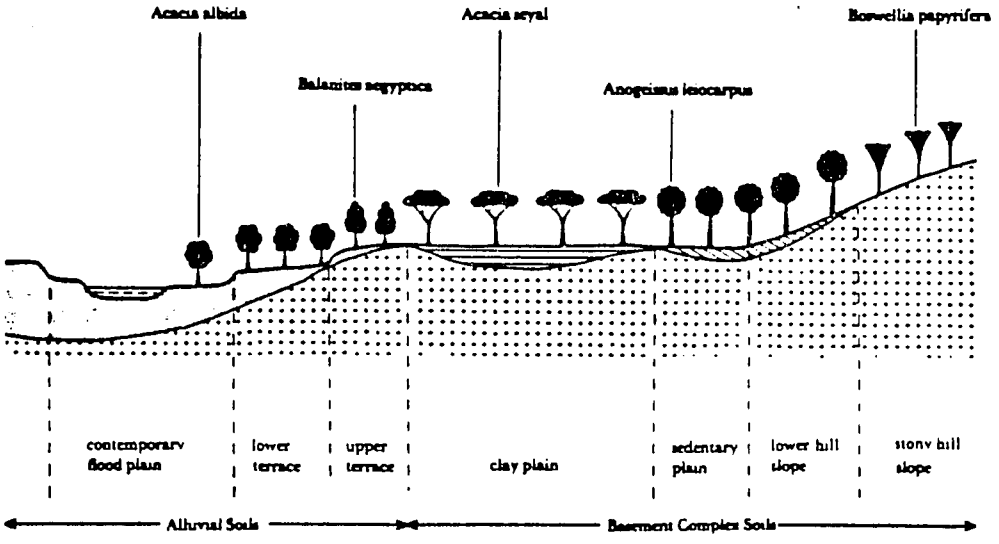
D. Riparian Vegetation near Kibi-Wadi Keira

E. Transect across Jebel Tia

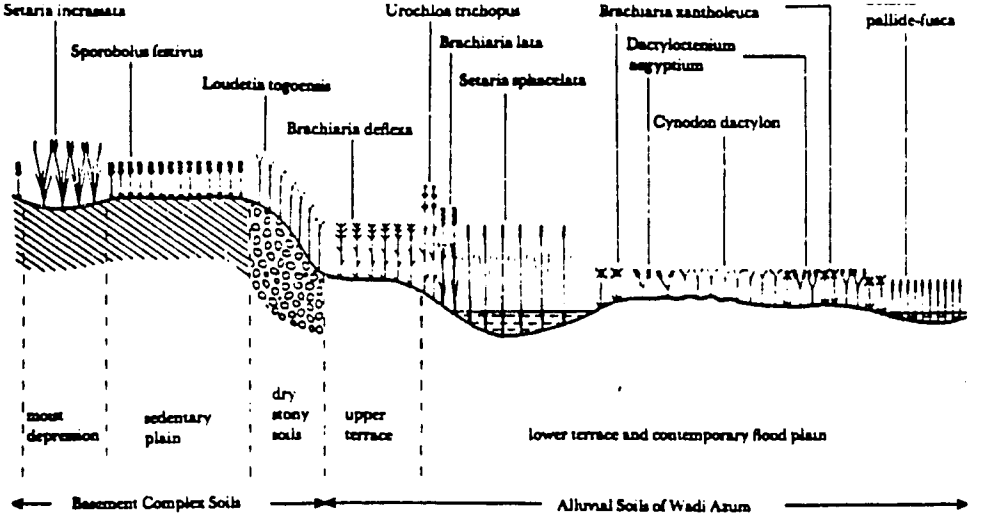
F. Transect across a Valley between the Mountain Slopes to the North of Deriba

G. Distribution of Herb and Grass Species at Tereng, 2450 m.

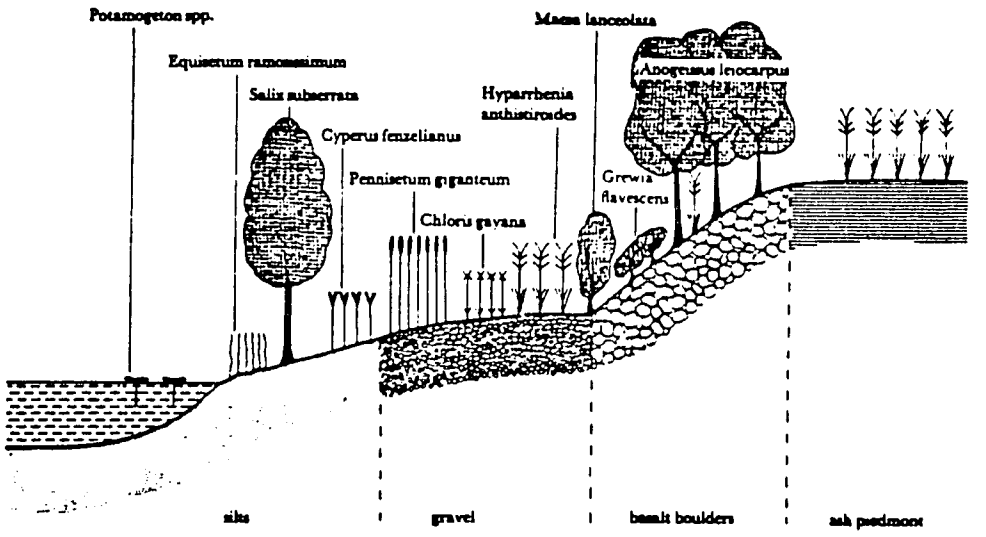
Source: Wickens. 1976.



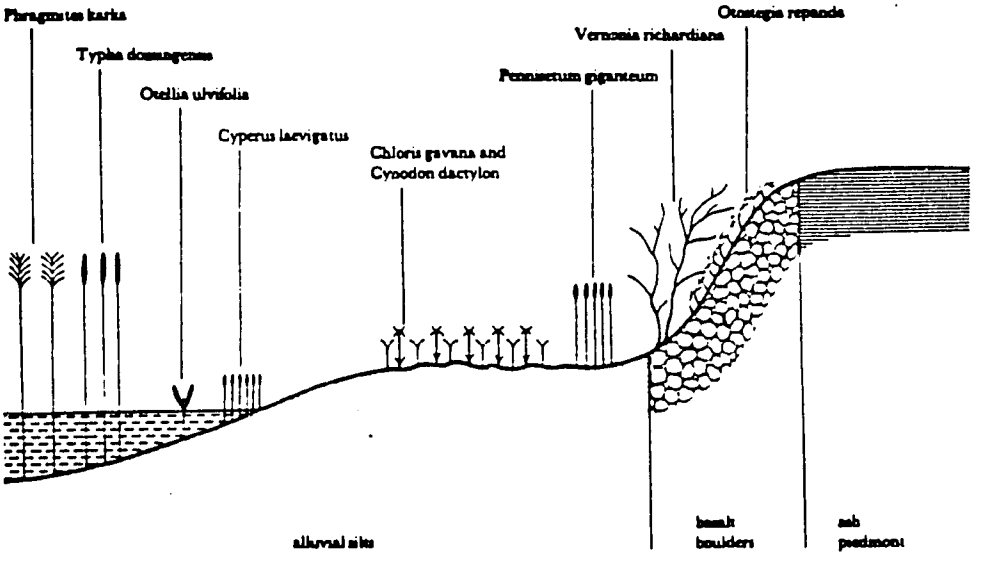
A. Zalingei Area



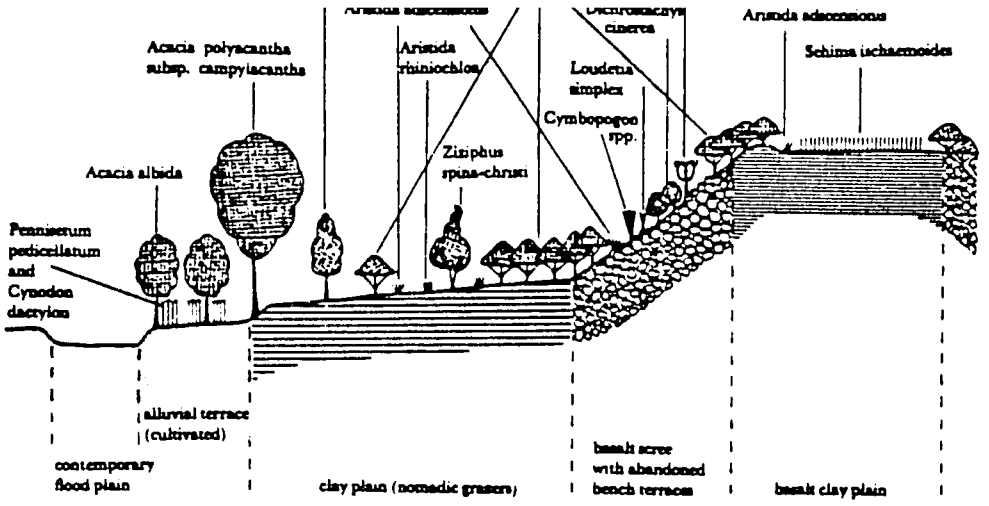
B. Transect from Basement Complex to Alluvial Soils at Adjakari, near Zalingei



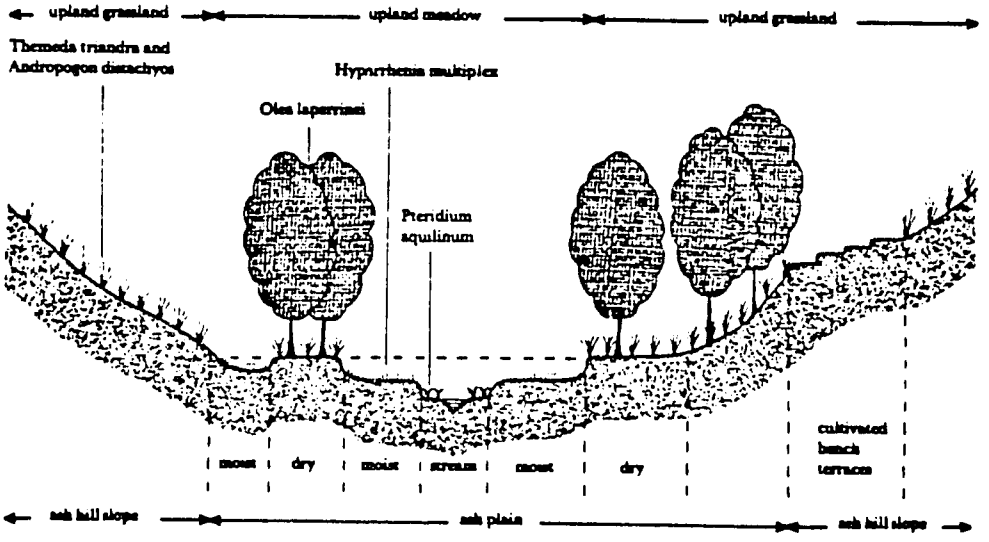
C. Riparian Vegetation near Nyertete



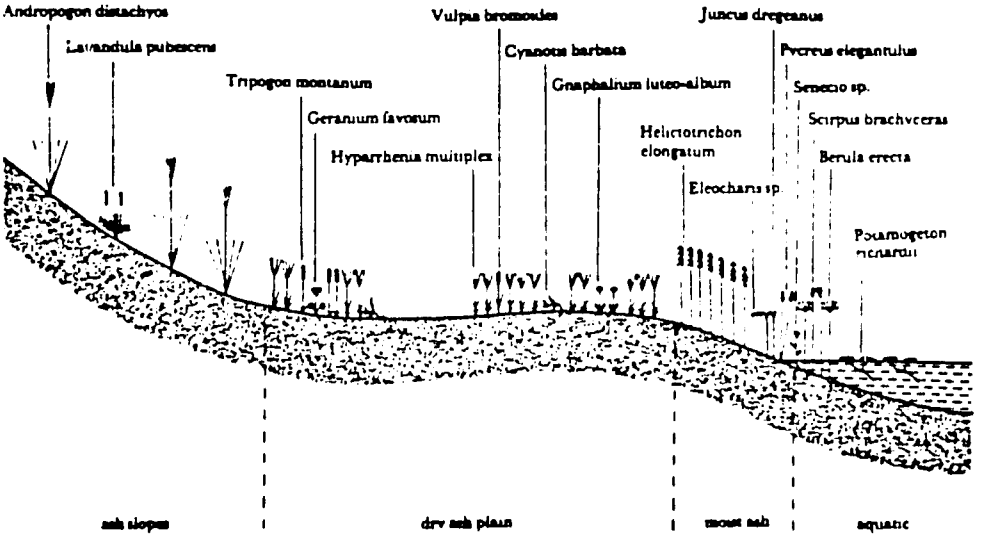
D. Riparian Vegetation near Kibi-Wadi Keira



E. Transect across Jebel Tia



F. Transect across a Valley between the Mountain Slopes to the North of Deriba



G. Distribution of Herb and Grass Species at Tereng, 2450 m.

Appendix VII

Fauna

Table 1. Mammals of Sudan

Table 2. Vertebrates Listed by the IUCN Red Data Books

Figure 1. Protected Areas Listed by IUCN (1971)

Table 3. National Park and Game Reserves Information

Elephantidae

Loxodonta africana

Procaviidae

Heterohyrax brucei
Procavia habessinica
P. ruficeps

Equinae

Equus asinus
E. burchellii

Rhinocerotidae

Ceratotherium simum
Diceros bicornis

Suidae

Sus scrofa
Phacochoerus aethiopicus

Hippopotamidae

Hippopotamus amphibius

Giraffidae

Giraffa camelopardalis

Bovidae

Tragelaphus scriptus
T. spekii
T. strepsiceros
Taurotragus derbianus
Syncerus caffer
Cephalophus caerulus
Sylvicapra grimmia
Kobus defassa
Adenota leucotis
Redunca bohor
Hippotragus equinus
Oryx damman
Addax nasomaculatus
Damaliscus korrigum
Alcelaphus buselaphus
Ourebia ourebi
Rhynchotragus guentheri
Gazella dorcas
G. leptoceros
G. rufifrons
G. thompsonii
G. dama
G. granti
G. soemmerringii
Capra ibex

Source: Setzer. 1956.

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Table 2. Vertebrates Listed by the IUCN Red Data Books. Mammalia (1978), Amphibia and Reptilia (1975)

ADDAX

Addax nasomaculatus (Blainville, 1816)

Order ARTIODACTYLA Family BOVIDAE

STATUS Vulnerable. This Saharan desert antelope has been decreasing in numbers over many decades, lacks adequate protection and is in danger of extinction from ruthless hunting over much of its range.

DISTRIBUTION Formerly found throughout the Sahara Desert from Rio de Oro to Egypt.(4) May still occur in small numbers in Algeria and Sudan and in somewhat greater numbers in Chad and Niger. The centre of abundance is the Majābat-al-Koubrā, a sandy waterless area in eastern Mauretania and western Mali.(3; 5)

POPULATION Egypt: Since about 1900 no permanent population has remained although the species may still enter the Gebel 'Uweinat region from the Sudan.(14) Sudan: Numerical status is very difficult to estimate but the majority are restricted to northern Darfur. The latest reliable reports are of a herd of 15 from the Wadi Howar district in 1968 and of several small herds being harassed by big game hunters in the same region. There is some evidence that addax move into the Sudan from Chad by way of the Mourdi Depression.(6; 9; 12; 14) Libya: In 1949, some 40-45 were seen in the Hamada-el-Homra, and again, in 1959, some were reported, but none have been seen since. There is a slight possibility that a few still live in the Edeyin de Murzuk (5; 6), and a report of several small herds being harassed by big game hunters in the same region in 1975. Chad: Addax are still locally common in the drier regions of northern Chad, e.g. the Bodélé, Djourab, Mourdi and southern Erdi regions. In 1970, the population in northern Chad was estimated, on the basis of aerial surveys, to be 1500 addax.(1; 5) More recent surveys would put this total a little higher at around 2500 head.(11; 12) Niger: Addax occur in western Niger along the Chad border.(5, 12) They also occur in the Ténéré, Bilma and eastern Aïr.(16; 5; 13) Jones (7) saw two addax and a further six dead ones, in the area north of Arlit in 1971. They are also reported from the Vallée de l'Azaouak, where they are reportedly hunted by Algerian border patrols. Algeria: The last addax in the northern Sahara were killed near Beni Abbes in the years 1920-1922; in the Tanezrouft area the last direct observation was in 1960, although Dupuy (3) found old traces in 1964. Some addax remain in the area between the Adrar des Iforhas to the Tassili du Hoggar and along the Niger border.(5; C. Grenot 1976, pers. comm.) Mauretania: The greatest numbers of addax reported were in the Majābat-al-koubrā where Monod, in 1960, counted 5361 tracks in a traverse of 35 km. Present reports show a considerable reduction in numbers. Trotignon states that addax still exist "en nombre", especially in the Dahr Tichit and Erg du Chech regions of the Mreyye. Hunting addax for meat commercially is still of considerable importance and practised widely.(3; 10; 15) Mali: Addax certainly still occur in the Malian parts of the Mreyye and Majābat al-Koubrā. They may also still occur in the Djebel Timetrine and the Tamezna. Tunisia: The last addax were killed about 1885.(5) Spanish Sahara: The last known herd was killed in 1942, although a single female was seen in 1963.(16) Ruthless hunting by local inhabitants, expatriates and military personnel remains the major factor contributing to its decline.

HABITAT: Waterless areas of the Sahara, particularly in dune regions; is necessarily dependent on sparse desert forage and consequently adversely affected when this is destroyed during the passage of nomadic domestic livestock. It is, however, able to maintain itself in areas into which livestock cannot venture.

CONSERVATION MEASURES TAKEN Addax are protected by law in most countries where they exist, but law enforcement in the Sahara scarcely exists. Apart from the naturally inaccessible areas like the Majābat-al-Koubrā, Chad's Ouadi Rime-Ouadi Achim Faunal Reserve is the only protected refuge for the addax, where the Reserve Guards have managed to some extent to reduce the poaching pressure.(2; 11) IUCN and UNEP are sponsoring a survey of the actual and potential habitats of addax. Included in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora, 1973; trade in these animals between acceding nations is subject to strict regulation and monitoring of its effects.

CONSERVATION MEASURES PROPOSED Establishment of effectively policed reserves within areas where addax still remain reasonably common, including the Majābat-al-Koubrā in Mauretania, the Tamezna area of Mali, Niger and Algeria, the Bilma-Ténéré area of Niger and the Erdi-Mourdi-Howar regions of Chad and Sudan.(6) Establishment of a centrally placed guard post from which camel patrols could operate throughout the year, in the Ouadi Rime-Ouadi Achim Faunal Reserve in Chad.(2) Cessation of licences to shoot addax issued by the Wildlife Administration of Sudan, and of advertising this species by professional hunting firms operating there.(8)

REFERENCES

1. Anna, M. (1970): Une nouvelle réserve de faune dans la République de Tchad. Direction des Parcs Nationaux du Tchad, Fort Lamy, No. 293/PNR.
2. Bassett, T.H. (1975): Oryx and addax in Chad. Oryx 13: 50-51.
3. Dupuy, A. (1971): SOS pour la conservation de la nature en Mauretanie. Science et nature 108: 31-34.
4. Ellerman, J.R. and Morrison-Scott, T.C.S. (1951): Checklist of Palaearctic and Indian Mammals 1758 to 1946. London: British Museum (Natural History).
5. Gillet, H. (1971): L'oryx algazelle et l'addax. Distribution géographique. Chances de survie. Comptes-rendues Soc. biogéog. 405.
6. IUCN (1976): Report of Consultants Meeting, Morges, Switzerland, January, 1976. Mimeo.
7. Jones, D. (1973): Destruction in Niger. Oryx 12 (2): 227-232.
8. Lamprey, H. (1975): Report on the Desert Encroachment Reconnaissance in Northern Sudan. Report to IUCN and UNEP. Mimeo.
9. Macpherson, Lord (1969): The Addax in Darfur Province, Sudan. IUCN Bull. 2 (12): 98.
10. Monod, T. (1958): Majābat-al-Koubrā Memoire, IFAN.
11. Newby, J. (1974): The Ecological Resources of the Ouadi Rime-Ouadi Achim Faunal Reserve. FAO, Rome.
12. Newby J. (1975): The Addax and Scimitar-horned Oryx in Chad. Report to IUCN. Mimeo.
13. Newby, J. (1975): The Addax and Scimitar-horned Oryx in Niger. Report to IUCN. Mimeo.
14. Osborn, D. and Krombein, K. (1969): Habitats, flora, mammals and wasps of Gebel 'Uweinat, Libyan desert. Smithsonian Contr. Zool. 11: 1-18.
15. Trotignon, J. (1975): Le statut et la conservation de l'addax et l'oryx et de la faune associée en Mauretanie. Report to IUCN. Mimeo.
16. Valverde, J. (1968): Ecological bases for fauna conservation in Western Sahara. Proc. IBP/CT Tech. Meeting Cons. Nat.

The original of this sheet was prepared, in January 1976, by John Newby: Parcs et réserves, B.P. 905, N'Djamena, Tchad.

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AFRICAN WILD ASS

Equus africanus (Fitzinger, 1857)

Order PERISSODACTYLA Family EQUIDAE

STATUS Endangered. Two sub-species are extant, one doubtfully extant and one extinct.(15) There is confusion both over nomenclature and doubts as to the amount of interbreeding with domestic asses. Originally widespread in northern Africa but now restricted to Ethiopia (Sardo, Danakil and perhaps Eritrea) and Somalia. To avoid further confusion the nomenclature used here follows van Bemmel (15), and it should be noted that E. africanus taeniopus (von Heuglin 1861) is used for much of E. a. somaliensis (=E. a. somalicus) of earlier RDB's. Some authors now regard the Nubian race (E. a. africanus) as extinct.

DISTRIBUTION E. a africanus: Formerly occurred in the mountainous semi-deserts of Nubia and eastern Sudan from the Nile to the Red Sea. Montagu (1975) considers this race to be extinct, at least its pure form, but several recent reports could refer to it: from the southwest corner of the Djourab, north of Tibesti-Emmedi, in northern Chad (15; I.R. Grimwood 1976, pers. comm.) and a small herd in the Matiyet et Melva saltmarshes, the northern edge of the Great Libyan sand sea. (11; E.J. Hufnagl 1965, pers. comm.; H. Klingel 1972, pers. comm.) E. a. somaliensis: Formerly ranged over Somalia and Ethiopia north to the Awash River; now found only south of Tendaho in Ethiopia and the Las Anod area of Somalia. E. a. taeniopus: Formerly from Tokar region in the north, south to the Awash River and along Red Sea coast in Eritrea; still occurs near Sardo and in Danakil Depression.(8; 14) The small population of asses located in northern Eritrea by Klingel (8) is considered by van Bemmel (15) but not Klingel to be of this race. Feral asses and wild asses which have interbred with feral asses occur in a number of places. The population on Socotra may be descended from E. a africanus brought by the ancient Egyptians.(5) Other feral populations occur in North America, where population was estimated at not more than 13,000 in the western USA (9); North Africa, Galapagos Islands and Australia.

POPULATION The Nubian race (E. a. africanus) is either extinct or very low in numbers. In the Depression and southern Danakil wild asses were rather rare, most being in the central Danakil between 10° and 12°11'N and between 40°30' and 42°E. The total population was estimated at a minimum of 2000 head, but noted that 1000 head would be realistic. The population densities range from 30/100 sq.km in parts of the Teo to between 1 and 5 in the southern Abbe. In Somalia, the populations near Las Anod and at Gebidebo total approximately 250 animals. (Klingel 1972, pers comm.) The original decline of populations coincided with various military campaigns in Ethiopia and Somalia during the first half of the 20th century. Wild asses are hunted by local people. Both the Somali and the Afar, in Danakil, use the meat or fat as medicine. The impact of hunting may be tolerable in normal years, but during drought periods, shooting can pose a serious threat to wild asses, at least locally. Poaching in Somalia has been reduced recently by the requisition by the Government of almost all firearms. (6; 13; P.M. Bally 1967, pers. comm.; A.M. Simonetta 1971, pers. comm.) In the Tendaho-Sardo area, chasing asses by tourists in vehicles for close-up photographs often causes complete exhaustion of the animal and could be a significant cause of mortality.(7)

HABITAT Uninhabited semi-desert regions. Wild asses are predominantly grazers and need to drink every second or third day. Increasingly severe competition from domestic livestock for limited pasture and water, particularly during periods of long drought, is probably an important factor in their decline.(3)

CONSERVATION MEASURES TAKEN Legally protected in the Sudan, Ethiopia and Somalia. Included in Class A of the African Convention (1969), i.e. it may be hunted or collected only on the authorization of the highest competent authority, if required in the national interest or for scientific purposes.

CONSERVATION MEASURES PROPOSED Inclusion in Appendix I of the Convention on International Trade in Wild Species of Fauna and Flora. The establishment of adequately protected reserves in the Teo area (about 2000 sq.km, south of the Awash River near the Mille Settlement) and in the Tendaho-Sardo area. Teo is a wilderness region between the Afar and Issa tribal areas and has the highest known popolations of Somali wild asses. Firm action would be needed to restrict human access and domestic stock grazing and to supervise tourists.(7)

REMARKS Wild asses have been bred in captivity, although many so-called Nubian wild asses in zoos are not derived from pure bred stock. In 1974 there were 17 male and 23 female African wild asses in 6 collections, of which only 6 males and 10 females could be subspecifically determined. The stud-book keeper for the African wild ass (E. a. somaliensis) is Claus Pohle, Tierpark Berlin. DDR-1136.

REFERENCES

1. Blancou, L. (1960): Destruction and protection of the fauna of French Equatorial and of French West Africa. Part II: The larger animals. Afr. Wild Life 14: 101-108.
2. Blower, J. (1968): The Wildlife of Ethiopia. Oryx 9(4): 276-285.
3. Funaioli, U. and Simonetta, A.M. (1966): The mammalian fauna of the Somali Republic: status and conservation problems. Monitore Zool. Ital. 74. (suppl.): 285-347.
4. Grimwood, I.R. (1965): Preliminary report on the status of the Somali wild ass (Equus asinus somaliensis) in Ethiopia. Mimeo.
5. Harper, F. (1945): Extinct and vanishing mammals of the Old World. Spec. Publ. Amer. Comm. Wildl. Protec. 12. 849 pp.
6. Klingel, H. (1972): Somali wild ass - status survey in the Danakil region, Ethiopia. (Interim report: WWF Project No. 496). Mimeo. 6 pp.
7. Klingel, H. (1971): Recommendations for the protection of the Somali wild ass in the Danakil region of Ethiopia. Mimeo. 2 pp.
8. Klingel, H. (1972): Report to WWF. Mimeo. 9 pp.
9. Laycock, G. (1966): The Alien Animals. New York.
10. Duplaix-Hall, N. (ed.) (1975): 1975 International Zoo Yearbook 15. London: Zoological Society of London.
11. Mackenzie, P.Z. (1954): Catalogue of wild mammals of the Sudan occurring in the natural orders Artiodactyla and Perissodactyla. Khartoum: Sudan Museum (Natural History). Publ. 4.
12. Montagu, I. (1975): The wild ass of Africa. Wildlife 17: 400.
13. Owen, T.R.H. (1960): Hunting big game with gun and camera in Africa. London: Herbert Jenkins.
14. Simon, N. (1962): Between the sunlight and the thunder; the wildlife of Kenya. London: Collins.
15. Bemmel, A.C.V., van. (1972): Some remarks on the African wild ass. Zool. Mededelingen 47(21): 261-272.

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CHEETAH

Acinonyx jubatus (Schreber, 1776)

Order CARNIVORA Family FELIDAE

STATUS Vulnerable. Severely reduced and faces a prospect of increasing attrition and even more limited distribution as the human population expands into its favoured habitats. Even inside national parks and game reserves its prospects cannot be regarded as good.

DISTRIBUTION The African race, A. j. jubatus: south of the Sahara from Nigeria, Sudan and Somalia to southern Africa. At present, survives throughout much of its former range, but in much reduced numbers and seems to diminish even where protected in national parks and reserves. Its distribution is discontinuous and numbers vary from common to rare - or even absent in some areas where it was formerly common.(1) The Asiatic race, A. j. venaticus formerly occurred from Sind, Afghanistan and southern Russia westwards to Syria and Palestine, and thence (although some authors regard this as a separate race A. j. Hecki) westwards across North Africa to Rio de Oro. Now known certainly only in Iran and on the Turkmen/Afghan border.(1; 4)

POPULATION The remaining African populations may total less than 15,000, within a probable range of 8000-25,000. Rough estimates of population sizes, based on informed local opinion and, for order of magnitude purposes only, indicate less than 2000 in Kenya, less than 200 in Uganda, less than 1000 in Tanzania, about 500 in Angola, less than 1000 in Zambia, 200 in Mozambique, 50 in Malawi, 2000 in Botswana, 400 in Rhodesia, 1500 in South West Africa, 700 in South Africa, less than 1000 throughout the Sahel zone, a few hundred in the savanna woodland zone of West Africa, rather more than 1000 in Sudan, around 1000 in Ethiopia, 300 or so in Somalia, and 300 or less in Zaire. In rough terms, these figures almost certainly represent half the cheetah totals in Africa in 1960, and present figures could well be reduced by one half within another 10 years, perhaps by 1980, as a result of degradation or loss of habitat, and over-hunting, particularly by ranchers. Two animal dealers are believed to have caught 1000 cheetahs in Namibia since 1962, either for export to the world's zoos and safari parks or for translocation to other parks of Africa.(3; 5; 6) Iran: now estimated at more than 250. (E. Firouz 1974, pers. comm.)

HABITAT Open semi-arid grasslands (but seldom areas of tall grass) scrubland (occasionally quite dense) and various types of savanna woodland, in all cases essentially in association with medium or small-sized herbivores; exceptionally, forest margins but never forest itself. These habitats are being reduced by agriculture, degradation of rangelands and competition from domestic stock following upon increasing occupation by human communities. Loss and degradation of habitat and associated depletion of prey species have been the principal factors in the cheetah's decline.(3)

CONSERVATION MEASURES TAKEN Totally protected in almost every country except South Africa and Namibia, where it is still considered vermin (amend by legislation pending). Ranching interests in Kenya, Tanzania, Rhodesia, Iran and Angola. Namibia and South Africa, however, often destroy cheetah suspected of marauding livestock. The cheetah occurs in less than half the parks and reserves of Africa, and totals no more than 3000 animals in these protected areas. Moreover, when it is reduced to relict populations in isolation from each other, it becomes singularly susceptible to disease, carnivore competition, shifts in prey community make-up, changes in vegetation configuration, and other natural limiting factors. In the main, its stability in protected areas shows a decline. Included in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora, 1973; trade in these animals between acceding nations is subject to severe restriction, trade for primarily commercial purposes is banned. The International Fur Trade Federation operated a three-year voluntary ban among its membership on the use of cheetah furs in 1971/74. The moratorium has worked moderately well in certain countries but has been widely disregarded in France, Italy, Spain, Scandinavia and Japan, where the demand for spotted fur has increased. Fully protected by law in Iran and the USSR, also in several reserves in Iran.

CONSERVATION MEASURES PROPOSED In terms of adaptability to change, the cheetah is one of the most vulnerable mammals. Conservation requirements, particularly outside parks and reserves, include more careful enforcement of protective laws and regulations, supervision of control so that only individual nuisance animals are removed when depredation occurs, control of over-grazing, and protection of wild prey species to reduce risk of predation on domestic animals. At the same time, the legitimate interests of ranchland communities in Africa should be recognized especially in those areas where pastoralists are attempting upgraded livestock husbandry and sometimes need to protect themselves in the event of undue predation.

REFERENCES

1. Ellerman, J.R., and Morrison-Scott, T.C.S. (1951): Checklist of Palaearctic and Indian mammals, 1758-1946. London: British Museum (Natural History).
2. Firouz, E. (1974): Environment Iran. National Society for the Conservation of Natural Resources and Human Environment, Tehran, Iran.
3. Myers, N. (1975): The Cheetah, Acinonyx jubatus, in Africa. IUCN Monograph 4. IUCN, Morges, Switzerland.
4. Talbot, L.M. (1960): A look at threatened species: Report on some animals of the Middle East and southern Asia which are threatened with extermination. Oryx 5: 153-293.
5. Richter, W. von (1972): Remarks on present distribution and abundance of some South African carnivores. J. Sn. Afr. Wild. Mgmt. Assoc. 2(11): 9-16.

CHIMPANZEE

Pan troglodytes Blumenbach 1799

Order PRIMATES Family PONGIDAE

STATUS Vulnerable. A wide-ranging, adaptable primate currently seriously depleted throughout its range. Particularly vulnerable because of its close relation to man, which gives it unique value for entertainment purposes and for scientific research. The main threats are mechanized exploitation of its habitat and indiscriminate collection. Habitat ranges from lowland forests to open savannas. No estimates of total numbers available but known to be abundant in some locations, scarce in others of former abundance, and virtually exterminated throughout large areas. Though most populations are seriously depleted and fragmented, none of the three recognized subspecies is currently believed to be threatened with extinction. The nominate race, P.t. troglodytes, and the western race, P.t. verus, are approaching this condition.

DISTRIBUTION Discontinuous, in forests and savannas of equatorial Africa, within limits of the Rift Valley to the east and the availability of drinking water to the north and south. River systems, mountain ranges and habitat which cannot be crossed form additional barriers. P.t. troglodytes ranges east of the Niger as far as the Congo. P.t. schweinfurthii occurs from north and east of the Congo to the White Nile, and P.t. verus ranges from west of the Niger as far as Senegal. Isolated populations beyond these present general boundaries may indicate the presence of earlier, broader patterns of dispersion.(1; 3; 5; 8)

POPULATION No estimates of total numbers are available but the trend is decidedly downward. In several countries where they were formerly found they are now virtually absent or rapidly declining, primarily owing to the inroads made on their habitat by progressive human development, and to uncontrolled capture which is the result of extensive demand in particular for use in the biomedical sciences. Also hunted for food, for the protection of crops, for trophies or sport, and to obtain captive juveniles as pets and for the animal trade. But several countries completely protect the species from exploitation and have secured some habitats in national parks and reserves (see under "Conservation measures taken"). An IUCN survey (1968) showed abundance in some localities, but scarcity or virtual absence in others where they were formerly abundant but where controls are lacking or ineffective. The survey was supported by research reports and population estimates for some areas, but these cannot provide a reliable overall assessment. The recorded average densities give an indication of the size of present populations in some areas. For example, Bournonville calculated approximately 12,500 chimpanzees within a 90,000 km² area of Guinea during 1964; Kortlandt estimated that there were between 5 and 10 chimpanzees per km² in the Beni Reserve of Zaïre; van Lawick-Goodall suggests 5 - 15 per km² in the Gombe Stream of Tanzania; and Reynolds between 18 and 26 per km² (and thus the presence of a total population of between 1,000 and 2,000) in the Budongo Forests of Uganda.(2; 4; 7; 8) The greatest danger to the populations is the isolation of many small units in marginal habitats. A slowly-maturing, long-lived, social primate can be easily wiped out by stress and disease once it becomes critically reduced in numbers - even if protected.

HABITAT An extremely diversified array of vegetation types, including humid evergreen lowland forests, montane vegetation up to an altitude of 3,000 metres, semi deciduous forests and open savannas. The optimum habitat appears to be situated in the transitional zone where the rain-forest belt blends into the Sudanian woodland belt, and consists of a mountainous landscape covered by a variegated mosaic of vegetation, including moist as well as drier types of forest, woodland, and savanna, according to the local conditions of topography, soil and hydrography.(2; 7; 9) The equatorial forests of Africa are increasingly being cleared and/or replaced with faster growing and commercially more valuable trees which are not usually species used by chimpanzees for food. Savanna areas are also being rapidly encroached upon for cultivation or habitation.

CONSERVATION MEASURES TAKEN Chimpanzees are fully protected in Uganda, Nigeria, Guinea, Gabon, Sudan and Zaïre. A scientific Reserve has been constituted at Gombe Stream Game Reserve, Tanzania, where a small population is under intensive study. They are present in Albert National Park in Zaïre, in the Queen Elizabeth Park in Uganda, in Niokolo Koba, Senegal, the Nimba and Tai Reserves of the Ivory Coast, the Mount Cameroun and Douala Edea Reserves in Cameroun, and Mbarizinya Game Reserve in the Sudan.

CONSERVATION MEASURES PROPOSED The introduction and upgrading of protection laws, including controlled and licensed capture of juveniles for international trade and the prohibition or control of hunting for food and for the protection of crops. The introduction of forestry practices which avoid monoculture and maintain trees and shrubs used by chimpanzees for food. The formation and development of parks and reserves, particularly within the western and central areas of the species' range. Chimpanzees are of unique value to man, and user-support for controlled acquisition and trade in live animals, and the development of captive breeding programmes, are strongly urged. Substantial financial support from research institutions and the pharmaceutical and biomedical industries is needed for these and other conservation measures to ensure the survival of all three subspecies in the wild.(6) Failing this support, a complete ban on the acquisition of captives for the international trade is indicated.

REMARKS Usually single infants are born (gestation period approximately 225 days) at intervals of 2½ to 4 years, depending on infant mortality, which is high owing to disease and human predation. Maturity is reached between 6 and 8 years and the potential life span extends beyond 40 years.

REFERENCES

1. Booth, A.H. (1958): The Zoogeography of West African Primates. Bull. IFAN 20(2) sér. A: 587-622.
2. Bournonville, D. de, (1967): Contribution à l'étude du chimpanzé en République de Guinée. Bull. IFAN 29(3): 1188-1269.
3. Butler, H. (1966): Some notes on the distribution of primates in the Sudan. Folia Primat. 4(6): 416-423.
4. Goodall, J. (1965): Chimpanzees of the Gombe Stream Reserve. (In Primate Behaviour: Field studies of monkeys and apes. I. De Vore, ed.) New York: Holt, Reinhardt.
5. Happold, D.C.D. (1968): Survey of Primates of Western Nigeria. Information compiled for IUCN 'Survey of African Primates'. 12 pp. Unpubl.
6. Harrisson, B. (1971): Conservation of nonhuman primates in 1970. Primates in Medicine 5: 1-99.
7. Kortland, A. (1967): Some results of a pilot study on chimpanzee ecology. 59 pp. Cyclostyled.
8. Reynolds, V. (1964): The "man of the woods". Nat. Hist., N.Y., 73(1): 44-51.
9. Thomas, D.K. (1961): The Gombe Stream Game Reserve. Tanganyika Notes and Records 56: 34-39.

AFRICAN ELEPHANT

Loxodonta africana (Blumenbach, 1797)

Order PROBOSCIDEA Family ELEPHANTIDAE

STATUS AND SUMMARY Vulnerable. Now restricted to Africa south of the Sahara. Numbers, which lowest current estimates put at 1.3 million, are declining over most of its range, primarily because of over-exploitation for ivory; somewhat over 100,000, for example, must have died to supply the 1976 African ivory exports. In the longer term the main threat is constriction of the elephant's range due to expanding human populations. Protected by law in most countries and found in many national parks and reserves; however protection is usually difficult to enforce. An IUCN/WWF Africa-wide survey of its status was begun in 1976, with a view to proposing effective conservation measures. Suppression of poaching and of illegal ivory dealing are clearly essential, combined with the setting aside of sufficiently large blocks of land for the elephant and other measures aimed at establishing a satisfactory basis for its coexistence with man.

DISTRIBUTION Africa south of the Sahara. In early Neolithic times also widely distributed in North Africa and the Sahara, surviving north of the Sahara until early historical times but becoming extinct there by the 6th century A.D. (1; 15). Within about the last 300 years it occupied virtually all sub-Saharan Africa except the very driest areas, viz. sub-desert steppes of the Sudanese Arid Zone, desert and sub-desert of the Somali Arid Zone, and the coastal desert and sub-desert of the South West Arid Zone (1). Today it is scarce and very local in South Africa, South West Africa/Namibia, Angola, Rhodesia, Ethiopia, Uganda and West Africa (20), long extinct in northern Somalia (1), and recently extinct in the Gambia, Guinea-Bissau, Lesotho and Swaziland (12; 17). Existing populations are generally regarded as belonging to one of two races, nominate L. a. africana of the savannas and L. a. cyclotis of the forests (see under Remarks).

POPULATION Data collected by the IUCN/SSC African Elephant Specialist Group in the first systematic enquiry into elephant numbers and trends throughout Africa, suggest that in 1976 there were not less than 1.3 million elephants spread over 34-36 countries (12). Informants cited 45 examples of declining populations and it is thought that elephants are undergoing an overall decline in 23 countries (12). In 3 countries - Tanzania (with approximately 300,000 elephants), Zaire and Somalia - trends are uncertain (9; 12; 17). In South Africa, Namibia, Botswana and Rhodesia populations are stable having recovered from the low ebb to which they were reduced at the beginning of the century (12). Trends in the remaining 4-6 countries are unknown. Of the 23 countries experiencing decline Mauretania has a highly endangered population droppings being the only recent evidence that the species still exists; and elsewhere in West Africa little more than relicts survive in isolated forest patches (12). In Kenya, total elephant numbers estimated by the IUCN Elephant survey in 1977 were 65,000-75,000 (an independent survey of the Kenya Rangeland Ecological Monitoring Unit (KREMU) provided an estimate of about 60,000 (6); this is less than half the number estimated by the Kenya Wildlife Department in 1973 (11). In Uganda, the population [illegible] by 85 per cent from 14,000 to just over 2,000 between 1971 and 1976, and sub-[illegible] declines have also been reported in Ruwenzori National Park (10). Although Kenya and Uganda have provided the best documentation, similar declines are believed to have occurred in many other places (12). Paradoxically in some parks and reserves (though they constitute less than 5 per cent of the total African elephant range) excessive populations are changing the habitat from woodland to grassland (8).

In general, despite the still apparently substantial size of the total African elephant population, the future of the species is by no means assured if one considers the rate at which elephant habitat is being occupied and elephants are being exploited; with more than half the populations declining the African elephant is considered a vulnerable species (12). Historical precedents, such as in South Africa, where elephants once plentiful were virtually eliminated in the 19th century, and more recently in Kabalega National Park, show how rapid the process of decline can be (10).

HABITAT AND ECOLOGY Habitats vary from desert-scrub, thorn-bush and savanna to dense lowland and montane dry and humid forests (14). The elephant is a very adaptable grazer and browser, feeding on grass, shrubs or trees and their leaves, twigs, terminal shoots, bark, roots or fruit (14; 15; 17). Where elephants are numerous, their habit of barking or felling trees may cause deforestation, but there is some evidence to suggest that this is a partial rather than the whole cause of this type of habitat change (3; 5; 18).

A social animal living in family units of 2-20 led by old females, but at times will form much larger aggregations. Bulls tend to live separately in small groups or alone, with occasional short term associations with family units when a female is in oestrus (2; 7; 8). A year round breeder; gestation about 22 months; puberty attained at 8-18 years of age; maternal care continues until puberty and may continue to be exercised indefinitely in respect of female calves within the family unit; potential longevity: 50-70 years (4; 15).

THREATS TO SURVIVAL Three main threats: (i) in the long-term, range reduction caused by an expanding human population and its subsequent demand for land, combined with the difficulty of reconciling the presence of wild elephants with human settlement and agriculture; (ii) habitat changes induced by elephants being restricted to smaller and smaller areas, when their more concentrated impact on the vegetation may exceed its regenerative capacity, a problem sometimes aggravated by severe drought (14); the elephant's ability to survive successfully in areas set aside for its protection is, however, a matter of some controversy, depending on one's assessment of the speed at which it can respond to changes in resource availability (5; 13); (iii) in the short term the greatest threat is human predation arising from demands for ivory, for meat (particularly in West Africa) and for crop protection (6; 10), the increased price of ivory and consequent boom in the ivory trade being the principal factor in the drastic decline of elephants in East Africa and elsewhere (8). A minimum of 976 tons of ivory was exported from Africa in 1976, but more ivory may have been smuggled out. An average tusk weight of 4.8 kg was calculated for 43,877 tusks received by the Tanzanian ivory room between 1971 and 1977 (mainly derived from crop protection shooting or natural mortality) and on average each elephant has 1.8 tusks. If those averages were generally valid 1976 exports would represent 112,000 elephants. Recent data suggest, however, that the ivory trade may be selecting heavier ivory than that available from natural mortality or from control shooting (12), and if so the number of elephants involved would be somewhat lower. On the other hand, it must also be borne in mind that only a fraction of the ivory from natural

mortality is ever recovered, that an increasing amount of ivory is processed in Africa, that private trophies are often unrecorded in export statistics, and that smuggling means that official statistics underestimate the size of the international ivory trade (12).

CONSERVATION MEASURES TAKEN The African elephant is listed in Appendix 2 of the 1973 Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), trade in it between acceding nations therefore being subject to regulation and monitoring. The USA has listed the species as threatened and will only allow import of recognizable parts or products of it from nations that are parties to CITES (16), and of sport trophies. Most African countries have game laws which restrict shooting of elephants to licensed hunters or Game Departments, but the laws are often abused or poorly enforced. Poaching is also rife in many national parks and reserves in which the elephant is nominally protected (12). The African elephant is one of the best studied large mammals and has been the subject of an IUCN/WWF Pan-African survey since 1976.

CONSERVATION MEASURES PROPOSED As an outcome of the survey to date, the IUCN/SSC Elephant Group has developed a four-point action programme for Research, Conservation, Economics and Education (19). Measures particularly needed include more effective enforcement of existing laws, reinforcement of anti-poaching units; a study of the ivory trade and new legislation to end illegal dealing (8); continual monitoring of the population dynamics of the African elephant (12); and, in the longer term and essential for their ultimate survival, guarantees that large self-sufficient units of land inhabited by elephant populations will be reserved in perpetuity. That in turn will depend on developing effective methods of reconciling the interests of such reserves with those of the human occupants of neighbouring areas, for example by ensuring that the latter derive direct and substantial benefits from appropriate management of elephants as a wildlife resource.

REMARKS For description of animal see (1; 14; 15). Two subspecies are usually recognized, the savanna-dwelling nominate africana and the smaller forest-dwelling cyclotis. Intermediates occur where the two meet and taxonomists differ about whether recognition should be at superspecies, species or subspecies level (1). This data sheet was compiled with the assistance of the IUCN/SSC African Elephant Specialist Group.

REFERENCES

1. Ansell, W.F.H. Part 5. Proboscidea. In Meester, J. and Setzer, H.W. (eds) The Mammals of Africa. An Identification Manual. Smithsonian Institution Press, Washington, D.C.
2. Croze, H. 1974. The Seronera elephant problem I: The bulls. E. Afr. Wildl. J. 12: 1-28.
3. Croze, H. 1974. The Seronera elephant problem II: The trees. E. Afr. Wildl. J. 12: 29-48.
4. Croze, H. 1978, pers. comm.
5. Croze, H., Hillman, A.K.K. and Lang, E. 1978. Elephants and their habitats: how do they tolerate each other? In Fowler, C.W. and Smith, T. (eds) Dynamics in large Mammal Populations. Wiley-Interscience, New York.
6. Dirschl, H.J., Mbugua, S.W. and Wetmore, S.P. 1978. Preliminary Results from an aerial census of livestock and wildlife of Kenya's Rangelands. Aerial Survey Technical Report Series No. 1. Kenya Rangeland Ecological Monitoring Unit. Ministry of Tourism and Wildlife, Kenya.
7. Douglas-Hamilton, I. 1972. On the Ecology and Behaviour of the African Elephant. D. Phil. Thesis, Oxford.
8. Douglas-Hamilton, I. 1977. Statement before the Merchant, Marine and Fisheries Committee, Washington.
9. Douglas-Hamilton, I. 1978. Where are all the elephants going? African Wildlife Leadership Foundation News 13(1).
10. Eltringham, S.K. and Malpas, R.C. 1976. Elephant numbers in the Ruwenzori and Kabalega Falls National Parks, Uganda. September 1976. Typed report.
11. Hillman, A.K.K. 1977. Interim report on the status of elephants in Kenya, 1977. Typed report.
12. IUCN/WWF Elephant Survey replies and data collection, 1976 onwards. Includes a preliminary report (by Douglas-Hamilton and Davitz, 1978, 18 pp., unpublished) on the production and distribution of ivory in Tanzania, 1971-77.
13. Laws, R.M. 1970. Elephants as agents of habitat and landscape change in East Africa. Oikos 21: 1-15.
14. Laws, R.M., Parker, I.S.C. and Johnstone, R.C.B. 1975. Elephants and their habitats. Clarendon Press, Oxford.
15. Sikes, S.K. 1971. The Natural History of the African Elephant. The World Naturalist. Weidenfeld and Nicolson, London.
16. USDI Fish and Wildlife Service, 1978. African Elephant Listed as Threatened. News Release May 10. Levitt 202/343-5634.
17. USDI Fish and Wildlife Service, 1978. Threatened Status Sought for African Elephant to Curb Slaughter for Ivory. Endangered Species Technical Bulletin. Vol. III (1): 1.
18. Western, D. and Praet, C. van, 1973. Cyclical changes in the habitat and climate of an East African ecosystem. Nature 241: 104-106.
19. WWF/IUCN Elephant Survey and Conservation Programme. Newsletter No. 1, November 1976.
20. WWF/IUCN Elephant Survey and Conservation Programme. Newsletter No. 3, August 1978.

SLENDER-HORNED GAZELLE or LODER'S GAZELLE

Gazella leptoceros (Cuvier, 1842)

Order ARTIODACTYLA Family BOVIDAE

STATUS Endangered as a result of excessive hunting and habitat degradation.

DISTRIBUTION Once found in the deserts of northern Africa from southern Algeria to the western side of the Nile River near Faiyum, including the central Sahara south as far as north-western Sudan extending into Tunisia and the Atlas Mountains in the north. Now occurs in extremely limited numbers in the desert regions of Algeria, Tunisia, Libya, Egypt, Sudan and Chad, covering the greater part of the northern half of the Sahara Desert from Algeria to Egypt and north-western Sudan to the mountains in the extreme north-west of Chad.(1; 2; 3; 5; 10)

POPULATION It was once abundant in those parts of the desert where there was sufficient vegetation to support it. Lavauden's (1926) prediction that its disappearance from the northern Sahara was only a question of years appears to have been confirmed. The remoteness of its range makes its status difficult to assess and population surveys have not been made.(4; 6)

HABITAT Sandy dunes and mountainous areas of the Sahara Desert. A nomadic animal, it feeds on desert vegetation and needs little water.(6)

CONSERVATION MEASURES TAKEN None, except importation into the United States is prohibited, except for scientific, educational or propagation purposes, under the terms of the US Endangered Species Act, 1969. Included in Class A of the African Convention (1969) i.e. it may be hunted or collected only on the authorization of the highest competent authority, if required in the national interest or for scientific purposes.

CONSERVATION MEASURES PROPOSED Complete protection with necessary surveys, research and studies followed by management plans. Consideration should be given to the establishment of wildlife reserves for this species. Captive propagation offers excellent opportunities for translocation to ranges where the animal has been exterminated. This species, under proper management, could be a most important source of protein.(8; 9; 10)

REMARKS Not protected or represented in any reserve or national park. In 1971 a total of 12 specimens were in zoos in the USA and one specimen was in Tunis Zoo. (7)

REFERENCES
1. Blancou, L. (1960): Destruction and protection of the fauna of French Equatorial Africa and of French West Africa. Part II: The larger mammals. Afr. Wildlife 14: 10-108.
2. Dekeyser, P.J. (1955): Les mammifères de l'Afrique Noire Française. Dakar: IFAN, Institutions AFR.
3. Ellerman, J.R. & Morrison-Scott, T.C.S. (1951): Checklist of Palearctic and Indian Mammals, 1758-1946: London: British Museum (Nat. Hist.).
4. Flower, S.S. (1932): Notes on the recent mammals of Egypt, with a list of the species recorded from that kingdom Proc. zool. Soc. Lond. 1932: 369-450.
5. Harper, Francis (1945): Extinct and vanishing mammals of the Old World. Spec. Publ. Amer. Comm. Int. Wildlife Protection No. 12.

TORA HARTEBEEST

Alcelaphus buselaphus tora (Gray, 1873)

Order ARTIODACTYLA Family BOVIDAE

STATUS Endangered because of excessive hunting and habitat degradation. Believed to have been depleted by rinderpest epidemics in the 1890's.

DISTRIBUTION The north-western and eastern regions of Ethiopia, extending into the Blue Nile district of the eastern Sudan and into eastern regions of southern Egypt. Its former range was more extensive but in the same general area.(1; 2)

POPULATION Colonel A. Forbes estimated that there were no more than 200 to 300 heads in the Sudan in 1965. It is now found in very small herds along the eastern border of the Sudan. No figures are available for Ethiopia.(2)

HABITAT Found on thinly-vegetated plains, prefers open grasslands from elevations of 1,250 m to 2,000 m.(1)

CONSERVATION MEASURES TAKEN In Sudan may be hunted only by special licence. Believed to have been given complete protection in Ethiopia. Included in Class B of the African Convention (1969) i.e. it may be hunted or collected only under special authorisation granted by the competent authority.(1; 2)

CONSERVATION MEASURES PROPOSED Recommended for total protection under the new Ethiopian Wildlife Conservation Regulations. Surveys, investigations and research should be conducted as a basis for management plans. Captive propagation with subsequent translocation to areas of suitable habitat should be considered.

REMARKS Normally a single young is born after a gestation period of 214 to 242 days. Life span is 11 to 20 years. The former range of this animal was extensive; if it could be restored and placed under proper management it could be an important source of protein.

REFERENCES
1. Bolton, M. (1971): Last chance for Swayne's Hartebeest. Biol. Con. 3(2): 147-148.
2. Sidney, J. (1965): The past and present distribution of some African ungulates. Trans. zool. Soc. London 30: 1-397.

LEOPARD

Panthera pardus (Linnaeus, 1758)

Order CARNIVORA Family FELIDAE

STATUS Vulnerable. Exterminated from large parts of its former range and depleted elsewhere. In some areas persecution and loss of habitat have taken a severe toll; at least five geographic races are threatened with extinction. But it is still widespread and maintaining good numbers, even increasing when not persecuted.

DISTRIBUTION Africa, and most of southern Asia from Turkey across the USSR and China to Korea, southwards to Arabia, Sri Lanka and Java. Now very local and rare in the desert areas of northern Africa and the Middle East. Much the most widespread of the felids; it is still common where prey is plentiful and protection assured, but has declined significantly and sometimes critically in about half of Africa. Exterminated from large parts of its former range in southern Africa, eastern Africa (notably Somalia and Ethiopia), and certain sectors of West Africa (especially in the coastal states). Depleted elsewhere, notably parts of Kenya, northern Tanzania, western Zambia, Ngamiland in Botswana, parts of Angola and Mozambique, also Chad, Mali and Senegal, and parts of the coastal states of West Africa.

POPULATION The leopard has had to give way to the advance of agriculture, deforestation, and depletion of its prey. In areas taken over for agriculture and stock-raising it has been either exterminated or depleted; but it is still widespread and maintaining good numbers where it persists. During the 1960's leopards were relentlessly trapped to meet a worldwide demand for their furs, and some populations were severely reduced. Efforts were made to correct this situation in several countries, notably Tanzania, Zambia and Botswana, e.g. through national predator management policies. In parts of southern Africa, the leopard is still considered vermin.(3-10) In moderately favourable habitats of the Zaire basin rain forest, it maintains a density of one to five or even three sq.km, and in optimal habitats even one to every sq.km. In the miombo woodland zone poaching pressure has varied greatly, and in large areas density rises to one animal per five sq.km. Because of tsetse fly, and dry and infertile soils, the miombo biome will be little affected by human activities except for the 10-15 per cent which constitute alluvial floodplains or "dambo" drainage systems. In South Africa thick thornbush in the Kruger Park and an abundance of impala prey permit densities of two leopard to three sq.km, possibly higher, in a few optimal localities, with an estimated minimum of 650 animals occupying the Park's 1,817,000 ha.

HABITAT Leopards inhabit a variety of biomes, from tropical rain forest, miombo woodland, savanna and rocky areas with heavy or scattered vegetation to the high, cold regions of the Himalayas, and the suburbs of Nairobi. In general, they are still widely found in all biomes of Africa south of the Sahara except for outright desert. One important factor is cover, both for hunting and for lying-up to feed and rest. Human modification of savanna ecotypes tends to the removal of trees and bush, although the leopard has proved to be exceptionally resilient and tolerant of changes to its habitat.

CONSERVATION MEASURES TAKEN The leopard is widely protected as a game animal; where not protected, as in Nigeria, South Africa and Namibia, it is fully protected in parks and reserves. Where it is still not protected or where it preys on man's increasing herds of domestic stock it has been persecuted severely. International action has been necessary to curb the drain on protected populations from illegal trapping and smuggling through these same countries into the world trade channels. The International Fur Trade Federation imposed a three-year voluntary ban on its members' use of leopard skins, from September 1971 to September 1974, which operated moderately well in the United Kingdom, marginally well in the Federal Republic of Germany and Switzerland, and scarcely at all in France, Italy, Spain, Scandinavia and Japan. In 1973, the demand for leopard skins was higher than ever before. Demand is perhaps twice as high in the principal consumer countries as five years ago, except for Japan which bought hardly any spotted furs in the late 1960's but is now buying heavily. Included in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora, 1973; trade in these animals between acceding nations is subject to severe restriction, trade for primarily commercial purposes is banned.

CONSERVATION MEASURES PROPOSED The leopard should remain in Appendix I of the International Convention until the livestock industry in Africa and Asia is prepared to admit that the wildlife conservationists have an interest as legitimate as that of the ranching community. It should likewise be banned to the international fur trade until major producer and consumer countries indicate their readiness to accept controls to regulate a sustained-yield offtake. In Africa much severer penalties are required to deter poaching and preventive killing by livestock owners.

REFERENCES

1. Blake, I. (1966): A leopard in the wilderness of Judea. IUCN Bull. New Series 1(18): 7.
2. Chapuis, M. (1961): Evolution and protection of the wildlife of Morocco. Afr. Wildlife 15(2): 107-112.
3. Dupuy, A. (1967): Repartition actuelle des espèces menacées de l'Algérie. Bull. Soc. Sci. Nat. Phys. Maroc. 47(3-4): 355-386.
4. Ellerman, J.R. and Morrison-Scott, T.C.S. (1951): Checklist of Palaearctic and Indian mammals, 1758-1946. London: Brit. Mus. (Nat. Hist.).
5. Harrison, D.L. (1968): The large mammals in Arabia. Oryx 9(5): 357-363.
6. Kumerloeve, H. (1967): Zur Verbreitung kleinasiatischer Raubund Huftiere sowie einiger Grossnager. Säugetier. Mitt. 15(4): 337-409.
7. Myers, N. (1976): The leopard Panthera pardus in Africa. IUCN Monograph 5. Morges, Switzerland.
8. Nasimovich, A.A. (1970): Rare and endangered species of mammals and their protection in the USSR. Engl. Transl. Henry Field (ed.). Field Research Projects 16. Miami, Florida. 10 pp.
9. Sanborn, C.C. and Hoogstraal, H. (1953): Some mammals of Yemen and their ectoparasites. Fieldiana: Zool. 33(2): 89-158.
10. Vesey-Fitzgerald, D.F. (1952): Wildlife in Arabia. Oryx 1(5): 232-235.
11. Lehmann, E., von. (1965): Über die Säugetiere im Waldgebiet NW Syriens. Sber. Ges. naturf. Freunde Berlin, N.F. 5(1). 22-48.
12. Richter, W., von. (1972): Remarks on present distribution and abundance of some South African carnivores. J. Sn. Afri. Wildl. Magmt. Assn. 2(1): 9-16.

SCIMITAR-HORNED ORYX

Oryx dammah (Cretzschmar, 1826)

Order ARTIODACTYLA Family BOVIDAE

STATUS Vulnerable. Has declined from great abundance in the past to a level at which it is highly vulnerable. Uncontrolled slaughter combined with pressure from livestock and livestock development schemes are responsible. Reasonably abundant only in Chad.

DISTRIBUTION Formerly throughout the Sahelian zone north and south of the Sahara from Spanish Sahara, Mauretania and Senegal to the Red Sea, but no extending north of the Grand Atlas. Resident populations have now disappeared from Egypt, Libya, Algeria, Tunisia, Morocco, Upper Volta and possibly the Spanish Sahara and Sudan. Confined to Chad, Niger, Mali and with, possibly, a few in Mauretania and the Sudan.(1; 6; 9; 11; 13; 14)

POPULATION Egypt: Very unlikely that any still exist in Egypt, in spite of old reports of the possibility that some animals may migrate into the Gebel 'Uweinat from Sudan.(12) Sudan: If present, very rare and part of a population living between Chad and the Sudan.(4; 11) Chad: By far the largest populations in Africa. Estimated in 1975 to be around 5500 head.(9; 11) Niger: Still occur in the Termit and Ténéré areas (10) and possibly a few in the area east of the Vallée de l'Azaouak. Algeria: Oryx have been observed in the Ahaggar and near In Azoua but these are believed to be migrants from Adrar des Iforhas (Mali) and Aïr and Ténéré in Niger.(3) Mali: Probably still occur in the Tamezna and also west of the Adrar des Iforhas.(6) Upper Volta: Now thought to be extinct. (H. Baumer 1975, pers. comm.) Mauretania: Monod (1958) recorded two oryx northeast of Oualata in 1957. In 1959 the two oryx killed in the region of Tariazet may have been the last in the country. If any do still exist, the Nema-Oualata area is the most likely place of occurrence.(13) Spanish Sahara: The last reported oryx was a dead one found in 1963.(11)

HABITAT The semi-desert fringe of the Sahara, which has been subject to heavy grazing over the centuries, a factor believed by many to have led to an increase of the desert to its present size. At present, increased numbers of people and livestock and the absence of control over grazing is causing extensive desertification. The oryx is not adapted to desert and consequently has been adversely affected by destruction of suitable habitat. The rate of desertification has been estimated at 100,000 ha per year.(5)

CONSERVATION MEASURES TAKEN Hunting by nomads or visitors is virtually uncontrolled in most countries in which this species occurs. It receives little effective protection in most of Niger, Mali, Mauretania and Sudan. Although officially protected by law in Sudan it is still sought by big-game hunters. In Chad, a reserve, the Ouadi Rimé-Ouadi Achim, of 77,950 sq.km was established to protect this and other Sahelo-Saharan species. Included in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora, 1973; trade in these animals between acceding nations is subject to strict regulation and monitoring of its effects.

CONSERVATION MEASURES PROPOSED A survey to determine its current status and distribution is being made.(7) This should lead to the establishment of other well-policed reserves in areas where it is still reasonably common. Effective protection of the Ouadi Rimé-Ouadi Achim Reserve is top priority. Studies of its economic potential as a semi-domesticated species could further its survival. In the long-run its survival depends on survival of the Sahelian habitat and arresting the processes leading to desertification.

REMARKS Gillet (2) and Newby (1976, pers. comm.) have noted the possible occurrence of two distinctive groups of morphologically different oryx in Chad. Two types are also known traditionally from both Sudan and Niger.(15)

REFERENCES

1. Gillet, H. (1965): L'Oryx algazelle et l'Addax du Tchad. Terre et la Vie 112(3): 257-272.
2. Gillet, H. (1970): L'Oryx algazelle et l'Addax. Distribution géographique. Chances de survie. Comptes-rendus, Soc. Biogéog. 405.
3. Grenot, C. (1974): Ecologie appliquée à la conservation et à l'élevage des ongulés sauvages au Sahara Algérien. C.N.R.S., Paris.
4. Lamprey, H. (1975): Report on the Desert Encroachment Reconnaissance in northern Sudan. Report to IUCN and UNEP. Mimeo.
5. Houérou, H.N. Le (1968): La désertification du Sahara septentrional et des steppes limitrophes. Proc. IBP/CT Tech. Meeting Cons. Nat., Hammamet, Tunisia.
6. IUCN. (1976): Consultants meeting on addax and oryx. Morges, Switzerland. January, 1976. Mimeo.
7. IUCN/UNEP Project 1219/1975 B/I/89.1.
8. Monod, T. (1958): Majabat al Koubra. Mémoire, IFAN.
9. Newby, J. (1974): The Ecological Resources of the Ouadi Rimé-Ouadi Achim Faunal Reserve. FAO Rome.
10. Newby, J. (1975): The addax and scimitar-horned oryx in Niger. Report to IUCN. Mimeo.
11. Newby, J. (1975): The addax and the scimitar-horned oryx in Chad. Report to IUCN. Mimeo.
12. Talbot, L. (1960): A look at threatened species. Oryx 5: 153-291.
13. Trotignon, J. (1975): Le status et la conservation de l'Addax et de l'Oryx et de la faune associée en Mauretanie. Report to IUCN. Mimeo.
14. Valverde, J. (1968): Ecological bases for fauna conservation in western Sahara. Proc. IBP/CT Tech. Meeting Cons. Nat., Hammamet, Tunisia.

The original of this sheet was prepared, in January 1976, by John Newby, Parcs et Réserves, B.P. 905, N'Djamena, Tchad.

BLACK RHINOCEROS

Diceros bicornis (Linnaeus, 1758)

Order PERISSODACTYLA Family RHINOCEROTIDAE

STATUS AND SUMMARY Vulnerable. Distribution now very sporadic in its African savanna habitats. Population thought to be anywhere between 10,000 and 30,000 with the minimum figure perhaps the more realistic. Decline attributed to poaching for its horn and habitat loss. Protected by law and occurs in national parks and reserves, although protection is often inadequate. Main conservation need is an effective ban on trade in rhino horn and particularly on its importation to Asian countries.

DISTRIBUTION African savanna zone. Formerly widespread from South West Africa/Namibia and southwestern Cape Province north through Botswana, Rhodesia, Mozambique, Malawi, Zambia, Angola, Zaire, Tanzania, Uganda and Kenya to Somalia, Ethiopia and the Sudan, thence westwards to the Central African Empire, northern Cameroun and Chad; also in Nigeria and further west, but no longer. In general, the species is still to be found over most of the extensive area indicated, but has been locally exterminated, with the survivors scattered in remnant populations, mostly in parks and reserves. For detailed accounts of distribution see (2; 13; 17; 26).

POPULATION Not known with any precision but probably 10,000-30,000 and everywhere depleted. The following rough estimates have been made: South Africa: 450 (14; 28); South West Africa/Namibia: 100 (28) or 'approximately 150 with more than 80 per cent in Etosha National Park' (18); Rhodesia: 1000 (28); Zambia: a 1975 report indicated the species was 'holding its own' and still common in the Luangwa Valley, where a 1973 UN/FAO survey had arrived at an estimate of 12,000 and an absolute minimum of 4000 (3); Tanzania: in the low thousands (28), 8-9000 (23), conservative estimate of 12,000 (19); Kenya: 1977/78 estimate of only 1800 (6), compared with 4500 in 1976 and 11,000 in 1968 (20), Tsavo National Park figures falling from 6000 in 1968 to 2500 in 1976 (20); Uganda: low hundreds (28), rare and possibly endangered (8); Sudan: on the verge of extinction (4); Central African Empire: at least 1000 (26); Mozambique: rare (5), in the low hundreds (28); Angola: threatened (5), in the low hundreds (28), in 1972 only reports were of probably less than 40 in the Parque Nacional do Iona and a small population in the Cuando-Cubango controlled hunting areas (16); Somalia: in the tens (28); Rwanda: in the tens (28); Ethiopia: no confirmed sightings for at least five years although species may still survive in the proposed Omo National Park in Mago District (27); Cameroun: in the tens (28); Chad: about 25 (10); Zaire: possibly extinct, the Zairian National Institute for the Conservation of Nature having recently stated that none have been seen since 1954 (1); Malawi: threatened (5), in the tens (28); Botswana: rare (5), in the tens (28).

HABITAT AND ECOLOGY Transitional zone or ecotone between grassland and forest (24), preferably thick thorn bush or acacia scrub, but also more open country and occasionally evergreen forest (28). The black rhino is a browser and lives on a variety of bushes and shrubs, it is usually inactive during the heat of the day (13; 24). The only stable social unit is the mother-child association (24). A calf is produced by the female about every 2½-3½ years (24), the gestation period being approximately 15 months (9; 24).

THREATS TO SURVIVAL Poaching for its horn which is considered by many Asian peoples to have aphrodisiac properties. World demand for rhino horn has increased in the last few years and as a consequence the price has increased (15; 19). In Tanzania horn fetched U.S. $45 per kilo in 1977 and has risen to $250 in 1978 (15). From 1969-76, 11,900 rhino horns, representing approximately 8885 rhinos, were exported from Kenya (19; 20). Progressive deterioration and loss of habitat due to rapidly increasing human populations poses another grave threat to the rhino's future. In some areas e.g. Tsavo East National Park, habitat destruction by elephants, sometimes made worse by drought, has also been detrimental (8; 11).

CONSERVATION MEASURES TAKEN Listed in Appendix I of the 1973 Convention on International Trade in Endangered Species of Wild Fauna and Flora, trade in it or its products therefore being subject to strict regulation by ratifying nations, trade for primarily commercial purposes banned. Listed in Class B of the 1968 African Convention on the Conservation of Nature and Natural Resources, and as such may only be hunted or collected under special authorisation granted by the competent authority. Legally protected throughout its range and occurs in many national parks and reserves; but protection is often inadequate (28).

CONSERVATION MEASURES PROPOSED Effective protection against poaching. Control of trade in rhino horn. A ban on the import of rhino horn to Asian countries would be extremely beneficial to the species.

REMARKS For description of animal see (2; 7; 12; 13; 29). Groves lists 7 subspecies (12). In 1976, 74 males and 85 females were held in 70 zoo collections (41 bred in captivity) (22).

REFERENCES

1. American Embassy Kinshasa to US Department of State, 5 Nov. 1977.
2. Ansell, W.F.H. Part 14. Order Perissodactyla. In Meester, J. and Setzer, H.W. (eds) The Mammals of Africa. An Identification Manual. Smithsonian Institution Press, Washington, D.C.
3. Ansell, W.F.H. 1969 and 1975. Black Rhinoceros in Zambia. Oryx 10(3): 176-192 and 13(1): 83-84.
4. Blower, J. 1978, pers. comm.
5. Bothma, J. du P. 1975. Conservation Status of the Larger Mammals of Southern Africa. Biol. Conserv. 7: 87-95.
6. Dirschl, H.J., Mbugua, S.W. and Wetmore, S.P. 1978. Preliminary Results from an aerial census of livestock and wildlife of Kenya's Rangelands. Aerial Survey Technical Report Series No. 1. Kenya Rangeland Ecological Monitoring Unit. Ministry of Tourism and Wildlife, Kenya.
7. Dorst, J. and Dandelot, P. 1970. A Field Guide to the Larger Mammals of Africa. Collins, London.
8. East African Wildlife Society Scientific and Technical Committee. Report of the Working Group on the Distribution and Status of East African Mammals 1977. Phase I: Large Mammals.
9. Frame, G.W. 1971. The Black Rhinoceros. Animals 13: 692-699.
10. Grimwood, I.R. 1975, pers. comm.
11. Goddard, J. 1970. Age Criteria and Vital Statistics of a Black Rhinoceros Population. E. Afr. Wildl. J. 8: 105-121.

12. Groves, C.P. 1967. Geographic Variation in the Black Rhinoceros, Diceros bicornis (L. 1758). Z. Säugetierk. 32: 267-276.
13. Guggisberg, C.A.W. 1966. S.O.S. Rhino. A Survival Book, André Deutsch.
14. Hey, D. 1977, pers. comm.
15. Honey, M. 1978. Mounting threat to Tanzania's big game. New African March: 33-34.
16. Huntley, B.J. 1972. An Interim Report on the Status of Red Data Book Species in Angola. Mimeo.
17. Joubert, E. 1971. The Past and Present Distribution and Status of the Black Rhinoceros (Diceros bicornis Linn. 1758) in South West Africa. Madoqua 1(4): 33-43.
18. Joubert, E. and Mostert, P.K.N. 1975. Distribution patterns and status of some mammals in South West Africa. Madoqua 9(1): 5-44.
19. Martin, D. 1978. Threat to the rhino. The Observer 9 April, p.7.
20. Monks, E. 1977. Now Rhino is on the way out in Kenya. Africana 6(7): 21.
21. Monks, E. 1978, pers. comm.
22. Olney, P.J.S. (ed.) 1977. International Zoo Yearbook 17. Zoological Soc. of London.
23. Rodgers, A. 1978, pers. comm.
24. Schenkel, R. and Schenkel-Hulliger, L. 1969. Ecology and Behaviour of the Black Rhinoceros (Diceros bicornis L.) Verlag Paul Parey, Hamburg and Berlin.
25. Sidney, J. 1965. The past and present distribution of some African ungulates. Trans. Zool. Soc. London 30.
26. Spinage, C.A. 1977, pers. comm.
27. Stephenson, J.A. 1977, pers. comm.
28. Vincent, J. 1977, pers. comm.
29. Walker, E.P. 1975. Mammals of the World. The Johns Hopkins University Press, Baltimore and London.

NORTHERN SQUARE-LIPPED RHINOCEROS

Ceratotherium simum cottoni (Lydekker, 1908)

Order PERISSODACTYLA Family RHINOCEROTIDAE

STATUS AND SUMMARY Endangered. Sporadic distribution in S.W. Sudan, N. Uganda, N.E. Zaire and possibly the Central African Empire. May total as few as 500 and certainly less that 1000, of which 400 are in the Garamba National Park, Zaire. Endangered by poaching for its horn and disturbance by military operations. Effective ban on trade in rhino horn needed, particularly on import to Asian countries.

DISTRIBUTION Africa. Formerly ranged from southeastern Sudan between 4° and 13° N. to southeastern Chad and south through the eastern Central African Empire to northeastern Zaire and northwestern Uganda (1; 11; 14). Now has an extremely sporadic distribution within this range, still occurring in southwestern Sudan west of the White Nile; in Uganda in the Ajai Game Reserve and Kabalega National Park (where it has been introduced); in Zaire in the Garamba National Park (1; 3; 6; 13; 14); and perhaps in the east of the C.A.E. (12).

POPULATION Possibly as few as 500 and almost certainly less than 1000. Zaire: a 1976 FAO survey of Garamba National Park estimated over 400 rhinos and from the large number of calves concluded that the population was healthy and expanding (10). A 1960 estimate for the park was 1000, but numbers declined greatly in the 1960s following incursions into the park by rebels from the Sudan (3; 10). Uganda: about 100 (14). Central African Empire: numbers unknown (12). Sudan: numbers unknown (14); none left in the Nimule National Park which was formerly one of its main strongholds. However, a viable population persists in the Shambe Reserve and adjoining areas south of the Sudd (2). Chad: extinct (1; 14).

HABITAT AND ECOLOGY Grasslands, whether in open acacia woodland or surrounding open country (14). A grazer, feeding almost entirely on grass. Usually rests in the shade in the heat of the day (6; 11; 15). Social system based on a very clearly delineated mosaic of adult male territories (8; 9). Gestation period about 16 months, calving normally occurring about every 2½-3 years (9).

THREATS TO SURVIVAL Poaching for its horn which in Asian countries is considered to have aphrodisiac properties. Disturbances arising from military operations (3; 11; 14).

CONSERVATION MEASURES TAKEN The Northern Square-lipped rhinoceros is listed in Appendix I of the 1973 Convention on International Trade in Endangered Species of Wild Fauna and Flora, trade in it or its products therefore being subject to strict regulation by ratifying nations and trade for primarily commercial purposes banned. Also listed in Class B of the 1968 African Convention on the Conservation of Nature and Natural Resources, which provides that it may be hunted or collected only under special authorization by the competent authority. Legally protected but enforcement has in the past often been handicapped or prevented by civil disturbances. Occurs in the Garamba National Park in Zaire, the Ajai Game Reserve and Kabalega National Park in Uganda, and the Shambe Reserve in the Sudan.

CONSERVATION MEASURES PROPOSED Effective ban on trade in rhino horn, which would be greatly facilitated if the import of rhino horn into Asian countries was prohibited. Increased protection in national parks and reserves. More precise information is needed on distribution and numbers if conservation and management are to be properly planned and implemented.

REMARKS For description of species see (1; 5; 6; 11; 15). In 1976, 4 males and 6 females of the northern subspecies were held in 4 zoo collections (7). The nominate C. s. simum, of southern Africa, which is the only other subspecies, was nearly exterminated shortly after the end of the 19th century, except in Zululand. However, as a result of good conservation its numbers have increased so greatly that it has now been widely reintroduced to areas of its former range (1; 4; 11; 14) and is also numerous in zoo collections. This data sheet was compiled with the assistance of Colonel J. Vincent, former Chairman of the IUCN/SSC African Rhino Group.

REFERENCES

1. Ansell, W.F.H. 1971. Part 14. Order Perissodactyla. In Meester, J. and Setzer, H.W. (eds). The Mammals of Africa. An Identification Manual. Smithsonian Institution Press, Washington, D.C.
2. Blower, J. 1978, pers. comm.
3. Curry-Lindahl, K. 1977. War and the White Rhinos. Oryx 11(4): 263-267.
4. Dolan, J.M. 1971. Southern White Rhinoceros. ZooNooz Vol. XLIV (5): 13-18.
5. Dorst, J. and Dandelot, P. 1970. A Field Guide to the Larger Mammals of Africa. Collins, London.
6. Guggisberg, C.A.W. 1966. S.O.S. Rhino. A Survival Book, Andre Deutsch.
7. Olney, P.J.S. (ed.) 1977. International Zoo Yearbook 17. Zoological Society of London.
8. Owen-Smith, N. 1971. Territoriality in the White Rhinoceros (Ceratotherium simum Burchell). Nature 231: 294-296.
9. Owen-Smith, N. 1972. Territoriality: the example of the White Rhinoceros. Zoologica Africana 7(1): 273-280.
10. Savidge, J.M., Woodford, M.H. and Croze, H. 1976. Report on a mission to Zaire April 3rd to 10th, 1976. FAO Mimeo.
11. Sidney, J. 1965. The past and present distribution of some African ungulates. Trans. Zool. Soc. London Vol. 30: 51-61.
12. Spinage, C.A. 1977, pers. comm.
13. Verschuren, J. 1975. Wildlife in Zaire. Oryx 13(1): 25-33.
14. Vincent, J. 1977, pers. comm.
15. Walker, E.P. 1975. Mammals of the World. The Johns Hopkins University Press, Baltimore and London.

NILE CROCODILE

Crocodylus niloticus Laurenti, 1768

Order CROCODYLIA Family CROCODYLIDAE

STATUS Vulnerable. Numbers have been drastically reduced almost everywhere, largely during the last 20 years to supply leather to meet a world wide demand.

DISTRIBUTION All of Africa except the northwest and central Sahara; also Malagasy Republic but probably few in the Comores. Formerly along the south coast of the Mediterranean and east to Syria; also in the Seychelles. Now extinct in Cape Province and rare in Natal south of Tugela river, South Africa.

POPULATION Destruction of habitat, e.g. damming of rivers, draining of swamps and lakes, and other human pressures, militate against any rehabilitation of the species. All reports agree that populations can only be restored by stringent conservation measures. The total adult population in Natal is considered to be fewer than 800 animals.

HABITAT Large rivers and lakes, fresh water marshes, river mouths and estuaries, rarely in mangrove swamps.

BREEDING RATE IN WILD Extensive literature, not yet reviewed.

CONSERVATION MEASURES TAKEN In Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora. Protected under class "B" by the African Conservation Convention of 1968. Protected in Uganda. However, in many African States the Nile Crocodile still has no legal protection, although it is legally protected in most National Parks and Game Reserves. Importation into the United States is prohibited under provision of the Endangered Species Act. South Africa has set up a research programme aimed at saving the species and restocking in areas where it has been exterminated.

CONSERVATION MEASURES PROPOSED Enforced protective legislation should be in operation throughout the entire geographical range. The collecting of crocodiles and their eggs should be controlled. State Game Departments should assume responsibility for controlling crocodile rearing and restocking projects. The IUCN Survival Service Commission, through its Crocodile Specialists Group, offers advice to interested Government agencies for such projects.

NUMBERS IN CAPTIVITY Still to be reviewed.

BREEDING POTENTIAL IN CAPTIVITY Rearing of Nile Crocodiles under controlled conditions has been shown to be quite feasible.

REFERENCES
1. King, F.W. and Brazaitis, P. (1971). Species identification of Commercial Crocodilian Skins. Zoologica 56(2): 15-70. New York.
2. Cott, H.B. and Pooley, A.C. (1972). The Status of Crocodiles in Africa. IUCN Publ. N.S. Suppl. Paper 33: 97 pp.

AFRICAN WILD DOG

Lycaon pictus (Temminck, 1820)

Order CARNIVORA Family CANIDAE

STATUS Depleted throughout its range. Vulnerable to continued persecution, shrinkage of range and reduction in numbers of natural prey.

DISTRIBUTION Throughout the savanna regions of Africa south of the Sahara, but now restricted to non-farming areas, west as far as the Ivory Coast and eastern border of Guinea then north to Mali, Niger and the southern parts of Algeria.(3)

POPULATION Depleted throughout its range. An IUCN survey in 1971 revealed a fair number outside the nature reserves in South Africa, about 140 in Kruger National Park, but none in Natal, the Orange Free State and most of the Cape Province; absent from the northern part of Namibia and depleted elsewhere; widely spread in Botswana, common in their national parks and outside; persisting only in game reserves in Rhodesia; good populations within the protected areas of Zambia but controlled outside owing to predation on the domestic animals of the increasing human population; rare in Tanzania even in national parks. Uncommon in the Ouadi Rimé-Ouadi Achim faunal reserve in Chad.(4; J.E. Newby 1976, pers. comm.)

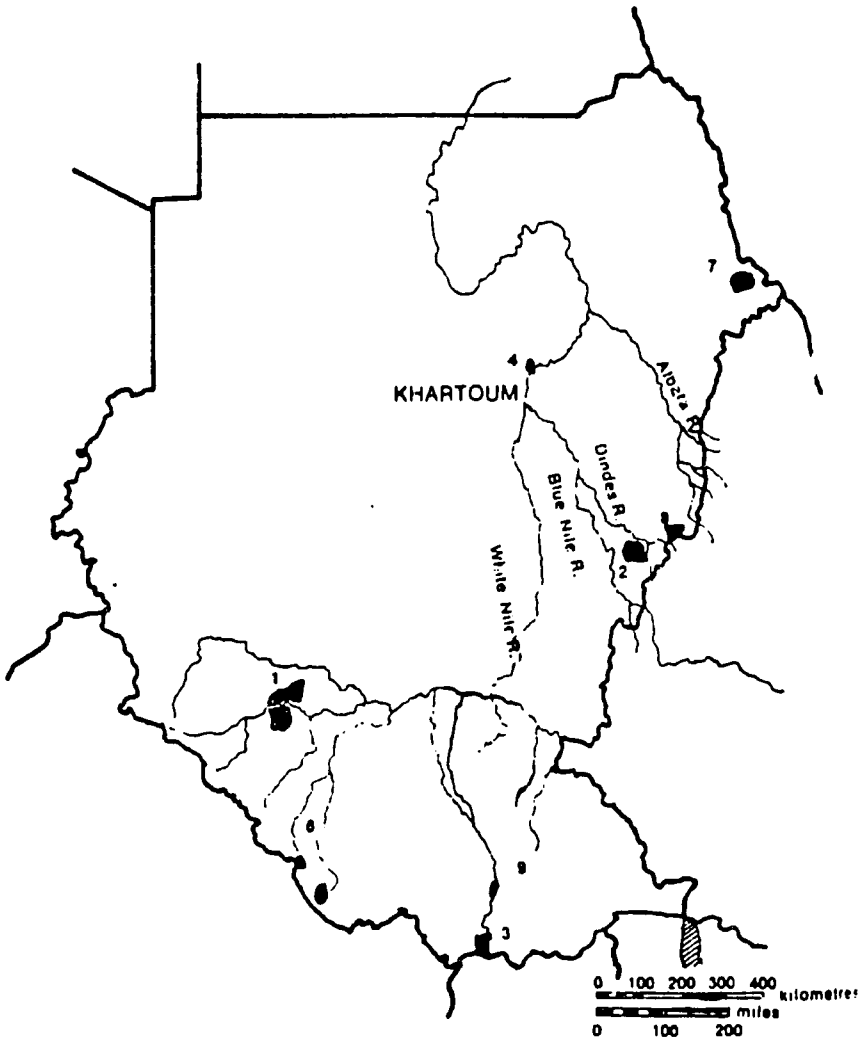
HABITAT Open or wooded savanna. Have been observed at the summit of Mt. Kilimanjaro and on Mt. Kenya above 2700 m.(2)

CONSERVATION MEASURES TAKEN They are relatively free from persecution in the large national parks and game reserves of most African states, but prejudice against them as killers still persists, and they are still sometimes killed in protected areas. They have full legal protection in Ethiopia, but enforcement is difficult owing to lack of conservation staff and problems of poor communications in remote areas.(1)

CONSERVATION MEASURES PROPOSED They should be given full protection of the law; control measures should be carefully supervised and eased wherever possible.

REMARKS They are primarily diurnal and hunt in packs of 6 to 20 - sometimes up to 40 in number. They are commonly regarded as harmful to game and domestic stock, but they play an important role in the balance of their environment.

REFERENCES
1. Bolton, M. (in press): Notes on the current status and distribution of some large mammals in Ethiopia.
2. Dorst, J., and Dandelot, P. (1970): A field guide to the larger mammals of Africa. Collins, London.
3. Meester, J., and Setzer, H.W. (1971): The mammals of Africa: an identification manual. Smithsonian Institution Press, Washington D.C.
4. Richter, W. von (1972): Remarks on present distribution and abundance of some South African carnivores. J. Sn. Afr. Wildl. Mgmt. Assoc. 2 (1): 9-16.



1. Southern National Park.
2. Dinder National Park.
3. Nimule National Park.
4. Sabaloka Game Reserve.
5. Mbarizunga Game Reserve.
6. Bire Kpatua Game Reserve.
7. Tokar Game Reserve.
8. Rahad Game Reserve.
9. Mongalla Game Reserve.

Figure 1. Protected Areas Listed by IUCN (1971)

Source: IUCN. 1971.

Table 3. National Park and Game Reserves Information

General Introduction :

The legal basis of the Parks and Reserves of the Sudan is provided by the Preservation of Wild Animals Ordinance and Regulations, 1935 and the National Parks, Sanctuaries and Reserves Regulations 1939 L.R.O. No. 23.

In addition to the three National Parks, some fifteen game reserves in all play an important part in assuring the protection of the country's wildlife assets, which include many interesting and some very rare species. With the concurrence of the authorities in Khartoum, a perhaps somewhat arbitrary choice has had to be made of the six of these for inclusion in the List, as generally satisfying the criteria of effective management laid down by the I.C.N.P. It has nevertheless been deemed appropriate to give a fair amount of detail about the nine other Reserves, when listing them in Section V.

Administration : responsibility of the Ministry of Animal Resources (Game and Fisheries). It is noted with regret that at the time when basic work on the present edition of the List was approaching completion (January 1966) political troubles were hampering effective administration of the five areas situated in the southern Provinces, namely Nos. 1, 3, 5, 6 and 9 on the List.

Land tenure : all the land is State-owned.

Research : largely sponsored by the University of Khartoum; in 1962, the protected areas were visited by a qualified ecologist.

1. SOUTHERN NATIONAL PARK.

a) Status : total protection; a generally uninhabited area, but occasionally at the beginning of the rains a few nomadic herdsmen with their stock find their way into the Park; no cultivation.

b) Area : 1,600,000 ha.

c) Staff : 15 units, which is far below the criterion requirement. But the Park deserves a place in the List in the light of the total absence of permanent inhabitants and the known intention of the Government to reinforce the staff (60 men have been requested), as soon as the political troubles of the region permit.

d) Budget : U.S. $ 12,000 (as against a criterion requirement of $ 80,000, but the same consideration as above apply). The actual allowance for staff salaries is $ 6,000, compared with $ 20,000 for the Dinder and $ 6,000 for the Nimule National Parks, but a further provision of about $ 28,000 under 4 budgetary heads is made available for the general running of the three Parks.

Date established : 1939.

Tourism : when political conditions allow, a great deal will have to be done to attract and welcome tourists to this remote area, where roads and hotel accommodation are scarce. The intention is to develop such facilities as soon as those for the Dinder National Park are completed.

Altitude : 600 m.

a) Fairly flat country, covered by bush and with some gallery forest.

b) Elephant *Loxodonta africana*, white rhinoceros *Ceratotherium simum*, giraffe *Giraffa camelopardalis*, giant eland *Taurotragus derbianus*, hartebeest *Alcelaphus buselaphus*, kob *Kobus kob*, roan antelope *Hippotragus equinus*, hippopotamus *H. amphibius*, giant forest hog *Hylochoerus meinertzhageni*, leopard and lion *Panthera pardus* and *leo*, colobus monkey *Colobus polykomos*, crocodile *Crocodylus niloticus*.

c) White rhinoceros.

2. DINDER NATIONAL PARK

a) Status: total protection; exploitation of gum arabic is allowed in the western sector, but under strict control; measures to suppress poaching have been taken, but the biggest threat to the area stems from an agricultural development programme which was being put into effect in January 1966, and involves an irrigation canal liable to cut an important annual migration route of various wild ungulates, which are already slaughtered in large numbers when they venture outside the Park.

b) Area: 650,000 ha.

c) Staff: 42 units, including a game warden and assistant game warden; it was intended to raise the staff to 70 units as soon as possible.

d) Budget: about U.S. $ 35,000 (criterion requirement $ 32,500).

Date established: 1935.

Tourism: a motor road crosses the Park from north-west to south-east and a dozen branch roads lead to the good game areas; a rest-camp with 50 beds at Galegu in the west of the Park, and three other camps; look-out posts (hides); an airstrip is planned (1965).

Altitude: 700-800 m.

a) *Acacia seyal/Balanites aegyptiaca* thornbush savannah in the north, and *Combretum hartmannianum* woodland in the south; clayey flood plain of the Dinder and Rahad rivers, with dom palm *Hyphaene thebaica* or gallery forest of *Acacia sieberiana*, *Tamarindus indica* and *Ficus* spp. along the banks and swampy areas (reeds, *Nymphaea* spp. and *Ipomoea* spp.).

b) Giraffe, hartebeest, reedbuck *Redunca arundinum*, roan antelope, bushbuck *Tragelaphus scriptus*, oribi *Ourebia oribi*, waterbuck *Kobus ellipsiprymnus*, greater kudu *Tragelaphus strepsiceros*, several species of gazelle, dik-dik *Madoqua* sp.; buffalo *Syncerus caffer*; lion; ostrich *Struthio camelus*. Black rhinoceros *Diceros bicornis*, leopard, cheetah *Acinonyx jubatus*, elephant (during rains), hyaenas *H. hyaena* and *C. crocuta* and jackal *Canis mesomelas* also recorded.

c) Black rhinoceros (?).

3. NIMULE NATIONAL PARK.

a) Status: full protection, entry by permit only; there are no inhabitants or domestic livestock; a little fishing is allowed in the Fula Rapids; the Park is of course in an areas which is at present in a disturbed state politically.

b) Area: 25,600 ha.

c) Staff: 10 units, including a game ranger, responsible to the Senior Inspector of Game Preservation at Juba; this more than satisfies the criterion but, due to the proximity of the Uganda frontier, the area needs close supervision.

d) Budget: U.S. $ 12,000 (criterion $ 1,250).

Date established: 1954, previously a Reserve since 1946.

Tourism: not yet developed, but this Park could be a great attraction as the animals are not shy; easy access could be provided from Uganda by railway and river steamer to Nimule and there is a ferry across the Nile.

Altitude: 500-800 m.

a) Plains bordering the Nile, with the Illingua mountain chain on the west cut by "khors" or valleys, through which small streams flow; Fula Rapids bush and savannah with a sprinkling of *Tamarindus indica*.

b) White rhinoceros, elephant, buffalo, waterbuck, reedbuck, hartebeest, oribi, kob, hippopotamus, warthog *Phacochoerus aethiopicus*.

c) White rhinoceros.

4. SABALOKA GAME RESERVE.

a) Status : full protection of fauna and flora, though there is a very small human population on the western border and a narrow strip of cultivation along the Nile; also some risk of poaching because of the proximity of Khartoum.

b) Area : 115,000 ha.

c) Staff : only two guards, but frequent assistance given by a neighbouring Game Warden and his 5 scouts.

d) Budget : no details, but criterion should be covered by staff salaries and allowances.

Date established : 1939.

Tourism : no special organisation but a number of visitors come from Khartoum.

Altitude : 800 m.

a) Rolling hilly country for the most part, on the left bank of the Nile: valleys with scattered *Acacia* bush and *Panicum turgidum* grassland; suitable habitat and an assured water supply in the nearby river for the wild sheep and ibex which the Reserve is specially designed to protect.

b) Aoudad or Barbary sheep *Ammotragus lervia*, ibex *Capra ibex* (reintroduced in 1948, after having vanished at the end of the last War).

5. MBARIZUNGA GAME RESERVE.

a) Status : protection of fauna and flora; uninhabited region, with no poaching, but situated in the zone which is unfortunately at present in a disturbed state.

b) Area : 15,000 ha.

c) Staff : one game guard under the supervision of the Game Preservation Officer at Yambio and assisted by Forest Department staff.

d) Budget : provision for salaries covers criterion.

Date established : 1939.

Tourism : not yet developed.

Altitude : 800 m.

a) A rather flat area, though near the Congo-Nile watershed; woodland derived from equatorial rain forest; gallery forest; papyrus.

b) Bongo *Taurotragus eurycerus*, yellow-backed duiker *Cephalophus silvicultor*, giant forest hog, chimpanzee, colobus monkey.

6. BIRE KPATUA GAME RESERVE.

a) Status : protection of flora and fauna; no human occupancy; the Reserve is in the presently disturbed zone.

b) Area : 12,500 ha.

c) Staff : 2 game guards.

d) Budget : provision for salaries covers criterion.

Date established : 1939.

Altitude : 800 m.

a) Like No. 5 above is fairly flat country, though near the Congo-Nile watershed; rain forest with dense undergrowth.

b) Bongo (it is of interest that this animal is left alone by the local Zande people, who believe it carries leprosy !); yellow-backed duiker, elephant, buffalo.

7. TOKAR GAME RESERVE.

a) Status: total protection of flora and fauna, but a few people live in the area, which is free from political troubles and not far from the Red Sea; used for grazing domestic camels.

b) Area: about 12,500 ha, but another contradictory report gives the much larger figure of 650,000 ha.

c) Staff: a Game Officer and five game scouts are stationed not far away at Sinkat and devote more than half their time to this Reserve.

d) Budget: salary provision covers criterion.

Date established: 1939.

Altitude: 200 m.

a) Desert salt-marsh area near the Red Sea, including the periodically flooded Tokar delta, with some *Acacia tortilis* scrub and part of the less arid Karora hills with relicts of dense *Olea* sp., *Juniperus procera* and many interesting plants.

b) Ibex, a few gazelles including *Gazella rufifrons* and *G. soemmeringi*, roan antelope, greater kudu, leopard.

8. RAHAD GAME RESERVE.

a) Status: total protection; an uninhabited region adjacent to the Dinder National Park and near the Ethiopian frontier.

b) Area: about 12,500 ha, but again there are contradictory reports giving a much larger figure.

c) Staff: benefits from the proximity of the Dinder National Park and the fact that a Game Officer and five game scouts are based not far away and devote about 3 weeks per month to supervising this Reserve.

d) Budget: salary provision covers criterion.

Date established: 1939.

Tourism: a few people come to this Reserve when they are visiting the Dinder National Park.

Altitude: 700 m.

a) Savannah; *Terminalia laxiflora, Sclerocarya birrea, Combretum harmannianum.*

b) Giraffe, hartebeest, reedbuck, oribi, ibex, roan antelope, bushbuck, Soemmering's gazelle, waterbuck, greater kudu, lion; ostrich. Black rhinoceros also reported.

c) Black rhinoceros (?).

9. MONGALLA GAME RESERVE.

a) Status: free from human occupancy and exploitation, although situated in a strip of country 40 km long and 2 km wide between the Juba-Mongalla road and the Nile; the only disturbance comes from footpaths leading from villages on the other side of the road down to the river, but the Reserve is of course in the zone which is at present politically troubled and extensive seasonal poaching has been reported.

b) Area: 7,500 ha.

c) Staff: one Game Scout and two game guards responsible to the Game Protection Officer at Juba.

d) Budget: salaries of staff would cover criterion.

Date established: 1939.

Altitude: 500 m.

a) The Nile riverine plain; well-scattered large trees, including dom palm *Hyphaene*, with no undergrowth, open grasslands in seasonally flooded areas, no obstruction to game-viewing; a favourite watering-place for wild animals during the dry season.

b) Elephant, buffalo, black rhinoceros; giraffe, zebra *Equus burchelli böhmi*, eland *Taurotragus oryx*, roan antelope, kob, reedbuck, waterbuck, bushbuck, lion, leopard, cheetah, hyaena; ostrich.

c) Black rhinoceros.

Areas excluded :

As indicated in the General Introduction, it is probable that some of the nine Reserves detailed below deserve to be in the List as much as some of the six chosen, but the reasons for their exclusion are briefly mentioned.

1. Zeraf Game Reserve (1939).

675,000 ha; no permanent staff, but an annual patrol is undertaken by the Senior Game Officer at Malakal; designed for the protection of the Nile lechwe *Kobus megaceros* population between the Bahr el Jebel and Bahr el Zeraf and of the sitatunga *Tragelaphus spekei*.

2. Numatina Game Reserve (1939).

250,000 ha, but only 2 wardens; lies to the north-west of the Southern National Park and has a similarly good selection of large animals.

3. Bengaigai Game Reserve (1939).

150,000 ha, but only 2 wardens; thick forest with fauna similar to that of No. 6 Bire Kpatua, e.g. bongo.

4. Buma Game Reserve (1960).

135,000 ha, but only 2 wardens; a mountainous area on the Ethiopian frontier, north-west of Lake Rudolf, with exceptional concentrations of game animals tending to migrate into Ethiopia; there is a village on the plateau and grazing of domestic livestock; inaccessible by road during nine months of the year.

5. Shambe Game Reserve (1935).

100,000 ha, but only 2 wardens; near Lake Shambe, papyrus marshlands with some *Hyparrhenia/Setaria* grassland and savannah woodland; habitat of the Nile lechwe (now scarce); other large animals including a few black rhinoceros, giraffe, elephant, buffalo, etc.

6. Badigeru or Bandingilu Game Reserve (1935).

50,000 ha, but only one warden; marshland near the Nile, with poor *Acacia seyal* thorn savannah; situated north of the Mbarizunga Reserve, No. 4, and south of Bor; black rhinoceros, elephant, giraffe, buffalo, zebra, eland and lion.

7. Juba Game Reserve (1939).

30,000 ha. but lacking proper supervision except for visits of inspection from the Juba headquarters of the Game Department (Southern Region); remnants of deciduous woodland bordering the Nile, now mainly grassland with many water channels; also many villages in the Reserve; white rhinoceros, elephant, buffalo.

8. Ashana Game Reserve (1939).

30,000 ha, two guards, but the Dinka tribesmen use the Reserve to pasture their cattle; grassy plains, with some gallery forest and woodland savannah; designed specially for the protection of the giant eland.

9. Fanyikang Game Reserve (1939).

13,000 ha, but without proper supervision; situated on an island in the Nile sudd region, a little to the east of Lake No; lechwe, sitatunga.

Appendix VIII

Sudan Sections in:

Environmental Policies

in

Developing Countries

Source: Johnson and Johnson. 1977.

I. ENVIRONMENTAL POLICY IN GENERAL

A. PROBLEMS

Insufficient international cooperation.

B. POLICY

Sudan's evaluation is that pollution and nuisance usually viewed as problems of the highly developed nations are really a gauge of the difference between the generation of those problems and the measure taken for their control; control cost money which the less developed countries do not have.[1]

C. LEGISLATION

D. ADMINISTRATION

II. USE OF NATURAL RESOURCES AND ENVIRONMENTAL CONSERVATION

A. AIR

A. PROBLEMS

1. Dust storms in the hottest seasons create pollution which damages health of all living things, and goods and property; also creates transportation problems through lowering of visibility and increases brake failure and skidding.[1]
2. Pollution created by fires and grass burning for agricultural purposes.[1]

B. POLICY

C. LEGISLATION

The Road Traffic Act 1962.

D. ADMINISTRATION

2. FRESH WATER

A. PROBLEMS

1. Inadequate water management, insufficient international cooperation to solve this problem.[1]
2. Serious pollution of the Nile River. White Nile is infested with water hyacinth *Eichhorn crassipes*. Results in obstruction of pumps, canals hydro electric plants; reduction of fish resources which is particularly unfortunate in the areas where this is the main source of food; creation of favourable conditions for mosquitos, simulids, crocodiles and poisonous snakes. In addition, much water is lost by evapotranspiration and it may spread to the neighbouring countries.[1]
3. High River siltation rate, resulting in reduction of effective storage capacity of dams and the fertility of land downstream.[1]

B. POLICY

The National "Freedom from Thirst" campaign was held conducted in 1972 mainly for the promotion and improvement of water management.[1]

C. LEGISLATION

1. *The Water Hyacinth Act 1960. (Amended 1967, 1969)* controls and prevents the spread of water hyacinth in rivers and waterways. Provides for declaration of infested areas, establishment of control posts etc.
2. Various legislation related to the Nile Pumps Control (Acts, regulations, amendments between 1961 and 1968). Concerned mainly with the practice of good husbandry and effective use of water.
3. *The Nile Water Use Control (Tenancies) Regulations 1969.*
4. *The Electricity and Water Supply Act, 1960, The Central Electricity and Water Corporation Act, 1966.*

D. ADMINISTRATION

1. Ministry of Irrigation and Hydro-Electricity.
2. Land Use and Rural Water Development Board.

3. SEA WATER

A. PROBLEMS

B. POLICY

C. LEGISLATION

D. ADMINISTRATION

4. SOIL

A. PROBLEMS

1. Erosion and denudation caused by goats and improper application of restrictive measures.
2. Salination of soil will become a problem because of the increasing use of fertilizers.
3. Sheet erosion and gullying dute to resettlement of mountain dwelling tribes on roads and hillsides

4. Erosion of forest soils due to the extreme climatic conditions, fires, and the forest clearance undertaken in efforts to eradicate the tsetse fly.

B. POLICY

C. LEGISLATION

1. The Agreement for the establishment of Arab Center for the studies of Dry and Barren Land (Ratification) Act, 1970. Includes study and classification of soil.
2. *The Unregistered Land Act, 1970 (Amended 1971).* All unregistered land is government property.
3. *The Agreement for establishing the Arab Agricultural Development Organization (Ratification), Act 1971.* Concerned with preservation of natural resources.

D. ADMINISTRATION

1. Ministry of Irrigation and Hydro Electricity.
2. Land Use and Rural Water Development Board.

5. FAUNA (INCL. FISHERIES)

A. PROBLEMS

1. Changes in Natural Habitat have reduced the population of wild animals. The increase in large mechanical agricultural schemes is an example of this.
2. Despite legal protection, some species of wild animals are in danger of extinction because of illegal hunting and collection. The Sommering gazelle is an example of this.[1]
3. Commercial hunting accounts for much loss of wildlife. The commercial exploitation of leopards has resulted in an explosion in the Baboon population which has been very distructive to crops and domestic stock. The ostrich is vanishing although it is an efficient breeder, "1,000 are killed annually for their feathers, which is used in Sudanese army uniform hats and for feather work" Unregulated trade in crocodile skins accounts for the disappearance of the crocodile from the Nile waters.[2]
4. Lack of Wildlife development for game cropping. In many instances domestic animals prove by comparison, to be less practical, lacking in protein, more damaging to vegetation and soil, and giving slower financial returns.[2]
6. Insufficient staff for control operations including for example, the collection of elephant tusks for auction

B. POLICY

1. There are serious attempts of protection of the varied and in some cases rare species of wildlife.
2. Three National Parks, fifteen Game Reserves and fifteen Game Sanctuaries have been established
3. Much research is undertaken on the study of wildlife.

C. LEGISLATION

1. *Game Preservation Ordinance, 1935,* based on London Convention 1933. This became inadequate in practice because of the large numbers of arms in existence.
2. *National Parks, Sanctuaries and Reserves Regulations, 1939.*

D. ADMINISTRATION

1. Ministry of Natural Resources and Rural Development.
2. Game and Fisheries Department.
3. Ministry of Animal Production; Game and Fisheries Department.
4. University of Khartoum, Department of Zoology.

6. FLORA (INCL. FORESTS)

A. PROBLEMS

1. Plant succession and ecology of the plains have been greatly disturbed by the absence of grazing by the almost extinct herds of the Soemmering Gazelle, among others.[1]
2. Constant retreat of the forest line due to shifting cultivation and overstocking of domestic animals around scarce water points.[1]
3. See Sec. II (4) A.

B. POLICY

1. It is intended to designate 6% of the country as forest reserve; up to now only 0.5% or 3 million feddans have been designated. Indigenous tree species are favoured wherever possible in afforestation and reforestation program.[1]
2. Cutting is concentrated and controlled in central and provincial forest reserves so as to facilitate immediate restocking and reduce tree clearance in other lands.[1]
3. Recent establishment of a forest research and education institute by the government in cooperation with the U.N. Special Fund.

C. LEGISLATION

D. ADMINISTRATION

1. Ministry of Natural Resources and Rural Development.
2. The Sudanese Graduate Foresters Association.

7. NON-RENEWABLE RESOURCES

A. PROBLEMS

B. POLICY

C. LEGISLATION

D. ADMINISTRATION

8. REGULATION OF NOISE

A. PROBLEMS

Noise population in the urban centers.[1]

B. POLICY

C. LEGISLATION

The Road Traffic Ordinance, 1941. An Ordinance to provide for the licencing, taxation and control of road traffic. Includes regulations regarding the use of silencers while in towns and villages.

D. ADMINISTRATION

9. SOLID WASTE DISPOSAL

A. PROBLEMS

Inadequate facilities for sewage disposal; "the bulk obstructs roadways and blocks drainage ditches, prevents plant growth which would otherwise stabilize the soil and has a depressing effect on the visual environment.[1]

B. POLICY

C. LEGISLATION

D. ADMINISTRATION

10. HAZARDOUS SUBSTANCES

A. PROBLEMS

1. Atomic energy and radioactive materials are used in medical application, the condition of equipment and protection devices is inadequate.[1]
2. Increasing use of fertilizers has caused corrosion of powerline towers. Included in these fertilizers are ammonium sulphate and urea.[1]
3. The use of herbicides to control water hyacinth is a constant threat to crops on irrigated land, especially cotton.[1]

B. POLICY

C. LEGISLATION

D. ADMINISTRATION

III. ENVIRONMENTAL PLANNING

1. LAND USE PLANNING

A. PROBLEMS

Insufficient development projects.[1]

B. POLICY

C. LEGISLATION

D. ADMINISTRATION

2. HUMAN SETTLEMENTS AND HOUSING

A. PROBLEMS

1. Overcrowded settlements, squatter slum areas; high rents, poor housing facilities. Urban centers cannot fill demands for employment.
2. Poor health conditions, inadequate facilities. Many diseases related to poor environmental conditions.[1]

B. POLICY

C. LEGISLATION

D. ADMINISTRATION

3. ENVIRONMENTAL ASPECTS OF ECONOMIC DEVELOPMENT

A. PROBLEM

B. POLICY

C. LEGISLATION

D. ADMINISTRATION

4. PROTECTED AREAS

A. PROBLEMS

B. POLICY

In addition to three National Parks, some 16 game reserves in all play an important part in assuring the protection of the country's wildlife assets, which include many interesting and some very rare species.[4]

C. LEGISLATION

1. *Preservation of Wild Animals Ordinance and Regulations, 1935.*
2. *National Parks, Sanctuaries and Reserves Regulations, 1939* L.R.O. No. 23.

D. ADMINISTRATION

1. Ministry of Animal Production; Game and Fisheries Department.
2. Ministry of Natural Resources and Rural Development.
3. University of Khartoum, Department of Zoology.
4. The Sudanese Graduate Foresters Association.

5. CLIMATIC AND GEOGRAPHIC MODIFICATIONS

A. PROBLEMS

B. POLICY

C. LEGISLATION

D. ADMINISTRATION

6. POPULATION POLICY

A. PROBLEMS

B. POLICY

C. LEGISLATION

D. ADMINISTRATION

IV. ENVIRONMENTAL SCIENCE, EDUCATION AND TECHNOLOGY

A. PROBLEMS

Insufficient concern for environmental questions by those living in the cities and in densely populated farming areas.[2]

B. POLICY

1. Efforts to create more interest in wildlife etc. in schools, through films, lectures, etc.[2]
2. See Sec. II (6) B.

C. LEGISLATION

D. ADMINISTRATION

1. Ministry of Animal Production; Game and Fisheries Department.
2. Ministry of Education.
3. University of Khartoum.

BIBLIOGRAPHY

1. Summary of National Report to the U.N. Conference on the Human Environment. Sudan (Democratic Republic) National Council for Research, Khartoum, 1971.
   From The Human Environment: Vol III: "Summaries of National Reports on Environmental Problems" Environment Series 201.
   Woodrow Wilson International Center for Scholars, Washington D.C. 1972.
2. Paper, The Role of Wildlife in Social and Economic Development of the Southern Sudan, Mabor and Kuatod, Sudan Veterinary Association.
   (presented at Southern Social and Economic Development Conference; Juba, Sept. 1970).
3. The Statesman's Yearbook 1972-1973.
   Ed. John Paxton, Macmillan Press, London, 1972.
4. U.N. List of National Parks and Equivalent Reserves I.U.C.N. International Commission on National Parks. Brussels, 1971.

Appendix IX

U.S. AID Projects in Sudan

Source: U.S. AID Computer Data Files

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COUNTRY/BUREAU SUDAN
PROJECT NUMBER 650001000
PROJECT TITLE SUDAN-EXTENSION EDUC TRNG FOR HUMAN NESO
PROJECT SUMMARY OPERATIONAL PROGRAM GRANT SUPPORTS CONTRACT WITH WORLD EDUCATION TO PROVIDE ADVISORY ASSISTANCE TO AHFAD UNIVERSITY COLLEGE FOR WOMEN (AHFAD) TO ESTABLISH THE CAPABILITY TO TRAIN WOMEN TO DELIVER INTEGRATED NON-FORMAL EXTENSION EDUCATION TO POOR ADULTS (MAINLY WOMEN) IN URBAN AND RURAL AREAS. @AHFAD STAFF AND STUDENTS WILL BE TRAINED IN NEEDS ASSESSMENT, LEARNER MATERIALS DEVELOPMENT, EVALUATION, SELF-HELP AND INCOME-GENERATING ACTIVITIES, AND PROGRAM MANAGEMENT. TRAINING WILL BE PROVIDED THROUGH NEWLY DESIGNED COURSES AND WORKSHOPS AND DURING VISITS TO EXTENSION SITES. OCCASIONALLY, SUDANESE GOVERNMENT MINISTRIES AND PRIVATE AGENCIES WILL BE INVITED TO PARTICIPATE IN TRAINING WORKSHOPS. @PHASE ONE ACTIVITIES WILL BEGIN WITH WORKSHOPS TO STUDY INSUFFICIENCIES OF OTHER EXTENSION DELIVERY AGENCIES IN ORDER TO AVOID THOSE MISTAKES IN DESIGNING AHFAD'S STRATEGY. COURSES ON THE PROCESS, TECHNIQUES, AND STRATEGIES OF EXTENSION EDUCATION WILL BE CLOSELY INTEGRATED WITH EXTENSION ACTIVITIE . OF THIRD AND FOURTH YEAR STUDENTS. THESE UPPERCLASSWOMEN WILL BE INVOLVED IN SITE SELECTION, LIAISON WITH VILLAGE LEADERS AND DIRECTORS OF INSTITUTIONS, SCHEDULE PLANNING, AND ORGANIZING TRANSPORTATION. THE AHFAD STAFF WILL ASSESS NEEDS IN SITES FOR WHICH ACTIVITIES ARE BEING PLANNED AND DESIGN CURRICULA AND LEARNING MATERIALS BASED ON ASSESSMENT SURVEYS. AFTER ESTABLISHING CRITERIA AND PROCEDURES FOR DISBURSING SELF-HELP AND REVOLVING FUNDS, AHFAD STAFF WILL RECEIVE PROPOSALS, DISBURSE FUNDS, AND DESIGN EVALUATING PROCEDURES FOR THESE SELF-HELP AND INCOME-GENERATING ACTIVITIES. AT MID-YEAR, WORLD EDUCATION WILL CONDUCT A WORKSHOP TO GATHER PLANNERS AND ADMINISTRATORS TO DISCUSS AND ASSESS ACTIVITIES TO DATE. INSTRUMENTS WILL BE DEVELOPED AND A SYSTEM DESIGNED TO GET SYSTEMATIC FEEDBACK IN ALL ASPECTS OF THE PROJECT. ANOTHER WORKSHOP TO ASSESS PROJECT EXPERIENCES WILL BE HELD AT YEAR'S END. PHASE TWO WILL INCORPORATE REVISIONS DEEMED NECESSARY BASED ON SUCH EVALUATIVE INPUT.

COUNTRY/BUREAU SUDAN
PROJECT NUMBER 650001100
PROJECT TITLE NORTHERN SUDAN PRIMARY HEALTH CARE I
PROJECT SUMMARY GRANT IS PROVIDED TO THE GOVT OF THE SUDAN TO IMPLEMENT A PRIMARY HEALTH CARE PROGRAM (PHCP) IN THE NORTHERN REGION OF SUDAN. PHCP IS A COMPREHENSIVE HEALTH DELIVERY SYSTEM WHICH IS COMMUNITY-BASED, SPECIFICALLY DESIGNED TO REACH THE RURAL POOR & NOMADS, AND RELIES ON COMMUNITY PARTICIPATION. THE COMPONENTS OF THE PHCP INCLUDE: 1) COMMUNITY HEALTH WORKERS (CHW'S) & NOMAD COMMUNITY HEALTH WORKERS (NCHW'S) WHO WILL PROVIDE SIMPLE CURATIVE & PREVENTIVE SERVICES AND WILL PARTICIPATE IN PROMOTIVE HEALTH PROGRAMS; 2) PRIMARY HEALTH CARE UNITS (PHCU'S)--SMALL HEALTH FACILITIES STAFFED BY CHW'S WHICH WILL SERVE POPULATIONS OF 9000 PERSONS; 3) A LOGISTICS/SUPPLY SYSTEM WHICH WILL PROVIDE EQUIPMENT, DRUGS & SUPPLIES TO THE CHW'S, NCHW'S & PHCU'S; 4) A HEALTH & MGMT INFORMATION SYSTEM WHICH WILL COLLECT DATA ON THE HEALTH PROBLEMS, SERVICES DELIVERED & SUPPLIES UTILIZED AT THE PHCU. AID WILL FUND TECH ASSISTANCE, TRAINING, COMMODITIES, AND CONSTRUCTION OF PHCU'S IN SUPPORT OF THE ABOVE COMPONENTS. @A LONG-TERM COMMUNITY HEALTH ADVISOR WILL ASSIST THE DIRECTOR GENERAL FOR RURAL & PROVINCIAL AFFAIRS, MOH, WITH THE OVERALL POLICY DIRECTION OF THE PHCP. THIS ADVISOR WILL ALSO PREPARE A REPORT WHICH WILL INCLUDE RECOMMENDATIONS FOR FUTURE AID ASSISTANCE TO THE PHCP & OTHER GOS NATL HEALTH PROGRAMS, AND A DESCRIPTION OF OTHER DONOR HEALTH ASSISTANCE. A LOGISTICS/SUPPLY EXPERT WILL HELP DEVELOP A LOGISTICS/SUPPLY SYSTEM FOR THE PHCP. A VITAL STATISTICS EXPERT WILL ASSIST WITH THE DEVELOPMENT OF A NATL HEALTH STATS INFO SYSTEM WITHIN THE MOH THAT WILL UTILIZE THE PHCP FOR GATHERING MUCH OF THE DATA. SHORT-TERM ADVISORS WILL BE FUNDED UNDER THE GRANT TO PROVIDE AS-NEEDED SUPPORT TO PHCP ACTIVITIES & OTHER HEALTH PROGS. @TRAINING FINANCED BY GRANT INCLUDES: 1) LONG-TERM US TRNG IN STATS, PUBLIC HEALTH & LOGISTICS/MGMT FOR 3 MOH COUNTERPARTS, SHRT-TRM US TRNG IN UNSPECIFIED AREAS FOR 12 MOH PERSNNL, SHRT-TRM 3RD COUNTRY TRNG IN PUBLIC HEALTH FOR 36 DEPUTY & ASSISTANT HLTH COMMISSIONERS; 2) 10-DAY REORIENTATION SESSIONS ON THE PHCP FOR 4120 PROVINCIAL SUPERVISORY HLTH PERSNNL AND 28 10-DAY REFRESHER COURSES FOR 1120 CHW'S @35 PHCU'S WILL ALSO BE CONSTRUCTED.

COUNTRY/BUREAU SUDAN
PROJECT NUMBER 650001800
PROJECT TITLE BLUE NILE AGRICULTURAL DEVELOPMENT
PROJECT SUMMARY GRANT PROVIDED TO THE GOVERNMENT OF SUDAN (GOS) TO DEVELOP AN EFFECTIVE SYSTEMS APPROACH TO IMPROVING THE ECONOMIC CONDITION OF SMALL FARMERS AND NOMADIC HERDERS IN THE TRADITIONAL RAINFED PRODUCTION SUB-SECTOR OF SUDAN. THE PROJECT WILL INVOLVE 2,500 FARM FAMILIES AND 3,300 NOMAD FAMILIES WITHIN BLUE NILE PROVINCE. THE INTEGRATED SERVICE SYSTEMS DEVELOPED, HOWEVER, WILL BE SUITABLE FOR REPLICATION OVER LARGER AREAS DURING FOLLOW-ON PROJECTS. MAJOR COMPONENTS INCLUDE AGRICULTURAL MECHANIZATION, IMPROVEMENT OF AGRONOMIC PRACTICES, LIVESTOCK MANAGEMENT, COOPERATIVES, AND CREDIT. @A BLUE NILE AGRICULTURAL SERVICE CENTER (BASC) WILL BE ESTABLISHED TO PROVIDE OVERALL PROJECT MANAGEMENT. FIELD ACTIVITIES WILL BE IMPLEMENTED THROUGH TWO "AGRICULTURAL DEVELOPMENT CENTERS" (ADC'S) TO BE LOCATED IN ESEIL AND KHAREN KHAREN, AS WELL AS A LIVESTOCK HEALTH STATION AT ABU SHENEINA. @MECHANIZATION SERVICES WILL BE PROVIDED BY THE ADC AT ESEIL TO 1000 FARMERS IN A SMALL TRIAL AREA. USAID WILL SUPPLY THE 10 EQUIPMENT UNITS CONSISTING OF A 65-HP TRACTOR, WIDE-LEVEL DISK WITH SEEDER BOX, AND A 2-WHEELED TRAILER. @A VERIFICATION TRAILS FARM WILL BE ESTABLISHED AT THE BASC TO IMPROVE AGRONOMIC PRACTICES RELATING TO SESAME AND SORGHUM CULTIVATION AND TO PRODUCE NEW VARIETIES AND BETTER QUALITY OF SEED. ONCE THE TECHNICAL PRODUCTION PACKAGES ARE DEVELOPED, THEY WILL BE INTRODUCED THROUGH NEW DEMONSTRATION FARMS AND EXTENSION SERVICES AT ESEIL, KHAREN KHAREN, AND ABU SHENEINA. @PILOT NOMAD GRAZING ASSOCIATIONS WILL BE ORGANIZED AS A VEHICLE FOR INTRODUCING IMPROVED PRACTICES WITH RESPECT TO ANIMAL HEALTH, PRODUCTION, AND RANGE MANAGEMENT. @FARMER SERVICES AND CREDIT WILL BE CHANNELED THROUGH 7 VILLAGE COOPS. THESE COOPS WILL ACT AS BRANCHES OF A CENTRAL "COOPERATIVE UNION" TO BE ESTABLISHED AT ESEIL WHICH, BY THE END OF THE PROJECT, WILL ASSUME MANAGEMENT AND FINANCIAL RESPONSIBILITY FOR MECHANIZATION AND CREDIT SERVICES. @USAID WILL ALSO FINANCE TECHNICAL ASSISTANCE, TRAINING OF LARGE NUMBERS OF PERSONNEL (FROM TRACTOR DRIVERS TO PROFESSIONALS), CONSTRUCTION, CREDIT FUNDS, AND ESTABLISHMENT OF A DATA MANAGEMENT AND PLANNING OFFICE.

COUNTRY/BUREAU SUDAN
PROJECT NUMBER 650001900
PROJECT TITLE PRIMARY HEALTH CARE PROGRAM
PROJECT SUMMARY OPERATIONAL PROG GRANT IS PROVIDED TO THE INTNATL MEDICAL & RESEARCH FOUNDATION (IMRF) TO ASSIST IN THE IMPLEMENTATION OF A RURAL PRIMARY HEALTH CARE PROGRAM IN SOUTHERN SUDAN. THE OPG WILL FINANCE TECHNICAL & SUPPORT PERSONNEL TRAINING & RETRAINING COURSES FOR HEALTH WORKERS,VEHICLES,AND CONSTRUCTION COSTS FOR TWO DISPENSARIES/TRNG CENTERS, THE TWO PLANNED TRNG CENTERS ARE EXPECTED TO PRODUCE 450 COMMUNITY HLTH WORKERS (CHW) & 1120 SUPERVISORY MEDICAL ASSISTANTS. A TOTAL OF 56 ONE-WEEK REFRESHER COURSES INVOLVING 1660 CHW'S & MEDICAL ASSISTANTS WILL BE CONDUCTED AT THE TRNG CENTERS OVER THE LIFE OF THE PROJ. ONE TRNG CENTER/DISPENSARY WILL BE CONSTRUCTED AT LIRIA,70KM EAST OF JUBA,AND THE OTHER WILL BE BUILT 500KM AWAY AT AKAT. THE SUDANESE MINISTRY OF HEALTH (MOH) WILL HAVE ULTIMATE RESPONSIBILITY FOR THE USE & MAINTENANCE OF THESE FACILITIES. IMRF PROJ PERSONNEL WILL INCLUDE A TRNG STAFF (CONSISTING OF A MEDICAL OFFICER,A PUBLIC HLTH NURSE,AND A SANITARY OVERSEER WHO WILL ASSIST IN THE MOH'S MANPOWER DEVELOPMENT PROG),A MEDICAL RECORDS TECHNICIAN (WHO WILL ESTABLISH A MEDICAL REPORTING SYSTEM FOR THE RURAL HLTH DISPENSARIES),AND A SENIOR SUPPLIES OFFICER (WHO WILL DEVELOP A MEDICAL & DRUG SUPPLY SYSTEM). EACH OF THESE TECH ADVISORS WILL HAVE A MOH COUNTERPART. THE PROJ TEAMS WILL RECEIVE TECH ADMINISTRATIVE SUPPORT FROM THE AFRICAN MEDICAL & RESEARCH FOUNDATIONS,IMRF'S AFFILIATED HEADQUARTERS & OPERATIONAL ORGANIZATION IN NAIROBI,KENYA. USAID WILL ALSO FUND 20% OF THE TIME SPENT BY THE NAIROBI STAFF IN SUPERVISING THE SUDAN PROJ. IN ADDITION,USAID WILL SUPPLY A LANDROVER FOR THE IMRF PROJECT TEAM IN SUDAN,FIVE LANDROVERS TO EACH OF FIVE OTHER CHW TRNG CENTERS,THREE LANDROVERS TO SIX PROVINCIAL HLTH DEPTS;600 BICYCLES FOR CHW'S & THEIR SUPERVISORS,FOUR GRINDING MILLS TO BE USED BY RESIDENTS WHILE VISITING DISPENSARIES,AND VARIOUS INSTRUCTIONAL & BUILDING SUPPLIES.

COUNTRY/BUREAU SUDAN
PROJECT NUMBER 650002000
PROJECT TITLE WESTERN SUDAN AGRICULTURAL RESEARCH
PROJECT SUMMARY GRANT,TECH ASSIST,PARTICIPANT TRAINING,AND COMMODITIES WILL BE PROVIDED TO THE GOVT OF SUDAN TO CONSERVE & REHABILITATE THE NATURAL RESOURCES OF WESTERN SUDAN,IN PART BY STRENGTHENING & EXPANDING THE INSTITUTIONAL CAPABILITIES OF THE SUDANESE AGRICULTURAL RESEARCH CORP (ARC). THE FIRST PHASE OF THE PROJ WILL INVOLVE THE CONSTRUCTION OF RESEARCH FACILITIES. A PROJECT CENTER WILL BE CONSTRUCTED AT NYALA IN WESTERN SUDAN & THREE RESEARCH STATIONS WILL BE CONSTRUCTED AT EL FASHER, EL OBEID,AND KADUGLI. THE PROJ CENTER AT NYALA WILL INCLUDE ARESEARCH CENTER,OFFICES,LABORATORIES,A DOCUMENTATION CENTER,A CONFERENCE ROOM,AND STAFF HOUSING. THE RESEARCH STATIONS WILL CONSIST OF OFFICES,FIELD LABORATORIES,FARM BUILDINGS,AND STAFF HOUSING. THE PLANNED RESEARCH PROG WILL INCLUDE LIVESTOCK/CROP PRODUCTION SYSTEMS RESEARCH AND WATER & LAND USE MANAGEMENT RESEARCH. THE LIVESTOCK/CROP PRODUCTION PROG WILL BE CONDUCTED AT THE THREE RESEARCH STATIONS AND WILL ENCOMPASS THE VARIOUS SOIL TYPES FOUND AT EACH STATION: INTEGRATED LIVESTOCK/CROP RESEARCH ON NON-CRACKING CLAY SOIL AT EL OBEID AND ON THE CRACKING CLAY SOILS AT KADUGLI;AND LIVESTOCK RESEARCH ON THE ARID DESERT FRINGE OF EL FASHER. RESEARCH ON WATER & LAND USE MGMT WILL BE DIRECTED FROM THE PROJ CENTER AT NYALA. NEW ADMINISTRATIVE UNITS (A PROJ SUPPORT UNIT,A PLANNING & EVALUATION UNIT,AND A TRAINING & EXTENSION UNIT) WILL BE ESTABLISHED TO CORRESPOND WITH THE ARC'S EXPANDED RESEARCH CAPABILITIES. APPROX 46 SCIENTISTS & SENIOR ADMINISTRATORS & 99 TECH SUPPORT STAFF WILL BE ASSIGNED TO THE PROJECT. THE KEY STAFF WILL BE COMPOSED OF SIX SUDANESE & 10 FOREIGN SPECIALISTS. THE AID-RECRUITED FOREIGN SPECIALISTS WILL INCLUDE A SENIOR RSRCH ADVISOR,A RSRCH PLNNG & EVAL ADVISOR,AN ARCHITECT/PLANNER,A DEPUTY PROJ DIRECTOR,A SOCIOLOGIST,A FARM MGMT ECONOMIST AN AGRI ENGINEER,AND A LIVESTOCK/CROP PRODUCTION SYST SPECIALIST. EIGHTY MAN-MOS OF SHORT-TERM ASSISTANCE WILL ALSO BE PROVIDED BY USAID. USAID WILL ALSO FINANCE OVERSEAS TRNG FOR 28 SUDANESE PARTICIPANTS (6PHD CANDIDATES,5 MS CANDIDATES,AND 17 NON-DEGREE CANDIDATES) AND ALL OPERATIONAL COSTS. IBRD & THE GOS WILL FINANCE CONSTRUCTION COSTS.

COUNTRY/BUREAU SUDAN
PROJECT NUMBER 650002100
PROJECT TITLE SUDAN--SOUTHERN MANPOWER DEVELOPMENT
PROJECT SUMMARY GRANT AND TECHNICAL ASSISTANCE ARE PROVIDED TO THE GOVT OF SUDAN TO STRENGTHEN THE HUMAN RESOURCE BASE IN THE AGRICULTURAL SECTOR THROUGH IMPROVEMENTS IN THE TRAINING AND UTILIZATION OF AGRICULTURAL PERSONNEL WHO WORK OR WILL WORK WITH SMALL FARMERS. PROJECT COMPONENTS INCLUDE: 1) STRENGTHENING THE TRAINING CAPACITY OF THE YAMBIO INSTITUTE OF AGRICULTURAL TECHNICIANS; 2) STRENGTHENING THE AGRICULTURAL TRAINING CENTER AT RUMBEK; AND 3) STRENGTHENING THE PLANNING CAPACITY OF THE MINISTRY OF AGR AT JUBA.@AT YAMBIO, AN INTEGRATED INSTRUCTIONAL PROGRAM WILL BE ESTABLISHED FOCUSING ON THE AGRICULTURAL AND SOCIO-ECONOMIC ASPECTS OF TRADITIONAL FARMING SYSTEMS. IN ADDITION, CURRICULUM WILL BE STRENGTHENED TO MEET THE NEEDS OF WOMEN AGR DEVELOPMENT TRAINEES, AND PROFESSIONAL QUALIFICATIONS OF THE TEACHING STAFF WILL BE UPGRADED THROUGH STUDY TOURS AND SHORT COURSES. A LIBRARY WILL ALSO BE ESTABLISHED, AND COMPLEMENTARY TEACHING MATERIALS WILL BE PROVIDED. THE YAMBIO INSTITUTE WILL BE INTEGRATED INTO A PROGRAM OF IN-SERVICE TRAINING AND CONTINUING EDUC DIRECTED BY THE MINAG AND UNIV OF JUBA.@AT RUMBEK THE CENTER'S CAPACITY WILL BE DEVELOPED TO TRAIN UP TO 120 VILLAGE-LEVEL AGRICULTURAL EXTENSIONISTS PER YEAR WITH SKILLS APPROPRIATE TO SMALL FARMER ENVIRONMENTS IN SOUTHERN SUDAN. AN EXTENDED FIELD TRAINIGN COMPONENT WILL ALSO BE ESTABLISHED, AND 20 FIELD DAYS PER YEAR WILL BE ORGANIZED FOR FARMERS/PASTORALISTS INVOLVING SPECIFIC ASPECTS OF IMPROVED CROP AND LIVESTOCK PRODUCTION.@AT JUBA,A PLAN FOR THE PLACEMENT AND UTILIZATION OF YAMBIO AND RUMBEK GRADUATES WILL BE FORMULATED AND IMPLEMENTED WITHIN THE DEPT OF EXTENSION. A PLAN TO INCORPORATE KNOWLEDGE ON THE SOCIO-ECONOMIC AND TECHNICAL ASPECTS OF IMPROVED AGR PRODUCTION INTO THE TRAINING OF AGR TECHNICIANS AND EXTENSIONISTS AT YAMBIO AND RUMBEK WILL ALSO BE FORMULATED AND IMPLEMENTED WITHIN THE MINAG DEPT OF RESEARCH AND TTAINING. IN ADDITION, THE CAPACITY TO CONDUCT, ORGANIZE, AND SUPPORT CONTINUING EDUC FOR TECHNICIANS AND EXTENSION AGENTS WILL BE ESTABLISHED IN THE MINAG AND UNIV OF JUBA, AND CAPACITY TO UPGRADE SKILLS OF YAMBIO & RUMBEK INSTRUCTORS WILL BE ESTABLISHED AT JUBA U.

COUNTRY/BUREAU SUDAN
PROJECT NUMBER 650002601
PROJECT TITLE WADI HALFA COMMUNITY DEVEL:WATER SUPPLY
PROJECT SUMMARY OPERATIONAL PROGRAM GRANT TO INTERNATIONAL VOLUNTARY SERVICES(IVS) WILL SUPPORT A SIX-PART COMMUNITY DEVELOPMENT PROJECT IN WADI HALFA, SUDAN. UNDER THE FIRST AND PRIMARY SUBACTIVITY, IVS TECHNICAL AND ADVISORY SERVICES WILL BE USED TO INCREASE THE DRINKING WATER SUPPLY SYSTEM TO A CAPACITY OF 10,000 CUBIC METERS PER DAY, ENOUGH FOR THE CURRENT POPULATION AND FOR AN EXPECTED 1988 POPULATION OF 30,000. THE GRANT WILLSUPPORT THE COST OF PUMP EQUIPMENT. @A NEW LAKESHORE PUMP WILL BE INSTALLED ON A FLOATING PLATFORM 30 TO 50 METERS FROM THE WATERLINE, WITH WATER THEN PIPED INLAND. THIS WILL ELIMINATE THE NEED FOR MOVING THE PUMP EACH TIME THE WATER LEVEL FLUCTUATES, AND WILL AVOID FOULING THE PUMPS WITH SAND SINCE THE WATER WILL NO LONGER BE PUMPED FROM THE SHALLOWS. PLATFORMS WILL BE CONSTRUCTED OF RAIL TIES, AVAILABLE AT THE PROJECT SITE AT NO EXTRA COST. THE EIGHT-INCH RING MAIN WILL REDUCE TO SIX INCHES IN DIAMETER, AND ONE-HALF INCH FEEDER LINES WILL BE REPLACED WITH TWO-INCH FEEDER LINES TO PROVIDE ADEQUATE SYSTEM DISTRIBUTION PRESSURE FOR COMMUNITIES THREE, FOUR, AND SIX. AN ADDITIONAL FILTRATION AND PUMPING FACILITY WILL BE INSTALLED SOUTH OF COMMUNITY THREE, FEEDING DIRECTLY INTO THE SIX-INCH RING MAIN. THIS WILL PROVIDE HIGH AND BALANCED PRESSURE THROUGHOUT THE SYSTEM AND ALLOW FOR FUTURE EXPANSION. A NEW PUMP WILL THEN BE INSTALLED ON A FLOATION PLATFORM SOUTH OF THE NEW STATION. SEDIMENTATION AND FILTER TANKS TO BE USED FOR THE NEW FILTRATION AND PUMPING FACILITY WILL BE THOSE SALVAGED FROM THE OLD STATION WHEN CONCRETE TANKS ARE COMPLETED. @THIS SUBPROJECT ADDS TWO DIESEL ENGINES TO THE EXISTING SYSTEM, WHICH WILL COST APPROXIMATELY 760 POUNDS(CURRENCY) PER ANNUM IN DIESEL FUEL, WORKING 48 HOURS PER WEEK. HOWEVER, ONCE A BALANCED WATER SUPPLY IS BEING PROVIDED TO EACH COMMUNITY, THE WADI HALFA PEOPLE'S COUNCIL WILL INTRODUCE A WATER RATE, CHARGEABLE TO EACH HOUSEHOLD AT A STANDARD RATE.

COUNTRY/BUREAU SUDAN
PROJECT NUMBER 650002602
PROJECT TITLE WADI HALFA COMMUNITY DEVEL:YOUTH TRAIN
PROJECT SUMMARY OPERATIONAL PROGRAM GRANT TO INTERNATIONAL VOLUNTARY SERVICES(IVS) WILL SUPPORT A SIX-PART COMMUNITY DEVELOPMENT PROJECT IN WADI HALFA, SUDAN. UNDER THE SECOND SUBACTIVITY, IVS TECHNICAL AND ADVISORY ASSISTANCE WILL BE USED IN IRRIGATION, HORTICULTURE, AND ARBORICULTURE, INCLUDING ON-THE-JOB TRAINING FOR YOUTHS THROUGH FIELD TESTING. @AN IVS IRRIGATION AGRONOMIST VOLUNTEER WILL INSTALL PUMPS AND DIVIDE THE INLAND IRRIGATION INTO THREE SECTIONS: A)HORTICULTURAL EXPERIMENTS INVOLVING TESTS OF FRUIT AND DATE TREES; B)WINTER ROTATIONS FOR BARLEY, SUGAR CANE, AND WHEAT; C)AND WINTER VEGETABLES SUCH AS ONIONS, BEETS, CABBAGE, PEAS, BEANS, POTATOES, AND SALADS. SHADE AND TIMBER TREES WILL BE PLANTED AROUND THE PERIPHERY AS A WINDBREAK. EMPHASIS WILL BE PLACED ON PRODUCING HIGH-YIELD VARIETIES OF TRADITIONAL CROPS TO VERIFY THE MOST ECONOMIC IRRIGATION AND CULTIVATION METHODS. INTRODUCTION OF NEW CROPS WILL AT FIRST PLAY A MINOR ROLE. @BOYS AND GIRLS BEING TRAINED WILL WORK WITH THEIR PARENTS. STUDENTS WILL WORK ON SMALL PLOTS TO GROW THEIR OWN VEGETABLES. THE PLOTS WILL BE ON TWO SECTIONS OF THE FARM (LAKESHORE AND INLAND IRRIGATION), EACH OF 50 FEDDANS, AND WILL ABSORB 250 YOUTHS ON A TWO-YEAR PART-TIME COURSE. @THE IRRIGATION AGRONOMIST WILL WORK CLOSELY WITH HIS COUNTERPART HORTICULTURALIST IN SUPERVISING CROP TRIALS. AFTER THE MOST PRODUCTIVE VARIETIES ARE IDENTIFIED, A SEED MULTIPLICATION AND DISTRIBUTION SYSTEM WILL BE INTRODUCED IN THE COMMUNITY. SEED AND CUTTINGS WILL BE PURCHASED FROM THE GOVERNMENT OF SUDAN'S AGRICULTURAL RESEARCH AND DEVELOPMENT STATION AT ATBARA. PRODUCE WILL BE MARKETED THROUGH THE COMMUNITY'S COOPERATIVE SOCIETY WITH TECHNICAL SERVICES OF THE ON-POST COOPERATIVES INSPECTOR. @IT IS EXPECTED THAT OFFSHOOT ACTIVITIES SUCH AS FRUIT AND VEGETABLE PACKING AND MARKETING, TRANSPORT, ANIMAL HUSBANDRY, DAIRY AND MEAT PROCESSING AND MARKETING WILL PROVIDE EMPLOYMENT AND INCOME TO ANYONE WHO ENGAGES INTO COMMERCE WITH WADI HALFA'S COOPERATIVE COMMUNITY.

COUNTRY/BUREAU SUDAN
PROJECT NUMBER 650002603
PROJECT TITLE WADI HALFA COMMUNITY DEVEL:IRRIGATION
PROJECT SUMMARY OPERATIONAL PROGRAM GRANT TO INTERNATIONAL VOLUNTEER SERVICES(IVS) WILL SUPPORT A SIX-PART COMMUNITY DEVELOPMENT PROJECT IN WADI HALFA, SUDAN. UNDER THE THIRD SUBACTIVITY, IVS TECHNICAL AND ADVISORY ASSISTANCE WILL BE USED TO TEST BOREHOLE IRRIGATION TO IRRIGATE A 50 FEDDAN CULTIVATION SITE INLAND FROM THE LAKESHORE AREA. THE SOIL AT THIS SITE IS OF MARGINALLY BETTER QUALITY THAN THE LAKESHORE AREA. THIS IRRIGATION COMPONENT OF WADI HALFA COMMUNITY DEVELOPMENT IS COMPLEMENTARY TO THE COOPERATIVE/YOUTH FARM ACTIVITY, WHICH IS USING PUMP IRRIGATION AT THE LAKESHORE SITE. SHOULD THE TEST PROVE THE AVAILABILITY OF SUFFICIENT GROUNGWATER AT RECOVERABLE DEPTHS, THE AREA OF POTENTIALLY ARABLE LAND WILL BE VASTLY IN CREASED. THE TWO CULTIVATION AREAS (LAKESHORE AND INLAND) WILL COME UNDER COMMON MANAGEMENT AND CONTROL, WITH COOPERATIVE CROP TRIALS TAKING PLACE SIMULTANEOUSLY. ∂A DANDO 400 TYPE MOBILE PERCUSSION DRILLING RIG WILL BE USED TO DRILL 200 TO 500 FEET THROUGH SAND, SOIL, AND SOFT SANDSTONE. FOUR TRAINEE DRILLERS WILL OPERATE AND MAINTAIN THE RIG THROUGH THE LIFE OF THE PROJECT. THE IVS WATER ENGINEER WILL SUPERVISE AND CONTROL THE USE OF THE RIG AND WILL TRAIN THE DRILLERS. ∂UP TO FIVE BOREHOLES WILL BE FITTED WITH A DIESEL POWERED SUCTION PUMP. ONE HOLE WILL FITTED WITH AN EXPERIMENTAL WINDMILL POWERED PUMP, AS THERE IS A PREVAILING WIND AT WADI HALFA. ∂THERE IS A RISK THAT WATER MAY NOT BE FOUND IN SUFFICIENT VOLUME. SHOULD THIS BE THE CASE, THE PUMPS PURCHASED FOR THIS PURCHASE WILL BE USED TO EXPAND THE LAKESHORE AREA BY 500 FEEDANS. THE RIG WILL BE USED FOR FURTHER WATER EXPLORATIO ON ALTERNATIVE SITES ALONG THE LAKE WHERE THE GEOLOGICAL STRUCTURE IS FAVORABLE. ∂IT WILL ALSO BE USED TO EXPAND THE SANITATION SCHEME TO CIPE WITH THE NEEDS OF THE EXPANDING POPULATION.

COUNTRY/BUREAU SUDAN
PROJECT NUMBER 650002604
PROJECT TITLE WADI HALFA COMMUNITY DEVEL: SANITATION
PROJECT SUMMARY OPERATIONAL PROGRAM GRANT TO INTERNATIONAL VOLUNTARY SERVICES(IVS) WILL SUPPORT A SIX-PART COMMUNITY DEVELOPMENT PROJECT IN WADI HALFA, SUDAN. UNDER THE FOURTH SUBACTIVITY, IVS TECHNICAL AND ADVISORY ASSISTANCE WILL BE USED TO DEVELOP HUMAN WASTE DISPOSAL FACILITIES TO REPALCE UNSANITARY METHODS. THE DANDO 400 TYPE MOBILE PERCUSSION DRILLING RIG USED FOR BOREHOLE IRRIGATION ALSO WILL BE USED TO DRILL A SERIES OF "LOAG DROP" LATRINES IN MAJOR PUBLIC PLACES. EACH WILL BE TOPPED BY A SIMPLE CEMENT SLAB WITH FOOTPRINTS," AND FITTED WITH A WOODEN LID. LATRINE STRUCTURES WILL BE OF MIND-BRICK, AND WITH CORRUGATED IRON ROOFS. A TAP WILL PROVIDE WATER FOR PERSONAL HYGIENCE. THE TOWN COUNCIL WILL UNDERTAKE CONSTRUCTION AD MAINTENANCE OF 48 OF THESE SIMPLE STRUCTURES. ∂TO ENSURE MAXIMUM POSSIBLE HEALTH BENEFIT TO THE COMMUNITY, A PROGRAM OF PUBLIC EDUCATION WILL BE DEVISED. THREE CHANNELS OF COMMUNICATION WILL BE USED: A) INFORMATON DISSEMINATED THROUGH THE DISSEMINATION THROUGH THE PEOPLE'S COUNCIL TO COMMUNITY LEADERS; C) INFORMATION TO THE GENERAL PUBLIC THROUGH POSTERS PLAERS; C) INFORMATION TO THE GENERAL PUBLIC THROUGH POSTERS PLACED IN ALL PUBLIC PLACES. ∂HEALTH EDUCATION WILL BE IMPLEMENTED IN COOPERATION WITH THE SENIOR MEDICAL OFFICER AND THE PUBLIC HEALTH OFFICER IN WADI HALFA.

COUNTRY/BUREAU SUDAN
PROJECT NUMBER 650002605
PROJECT TITLE WADI HALFA COMMUNITY DEVEL:NUTR EDUC
PROJECT SUMMARY OPERATIONAL PROGRAM GRANT(OPG) TO INTERNATIONAL VOLUNTARY SERVICES(IVS) WILL SUPPORT A SIX-PART COMMUNITY DEVELOPMENT PROJECT IN WADI HALFA, SUDAN. UNDER THE FIFTH SUBACTIVITY, IVS WILL SUPPORT CATHOLIC RELIEF SERVICES(CRS) OUT OF OPG FUNDS TO ASSIST THE SUDAN MINISTRY OF HEALTH TO INITIATE A PROGRAM OF HEALTH AND NUTRITION EDUCATION FOR PRE-SCHOOL CHILDREN IN WADI HALFA. CRS EXPECTS THE PROGRAM TO REACH 1,000 CHILDREN PER MONTH. @NUTRITION EDUCATION ACTIVITIES WILL BE DIRECTLY OVERSEEN BY THE TOWN'S PUBLIC HEALTH NURSE. THE NURSE WILL HAVE BEEN TRAINED IN MATERNAL-CHILD HEALTH AND WILL GO TO KHARTOUM FOR TWO WEEKS OF ORIENTATION. ALSO, A WADI HALFA SCHOOL TEACHER WILL ATTEND A FOUR-MONTH COURSE IN NUTRITION EDUCATION, AND ON COMPLETING HER TRAINING WILL ASSIST THE PUBLIC HEALTH NURSE FULL-TIME. THE TOWN'S MEDICAL OFFICER WILL SUPERVISE THE PROGRAM DAY TO DAY. @CHILDREN AND THEIR MOTHERS WILL VISIT THE CENTER AT LEAST ONCE A MONTH. EACH CHILD WILL BE EXAMINED AND WEIGHED, AND A CHART WILL RECORD WEIGHTS FOR ALL CHILDREN ATTENDING THE CENTER ON A PARTICULAR DAY. THE NURSE WILL DETERMINE A CHILD'S PHYSICAL STATUS IN TERMS OF THE HARVARD GROWTH STANDARD. MOTHERS WILL RECEIVE PRIVATE CONSULTATIONS TO LEARN THE CHILD'S HEALTH STATUS AND WHAT CORRECTIVE STEPS ARE NECESSARY TO ENSURE A CHILD'S PROPER GROWTH. CHILDREN WILL BE IMMUNIZED AGAINST INFECTIOUS DISEASES WHEN VACCINES ARE AVAILABLE AND TREATED FOR MINOR AILMENTS. SERIOUSLY ILL CASES WILL BE TRANSFERRED TO THE HEALTH CENTER PHYSICIAN. A GROUP LECTURE OR A NUTRITION OR HEALTH DEMONSTRATION WILL BE GIVEN TO ALL MOTHERS BY THE NUTRITION EDUCATOR. SUPPLEMENTARY FOODS (TWO KILOS OF NONFAT DRY MILK AND ONE KILO OF OIL) WILL BE GIVEN TO THE CHILD ON EACH CLINIC VISIT TO: A)BE A CORRECTIVE ELEMENT IN A CHILD'S DIET; B)BE A MEANS OF EDUCATING MOTHERS ABOUT NUTRITION; AND C)BE AN ECONOMIC AID TO THE FAMILY. @BASED ON 1,000 CHILDREN, THE VALUE OF THE FOOD ASSISTANCE THAT CRS WILL PROVIDE TO WADI HALFA IN A ONE-YEAR PERIOD IS $57,552. ADDED TO THE PROGRAM VALUE WILL BE CLEARANCE, INLAND TRANSPORT, AND PERSONNEL COSTS BORNE BY THE MINISTRY OF HEALTH, AND OTHER INPUTS BY CRS.

COUNTRY/BUREAU SUDAN
PROJECT NUMBER 650003001
PROJECT TITLE RURAL HEALTH SUPPORT
PROJECT SUMMARY Grant is provided to the Government of Sudan (GOS) to improve its capability to provide primary health care to the country's northern and southern provinces. Project consists of two subprojects. Subproject one will improve the personnel and facility resources of the GOS's Primary Health Care Program (PHCP). GOS will supervise subproject implementation by a private contractor in the north and by the African Medical and Research Foundation in the south.@Six training facilities for health workers will be constructed and equipped. Some 4,863 community health workers (CHW's) and village midwives (VMW's) will receive short-term in-country and participant training, strongly emphasizing preventive health. Continuing education programs will be provided for existing staff to update and expand their skills, and to enable them to tutor new health care personnel.@Seven radio programs of two types will be produced and broadcasted in two local dialects. First, CHW's will produce radio programs in two southern provinces to promote preventive medicine. Small village groups will meet regularly to listen to the broadcasts and discuss the programs, and CHW's or community leaders will visit the groups periodically to answer any questions. Second, educational radio programs for CHW's will be produced which teach practical information about health, sanitation, and child care.@Six dispensaries in the north and six in the south, providing simple preventive/curative care, as well as maternal/child health (MCH) services, will be constructed and provided with drugs and other supplies; each will cover three Primary Health Care Units (PHCU's). In addition, building materials will be provided to speed construction of PHCU's offering outpatient services.@In continuity with a U.N. Fund for Population Activities program to integrate MCH services into the PCHP, 4,000 rural and urban CHW's, VMW's, and Traditional Birth Attendants will be trained at the district level. Two VMW training schools will be constructed and equipped with training materials. The health cadre will be equipped with drugs and midwifery kits.

COUNTRY/BUREAU SUDAN
PROJECT NUMBER 650003002
PROJECT TITLE RURAL HEALTH SUPPORT
PROJECT SUMMARY Grant is provided to the Government of Sudan (GOS) to improve its capability to provide primary health care to northern and southern provinces. Project consists of two subprojects. Subproject two will improve the administrative system of the GOS's Primary Health Care Program (PHCP). GOS will supervise subproject implementation by a private contractor in the north and by the African Medical and Research Foundation in the south. To improve PHCP planning and management functions at the central, regional, and provincial levels, regional Ministry of Health (RMOH) personnel will develop three health planning systems, train health administrators, and develop annual budgets and recurrent cost projections. In the south, RMOH personnel will be assisted in resource allocations, health program budgeting and administration, operations research design, health economics, and personnel and facility survey methodologies. Administrators from all MOH sectors will take part in in-service training and field work in information/statistics, health service planning and management, personnel procedures, and budget and audit systems. Other training will include participant training in Kenya for two southern MOH personnel in health administration; 10 north-south seminars in logistics/supply systems, health program budgeting, and personnel management; and research into PHCP administrative problems. To strengthen the Health Management Information System (HMIS), short courses will be given to statisticians in seven northern and three southern provinces in health statistics collection/analysis. Assistant health commissioners will participate in a national course on HMIS use in order to design and budget health programs for prevalent diseases. To improve supply management and transport, short courses will be given to all levels of GOS logistic/supply personnel, and eight trucks will be provided. To store commodities, 12 warehouses will be constructed and equipped with a handling and inventory control system to improve commodity packaging and disbursement. They will also serve as sites for on-the-job training of pharmacists and storekeepers.

COUNTRY/BUREAU SUDAN
PROJECT NUMBER 650003600
PROJECT TITLE SOUTHERN ACCESS ROAD
PROJECT SUMMARY Grant is provided to the Government of Sudan (GOS) to assist in constructing an all-weather road connecting Sudan's Southern Region with Kenya. A Joint National Authorization Officer, mutually agreed upon by GOS and the Government of Kenya (GOK), will supervise project implementation by a private construction contractor with assistance from an engineering consultant and pertinent GOS and GOK agencies. Grant funds will be used for construction in Sudan only. A 620 km road will be constructed between Juba, Sudan, and Lodwar, Kenya to meet modified Minimum Commercial Access standards. Construction will include 48 minor structures (36 in Sudan) and 8 major structures (seven in Sudan), including 111 box culverts and 13 bridges, as well as drainage structures, pipes, and 58 km of diversion roads (45 km in Sudan) to connect structures with existing roads. Stone drifts between Lokickokio and Kapoeta will be constructed by GOS Force Account. All structures will be designed to give correct hydraulic waterway openings at specified rainfall frequencies and height. Road width will be 6.0 meters to serve up to 250 vehicles per day, with a minimum grade rise of 0.6 meters to protect the roadbed from surface drainage and prevent erosion. Pavement thickness will be 15 cm of lateritic or gravel materials. Load restrictions of 12,000 kilos per vehicle will be enforced at two permanent weigh stations to be constructed (one in each country). New roads will be designed for a speed of 80 km per hour; diversion roads for a minimum speed of 50 km per hour. The contractor will provide on-the-job training to counterpart foremen and heavy equipment operators. The contractor will also provide technical assistance, on-the-job training, and spare parts to three units (two in Sudan, one in Kenya) to gravel 582 km of existing roads. Maintenance centers in Juba and Lodwar will be upgraded by the provision of on-the-job training to counterpart mechanics and procurement clerks. Routine maintenance of the existing road between Lodwar and 40 km east of Juba will be financed by GOS Force Account.

COUNTRY/BUREAU SUDAN
PROJECT NUMBER 6500 10000
PROJECT TITLE SUDAN - RAHAD PROJECT
PROJECT SUMMARY RAHAD RIVER IRRIGATION PROJECT CONSISTS OF DEVELOPMENT OF 300,000 ACRES OF LAND FOR IRRIGATED AGRICULTURE ON THE EAST BANK OF THE RAHAD RIVER IN SUDAN BY PUMPING IRRIGATION WATER FROM BELOW THE ROSEIRES DAM THROUGH A SUPPLY CANAL USING PUMPS POWERED BY ELECTRICITY FROM DAM. PROJECT CONDUCTED BY RAHAD CORP, NEWLY ESTABLISHED SEMI-AUTONOMOUS GOVT AGENCY. INVOLVES CONSTRUCTION OF SUPPLY AND DISTRIBUTION CANALS AND DRAINAGE WORKS AS WELL AS INSTALLATION OF AGRICULTURAL PROCESSING EQUIPMENT AND STORAGE FACILITIES. SETTLES 13,700 TENANTS WITH NECESSARY INFRASTRUCTURE. SUBSTANTIAL FUNDING BY IDA AND KUWAIT DEVELOPMENT FUND. PROJECT IS REPLICATION OF SUCCESSFUL GEZIRA PROJECT.

COUNTRY/BUREAU SUDAN
PROJECT NUMBER 6500 10 300
PROJECT TITLE SOUTH REGION AGR REHABILITATION DEVEL
PROJECT SUMMARY IVS PROVIDES PERSONNEL FOR FOODCROPS DEVELOPMENT SUBPROJECT, LIVESTICK MARKETING AND SURVEY SUBPROJECT OF BROADER WORLD BANK AGR REHAB DEVEL PROJECT IN SOUTHERN SUDAN. FOODCROPS COMPONENT INCREASES FOOD PRODUCTION BY MULTIPLICATION AND SALE OF IMPROVED SEEDS. CROP TRAIL STATIONS DEVELOP VARIETIES, PROVIDE INFORMATION ON CASH CROPS. EXTENSION STAFF IS TRAINED AT COMMUNICATIONS CENTER AND FIELD SURVEYS PROVIDE FEEDBACK ON PROBLEMS, NEEDS. LIVESTOCK MARKETING COMPONENT GATHERS DATA WHICH IS ANALYZED BY MARKET RESEARCH DIVISION. MARKETING TEAMS INCREASE OFFTAKE FROM REGIONAL HERD BY PURCHASING ANIMALS FOR WHICH BUYERS CANNOT BE FOUND. EXPERIENCE, DATA LEAD TO PROPOSALS FOR MARKETING PROGRAM.

1. Climate

Allen, W.J., Jr. 1962. An Annotated Bibliography on Climatic Maps of Sudan. U.S. Weather Bureau.

Bhalotra, Y.P.R. 1958. Duststorms at Khartoum, Memoir No. 1. Sudan Meteorological Service.

-----. 1959. Adverse Weather Conditions at Khartoum, El Obeid and Wadi Halfa, Memoir No. 2. Sudan Meteorological Service.

-----. 1960. Simultaneity of Adverse Weather Conditions at Khartoum and Port Sudan, Technical Note No. 2, Sudan Meteorological Service.

-----. 1963. Meteorology of the Sudan, Memoir No. 6, Sudan Meteorological Service.

Davenport, D.C. & Hudson, J.P. 1967. Changes in evaporation rates along a 17-km transect in the Sudan Gezira. Agricultural Meteorology 14:339-352.

-----. 1967. Meteorological observations and Penman estimates along a 17-km transect in the Sudan. Agricultural Meteorology 4:405-414.

Davies, H.R.J. 1959. Khartoum Weather. Journal of Geography 58:286-293.

el-Fandy, M.G. and Soliman, K.H. 1950. Summer Weather of the Sudan, Correspondence. Quart. Journ. Roy. Met. Soc. 76:487-489.

Fleming, J. 1953. Sandstorms in the Sudan. Met. Mag. 82:26-27.

Freeman, H.W. 1952. Duststorms of the Anglo-Egyptian Sudan. Meteorological Office, Meteorological Report, No. 11.

Hudson, J.P. 1963. Variations in evaporation rates in Gezira cotton fields. Emp. Cotton Growing Rev. 40:253-261.

Jackson, J.K. 1957. Changes in the climate and vegetation of the Sudan. Sudan Notes Rec. 38:47-66.

Kruger, E. 1960. Forecasting Divergence as a Tool to Forecast Thunderstorms in the Sudan. In: Tropical Meteorology in Africa (Bargman, D.J., ed.). pp. 156-167. (Munitalp Foundation, Nairobi).

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Matthews, L.S. 1955. The frequency of daily rainfall of specified amounts in the Sudan. Sudan Meteorological Service, Pamphlet No. 6.

Oliver, J. 1965. The Climate of Khartoum Province. Guide to the Natural History of Khartoum Province, Part II, Sudan Notes and Records 46:1-37.

-----. 1965. Evaporation losses and rainfall regime in central and northern Sudan. Weather 20:58-64.

Rogers, P. 1956. Sferics in the Sudan. W.M.O. Bulletin 5:159-160.

Sudan Meteorological Service. 1955. Rain-Day Averages: 1921-1950. Pamphlet, No. 4.

-----. 1955. Khartoum Temperatures. Pamphlet, No. 5.

-----. 1955. The Frequency of Daily Rainfalls of Specified amounts in the Sudan. Pamphlet, No. 6.

-----. 1955. Developments of Cumulonimbus Cloud over the Sudan. Technical Note, No. 1.

-----. 1955. Thunderstorms over Sudan. Technical Note, No. 2.

-----. 1955-58. Meteorological Reports for 1950, 1953, 1954, 1955, 1956.

-----. 1956. Rain and Agriculture in the Sudan. Technical Note, No. 3.

-----. 1957. Average Pentade Rainfall, 1921-50. Pamphlet, No. 7.

-----. 1957. Rainfall Averages, 1921-50. Pamphlet, No. 1.

-----. 1957. Wind Speed Statistic. Pamphlet, No. 3.

-----. 1957. Annual Rainfall Parameters, 1921-50. (A.W. Ireland) Pamphlet, No. 2.

-----. 1962. Annual Report of Agrometeorology, 1st April 1961 to 31st March 1962.

el-Tom, M.A. 1966. Some aspects of the annual and monthly rainfall over the Sudan. Unpublished M.A. Thesis, University of Durham.

2. Geology, Minerals, Soils

Ali, M.A. and O.A.A. Fadl. 1977. Irrigation of a Saline-Sodic Site in the Sudan Gezira. II: Salt Movement and Sodicity Changes. Tropical Agriculture 54(3):279-283.

Ayed, I.A. 1968. Analyses of profile samples of differing productivity. Sudan Agric. J., 3:105-112.

Blokhuis, W.A., L.H.J. Ochtman and K.H. Peters. 1964. Vertisols in the Gezira and the Khasma el Girba clay plains. Trans. Int. Congr. Soil Sci., 8th, Bucharest, 5:591-603.

Drover, D.P. 1966. Moisture retention in some soils of the Sudan. African Soils 11(3).

Fadl, O.A.A. and M.A. Ali. 1977. Irrigation of a saline-sodic site in the Sudan Gezira. I. Water movement. Trop. Agric. (Trinidad) 54:157-165.

Finck, A. 1961. Classification of Gezira clay soil. Soil Sci. 92:263-267.

Hamid, K.S. and M.A. Mustafa. 1975. Dispersion as an index of relative hydraulic conductivity in salt-affected soils of the Sudan. Geoderma 14:107-114.

Hellden, U. 1978. Evaluation of Landsat-2 Imagery for Desertification Studies in Northern Kordofan, Sudan. Rapporter & Notiser No. 38. Geography Dept., University of Lund, Sweden.

Hunting Technical Services. 1963. Land and Water Use Survey in Kordofan Province, Republic of the Sudan - Report on the Survey of Geology, Geomorphology and Soils, Vegetation and Present Land Use. Doxiadis Associates, Athens.

-----. 1964. Roseres Soil Survey. Report No. 5, Min. of Agric., Sudan.

-----. 1976. Sag el Na'am Evaluation on Pre-Investment Study. Khartoum.

Karouri, M.O.H. and H.J. Kaufmann. 1966. Salinity and Alkalinity Problems in Soils of Northern Province. Proc. 10th Agric. Res. Colloquim. Res. Div., Min. of Agric., Sudan.

Kutilek, M. 1969. Soil moisture retention of clay plain soils as influenced by ESP and the initial bulk density, drying cyclus. Sudan Agric. J. 4:97-114.

Mustafa, M.A. and K.S. Hamid. 1977. Comparisons of Two Models for Predicting the Relative Hydraulic Conductivity of Salt-Affected Swelling Soils. Soil Science 123(3):149-154.

Tom, O.A. 1973. Semi-Detailed Survey of South Khartoum Area and Blue Nile Provinces. Soil Survey Dept., Wad Medani, Sudan.

Tothill, J.D. 1964. The origin of the Sudan Gezira Clay Plain. Sudan Notes and Records 27:153-183.

De Vos, N.C.J.H. and Virgo, K.J. 1969. Soil structure in Vertisols of the Blue Nile Clay Plains, Sudan. J. Soil Sci. 20:189-206.

White, L.P. 1967. Ash soils in western Sudan. J. Soil Sci. 18:309-317.

Williams, M.A.J. 1968. Soil Salinity in the West Central Gezira, Republic of the Sudan. Soil Science 105(6):451-464.

Worrall, G.A. 1950. A Pedological study of the Khartoum district, Sudan. Ph.D. Thesis, London University.

-----. 1958. Soils and Land use in the vicinity of the Three Towns. Sudan Notes and Records 39:2-9.

Zein El Abedine, A., G.H. Robinson and J. Tyego. 1969. A study of certain physical properties of a Vertisol in the Gezira area, Republic of Sudan. Soil Science 108:359-367.

Zein El Abedine, A. and E.L. Strmecki. 1970. An investigation into the hydraulic conductivity of Gezira soils. Sudan Agric. J. 5:16-29.

3. Flora and Fauna

Ahti, T., L.H. Ahti and B. Peterson. 1973. Flora of inundated Wadi Halfa reach of the Nile, Sudanese Nubia, with notes to adjacent areas. Annales Botanici Fennici 10:131-162.

al-Amin, H. 1973. A general list of common forest trees and shrubs of the Sudan. Soba.

Andrews, F.W. 1950, 1952, 1956. The flowering plants of the Anglo-Egyptian Sudan. 3 Bde. Arbroath.

Bishai, H.M. 1960/1961. The effect of the water hyacinth. Eichhornia crassipes, on the fisheries of the Sudan. Rep. hydrobiol. Res. Unit Univ. Khartoum 8:29-36.

-----. 1961. The effect of pressure on the distribution of some Nile fish. J. exp. Zool. 147:113-124.

-----. 1962. The water characteristics of the Nile in the Sudan with a note on the effect of Eichhornia crassipes, on the hydrobiology of the Nile. Hydrobiologia 19:357-382.

-----. 1965. Resistance of Tilapia nilotica L. to high temperatures. Hydrobiologia 25:473-488.

Brown, L. 1969. Wildlife v sheep and cattle in Africa. Oryx 10(2):92-101.

Cloudsley-Thompson, J.L. 1963. Wildlife in the Sudan. Geog. Mag. 35:589-597.

-----. 1965. The Fauna of Jebel Marra, Western Sudan. Sudan Silva 2(16):24-28.

-----. 1966. Wildlife in Equatoria. Turtox News 44:114-117.

Cloudsley-Thompson, J.L. and J.A. Cloudsley-Thompson. 1969. Wildlife by the Dinder River, Sudan. Tutrox News 47:114-116.

Cunnison, I.G. 1956. Giraffe Hunting among the Humr Tribe. Sudan Notes Rec. 37:49-60.

Darling, F.F. 1961. Towards a Game Policy for the Republic of Sudan. Unpubl. report submitted to the Sudan Govt.

Dasmann, W.P. 1972. Development and Management of the Dinder National Park and its Wildlife. UN/FAO Report No. TA3113.

Field, P.A.G. 1974. Report on a Feasibility Study on a Proposed Conservation Area in Southern Darfur, Sudan. Ministry of Overseas Development, London.

Gay, P.A. 1956/1957. Some aspects of the riverain flora of the White Nile and Bahr El-Ghazal. Rep. hydrobiol. Res. Unit Univ. Khartoum 4:10-20.

-----. Eichhornia crassipes in the Nile of the Sudan. Nature, Lond. 182:538-539.

Greig-Smith, P. and Chadwick, M.J. 1965. Acacia-Capparis semi-desert scrub in the Sudan. J. Ecol. 53:465-474.

Gronblad, R.G., G. Prowse and A.M. Scott. 1958. Sudanese Desmids. Acta Botanica Fennica 58:1-58.

Halwagy, R. 1960/1961. Studies on the succession of vegetation on some islands and sand bars in the Nile near Khartoum. Rep. hydrobiol. Res. Unit Univ. Khartoum 8:20-22.

Hanson, H.C. and E.D. Churchill. 1961. Plant Communities, Reinhold, N.Y.

Happold, D.C.D. 1966. Dragonflies of Jebel Marra, Sudan. Proc. R. ent. Soc. Lond. (A) 41:87-91.

-----. 1966. The Future for Wildlife in the Sudan. Oryx 8:360-373.

-----. 1966. The Mammals of Jebel Marra, Sudan. J. Zool., Lond 149:126-136.

Harrison, M.N. and J.K. Jackson. 1958. Ecological classification of the vegetation of the Sudan. Sudan Forestry Bull., N.S. 2:45 pp.

Holsworth, W.H. 1968. Report to the Government of the Sudan on Dinder National Park. UN/FAO Report No. TA2457.

IUCN. 1977. World Directory of National Parks and Other Protected Areas, Vol. I & II. IUCN, Morges, Switzerland.

Kassas, M. 1956. Landform and plant cover in the Omdurman desert, Sudan. Bull. Soc. Geog. d'Egypte 29:43-58.

Moore, G. 1974. Wildlife and National Parks Legislation. UN/FAO Report No. TA 330.

Obeid, M. 1975. Aquatic weeds in the Sudan with special reference to the water hyacinth. (Ed.) National Council for Research, Sudan and U.S.A. National Academy of Sciences. 150 pp.

Obeid, M. and A. Mahmoud. 1969. The Vegetation of Khartoum Province. Guide to the Natural History of Khartoum Province, Part IV. Sudan Notes and Records 50:1-20.

Osman, H. el-S. and B. Fadlalla. 1974. The Effect of Level of Water Intake on Some Aspects of Digestion and Nitrogen Metabolism of the Desert Sheep of the Sudan. Jounal of Agricultural Science 82(1):61-69.

Rasheed, M.A. 1975. Present and Future Man-Power and Labour Force in Forestry Department. 1st Agric. Conf., April 1975. Khartoum (in Arabic).

Sandon, H. 1950. An illustrated guide to the freshwater fishes of the Sudan. Sudan Notes Rec. 1-61.

Seif el Din, A. 1969. The natural regeneration of Acacia senegal. M.Sc. Thesis, University of Khartoum.

Smith, J. 1949. Distribution of tree species in the Sudan in relation to rainfall and soil texture. Minst. Agric. Sudan, No. 4.

Sudan, Wildlife Administration. 1935. Wild Animals Ordinance, 1935. Khartoum.

Sudanese Environmental Conservation Society. 1978. Seminar on the Problems of the Dinder National Park. Unpubl. report. Khartoum.

Tackholm, V. 1970. A botanic expedition to the Sudan in 1938 by M. Drar. Cairo. Cairo University Herbarium Publ. 3.

Thornton, I.W.B. 1957. Faunal succession in umbels of Cyperus papyrus L. on the Upper White Nile. Proc. R. Ent. Soc. 32:119-131.

Worall, G.A. 1960. Patchiness in vegetation in the northern Sudan. J. Ecol. 48:107-115.

-----. 1960. Tree patterns in the Sudan. J. Soil Sci. 11:63-67.

4. Water Resources and Management

Ali Saleh, A.M. 1980. At-tašrī' al-mā'ī fī as-Sūdān. In: The First Arab Symposium on Water Resources, November 1978, Vol. 2: Water Legislation. Damascus: Arab Center for the Studies of Arid Zones and Dry Lands. pp. 3-19.

Anon. 1954. The Jonglei Investigation Team Report. Vols. I-V. Sudan Govt.

Barbour, K.M. 1961. Population and Water in Central Sudan. In: Essays on African Population, K.M. Barbour and R.M. Prothero, eds. London: Routledge and Kegan Paul.

Berry, L. 1960/1961. The characteristics and mode of formation of Nile islands between Malakal and Sabaloka. Rep. hydrobiol. Res. Unit Univ. Khartoum 8:7-13.

-----. 1960/1961. The physical history and development of the White Nile. Rep. hydrobiol. Res. Unit Univ. Khartoum 8:14-19.

Brook, A.J. 1954. A systematic account of the phytoplankton of the Blue and White Nile at Khartoum. Ann. Mag. Nat. Hist. 12(7):648-656.

Caponera, D.A. 1978. Water Laws in Moslem Countries, Vol. 2. Rome: FAO. iii + 311 pp. (FAO Irrigation and Drainage Paper 20/2).

Fott, B. and A.G.A. Karim. 1973. Spirulina plankton community in a lake in Jebel Marra Sudan. Arch. Protistenk 115:408-418.

Heinritz, G. 1977. Die Entwicklung junger Bewässerungsobjekte unter dem Einfluß gruppenspezifischen Pächtetverhaltens. Geographische Zeitschrift 65:188-215.

-----. 1980. Das Rahad-Scheme. Ein neues Bewässerungprojekt in der Republik Sudan. Zeitschrift für Wirtschaftsgeographie 1980:81-87.

el-Hemry, I.I. and P.S. Eagleson. 1980. Water Balance Estimates of the Machar Marshes. Cambridge, Mass.: Massachusetts Institute of Technology. (Dept. of Civil Engineering Report No. 260). 223 pp.

Hunting Technical Services. 1958. Jebel Marra Investigations--Report of Phase I Studies. Hunting Technical Services Ltd. London. 112 p.

Jahn, S. al A. 1975. Sudanese Native Methods for the Purification of Nile Water during the Flood Season. In: Biological Control of Water Pollution. (J. Tourbier and R.W. Pierson, eds.). Univ. of Pennsylvania Press, pp. 95-106.

Kheiralla, M.K. 1966. A study of the Nubian Sandstone Formation of the Nile between 14°N and 17°42N with reference to the ground water geology. M.Sc. Thesis, University of Khartoum.

Mann, O. 1977. The Jonglei Canal: Environmental and Social Aspects. Nairobi: Environment Liaison Center.

Monakov, A.V. 1969. The zooplankton and zoobenthos of the White Nile and adjoining waters of the Republic of Sudan. Hydrobiologia 33:161-185.

Prowse, G.A. and J.F. Talling. 1958. The seasonal growth of plankton algae in the White Nile. Limmol. Oceanogr. 3:222-238.

Rzóska, J., A.J. Brook and G.A. Prowse. 1955. Seasonal plankton development in the White and Blue Nile at Khartoum. Proc. Internat. Congress Limnol. 12:327-334.

Saeed, el-T.M. 1972. The Hydrogeology of Kassala District, Kassala Province. Geological and Mineral Resources Dept. Bulletin No. 21. Khartoum.

Satakopan, V. 1961. Water balance in the Sudan. Sudan Meteorological Service, Memoir No. 5.

Soleiman, Y. 1968. The Hydrogeology of part of Eastern Sudan (Gedaref District). Geological Survey Dept. Bulletin No. 16, Khartoum.

Sudan. Authority for the Development of the Jonglei Area (Abel Alier). n.d. Statement to the People's Regional Assembly on the Proposed Jonglei Canal. Khartoum.

Sudan. Executive Organ for Development Projects in the Jonglei Area. 1975. The Jonglei Project: Phase I. Khartoum.

Sudan. Ministry of Irrigation. 1975. Control and Use of the Nile Waters in the Sudan. Khartoum.

Sudan. Ministry of Irrigation (Abdullahi Ibrahim). 1977. Likely Irrigated Agriculture of 2000 AD in the DRS. Khartoum.

Sudan. Ministry of Irrigation (A.M. Khalifa and M.A. al-Nasry). 1977. Improving the Water Yield of the River Nile by Minimizing the Losses in the Swamps. UN Water Conference, Mar del Plata, Argentina.

Sudan. Ministry of Irrigation (Kemal Ali Mohammed). 1977. The Projects for the Increase of the Nile Yield with Special Reference to the Jonglei Project. UN Water Conference, Mar del Plata, Argentina.

Sudan. Ministry of Irrigation (H.S. Adam and H.G. Farbrother). 1977. Crop-Water Use in Irrigated and Rainfed Agriculture in the DRS. UN Water Conference, Mar del Plata.

Sudan. National Preparatory Committee for UN Water Conference. 1977. The Water Resources of the Sudan. Khartoum.

Sudan. NCR, ARC (Saghayroun al-Zein). 1976. The Water Resources of the Nile for Agricultural Development in the Sudan. In: Aquatic Weeds in the Sudan, M. Obeid, ed. Khartoum.

-----. 1976. Staff Summary Report of Regional Workshop on Aquatic Weed Management and Utilization in the Nile Basin. Khartoum.

Talling, J.F. 1954. Chemical and physical characteristics of Nile waters in relation to phytoplankton production. Rep. hydrobiol. Res. Unit Univ. Khartoum 1:10-12.

-----. 1955/1956. Water characteristics an phytoplankton production. Rep. hydrobiol. Res. Unit Univ. Khartoum 3:8-12.

-----. 1956/1957. Some physical, chemical and algological aspects of Nile hydrobiology. Rep. hydrobiol. Res. Unit Univ. Khartoum 4:6-8.

-----. 1957. The longitudinal succession of water characteristics in the White Nile, Hydrobiologia 11:73-89.

Yassin, A.S. 1966. The ground water geology of the Gezira. M.Sc. Thesis, University of Khartoum.

5. Land Use and Agriculture

Abuzeid, O. 1975. The Potential and Prospects for Sugar Production. Sudan International 1(12-13):28-30.

Adams, M.E. 1977. An Agricultural Development Plan for Southern Dafur. In: Essays on the Economy and Society of Sudan, Ali M. El Hassan, ed. Vol. 1, Khartoum, pp. 15-32.

-----. 1977. Developing the Traditional Sector in Sudan. Khartoum.

AFSED. 1977. Basic Programme for Agricultural Development in the Sudan 1976-85: An Invitation to the Founders. Unofficial translation, British Council of Industries. London.

Agrar-und Hydrotechnik GmbH. 1975. Increase of Agricultural Production in the Sudan. Essen.

-----. 1977. Nuba Mountains Region--Development Potential Survey. Essen.

Arab Organization for Agricultural Development. 1974. Project for Mechanized Production of Sorghum, Oil Seeds, and Fodder: Southern Funj Region, Sudan. Khartoum. (In Arabic).

Babiker, A.B.A. 1974. Die Landwirtschaft in der Demokratischen Republik Sudan. Petermanns Geographische Mitteilungen 118:181-188.

Barnett, T. 1975. The Gezira Scheme: Production of Cotton and Reproduction of Underdevelopment. In: Beyond the Sociology of Development, I.O. et al., eds. London: Routledge & Kegan Paul.

-----. 1977. The Gezira Scheme. London: Frank Cass and Company, Ltd.

Cloudsley-Thompson, J.L. 1971. Recent expansion of the Sahara. Intern. J. Environmental Studies 2:35-39.

Cunnison, I.G. 1960. The Social Role of Cattle. Sudan J. Vet. Sci. & Anim. Husb. 1:8-25.

Davies, H.R.J. 1964. The West African in the Economic Geography of Sudan. Geography 49:222-235.

-----. 1964. An Agricultural Revolution in the African Tropics: The Development of Mechanised Agriculture on the Clay Plains of the Republic of Sudan. Tijdschrift voor Economische en Sociale Geografie 55:101-108.

Dixey, F. and G. Aubert. 1962. Arid Zone Research in the Sudan. Arid Zone, No. 16. pp. 5-16. UNESCO, Paris.

Fadialla, A. 1972. Gerih el Sarha Rural Development Scheme. University of Khartoum, Department of Geography.

FAO. 1973. Perspective Study of Agricultural Development for the Democratic Republic of Sudan: Farm Mechanization. ESP/AGL/PS/SUD/ 73/13. Rome.

-----. 1973. Perspective Study of Agricultural Development for the Democratic Republic of Sudan: Food Supplies and Nutrition. ESP/AGL/PS/SUD/ 73/4. Rome.

-----. 1973. Perspective Study of Agricultural Development for the Democratic Republic of Sudan: Land and Water Development and Use. ESP/AGL/PS/SUD/ 73/6. Rome.

el-Hadari, A.R. 1969. Economics of Dura Production in the Mechanized Crop Production Schemes. Faculty of Agriculture, Khartoum.

el-Hadari, A.R. and G. Ballal. 1976. Agricultural Marketing and Credit through Cooperative Societies: A Case Study of the Khashm el Girba Scheme in Sudan. Faculty of Agriculture, Khartoum.

Harrison, M.N. 1955. Report on grazing survey of the Sudan. Republic of Sudan. Mimeo.

Hoyle, S.G. 1977. The Khashm el-Girba Agricultural Scheme: An Example of an Attempt to Settle Nomads. In: Landuse and Development, P. O'Keefe and B. Wisner, eds. African Environment Special Report 5. London: International African Institute. pp. 116-131.

-----. 1977. The Settlement of Nomads in the Sudan: The Case of Khashm el Girba Agricultural Scheme. Ph.D. thesis, University of London.

Ibrahim, F. 1978. Anthropogenic Causes of Desertification in Western Sudan. Geo Journal 2-3:243-254.

Jackson, J.K. and M.K. Shawki. 1950. Shifting cultivation in the Sudan. Mem. For. Div. Sudan, No. 2.

van der Kevie, W. 1971. Manual for Land Suitability Classified for Agriculture. Technical Bulletin No. 21. Soil Survey Administration, Wad Medani.

Khogali, M.M. 1976. Western Sudanese Migrants to Khashm el Girba Agricultural Region: A Case Study. Department of Geography, University of Khartoum.

-----. 1978. Nomads and Their Sedentarization in the Sudan. Department of Geography, University of Khartoum.

Lamprey, H.F. 1975. Report on the Desert Encroachment Reconnaissance, Northern Sudan. National Council for Research, Sudan.

-----. 1975. Report on the desert encroachment reconnaissance in northern Sudan. Nairobi, UNEP. Mimeo.

Lebon, J.H.G. 1965. Land-Use in Sudan, World Land Use Surv. Mono. No. 4.

Mukhtar, H.A.M. 1977. Range Development in the Democratic Republic of the Sudan. Addis Ababa.

Mukhtar, M.A. 1975. Production and Use of Wood Fuel in the Sudan. Proc. 1st Agric. Conf., April 1975. Khartoum (in Arabic).

-----. 1978. Wood Fuel as a Source of Energy in the Sudan. Proc. 1st Energy Conf., April 1978. Khartoum, Ministry of Energy and Mining.

Musnad, H.A. 1970. Forests as a Means of Utilising Marginal Lands in the Sudan. Paper read at the First Conference of Arab Agriculturalists.

-----. 1971. Soil Moisture Conservation for Plant Growth in the Arid Climate of Northern Sudan. M.Sc. thesis, University of Khartoum.

-----. 1975. Soil Conservation and Land Use in the Sudan. Sudan Silva 3:34-38.

-----. 1977. Land Reclamation in Kerma Basin. Sudan Silva 3:69-78.

Oesterdiekhoff, P. and J. Tait. 1979. Kapitalisierung und Proletarisierung in den Agrarsektoren des Sudan. In: Die Überwindung der ländlichen Armut in der Dritten Welt, Hannisch and Tetzlaff, eds. Frankfurt. pp. 115-142.

Olsson, L. 1978. Demand for Seasonal Labourers in Irrigated Agriculture in Sudan. A Case Study of the Rahad Scheme. Bangkok.

Osman, A.E. 1979. Productivity of Irrigated Tropical Grasses under Different Clipping Frequencies in the Semidesert Region of the Sudan. Journal of Range Mangement 32(3):182-185.

Saeed, O.I. 1975. Evaluation of Khashm el Girba Agricultural Corporation. Khartoum. 1975.

Shakkak, K.I. 1977. Mechanisation of Agriculture in the Clay Plains of the Sudan, with Special Reference to the Gadaref District. M.A. thesis, University of Khartoum.

Snow, O.W. 1952. Animal Foodstuffs. Agriculture in the Sudan. Oxford University Press, London. pp. 668-683.

Sörbo, G.M. 1972. Economic Adaptations in Khashm el Girba. African Studies Seminar Series, No. 14. Faculty of Arts, University of Khartoum.

-----. 1977. Nomads on the Scheme: A Study of Irrigation, Agriculture and Pastoralism in Eastern Sudan. In: Landuse and Development, P. O'Keefe and B. Wisner, eds. African Environment Special Report 5. London: International African Institute. pp. 13^-150.

Sudan. Agricultural Section, National Planning Commission. 1975. Summaries of Major Projects Proposed for Agricultural Development. Issues No. 1, Khartoum.

Sudan. Ministry of Agriculture. 1974. Food and the Sudan. Khartoum: Khartoum University Press.

-----. 1976. Current Agricultural Statistics. CAS-1, (2).

Sudan. Ministry of Agriculture, Food and Natural Resources, and Agricultural Research Council. 1976. Sudan's Desert Encroachment Control and Rehabilitation Programme. Khartoum.

Sudan Sugar Corporation. 1975. Sugar for the Sudan and Neighboring Countries. Khartoum.

Sudan Sugar Corporation and Cane Machinery and Engineering. 1975. The Sudan Sugar Industry.

Tetzlaff, R. n.d. Die Durchkapitalisierung der Landwirtschaft im Sudan und ihre Auswirkungen auf den traditionellen Sektor: Eine Strategie zur Überwindung

ländlicher Armut? In: Agrarreform in der Dritten Welt, H. Elsenhaus, ed. Campus o.J. pp. 339-363.

University of Leeds. 1975. Study of Agricultural Development in the Sudan Central Rainlands.

Watson, R.M., C.I. Tippett, F. Razk, F. Jolly, J.J. Beckett, V. Scholes and F. Casbon. 1977. Sudan national livestock survey and resource census. Nairobi, Resource Management and Research Ltd. Mimeo.

Wickens, G.E. 1966. Present Land Use Survey of the United Nations Special Fund Jebel Marra Project in the Republic of the Sudan. Food and Agricultural Organization, Rome.

Wilson, R.T. and S.E. Clarke. 1975. Studies on the Livestock of Southern Darfur, Sudan. I. The Ecology and Livestock Resources of the Area. Trop. Anim. Hlth. Prod. 7:165-185.

6. Public Health, Socio-Economic Aspects, Development

Abu Sin, M. el-H. 1975. A Survey and Analysis of Population Mobility within Northern and Central Sudan. Ph.D. Thesis, Bedford.

Agunda, O. 1973. The State and the Economy in the Sudan from a Political Scientist's Point of View. The Journal of Developing Areas 7:431-448.

el-Arifi, S. 1971. Urbanization and Distribution of Economic Development in the Sudan. African Urban Notes 6:115-140.

-----. 1975. Landlordism among Small Farmers. The Case of the Gezira Tenant in the Sudan. Sudan Journal of Economic and Social Studies 1(2):10-14.

-----. 1978. Local Government and Local Participation in Development in the Sudan, Proc. Conf. on Rural Participation, March 1978. Inst. Devt. Studies, University of Nairobi.

Asad, T., I. Cunnison and L.G. Hill. 1976. Settlement of Nomads in the Sudan: A Critique of Present Plans. In: Some Aspects of Pastoral Nomadism in the Sudan, A.G.M. Ahmed, ed. Khartoum: Sudan National Population Committee and the Economic and Social Research Council. pp. 174-192.

Babiker, A.B.A. 1974. Einige Aspekte des Urbanisierungsprozesses in der Demokratischen Republik Sudan. Wiss. Zeitschrift Universität Halle 23:75-82.

Barbour, K.M. 1961. The Republic of Sudan. University of London Press.

Briggs, J.A. 1976. Aspects of the Development Process in Africa: A Study of the Southern Gummuiya Area of Central Sudan. Ph.D. thesis, University of Wales.

el-Bushra, el-S. 1969. Occupational Classification of Sudanese Towns. Sudan Notes and Records 50:75-96.

-----. 1970. The Khartoum Conurbation: An Economic and Social Analysis. Ph.D. Thesis, Bedford.

-----. 1971. The Evolution of the Three Towns. African Urban Notes 6(2):14-17.

-----. 1972. The Development of Industry in Greater Khartoum, Sudan. The East African Geographical Review, No. 10:29-30.

-----. 1972. Urbanization in the Sudan. Phil. Society of the Sudan. Proceedings of the 17th Annual Conference. Khartoum.

-----. 1975 Sudan's Triple Capital: Morphology and Functions. Ekistics 39:246-250.

-----. 1976. An Atlas of Khartoum Conurbation. Khartoum.

Dakawi, H.M. 1975/76. Hag Yousif Shanty Town. Diss. Univeristy of Khartoum.

Duffield, M. 1978. Hausa and Fulani Settlement and the Development of Capitalism in the Sudan. Ph.D. Centre of West African Studies, Univ. of Birmingham.

-----. 1979. Threat of Scapegoat. Sundanow, Martz 1979, (Khartoum):40-42.

Elias B.O. and H.Y. Bedawi. 1972. The Squatter Housing Problem: A Review of Government Policy and Solutions. Phil. Society of the Sudan. Proceedings of the 17th Annual Conference. Khartoum. pp. 213-221.

Fahim, H.M. 1973. Social Science Research in Relation to the Khashm el Girba Scheme in the Sudan. African and Asian Studies Seminar Series 19.

Fawzi, D. 1973. La République du Sudan échec d'une expérience de décollage économique dans la voie capitaliste par une ancienne dépendance coloniale. Algiers: SNED.

Galal-el-din, M. el A. 1973. Internal Migration in the Sudan since World War II, with Special Reference to Migration to Greater Khartoum. Ph.D. Thesis, London.

al-Hassan, A.M., ed. 1976. An Introduction to the Sudan Economy. Khartoum: Khartoum University Press.

Henin, R.A. 1963. Economic Development and Internal Migration in the Sudan. Sudan Notes and Records 44:100-119.

McLoughlin, P.F.M. 1964. The Sudan's Three Towns: A Demographic and Economic Profile of An African Urban Complex. Economic Development and Cultural Change 12(2):159.

Mohamed, Y.A. 1975. Some Spatial Aspects of Rural Change in Western Sudan. Ph.D. thesis, Univ. of Liverpool.

Mustafa, M. el-M and K. Affan. 1977. The Sudanese Labour Market: An Overview of its Characteristics and Problems, with Special Emphasis on the Urban Labour Market. In: Growth, Employment and Equity, A.M. el-Hassan, ed. Khartoum. pp. 193-213.

Oberai, A.S. 1977. Migration, Unemployment and the Urban Labour Market. A Case Study of Sudan. International Labour Review 115:211-223.

Sudan. Ministry of Finance, Plan, and National Economy. 1976. Initial Highlights of the Six Year Plan for Economic and Social Development 1977-78 - 1982-83. Khartoum. (In Arabic)

-----. 1977. Economic Survey 1975-76. Khartoum.

-----. 1978. Economic Survey 1976-77. Khartoum.

Sudan. NPC. 1975. Economic Survey 1974. Khartoum.

Sudan. NPC, Transport and Communications Section. 1975. Transport Statistical Bulletin 1974. Khartoum.

Sudan. 1977. Six Year Development Plan (1977-1982). Khartoum.

Swareldahab, A. 1978. Labour Force in the Manufacturing Industries of Khartoum North - A Case Study in Demographic and Socio-Economic Characteristics of Industrial Labour Force in Sudan. M.A. thesis, Khartoum.

Tait, J. 1978. Diversifizierung, Mechanisierung und Kapitalisierung der Produktion im Sudan Gezira Schema. Afrika Spektrum 13:165-178.

-----. 1980. Interner Kolonialismus und ethnisch-soziale Segregation im Sudan: Nigerianisch-westafrikanische Arbeitsmigranten und das Arbeitsmarktsystem in der Gezira. Afrika Spektrum 14:361-381.

World Bank. 1972. The Economic Development and Prospects of the Sudan, Vol. I. Main Report.

-----. 1972. The Economic Development and Prospects of the Sudan, Vol. II. Annex 1: The Public Enterprises.

-----. 1972. The Economic Development and Prospects of the Sudan, Vol. III. Annex 2: The Agricultural Sector.

-----. 1973. Report of a Special Mission on the Economic Development of Southern Sudan. Washington, D.C.

-----. 1975. Performance Audit Report.

-----. 1976. Report on Reconnaissance Mission to the Khashm el Girba Scheme.

-----. 1976. South Kordofan Agriculture Development. Khartoum.