

DRAFT

Environmental Profile

of

The Democratic Republic of Sudan

Prepared by the

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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), Office of Forestry, Environment, and Natural Resources (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 AID 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 AID 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 USMAB and ST/FNR and should be addressed to either:

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SUMMARY

The Democratic Republic of Sudan, situated in northeast Africa, is the largest country on the continent. Sudan spans three major ecological zones, from very arid desert in the north to savanna in the south. The southernmost highlands even include small patches of rain forest. Three major regions are usually distinguished geographically, also: the northern desert, the plains, and the Sudd or swampy region in the south. The few highland areas scattered throughout Sudan are sometimes considered a separate region, as is the Nile Valley.

Sudan is still in the very early stages of development. The economy is heavily oriented toward agriculture, and a very little industrial base has been developed. Accordingly, the major environmental problems concern areas such as agriculture and public health. The most important of these are noted below.

Desertification and accompanying phenomena pose a major threat to Sudan's environment. Monitoring over the last several decades has shown that the desert is shifting southwards at a rate of five to ten km per year. Substantial agricultural land is lost along the fringes of the desert, as well as in other areas of Sudan where severe erosion or salinization destroy productivity.

Major human causes behind desertification include over-intensive cultivation, overgrazing, wood cutting and deforestation, depletion of aquifers, and burning of grasslands, scrub, and forests. Expansion of cultivated area in wet years is particularly dangerous. When the inevitable dry years follow, the soil is very vulnerable to wind and water erosion because the natural ground cover has been eliminated. Soil depletion has also increased as population pressure on the land rises. Traditional fallow systems which allowed soils to recover are being rapidly abandoned in attempts to harvest crops annually from the same field. Rising water demands have also led to depletion of water tables. Land is abandoned to the desert when water supplies are exhausted.

Yields on agricultural land have declined drastically in many areas, and some lands have been abandoned entirely because the soil will no longer support cropping. In other cases, mobile sand dunes have covered productive land.

The pastoral sector also contributes to desertification as herd sizes increase and overgrazing becomes widespread. The number of livestock in the mid 1970s was six to seven times greater than in the mid 1920s, and this has often led to rapid depletion of ground cover. Wind and water erosion then remove

the topsoil and the carrying capacity of the range is permanently reduced. Removal of tree and brush cover for fuel wood is also widespread. Nomads alone uproot an estimated 548 million acacia shrubs annually, but wood is also the primary energy source for the more numerous cultivators.

Environmental health problems are widespread. Development of surface water resources, especially irrigation networks, has often led to increased incidence of malaria and bilharzia. Efforts to control these two diseases have not been as successful as have programs to eradicate several other major diseases. Other health problems stem from the inavailability of uncontaminated water supplies. Over half of Sudan's rural population does not have access to safe water. Low income areas in cities likewise face this problem, and rapid urbanization is straining urban water and other facilities. Lack of adequate sanitation facilities is actually a greater problem in urban areas, because population densities are high. Only the three cities area has central sewage systems, and only a small proportion of houses are actually served by these systems.

Plant and animal pests are of serious concern in the Sudan, particularly water hyacinth. The entire stretch of the Nile from Juba to the Jebel Aulia Dam has been infested by water hyacinth, which causes a water loss of up to seven billion cubic meters annually, about one-tenth of the normal yield of the river. In addition, water hyacinth clogs irrigation pumps and canals, disrupts river transportation and the operation of hydroelectric plants, and improves the environment for mosquitos and freshwater snails. Other plant pests also infest cultivated fields, and animal pests, such as locusts and Quelea birds, may destroy substantial areas of crops.

Wildlife is under severe pressure in many parts of Sudan. Surveys in the Darfur and Kassala Provinces indicate that large mammals may not inhabit those areas by early in the 21st century. Hunting and poaching have caused major declines in the population of a few species. Most wildlife, however, is under pressure primarily because of habitat destruction as agricultural and pastoral activities expand, or as desertification proceeds. Sudan has established a system of game reserves and sanctuaries, as well as several national parks. Protection is practically non-existent on reserves and sanctuaries and in many cases the animals for which these have been established are no longer found in them. Wildlife has fared better in the parks, which still preserve relatively large populations and undisturbed habitats.

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

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

| 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 = 0.1-0.2E 0.44E |
| M1.2 | DRY MONSOON, long dry season, cool winter | 3-4 | 7 | 5 | 600-850 | 38-39 | 5-13 | R Ln = 0.1-0.2E 0.44E |
| 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 |

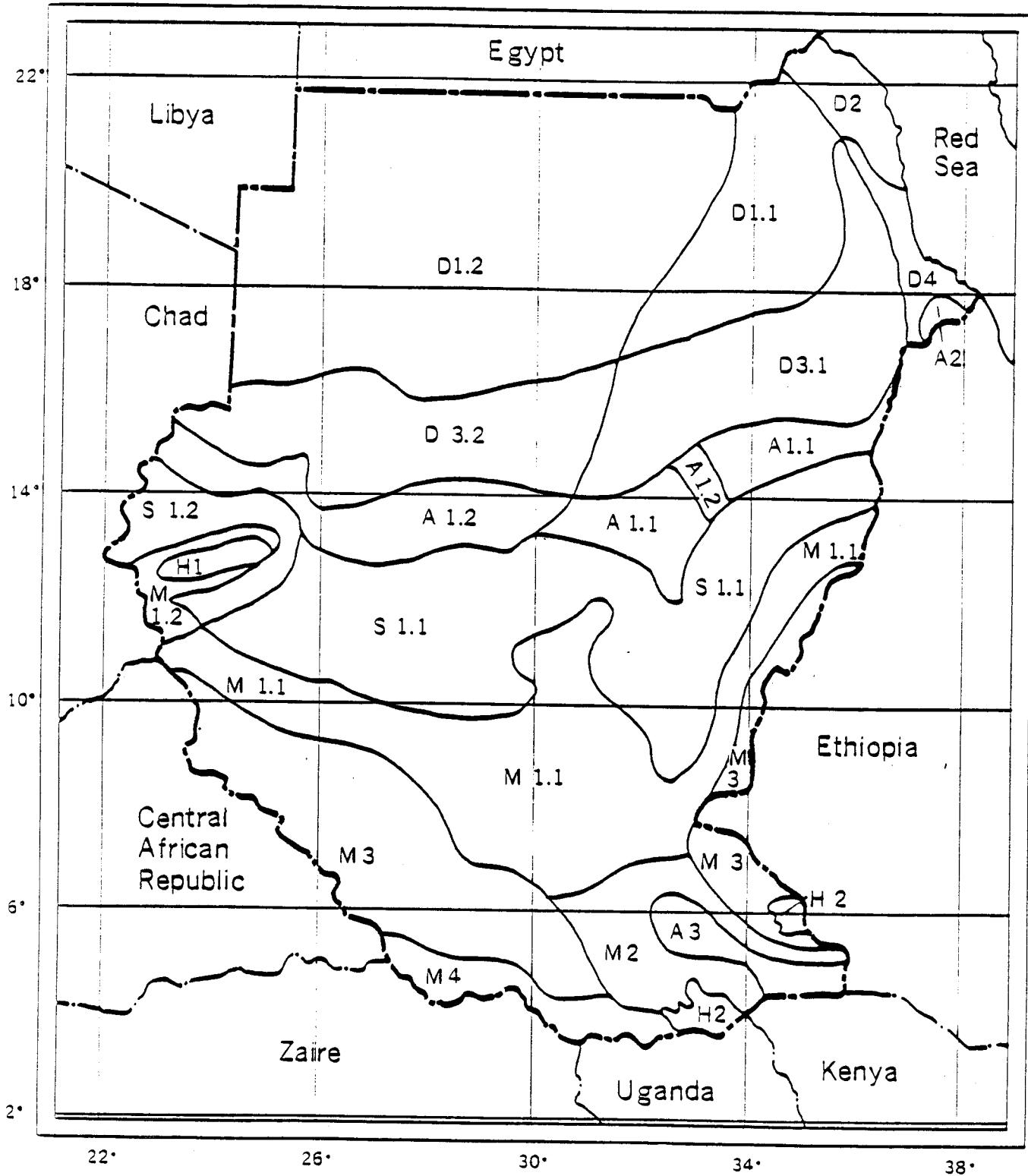


Figure 2.1. Climatic Zones in the Sudan

Source: Thimm. 1979.

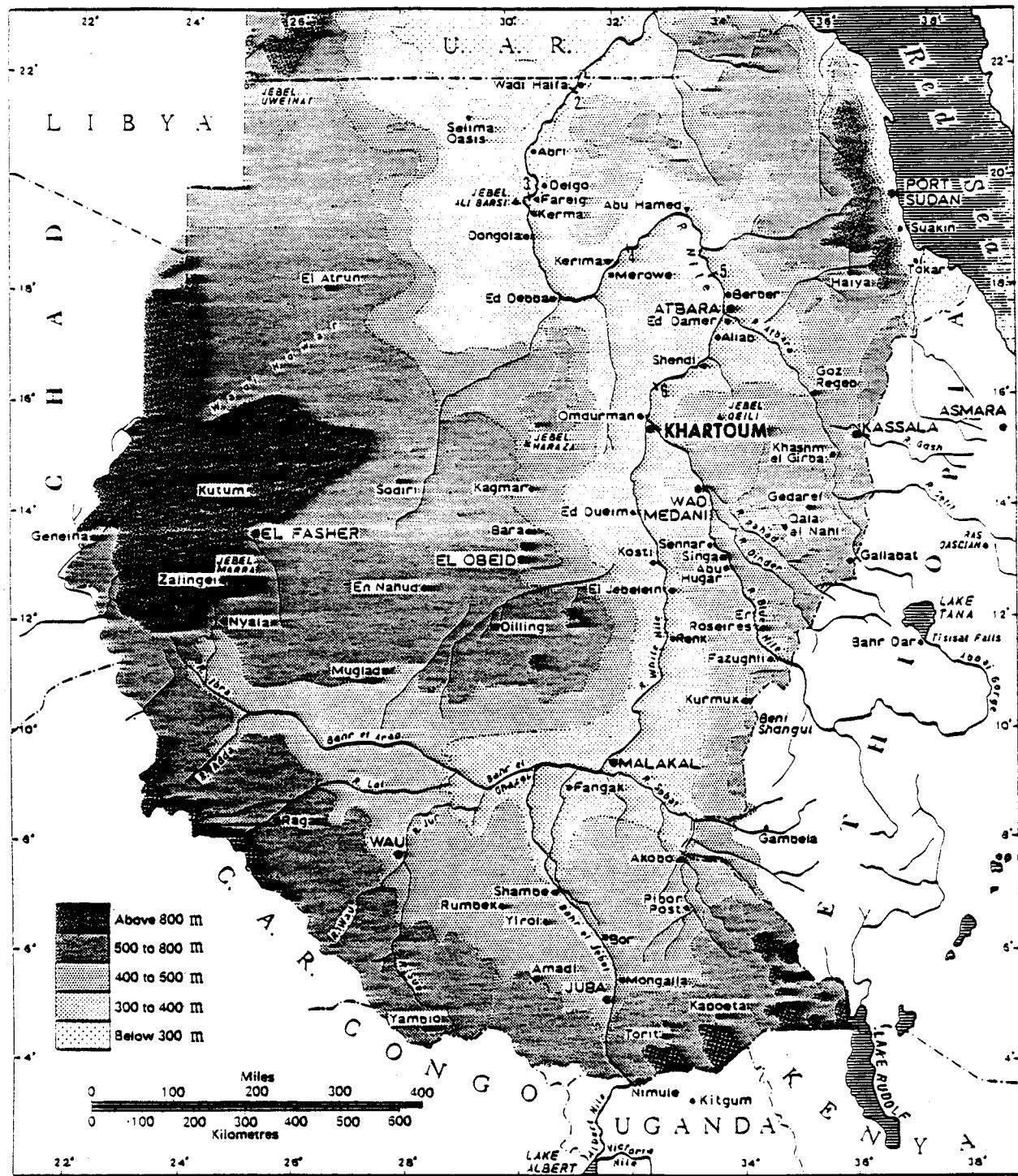


Figure 2.2. Physical and General Locality Map

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).

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

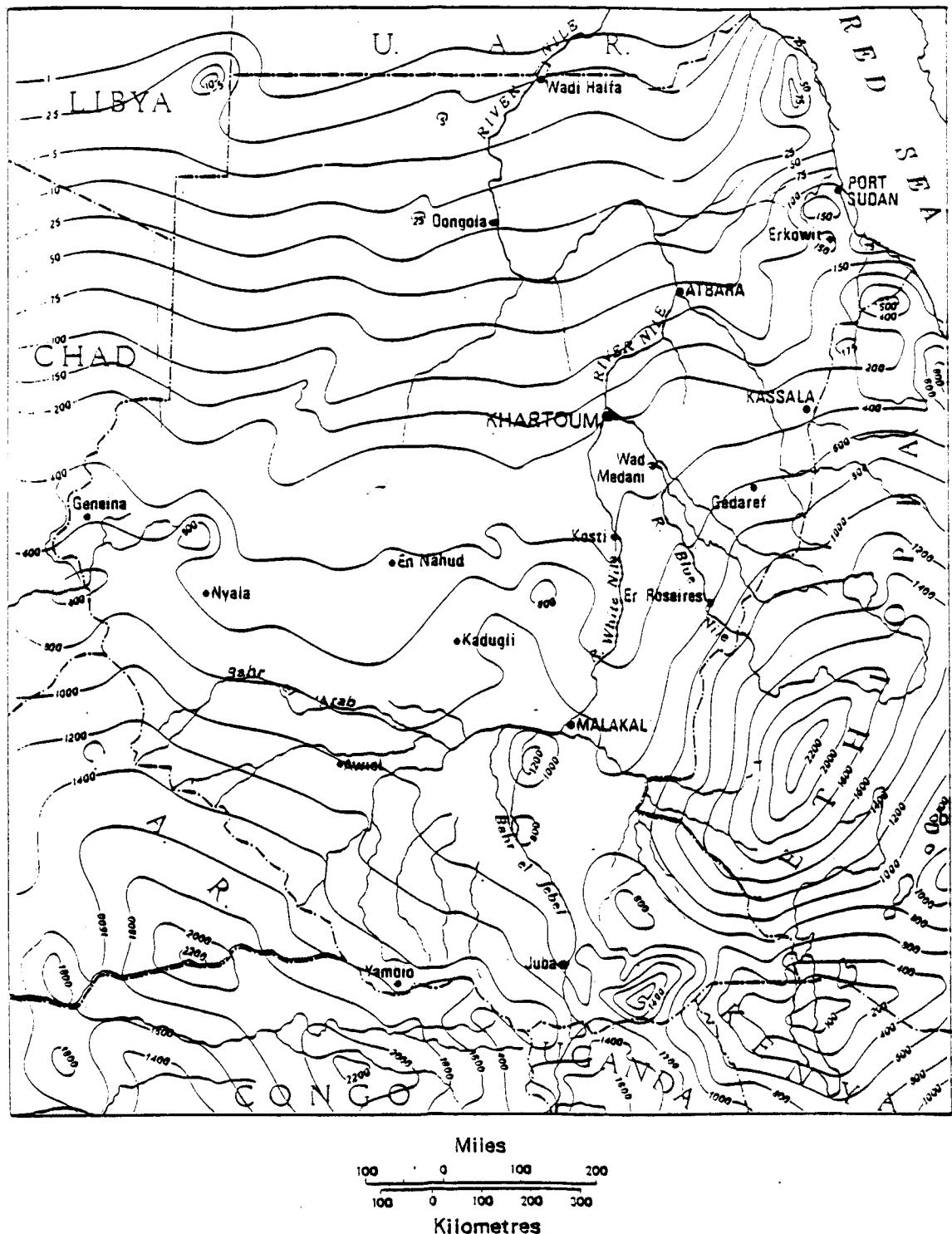


Figure 2.3. Mean Annual Rainfall (in mm.)

Source: Whiteman. 1971.

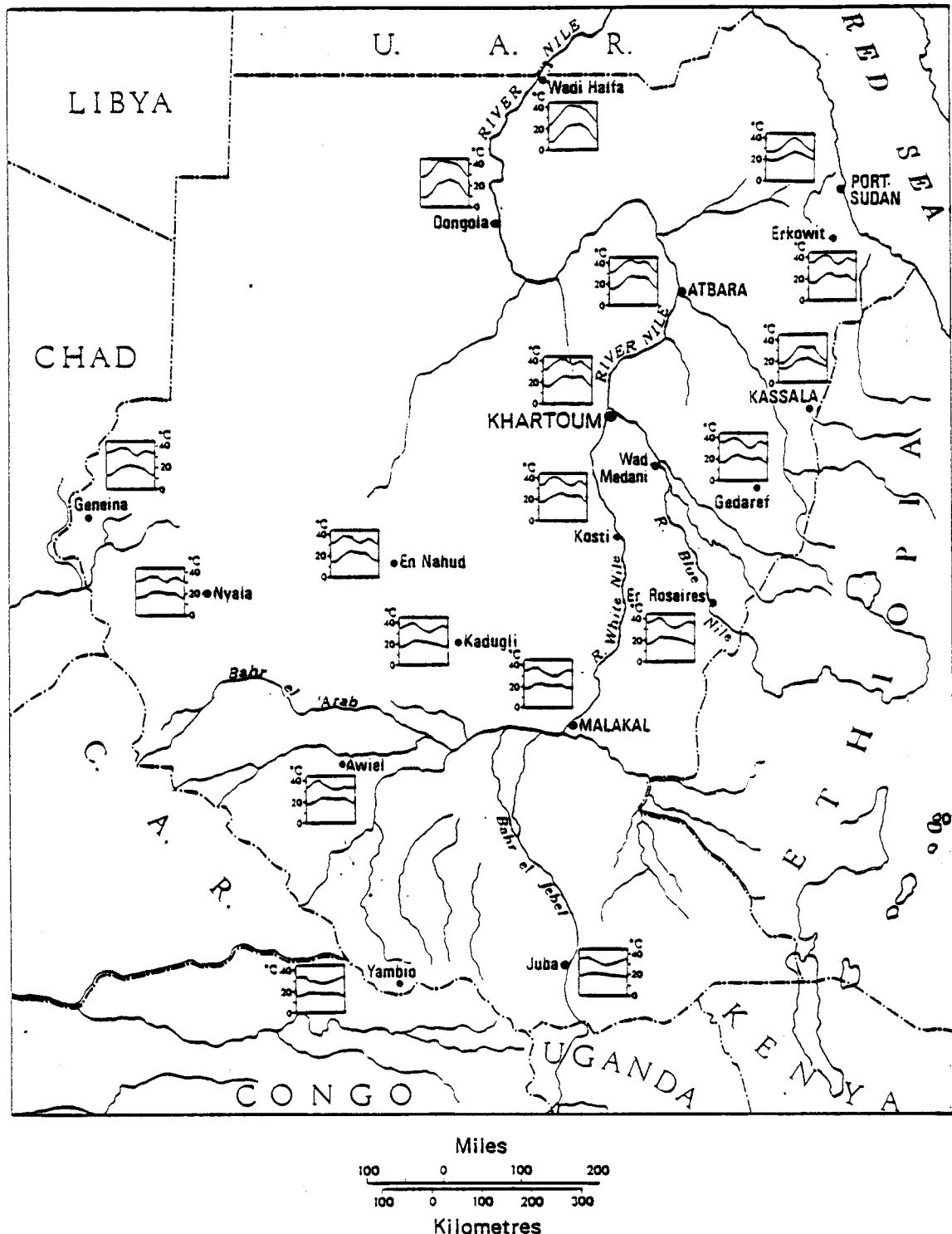


Figure 2.4. Mean Daily Temperature

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 (1978). 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 indigenous 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).

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

Table 2.1. Population, Urbanization and Growth

| | 1955/56 | | 1973 | | Growth Rate |
|--------------------|-----------------------|---------|-----------------------|---------|-------------|
| | Population (000's) | Percent | Population (000's) | Percent | |
| Northern Provinces | | | | | |
| Urban | 690.4 | 9% | 2,213.0 | 19% | 6.9% |
| Rural | <u>6,789.0</u> | 91% | <u>9,520.4</u> | 81% | <u>2.0%</u> |
| Total | 7,479.4 | | 11,733.4 | | 2.6% |
| Southern Provinces | | | | | |
| Urban | 46.7 | 2% | 274.7 | 9% | +10.7% |
| Rural | <u>2,736.4</u> | 98% | <u>2,750.2</u> | 91% | <u>-</u> |
| Total | 2,783.1 | | 3,024.9 | | .5% |
| Total Sudan | | | | | |
| Urban | 737.1 | 7% | 2,487.7 | 17% | 7.2% |
| Rural | <u>9,525.4</u> | 93% | <u>12,270.6</u> | 83% | <u>1.5%</u> |
| 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 |
|-------------------------|------------------|-------------------|-------------------|
| <u>Urban Population</u> | | | |
| 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 | <u>470.1</u> | <u>597.1</u> | <u>834.7</u> |
| Total Urban | 2,736.9 (18%) | 3,978.9 (24%) | 6,345.6 (31%) |
| (Growth Rate) | (+7.2%/yr) | (+7.3%/yr) | (+6.9%/yr) |
| <u>Rural Population</u> | | | |
| | 12,082.1 (82%) | 12,898.0 (76%) | 14,002.9 (69%) |
| (Growth Rate) | <u>(1.5%/yr)</u> | <u>(+1.3%/yr)</u> | <u>(+1.2%/yr)</u> |
| 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 4.3. Urban Centers Ranked by 1973 Population

| <u>City (Province)</u> | <u>Resident Population</u> (000's) | | | <u>Annual Growth Rate</u> | |
|-------------------------------|---------------------------------------|----------------|----------------|---------------------------|----------------|
| | <u>1955-56</u> | <u>1964-65</u> | <u>1973-74</u> | <u>1964/65</u> | <u>1973/74</u> |
| 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 | 6.5 |
| *Wad Medani (Gezira) | 47.7 | 63.7 | 118.0 | 3.1 | 7.5 |
| *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 | 4.8 |
| *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 | 26.3 | 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.

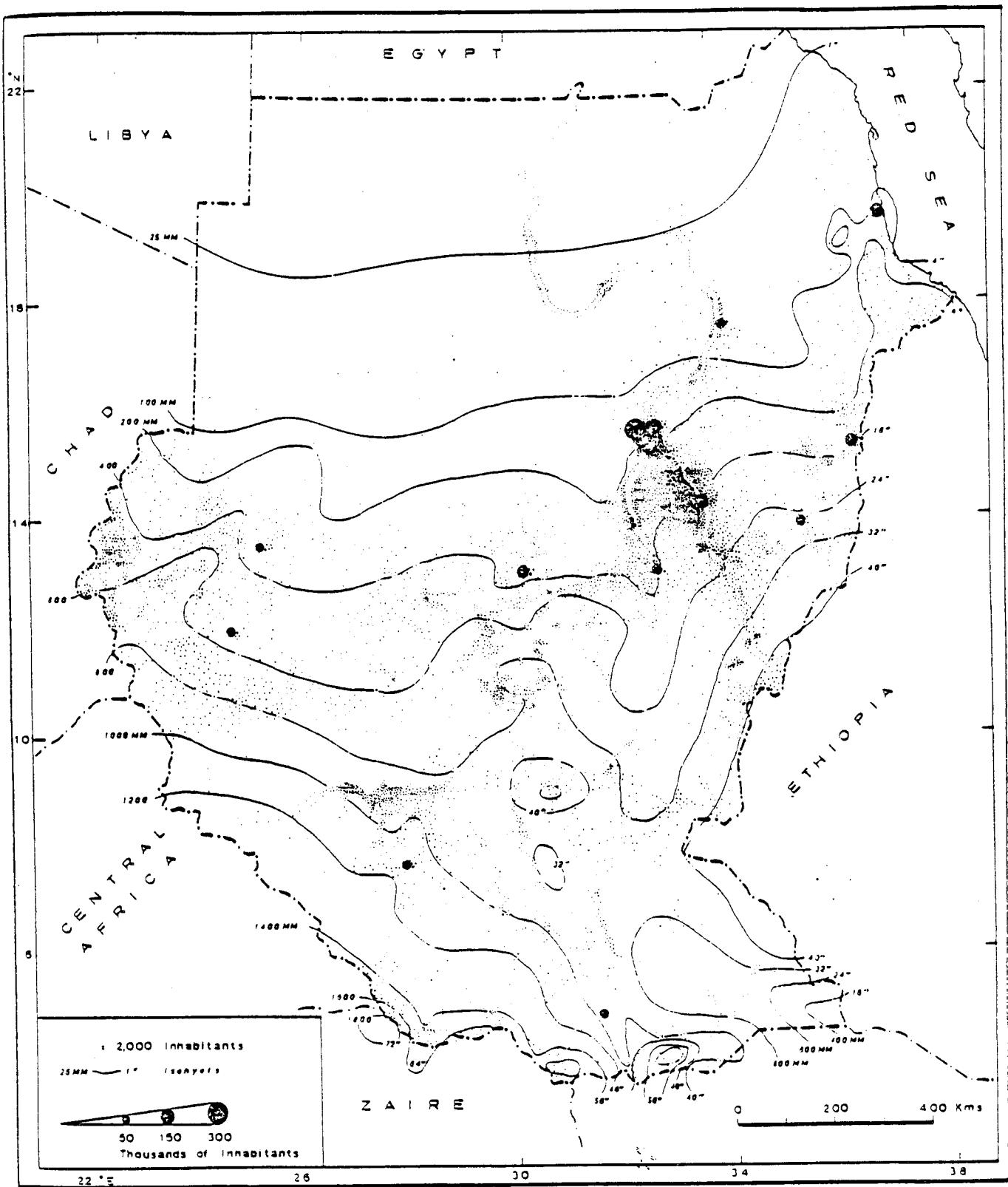


Figure 2.5. Distribution of Population, 1973

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 | 3,990,000 | 38.8 |
| | Kordofan | | |
| | Dariur | | |
| 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 |
| Darfuri 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.

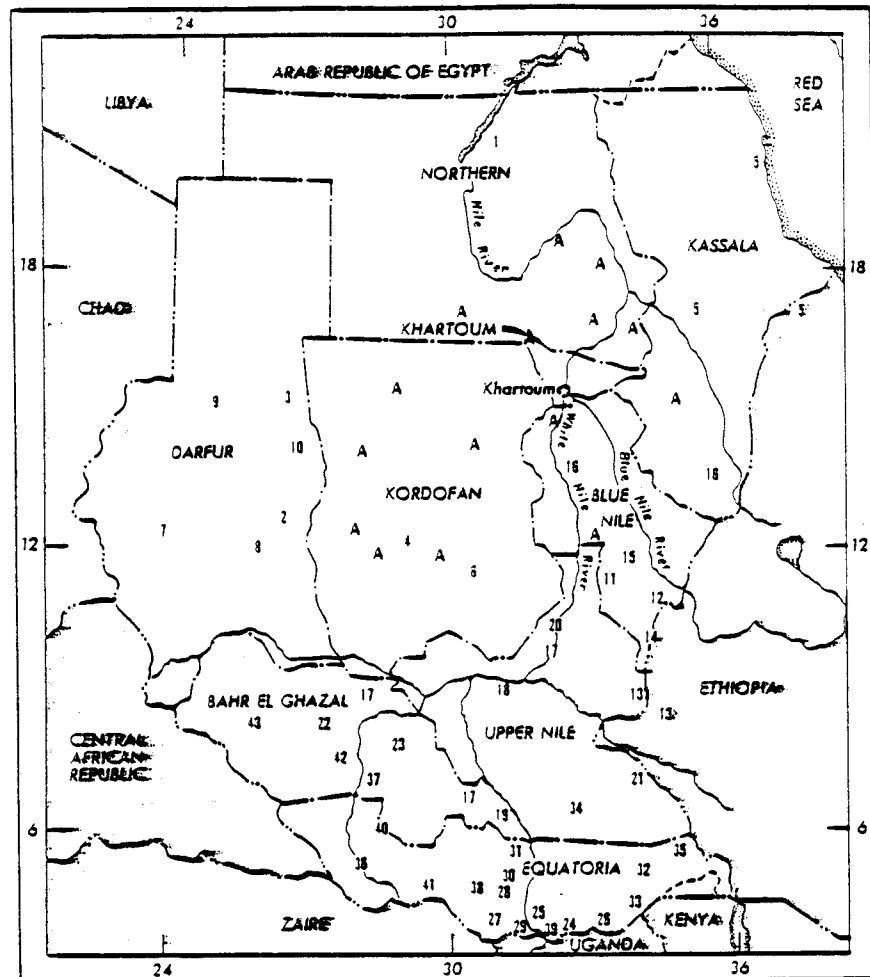
Source: Nelson et al. 1973.

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 resistance 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 | Murie |
| 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 Nilotc 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 Nilotc. 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 Equatoria 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

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)

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

Source: U.S. AID. 1978.

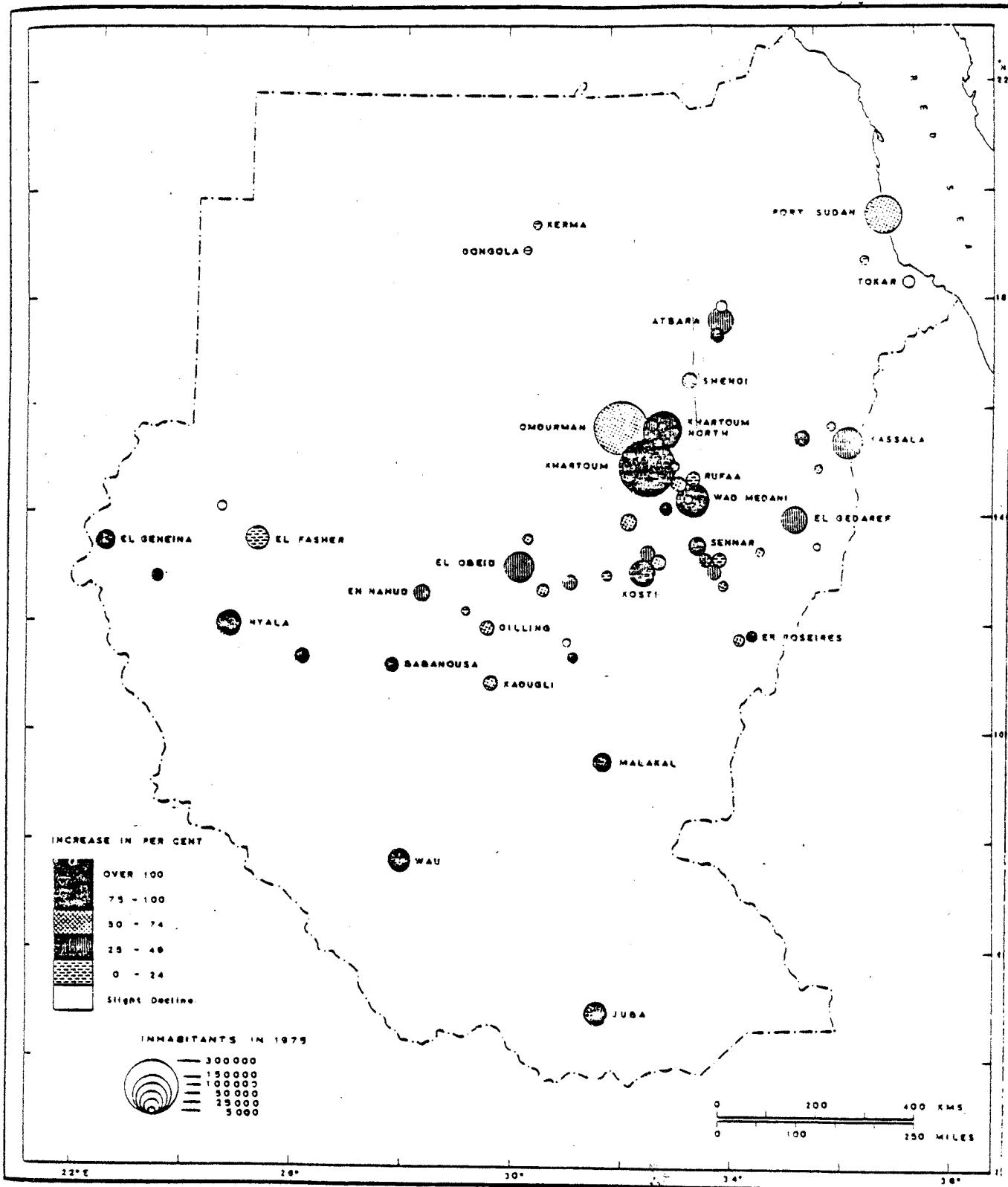


Figure 2.7. Main Urban Centers and Growth, 1965-75

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

pilgrim route for West Africian 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

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 sandfly..... | 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 reported 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..... | South, mainly Bahr al Ghazal and Equatoria. |
| Yaws (nonvenereal treponematosus)..... | By direct contact with skin lesions of infected persons. | Endemic in southern half of country, but effectively controlled since last severe epidemic in 1940; rare in urban areas. |
| Yellow fever..... | By the bite of an infective mosquito..... | |

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 fatality rate of hospitalized cases is the third highest cause of death reported in hospitals.

Onchocerciasis (River Blindness) is a water borne or riparian related disease, occurring 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 subsistence oriented for the majority of the population. There are

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 L.S.m. 1 | 1970/71 L.S.m. 1 | 1971/72 L.S.m. 1 | 1972/73 L.S.m. 1 | 1973/74 L.S.m. 1 | 1974/75 L.S.m. 1 | 1975/76* L.S.m. 1 | 1976/77* L.S.m. 1 | 1977/78 L.S.m. 1 |
|---------------------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-------------------------|-------------------------|------------------------|
| Agriculture | 263.7 | 294.4 | 308.7 | 324.1 | 39.0 | 344.6 | 38.4 | 516.4 | 585.3 |
| Commerce, Finance, and Services | 236.0 | 255.6 | 33.6 | 284.1 | 34.1 | 313.3 | 411.5 | 510.5 | 608.7 |
| Industry and Mining | 66.8 | 69.2 | 9.1 | 76.8 | 9.2 | 82.9 | 9.2 | 111.3 | 142.9 |
| Transport and Communications | 51.1 | 50.7 | 6.7 | 51.3 | 6.2 | 61.5 | 6.9 | 74.8 | 89.4 |
| Construction | 24.3 | 23.3 | 3.5 | 26.4 | 3.2 | 31.2 | 61.0 | 65.0 | 81.8 |
| Electricity and Water | 16.5 | 16.6 | 2.4 | 16.9 | 2.0 | 17.5 | 2.0 | 18.6 | 20.9 |
| <u>Sub-total (A)</u> | <u>650.4</u> | <u>709.8</u> | <u>779.6</u> | <u>851.0</u> | <u>1,193.6</u> | <u>1,422.0</u> | <u>1,671.0</u> | <u>1,966.6</u> | <u>2,096.9</u> |
| Percent of Total | | | | | | | | | |
| (B) Customs duties | 43.1 | 6.1 | 51.3 | 6.7 | 52.0 | 6.3 | 45.0 | 52.6 | 4.2 |
| <u>GDP/TOTAL</u> | <u>(A + B)</u> | <u>701.5</u> | <u>761.1</u> | <u>100%</u> | <u>832.4</u> | <u>100%</u> | <u>896.8</u> | <u>1,246.2</u> | <u>100%</u> |
| | | | | | | | | | |
| | | | | | | | | | |

* 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 subsistence 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.

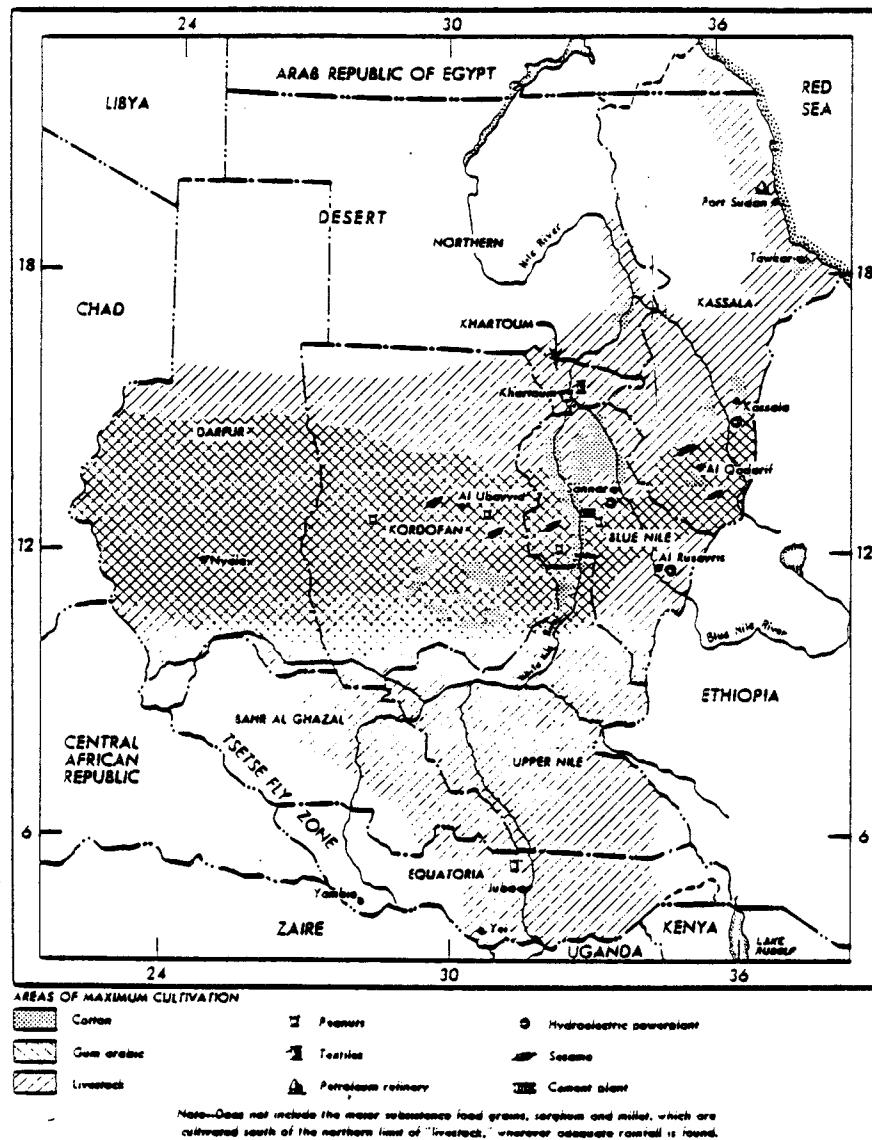


Figure 2.8. Economic Activity of Sudan, 1970

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

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

Table 3.1. Major Geological Formations

| Name of unit | Age | Surface area (%) |
|--|--------------------------|--------------------------------|
| Superficial deposits | Quaternary-Tertiary | Not differentiated |
| Continental-marine formations | Quaternary-Tertiary- | <1 |
| Red Sea Littoral | Mesozoic | |
| 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.

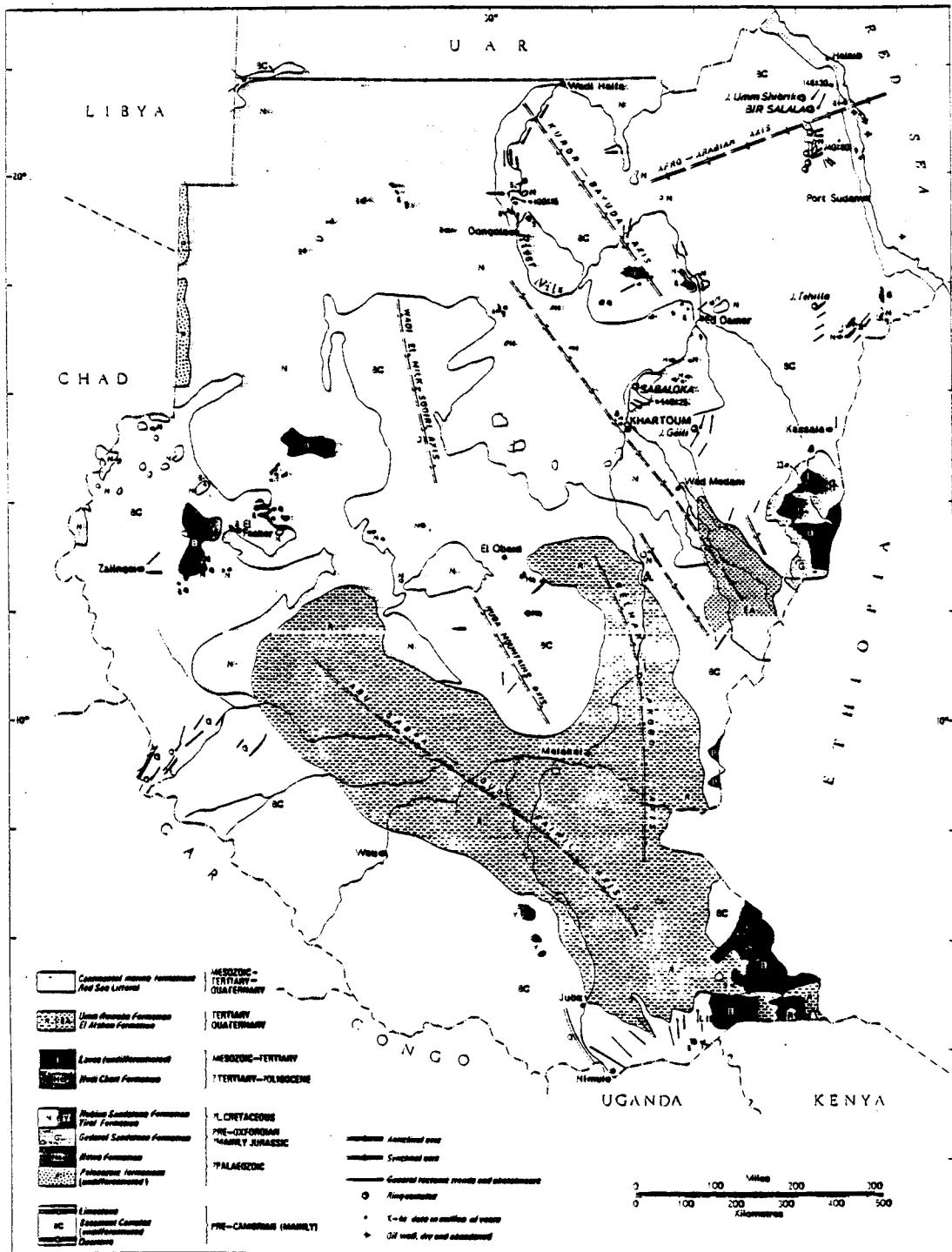


Figure 3.1. General Geological Map of Sudan

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

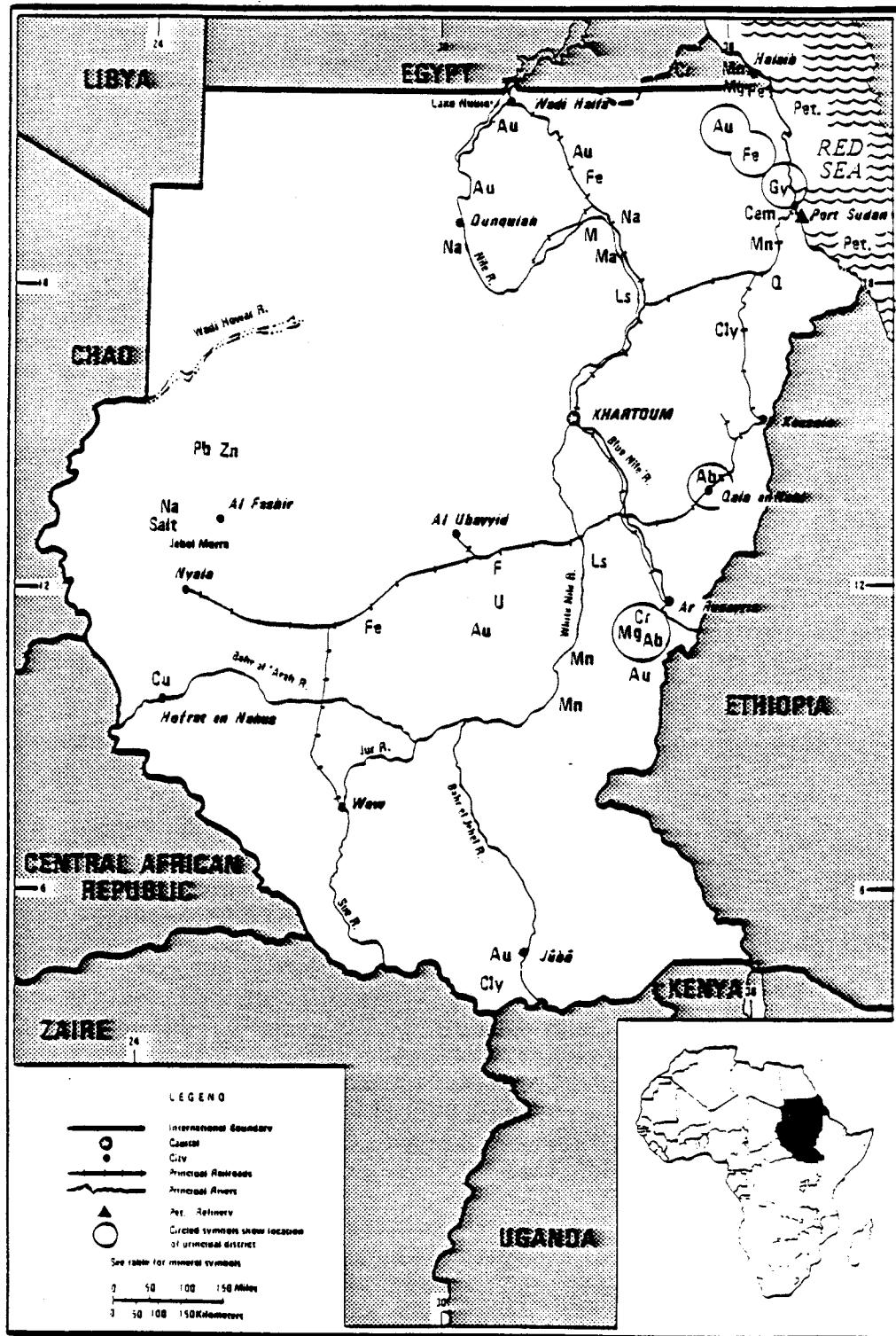


Figure 3.2. Major Occurrences of Minerals

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

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 |
| Daeim | 0.9 | — | 3.7 | 3.7 |
| Kassalla | 5.1 | — | 5.6 | 5.6 |
| Atbarra | 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 |
| Umroaba | 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 £/s | % of total cost | Oil equivalent 1,000 tons | % of total energy used | % of commercial energy | Per capital E. Cons Kg. Oil's | Cost | Distribution among economical sectors % |
|-----------------------|--------------------|---------------------------------------|------------------------------|----------|-----------------|---------------------------|------------------------|------------------------|-------------------------------|-----------------|---|
| | | | | | | | | | Resident | Elec- tri- city | Trans- port |
| | | | | | | | | | Resi- tial | Indus- trial | Agricul- ture |
| 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 |
| <u>Electricity</u> | | | | | | | | | 1.04 | ----- | ----- |
| I. Hydro | G.W.H. | 658.8 | ----- | ----- | ----- | 50.8 | 1.00 | 1.47 | ----- | ----- | ----- |
| ii. Thermal | Oil | 213.2 | ----- | ----- | (16.5)* | ----- | 0.48 | ----- | ----- | ----- | ----- |
| iii. Thermal | Biomass | 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 |
| 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 |
| NON-COMMERCIAL | | | | | | | | | | | |
| Biomass | | | | | | | | | % of Non-Com. H | | |
| I. Wood Fuel | Firewood | 1,065.0 | ----- | 6,000 | 11.10 | 3,534.0 | 69.13 | ----- | 196.43 | 0.333 | 98.0 |
| | 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 |
| ii. Agri- Residue | Corp. | 120.0 | ----- | 15 | 0.03 | 40.0 | 0.78 | ----- | 2.22 | ----- | 75.0 |
| Residue | Animal | 50.0 | ----- | 12 | 0.02 | 30.0 | 0.59 | ----- | 1.66 | ----- | 100.0 |
| Refuse | Total Agr. Residue | 170.0 | ----- | 27 | 0.05 | 70.0 | 1.37 | 1.75 | 3.88 | 0.002 | 86.0 |
| Animate | Million H.P. hour | 750.0 | ----- | 15,000 | 27.84 | 43.5 | 0.85 | 1.10 | 2.41 | 0.833 | 25.0 |
| Total Non-Commercial | | ----- | 54,027 | 100.00 | 3,953.5 | 77.34 | ----- | 219.72 | 3,001 | 97.534 | 0.002 |
| Grand Total | | 1,202 | 262,689 | ----- | 5,112.0 | 100.00 | ----- | 262.29 | 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)

$$= \frac{5112 (1,000 Tons)}{3198.9 (\text{in millions})} = 1.60$$

Commercial energy consumption per capital £.s. of G.D.P. (Kilogram Oil equivalent)

$$= \frac{1138.5}{3198.9} = 0.36$$

Non-Commercial energy consumption per capital £.s. of G.D.P. (Kilogram Oil equivalent)

$$= \frac{393.5}{3198.9} = 1.24$$

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

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

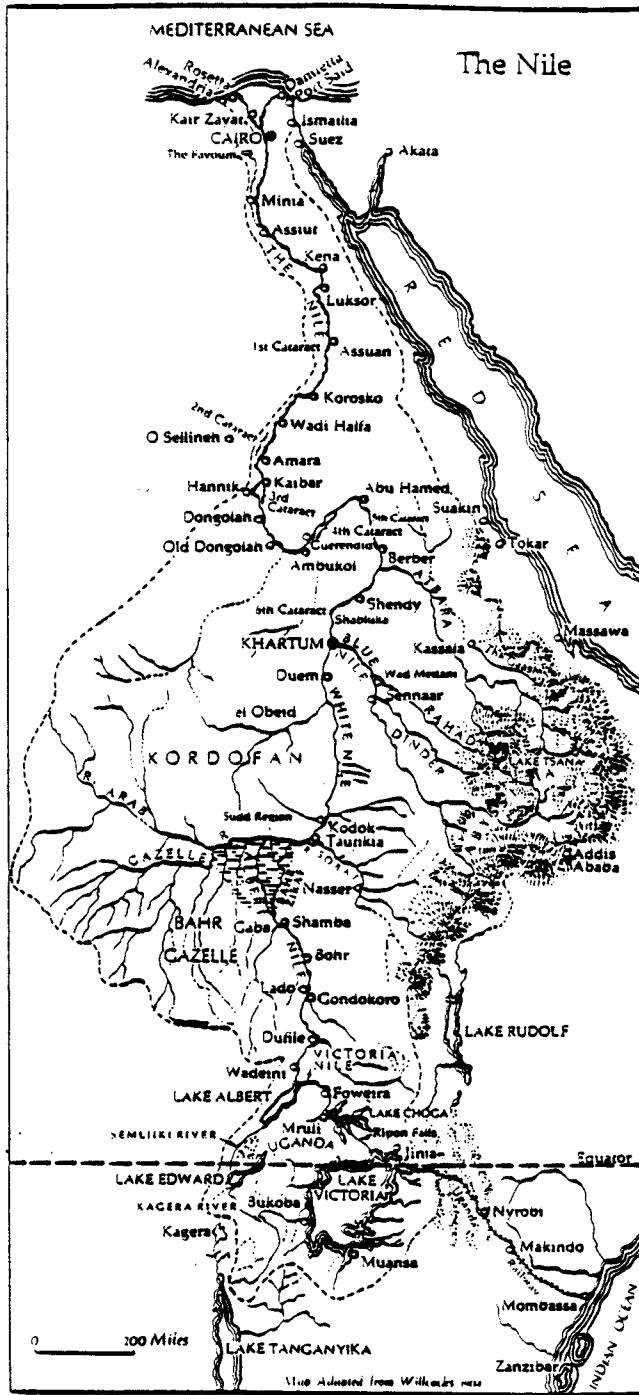


Figure 3.3. The Nile Basin

Source: Waterbury. 1979.

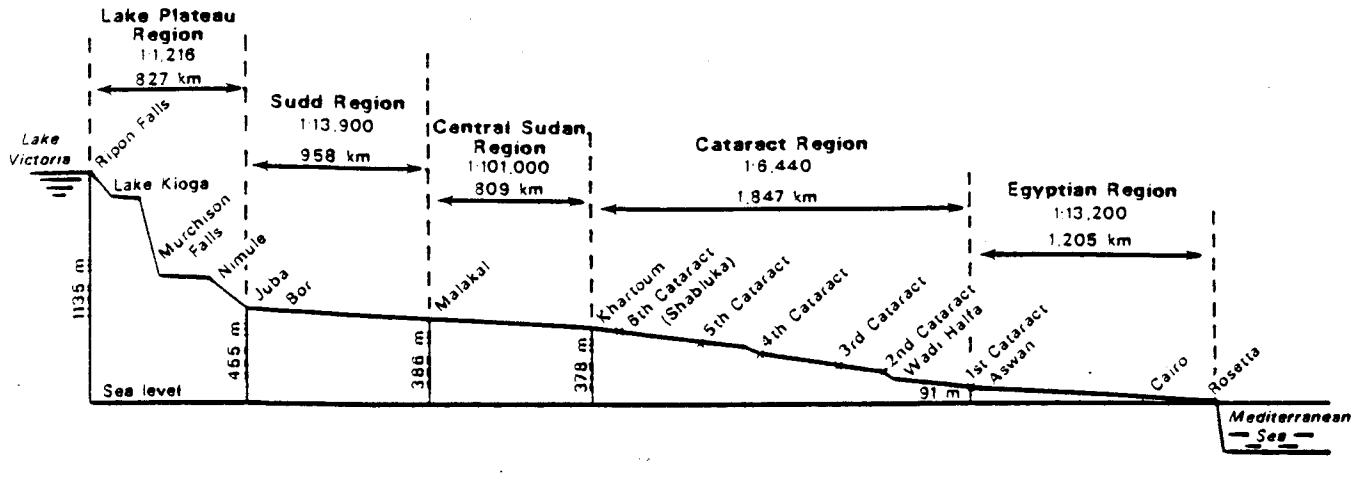


Figure 3.4a. Slope of the Nile from Lake Victoria to the Mediterranean

Source: Waterbury. 1979.

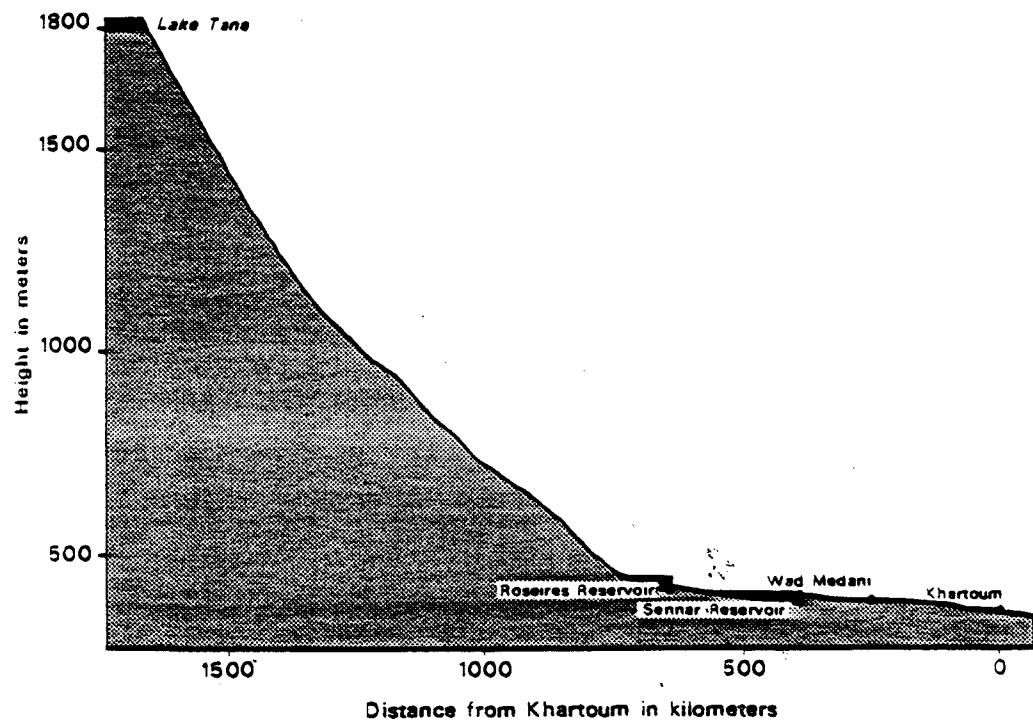


Figure 3.4b. Longitudinal Profile of the Blue Nile

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 | Precipi- tation | Runoff | Evapo- transpi- ration | Water yield | Mean annual discharge | |
|---------------|--------------------------------------|-----------------|--------------------|--------|------------------------------|----------------|-----------------------------|-------------------|
| Unit | | km ² | mm | mm | mm | % | l/s/km ² | m ³ /s |
| Victoria Nile | Ripon Falls above confluence with | 269,000 | 1302 | 81 | 1224 | 0.06 | 2.6 | 699 |
| Semliki | Victoria Nile | 22,500 | 1395 | 88 | 1307 | 0.06 | 2.8 | 63 |
| Albert Nile | below Albert Lake | 281,500 | 1369 | 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 | | 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).

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

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

| River | Station | Catchment area km ² | 1963 | | 1964 | | 1965 | | 1966 | |
|---------------|------------------------|-----------------------------------|--------------------------------|----|--------------------------------|------|--------------------------------|-----|--------------------------------|------|
| | | | 10 ⁶ m ³ | mm | 10 ⁶ m ³ | mm | 10 ⁶ m ³ | mm | 10 ⁶ m ³ | mm |
| Wadi Toro | Dam site | 765 | — | — | 70 | 90 | 21.1 | 28 | 9.5 | 12 |
| Wadi Bala | | 34 | — | — | — | — | 1.7 | 50 | 1.3 | 38 |
| Wadi Nyertere | Nyertete | 81 | — | — | 10.7 | 132 | 4.2 | 52 | 4.2 | 52 |
| Wadi Golot | Dam site | 120 | — | — | — | — | 6.65 | 55 | 5.45 | 46 |
| Wadi Gendi | Kalckitting | 146 | — | — | — | — | — | — | 3.5 | 24 |
| Wadi Aribi | 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 (area east of Malakal not noted) | 5,200 |

Source: Balek. 1977.

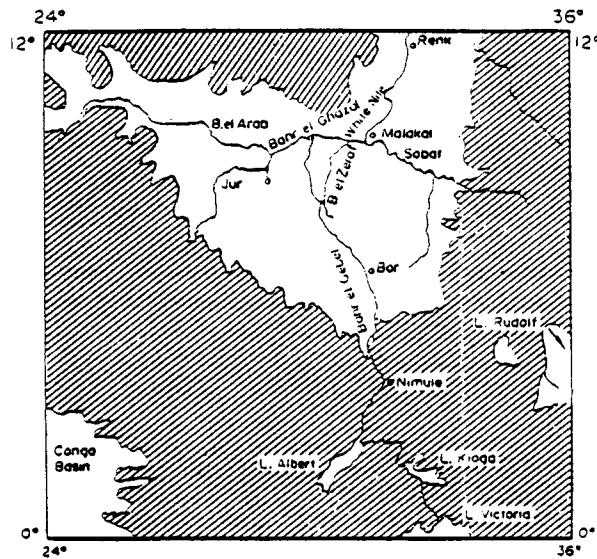


Figure 3.5. Map Showing the Upper Nile Swamp Depression

(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 | 13.6 | 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

-
- ¹¹Sources: 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.

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

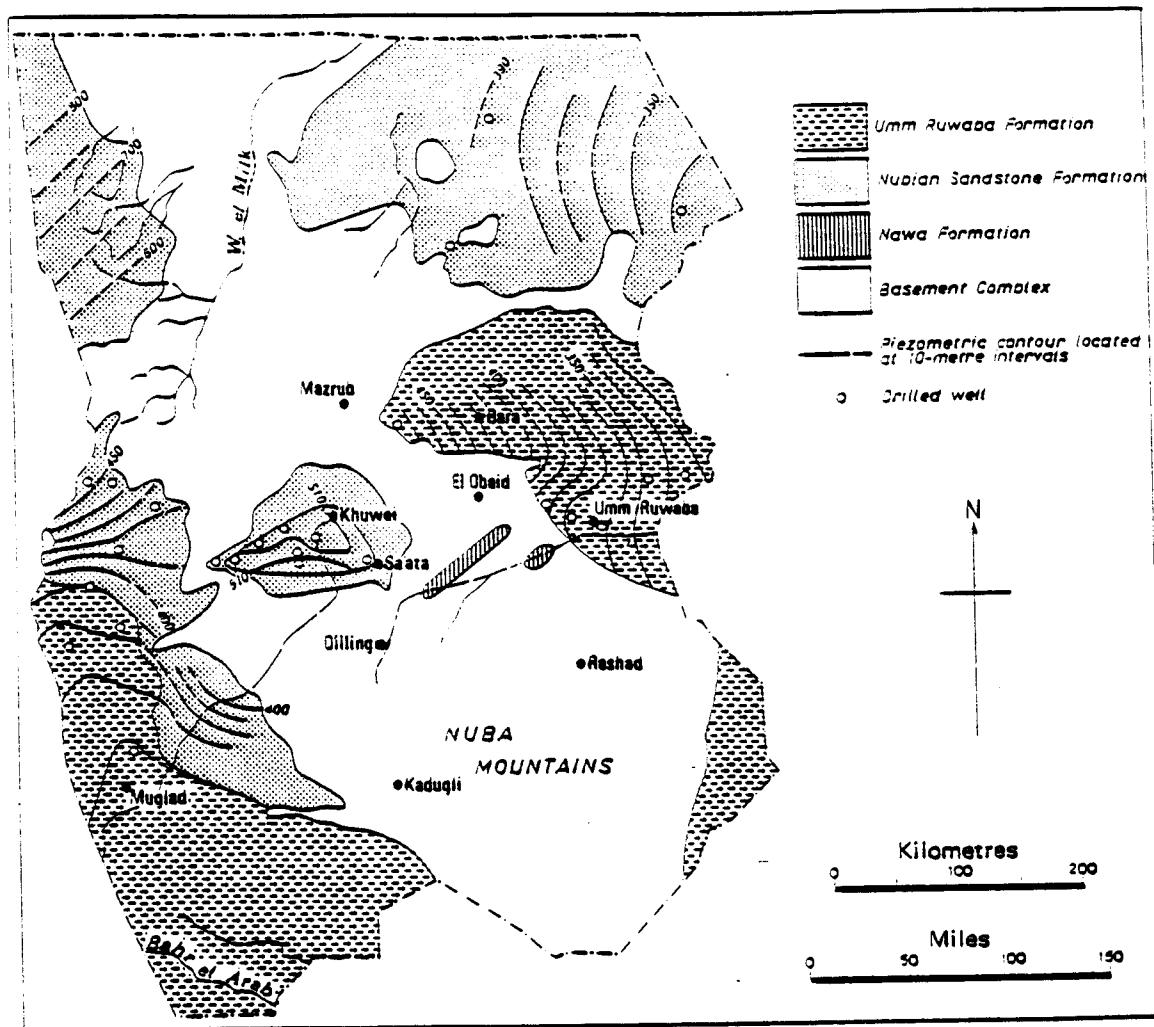


Figure 3.6. Standing Water-Level Contour Map and Formations, Kordofan

Source: Whiteman. 1971.

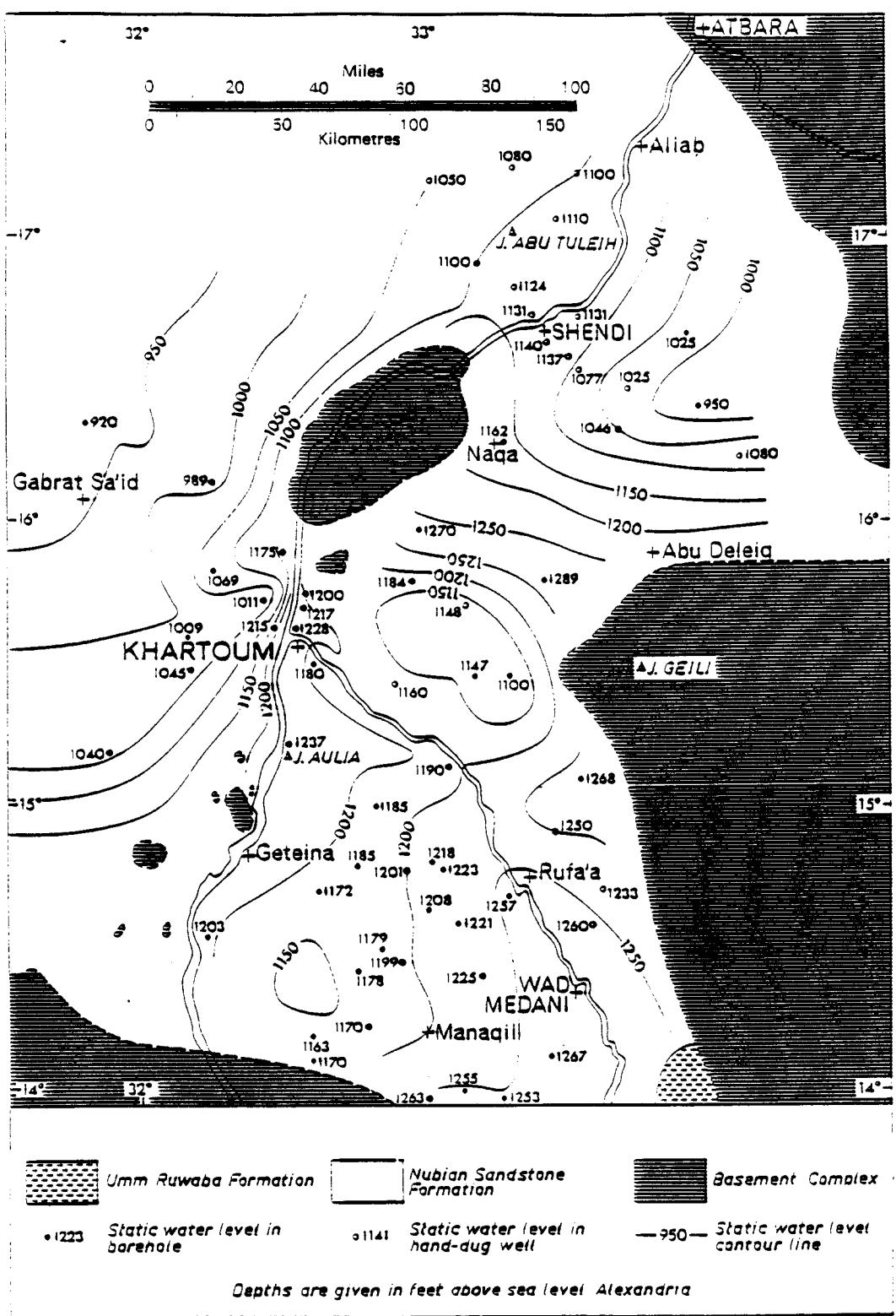


Figure 3.7. Standing Water-Level Contour Map, Gezira-Khartoum-Shendi Region

Source: Whiteman. 1971.

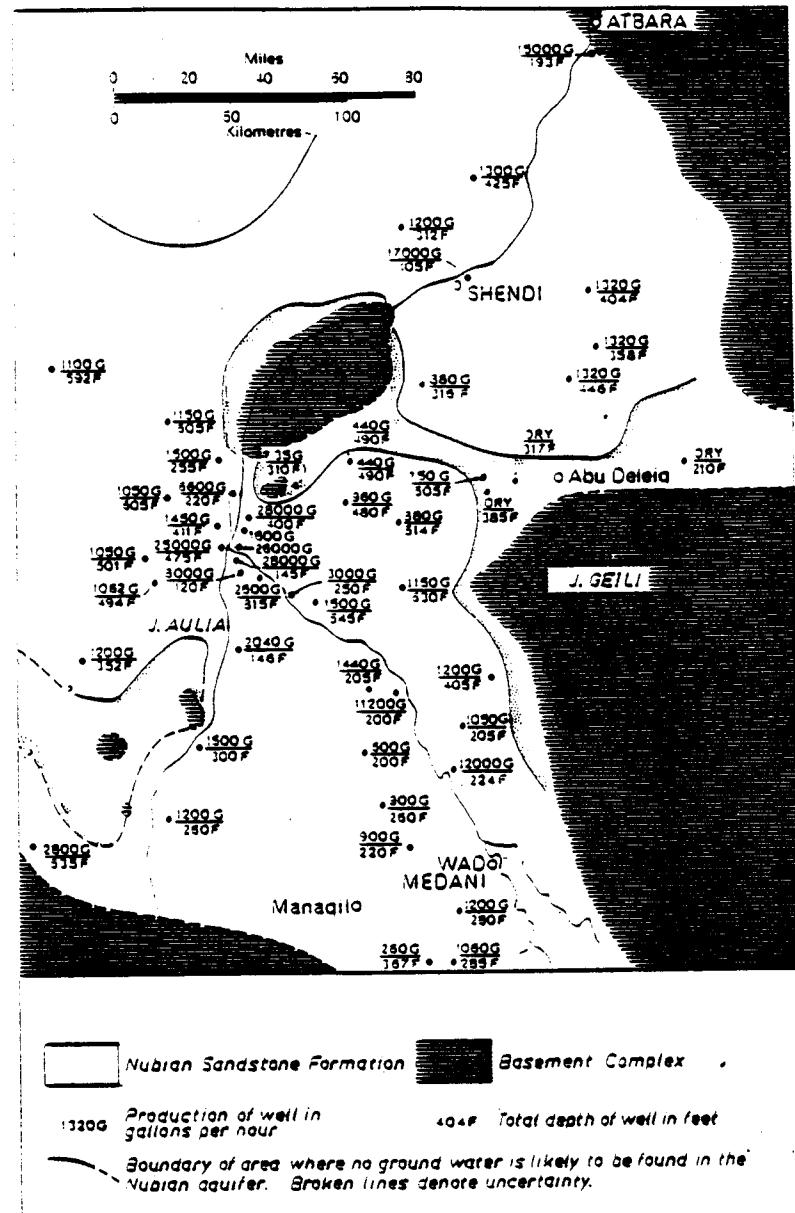


Figure 3.8. Approximate Yields and Total Depth,
Nubian Sandstone Formation Wells, Gezira-Khartoum-
Shendi Areas

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.

-
- 13Sources: 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.

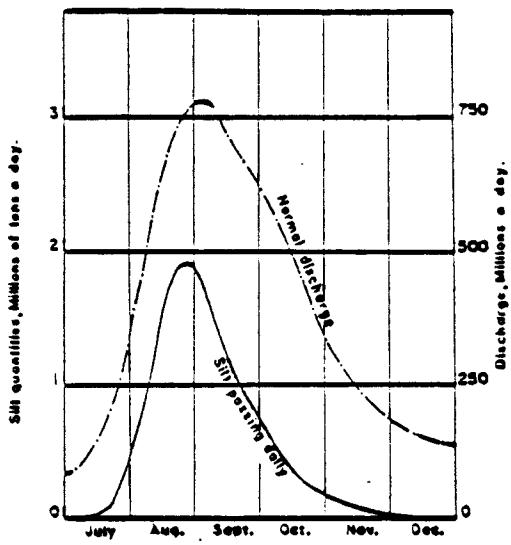


Figure 3.9. Suspended Load of the Nile at Wadi Halfa

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 ₂ | |
| 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: Hassan F. M. H., 1967 |

Source: Buursink. 1971.

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

| Site area (km ²) | Date | (m) approx. | Depth | Transparency (m) | Conductivity ($\mu\text{mho/cm}$) | pH | Alkalinity (10^{-4} N) | Oxygen | | | PO ₄ P (mg/l) |
|-------------------------------------|-----------|-------------|---------|------------------|-------------------------------------|------|------------------------------------|---------|----------|------------------------|--------------------------|
| | | | | | | | | mg/l | Salt (%) | Cl ⁻ (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 0.8 | Jan. 1949 | 1.2 | — | — | — | — | 6.45-8.45 | 76-108 | — | — | — |
| | Jan. 1954 | 1.3 | 0.28-33 | — | 8.1-8.3 | 31.4 | 8.5-10.2 | 105-125 | 1.4 | 0.01 | — |
| | Jan. 1949 | 2.0 | — | — | 7.25 | — | 6.1-7.15 | 78-98 | — | — | — |
| Lake No c. 30 5 | Dec. 1953 | — | 47.55 | 200 | 8.4 | 25.9 | 8.0 | 102 | 10 | 0.015 | — |
| | June 1954 | — | — | — | 8.2 | 21.4 | 7.1 | 90 | — | 0.06 | — |
| | Dec. 1960 | — | — | 250 | — | — | — | — | — | — | — |
| Feb. 1964 May 1964 | Feb. 1964 | — | 100 | — | 7.65 | — | 6.90 | 89 | — | — | — |
| | May 1964 | 95 | — | — | 8.0 | — | 8.14 | 120 | — | — | — |
| | Jun. 1954 | 2.5 | 2.50 | 40-55 | 6.4-7.2 | 25.4 | 8.0 | 95 | — | — | — |
| Lake Anibadi c. 15 open water | Jan. 1949 | 2.2 | 2.00 | — | — | — | 1.8-7.15 | 23-92 | — | — | — |
| | Jun. 1949 | 3.0 | — | — | — | — | 6.9 | 85 | — | — | — |
| | Feb. 1954 | 0.25-62 | — | 8.6 | 29 | 11.5 | 140 | 6.5 | — | — | — |
| Khor Perboi 1.0 Khor Atar c. 5.0 | Apr. 1964 | — | 0.45 | — | 8.0 | — | 6.88 | 95 | — | — | — |

Source: Rzoska. 1974.

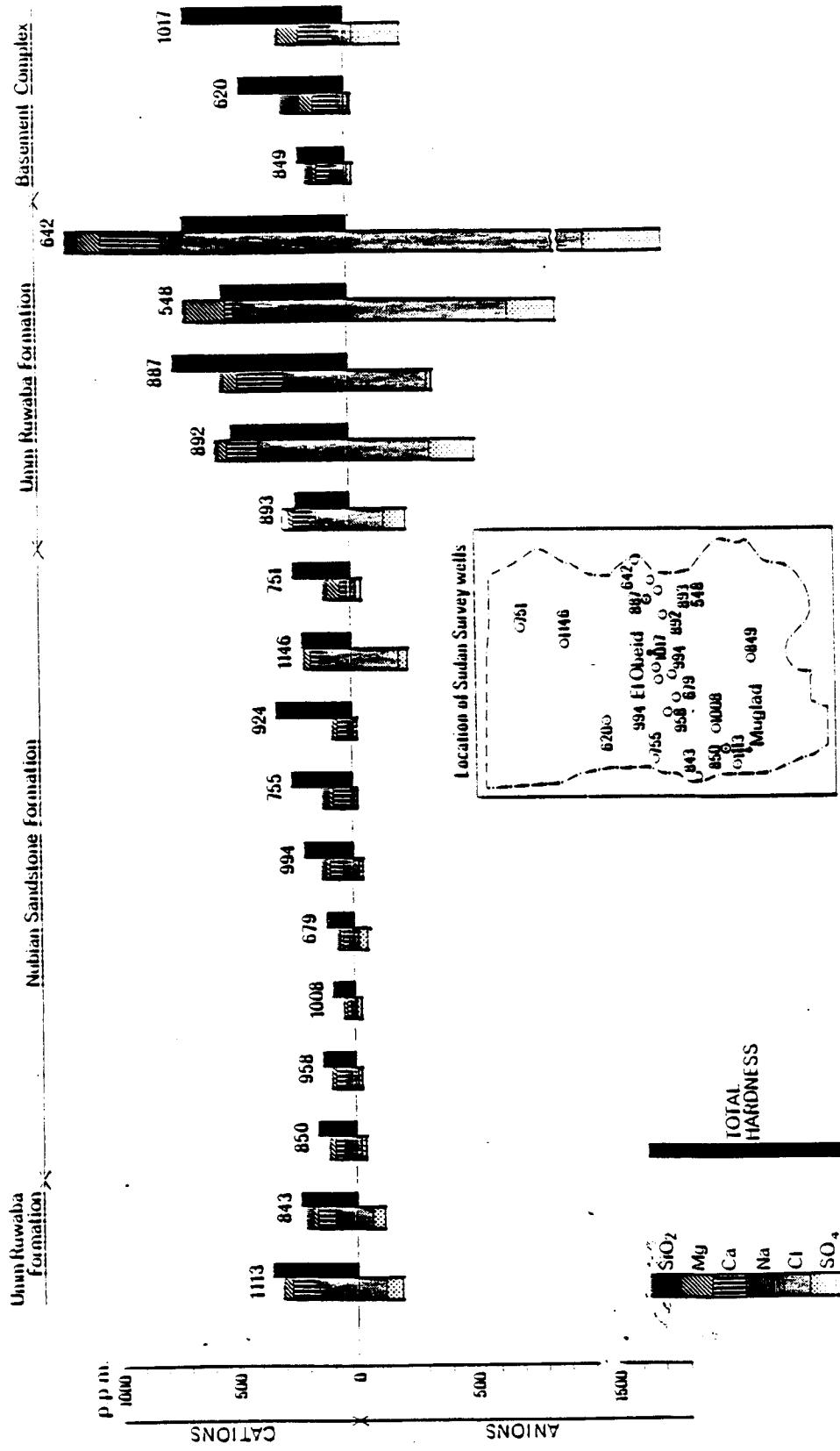


Figure 3.10. Chemical Properties of Groundwater, Kordofan

Source: Whiteman. 1971.

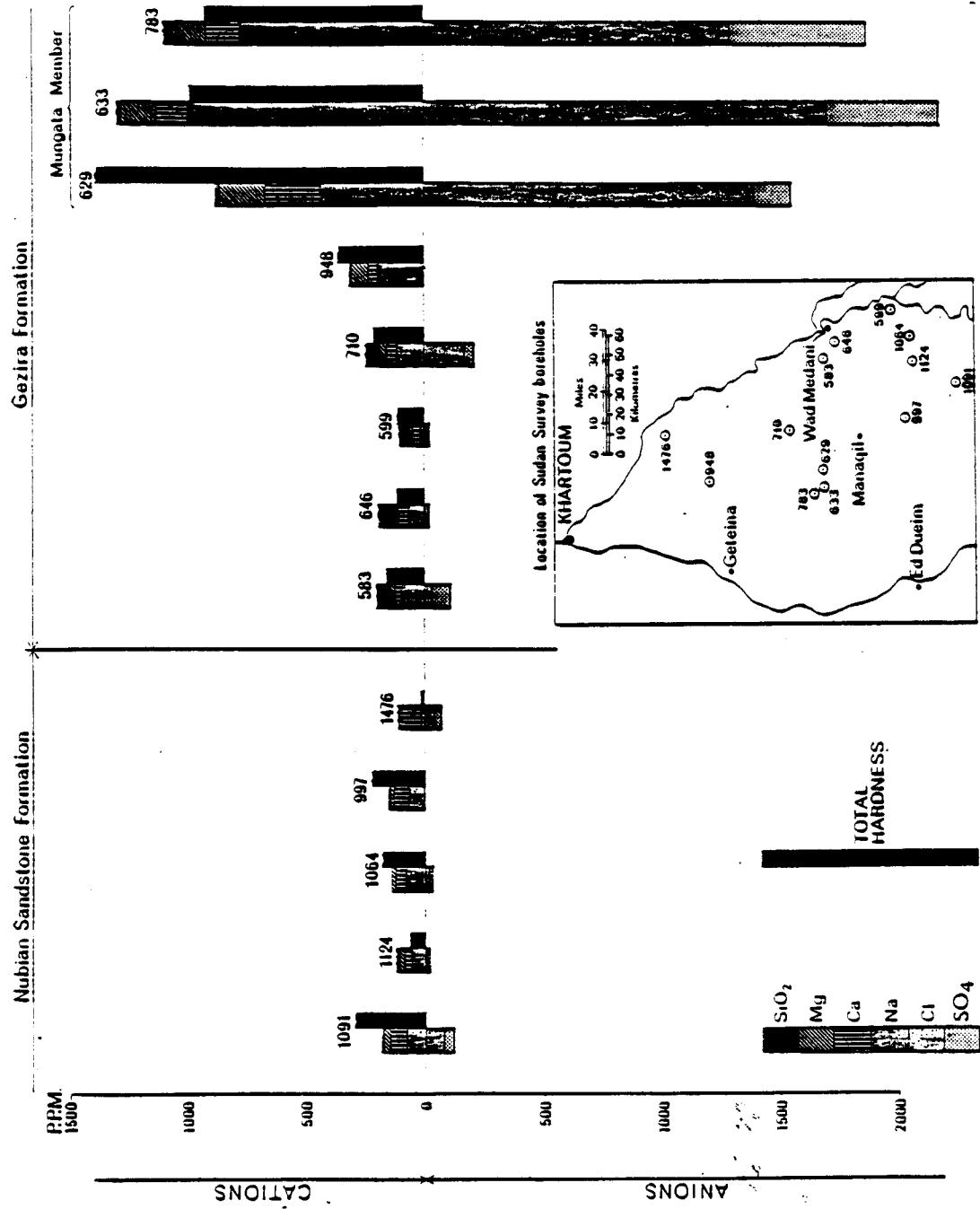


Figure 3.11. Chemical Properties of Groundwater, El-Gezira

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 | 223 | 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. m³)

| 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 | 350 |
| Storage Losses | | |
| Jebel Auliya | 1.000 | 1.000 |
| Sennar/Roseires | .700 | 1.000 <small>(after heightening of Roseires)</small> |
| 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-Girba 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 |
|---|-------------------------|---|
| <i>Blue Nile</i> | | |
| 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 |
| <i>White Nile</i> | | |
| Pump Schemes incl. Melut Asalaya, Kenana* | 620 | 2,840 |
| <i>Main Nile</i> | | |
| Pump Schemes, downstream Khartoum | 420 | 1,603 |
| <i>Others</i> | | |
| 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 Jabel Auliya and Roseires Reservoirs.

Source: Waterbury. 1979.

Table 3.14. Existing Irrigation Schemes

| <u>Irrigation method</u> | <u>Schemes</u> | <u>NET commanded area (feddans)</u> | <u>% of Total</u> | <u>Source of water</u> |
|--------------------------|--------------------------------------|-------------------------------------|-------------------|------------------------|
| Gravity | Gezira | 1,114,000 | 26.5 | Blue Nile |
| | Managil | 946,000 | 22.5 | Blue Nile |
| | Ranad (stage 1) | 150,000 | 3.6 | Blue Nile |
| | New Halfa | <u>390,000</u> | <u>9.2</u> | 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 (805,000 f.) | 435,000 | 10.3 | White Nile |
| | | 270,000 | 6.4 | Blue Nile |
| | | 100,000 1/ | 2.3 | Main Nile |
| | Private schemes 2/ | 63,000 | 1.5 | Blue Nile |
| | Private schemes | <u>235,000</u> | <u>5.6</u> | Main Nile |
| | Sub-total | 1,432,000 | 34.0 | |
| Flush | Gash delta | 50,000 | 1.2 | Gash R. |
| | Tokar delta | <u>60,000</u> | <u>1.4</u> | Baraka R. |
| | Sub-total | 110,000 | 2.6 | |
| Basin | North. Prov. Sch. | 50,000 | 1.2 | Main Nile |
| Tubewell | Sag el Natam | 3,000 | 0.1 | Groundwater |
| | Private schemes | <u>15,000</u> | <u>0.3</u> | 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. 1980s

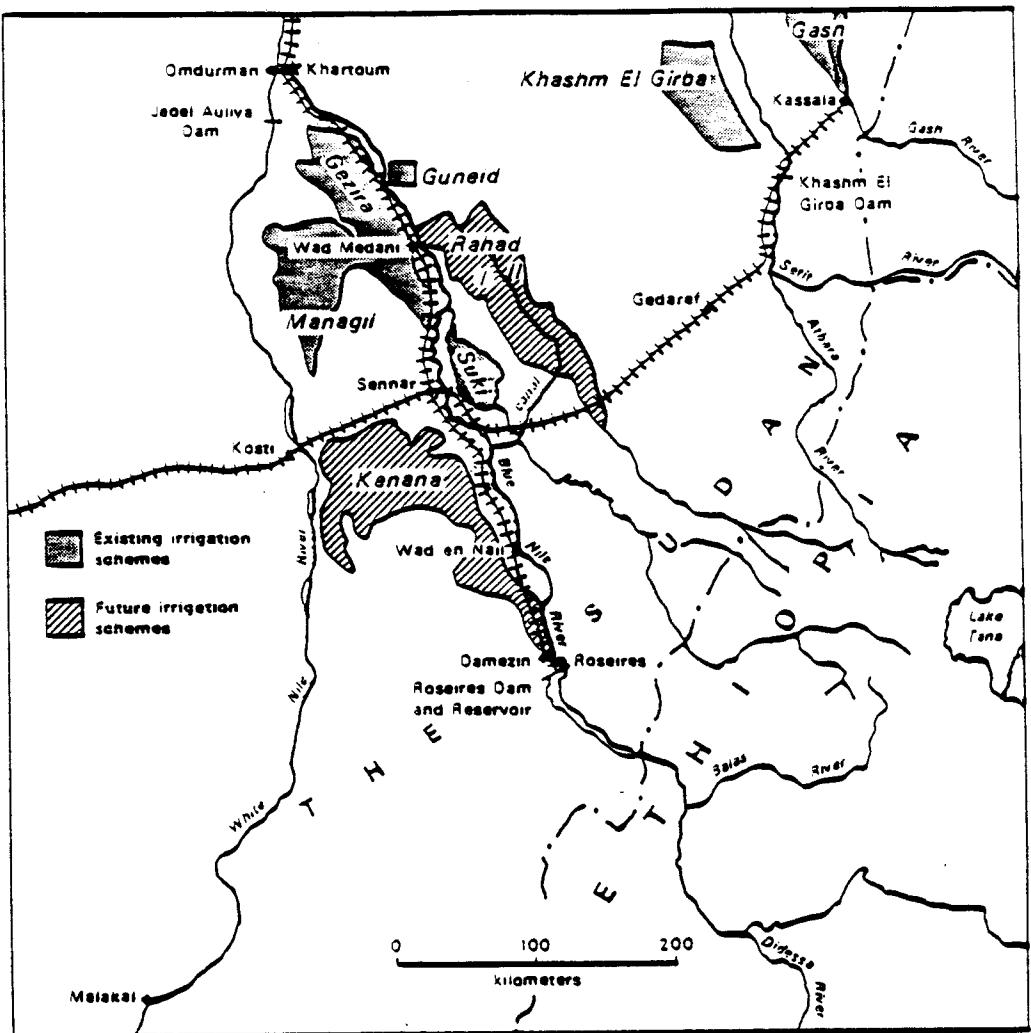


Figure 3.12. Major Irrigation Schemes

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

¹⁴Sources: 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 |
| Two men | 5 | Shadouf is about 2.5 metres. |
| <i>High-lift Sagia</i> | | |
| Lift 6.8 metres | 9 | The draught animals for both |
| Lift 4.6 metres | 12 | type of sagia may be either |
| Lift 2.4 metres | 15 | camels or bulls (oxen). |
| Lift 1.2 metres | 24 | |
| <i>Low-lift Sagia</i> | | |
| One draft animal | 40 | The lift does not in practice |
| Two draft animals | 80 | much exceed 1.5 metres. |

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 require- ments in million m ³ |
|-------------------------|--|--|---------------------------------|---|
| Humans | 4 | 7.2 | 12 | 86.4 |
| Camels | 2 | 3.6 | 3.6 | 13.0 |
| Cattle | 5 | 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 | 9.0 | 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 | 5,000 | 55 |
| Kosti | 67,000 | 8 | 8,000 | 119 |
| El-Gedaref | 56,000 | 9 | 5,000 | 75 |
| Albare | 54,000 | 10 | 12,000 | 188 |
| Nyala | 53,000 | 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 | 75 |
| Sennar | 33,000 | 17 | 4,500 | 138 |
| En Nafud | 28,000 | 18 | 1,060 | 38 |
| Ed Dauim | 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 | <u>Hydroelectric capacity MW</u> | | |
|------------------------|-----------|-------------------------|--|----------------------------------|---------------|--------------|
| | | | | 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.

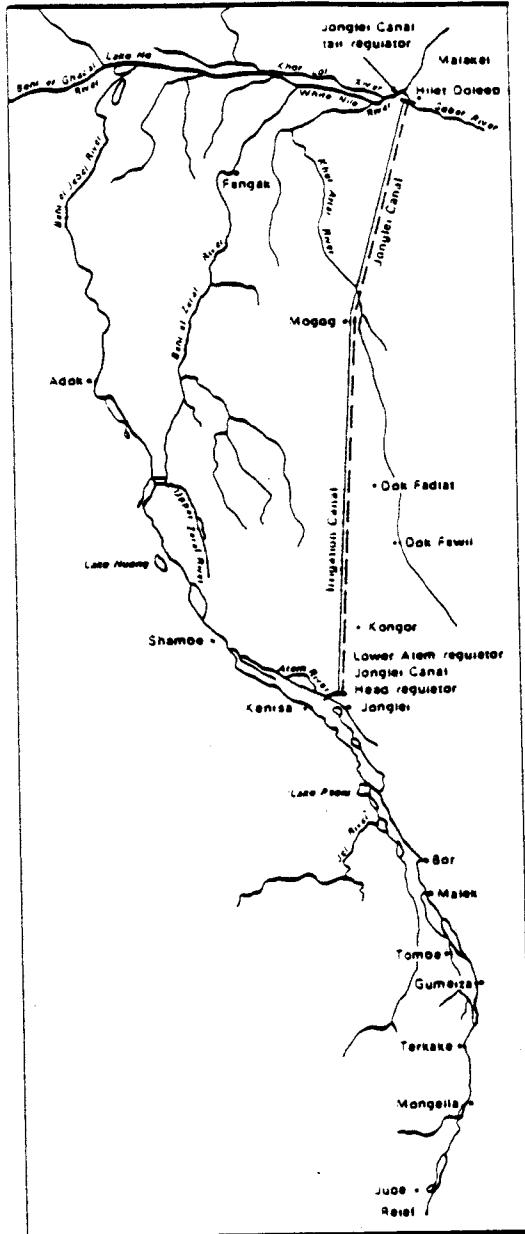


Figure 3.13. Jonglei Canal

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 luvis, and generally occur in level or undulating terrain. These arenosols are generally poor in organic carbon, nitrogen, exchangeable bases and P₂O₅, 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 | |
|--------------------------|--------------------|-------------|----------------------------------|-------------------------------------|------------------------------------|
| Sc8-2b* | Bs, I | | 139 | Jebel Marra | |
| Sc9-2b* | Vc | | 160 | Jebel Marra | |
| Sd3l-2c* | Bh | Lithic | 61 | Southern Red Sea Hills | |
| Se9-3c* | Lc | Vp | 54 | Southern Ethiopian border | |
| Se45-2a* | Th | | 173 | Jebel Marra | |
| Se51-2a | Bc, Vc | Xk, Zo, Jc | 1,961 | Ethiopian border north of Blue Nile | |
| Sh12-3c | Ao | Jd | Lithic | 211 | Ethiopian border north of Sobat R. |
| Po2-2ab | Qf | | Petric | 340 | Southwest border |
| Po28-3ab | Gd | | | 1,723 | Southern border |
| Po48-2ab* | Fp | Ap, Vc | | 41 | Southern border |
| Po50-2a* | | Ap, Vp | | 14 | Southern border |
| Pp8-2ab | Af, Rd | Gd, I, Jd | Petric | 13,436 | Western Equatoria |
| Gd5-2a* | Jd | | | 82 | Western Equatoria |
| 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-Sc-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 | Gc, Gm | Vc | | 2,613 | Southern Nile Valley |
| Lcl3-1a | Qc | Bc, Bv | | 822 | Central Kordofan |
| Lfl8-1a | Re | | Petric | 1,009 | Southern highlands |
| Lfl8-2a | Re | | Lithic | 1,699 | Southern highlands |
| Lf28-2/3b | Af, 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 |
| Nel3-3b | Vp | Bs, 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 | Q1 | | 14,001 | Darfur, Kordofan | |
| qc15-1a* | Re | S, A | 258 | Western Darfur | |
| qc17-1a* | S, Ws | | 54 | Western Darfur | |
| qc21-1a | Q1, 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 | |
| Re16-2* | 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 | | Ja, 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 Kordofan |
| 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 | | 3,128 | 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 | Je, Xk | | Stony | 3,028 | West of Red Sea Hills |
| Xl14-2a | 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 | Millie 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 | Callic Luvisols |
| Lo | Orthic Luvisols |
| Lp | Plinthic Luvisols |
| Ne | Euetric Nitrosols |
| Nh | Humic Nitrosols |
| Oc | not defined in source |
| Oe | Eutric Histosols |
| Qc | Cambic Arenosols |
| Qf | Ferralic Arenosols |
| Qi | Luvic Arenosols |
| R (on Figure) | Rock debris or desert detritus |
| R (on Table) | Regosols |
| S | Solonetz |
| So | Orthic Solonetzs |
| Th | Humic Andosols |
| Tv | Vitric Andosols |
| V | Vertisols |
| Vc | Chromic Vertisols |
| Vp | Pellic Vertisols |
| Ws | Solodic Planosols |
| X | Xerosols |
| Xh | Haplic Xerosols |
| Xk | Callic Xerosols |
| Xl | Luvic Xerosols |
| Y | Yermosols |
| Yh | Haplic Yermosols |
| Yk | Callic Yermosols |
| Yt | Takyric Yermosols |
| Yy | Gypsic Yermosols |
| Z | Solonchaks |
| Zg | Gleyic Solonchaks |
| Zo | Orthic Solonchaks |
| Rd | Dystric Regosols |
| Re | Eutric Regosols |

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 exchangeable bases and with total P₂O₅. 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 Equatoria; 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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- 15Sources: 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 |
| <i>Total Surface Area of the Sudan</i> | 596,383 | 100 | | |
| <i>Not suited for agriculture:</i> | | | | |
| total: | 304,595 | 51 | | |
| of which water courses | (30,895) | | | |
| swamp, desert | (273,700) | | | |
| <i>Suitable for agriculture</i> | | | | |
| 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) |
| <i>Arable land breakdown</i> | | | | |
| Irrigated | 3,218 | .54 | 4,438 | .7 |
| Nonirrigated | 21,835 | 3.66 | 35,236 | 5.9 |
| <i>Area harvested</i> | | | | |
| Irrigated | 2,348 | .39 | 3,548 | .6 |
| Nonirrigated | 8,734 | 1.47 | 15,856 | 2.65 |
| <i>Cropping intensity</i> | | | | |
| 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 | 1,970 |
| 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 Equatoria 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

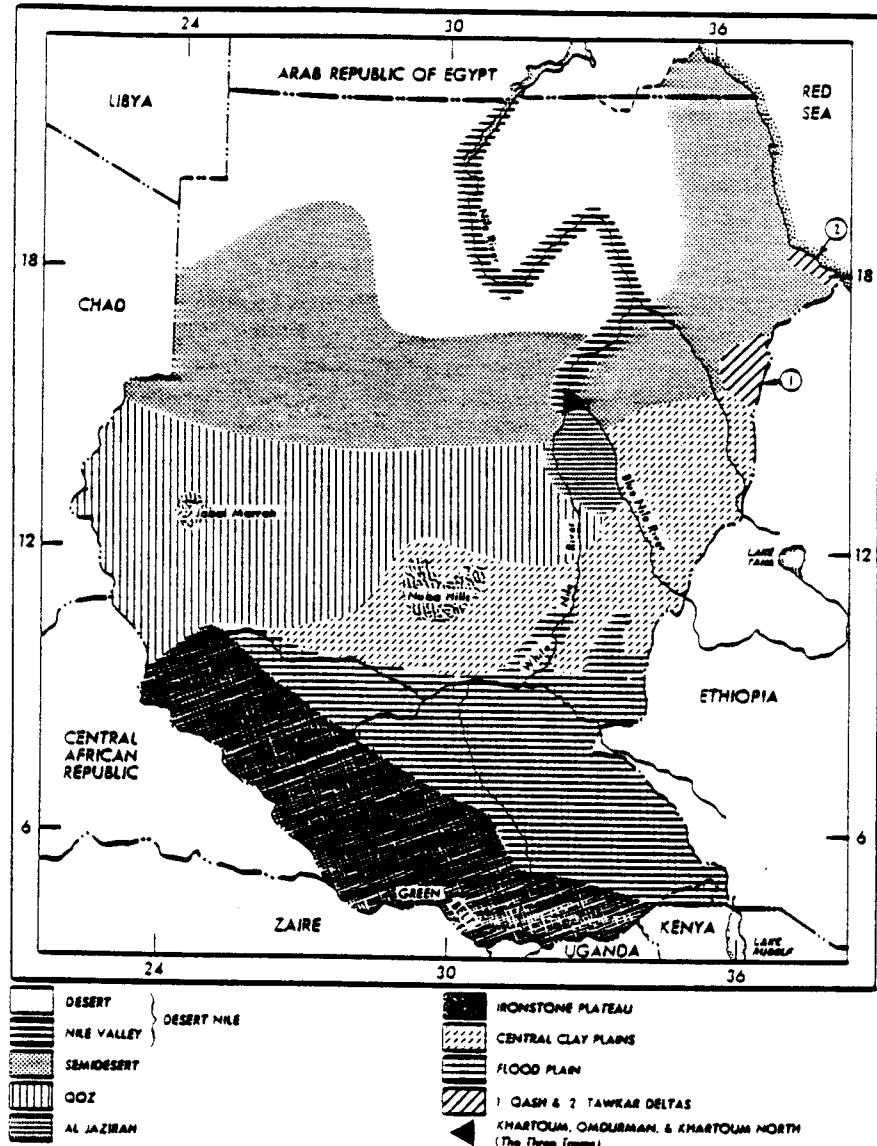


Figure 3.15. Economic Regions of Sudan

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 crops, 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 distributary 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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- ¹⁶Sources: 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.

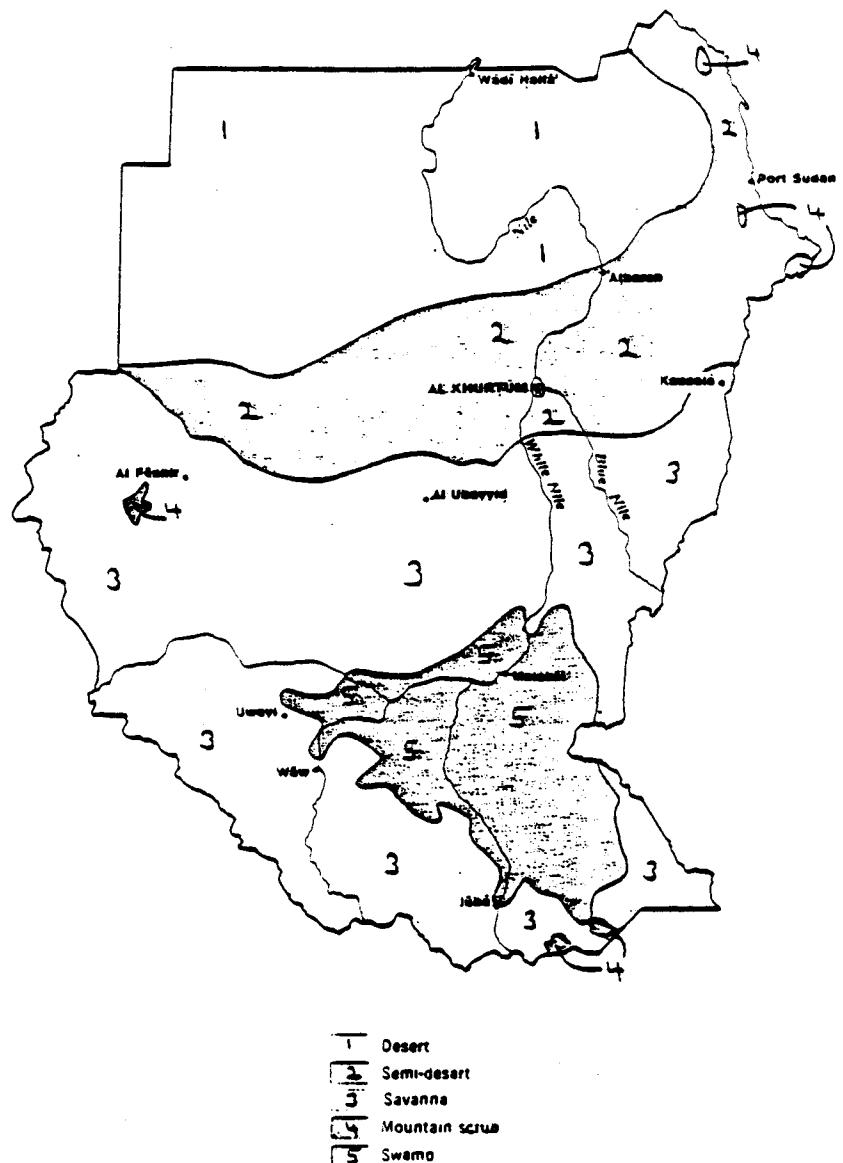


Figure 3.16. Vegetation Zones

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 glaucocephala - 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-Commiphora 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. camphyacantha 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-Albizia 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 gaquiedi, Hagenia abyssinica, Acacia xiphocarpa, Albizia guummifera 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, Mildbraediadendron 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

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 | 1,351 | 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 tahn | 2,649 | 3,804 | 1,107 | 588 |
| 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, includi:

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

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

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

Source: U.N. 1981.

Table 3.26. Livestock and Livestock Products

| LIVESTOCK ('000 head, year ending September) | | | |
|---|--------|--------|--------|
| | 1977 | 1978 | 1979 |
| Cattle | 15,392 | 15,305 | 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 | 53.0 |
| 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 somerengi), 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 | | | |
| <u>Manis temminckii</u> | Scaly Anteater | | E |
| <u>Equus asinus</u> | African Wild Ass | X | E |
| <u>Acinonyx jubatus</u> | Cheeta | X | T |
| <u>Dugong dugong</u> | Dugong | | E |
| <u>Loxodonta africana</u> | African Elephant | X | E |
| <u>Gazella leptoceros</u> | Slender-horned Gazelle | X | E |
| <u>Addax nasomaculatus</u> | Addax | X | |
| <u>Oryx dammah</u> | Scimitar-horned Oryx | X | |
| <u>Alcelaphus buselaphus tora</u> | Tora Hartebeest | X | E |
| <u>Panthera pardus</u> | Leopard | X | E |
| <u>Cerathotherium simum cottoni</u> | Northern White Rhinoceros | X | E |
| <u>Diceros bicornis</u> | Black Rhinoceros | X | |
| <u>Equus grevyi</u> | Grevy's Zebra | | T |
| <u>Pan troglodytes</u> | Chimpanzee | X | |
| <u>Lycaon pictus</u> | African Wild Dog | X | |
| BIRDS | | | |
| <u>Falco peregrinus</u> | Eurasian Peregrine Falcon | | E |
| REPTILES | | | |
| <u>Crocodylus niloticus</u> | 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 carnivores, 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 <u>in</u> Wilson 1980). |
| Porcupine | One record (Shaw 1936 <u>in</u> 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 carnivores 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 campaign 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 information 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 Ibex 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 (Damaliscus 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, covering 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 among 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 increasing, 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.

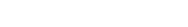
LAND MISUSE IN SUDAN

- 1 Overstocking on semiarid grazing by camel owning tribes.
- 2 Overtcultivation on Gedaref Ridge and vicinity.
- 3 Overtcultivation and overgrazing of Blue and White Nile Riverain zones.
- 4 Overtcultivation 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 overtcultivation on "high" land of Nilotes.
- 10 Erosion and degradation of high savanna by overtcultivation and fire in the Green Belt, Western Equatoria Province.

Country Boundary



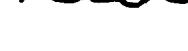
Original Province Boundaries



Railway



Rivers



Non-Perennial Rivers



Towns



Limits Low Woodland - Savanna

Scale: 1 : 8,000,000

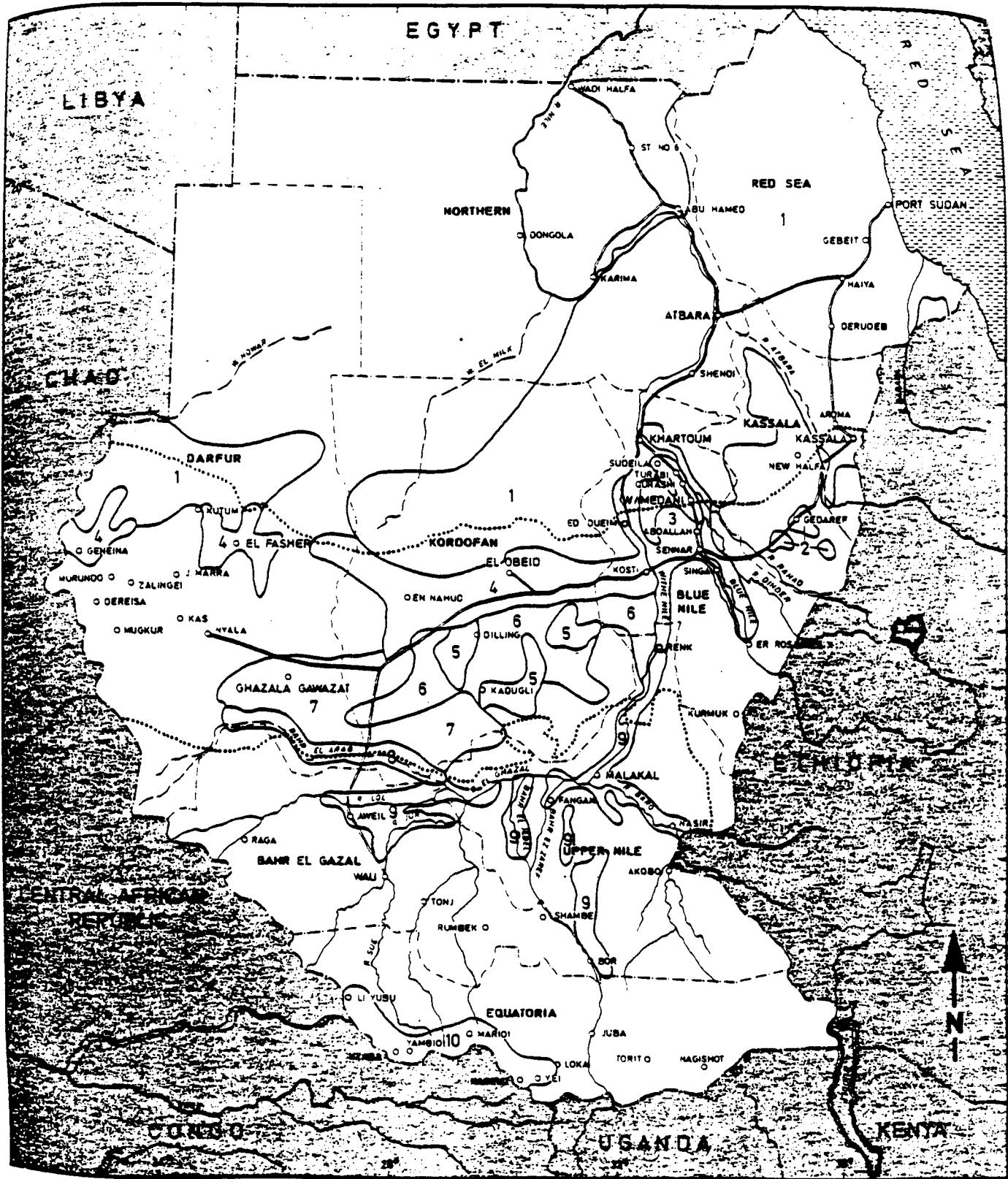


Figure 4.1. Land Misuse in Sudan

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 damming 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 predominant 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 live-stock 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

| Year | Groundnuts | | | Sesame | | |
|------|------------------------------------|-------------------------------|-----------------------------------|------------------------------------|-------------------------------|-----------------------------------|
| | 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, 1961/73

| Year | Dura (Sorghum) | | | Dughon (Millet) | | | Maize | | |
|------|------------------------------------|--------------------------------|-------------------------|------------------------------------|--------------------------------|-------------------------|------------------------------------|--------------------------------|-------------------------|
| | Total area cropped (feddans) | Total production m. tons | Avg. yield kg/feddan | Total area cropped (feddans) | Total production m. tons | Avg. Yield kg/feddan | Total area cropped (feddans) | Total production m. tons | Avg. yield kg/feddan |
| 1961 | 508,700 | 215,800 | 424 | 192,200 | 104,000 | 542 | | | |
| 1962 | 418,000 | 159,000 | 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 | 167 | 15,000 | 4,000 | 267 |
| 1968 | 468,000 | 145,000 | 310 | 509,000 | 93,000 | 163 | 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 reconnaissance 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 obliterated 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 mmmhos/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 | 0.8 | 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 | 15.8 |
| 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 | 8.7 | 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 | | 0.8 | 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 | 18.3 | 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 | 1.4 | | 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

²⁰Sources: . 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 |
|-------------------------------|--------------------------|--------------------|
| <u>Biomphalaria pfeifferi</u> | <u>S. mansoni</u> | Abundant |
| <u>B. sudanica</u> | <u>S. mansoni</u> | Common |
| <u>B. alexandria</u> | <u>S. mansoni</u> | Common |
| <u>Bulinus truncatus</u> | <u>S. haematobium</u> | Abundant |
| <u>B. Forskalii</u> | non-transmitter | Common |
| <u>Lymnaea natalensis</u> | <u>Fasciola hepatica</u> | |
| <u>Cleopatra ferruginea</u> | non-transmitter | |
| <u>Melanoides tuberculata</u> | 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

| <u>Wall Material</u> | Roof Material | | | | | <u>Total</u> |
|----------------------|---------------|-------------|--------------------|------------------|--------------|--------------|
| | <u>Baladi</u> | <u>Wood</u> | <u>Zinc Sheet*</u> | <u>Con-crete</u> | <u>Other</u> | |
| 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 | <u>.3</u> | <u>.3</u> | <u>.9</u> | <u>.3</u> | <u>4.2</u> | <u>6.1</u> |
| 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

| | <u>Sudan Urban</u> | <u>Khartoum 3 Cities</u> | <u>Port Sudan</u> | <u>EI Obeid</u> | <u>Juba</u> |
|--------------------------------|------------------------|------------------------------|-----------------------|---------------------|-------------|
| 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 expended 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.

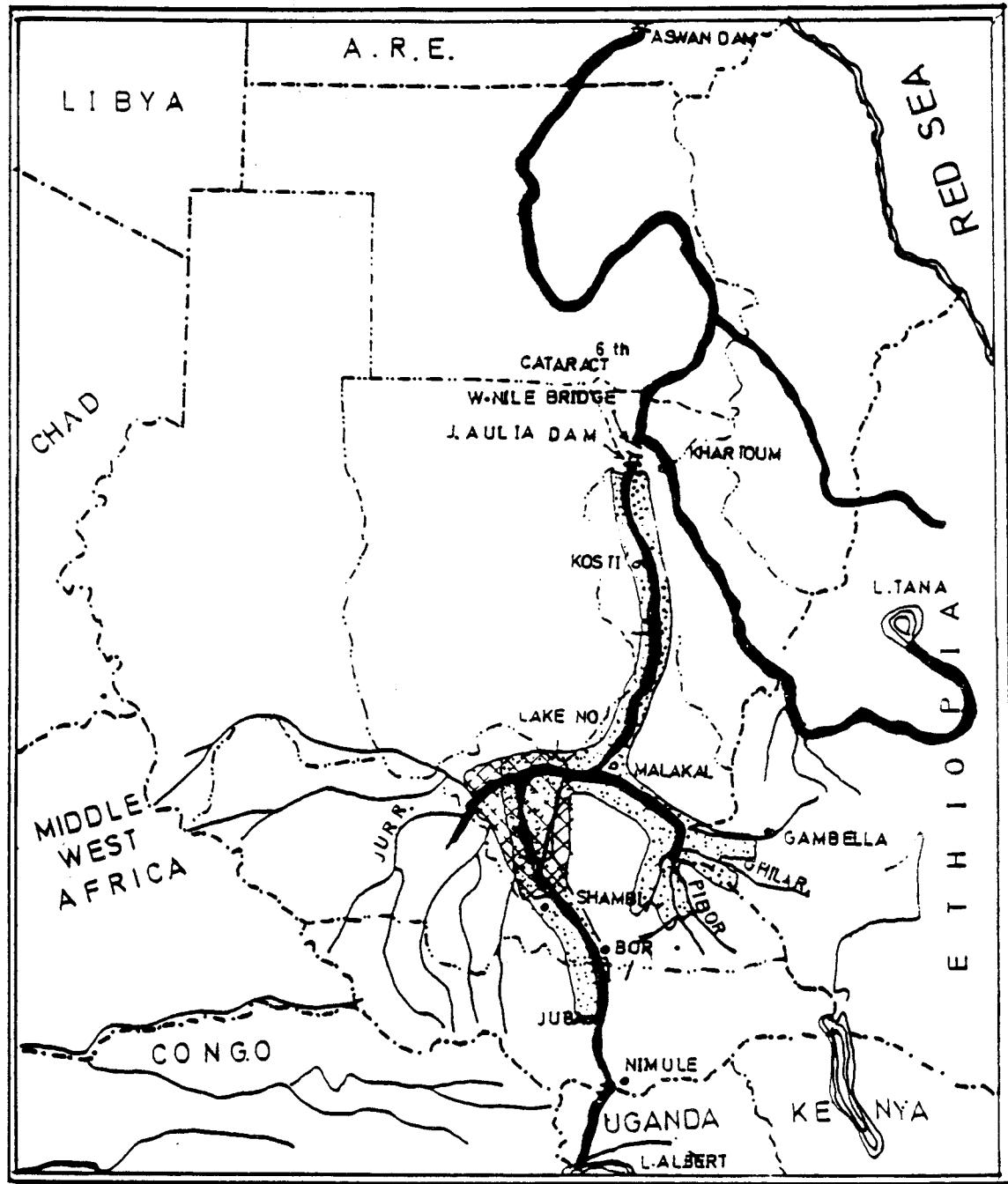
Refugees in the urban areas, particularly Khartoum, Kassala, and Port Sudan, live in crowded squatters' huts. These single-room huts, with no access to water or sanitation facilities, often hold as many as four families. The government's solution is to move the refugees into organized settlements outside 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.



Scale 1:8,000,000

- Hyacinth-infested Area
- Sudd Region

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, Cyperus 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 sometimes

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.

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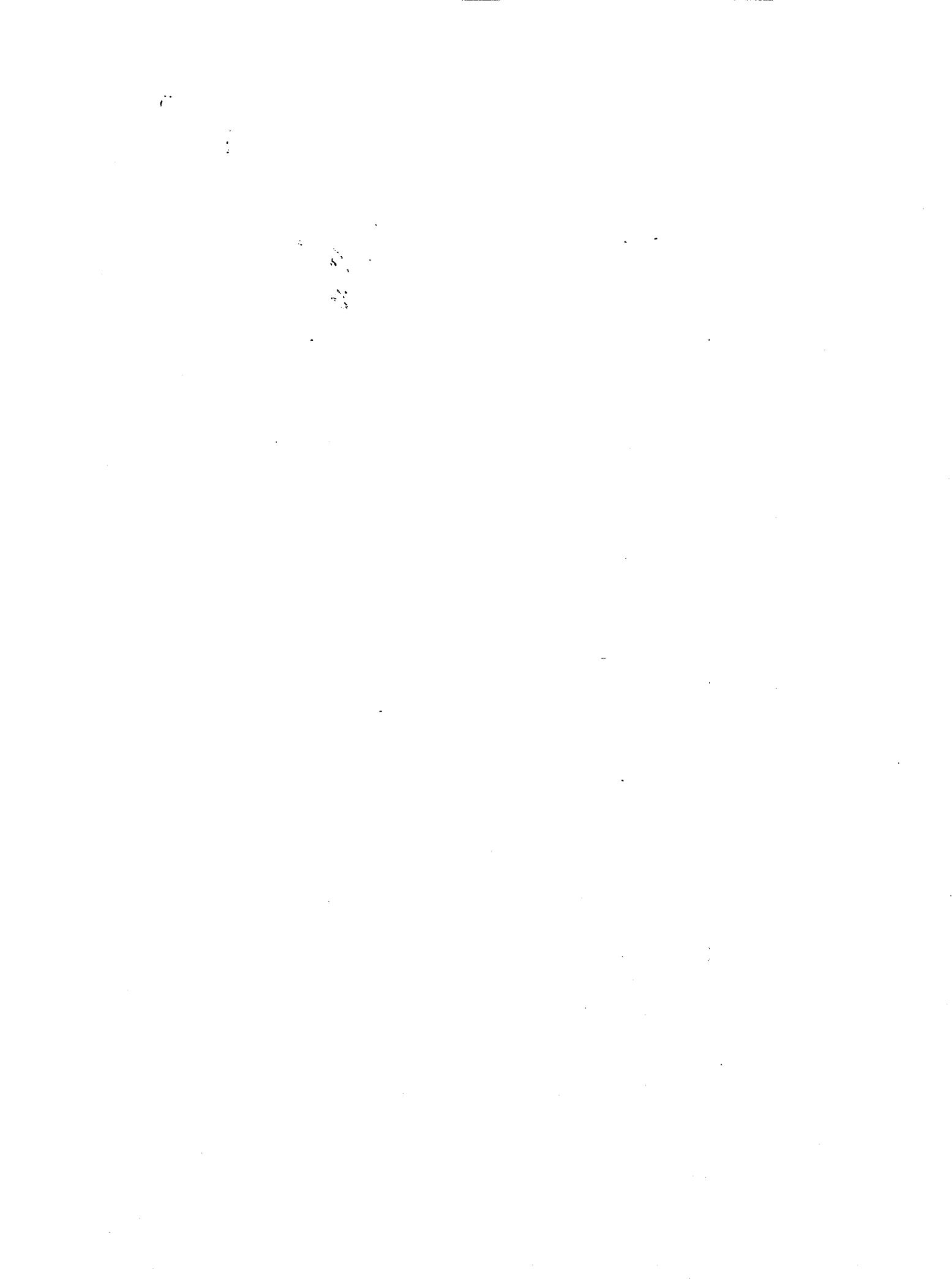
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Appendix I
Geography and Climate

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

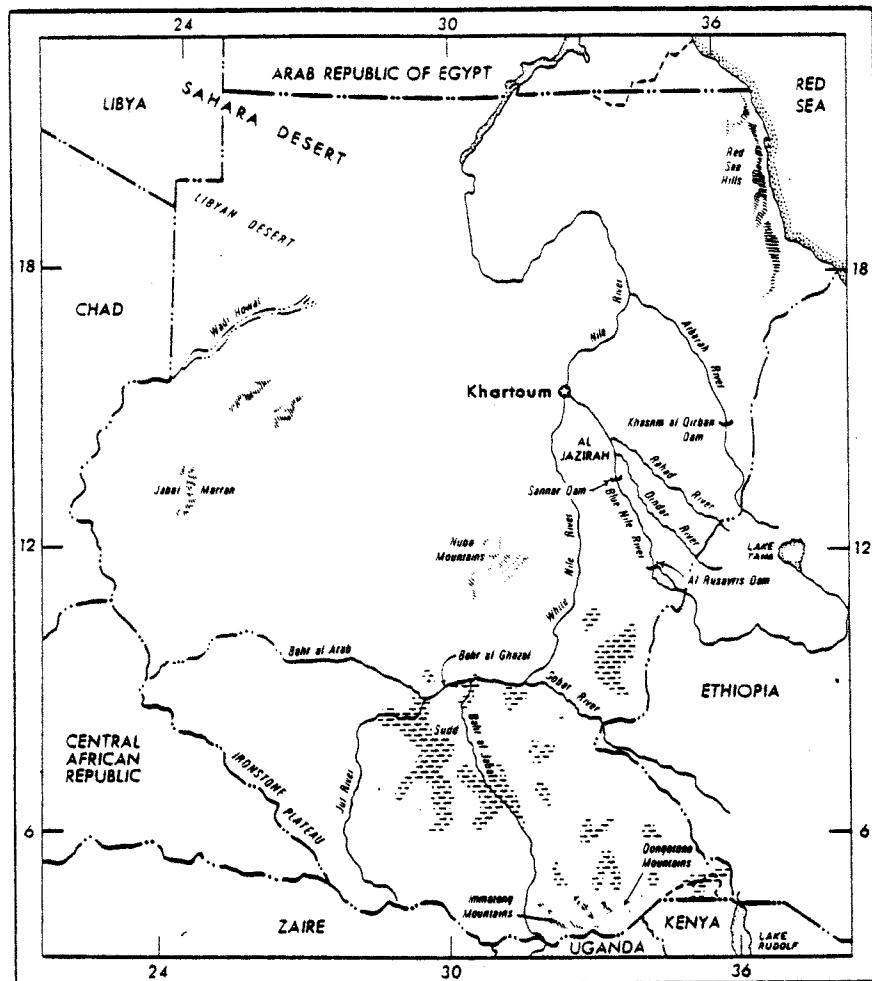


Figure 1. Physical Features

Source: Nelson et al. 1973.

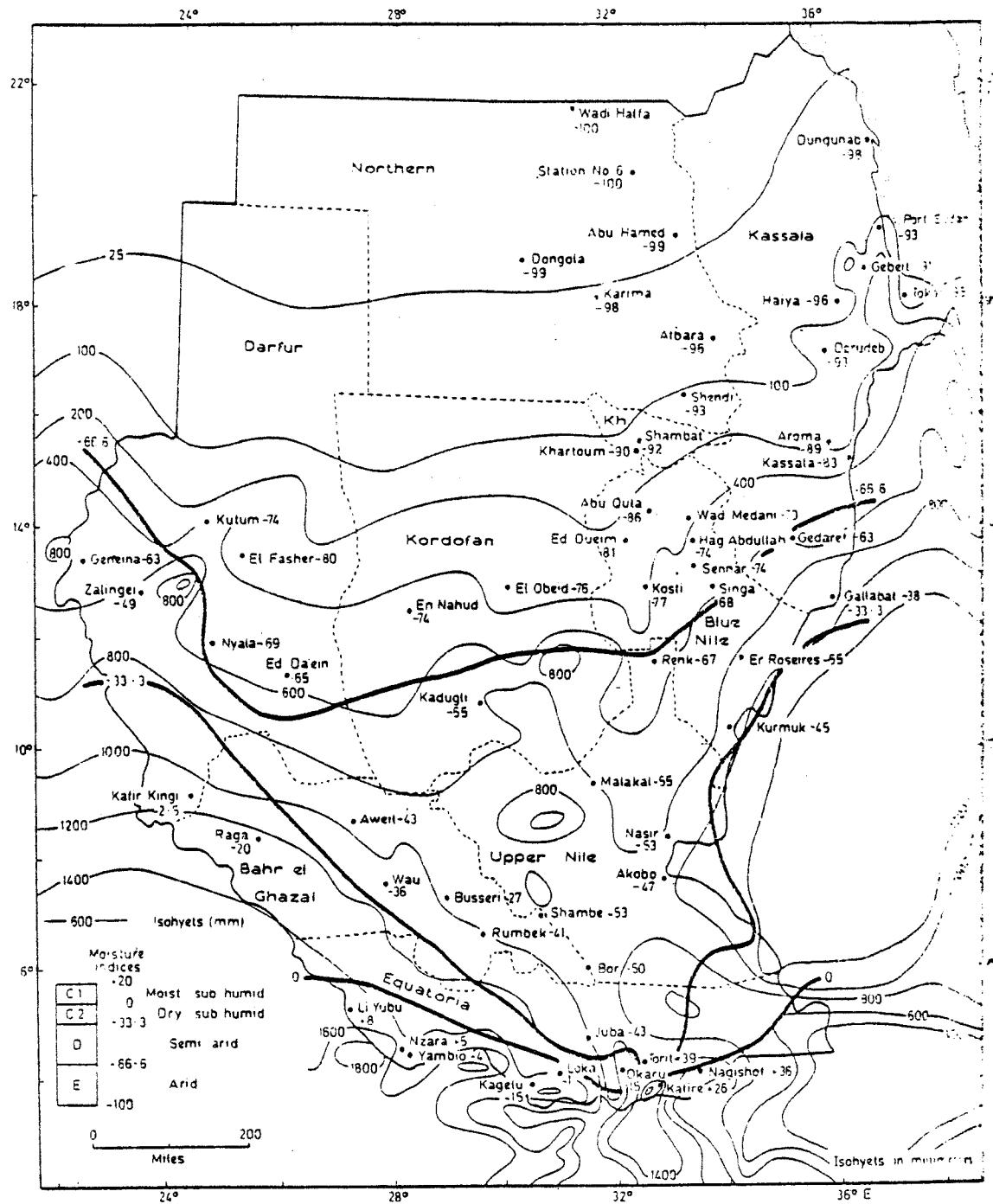


Figure 2. Rainfall and Moisture Regions

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 ($\geq 10\text{mm}$) 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 $\geq 1.0\text{mm}$: | | FALLS $\geq 10.0\text{mm}$: | | HEAVIEST DAILY RAINFALL (mm.) |
|------------------|---------------------------|-----------------------------|-----------------------------|-----------------------------------|------------------------------|-----------------------------------|--|
| | | | NO. OF RAIN DAYS | PERCENT OF ALL RAIN DAYS | NO. OF RAIN DAYS | PERCENT OF ALL RAIN DAYS | |
| Abu Mamed | 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 | 85.0 |
| 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.) | STAN- DARD DEVI- ATION (mm.) | COEFFI- CIENT OF VARIA- TION (Per Cent) |
|-----------------------|-------------------------|---------------------------|--|--|
| Abu Hamed | 19 | 7 | 30 | 158 |
| Zeidab | 70 | 63 | 50 | 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/cm²/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 (°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.

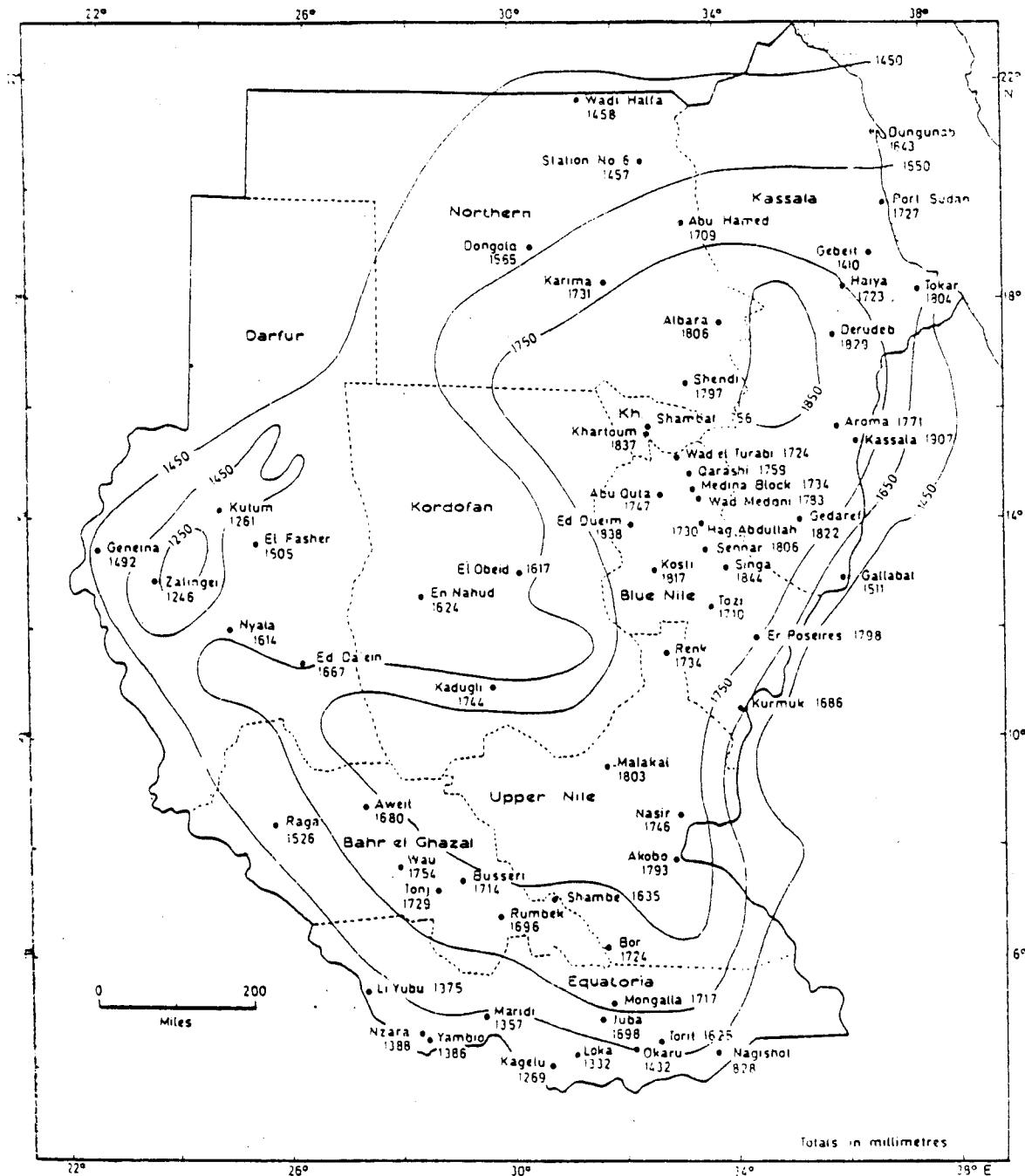


Figure 3. Annual Potential Evapotranspiration

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.

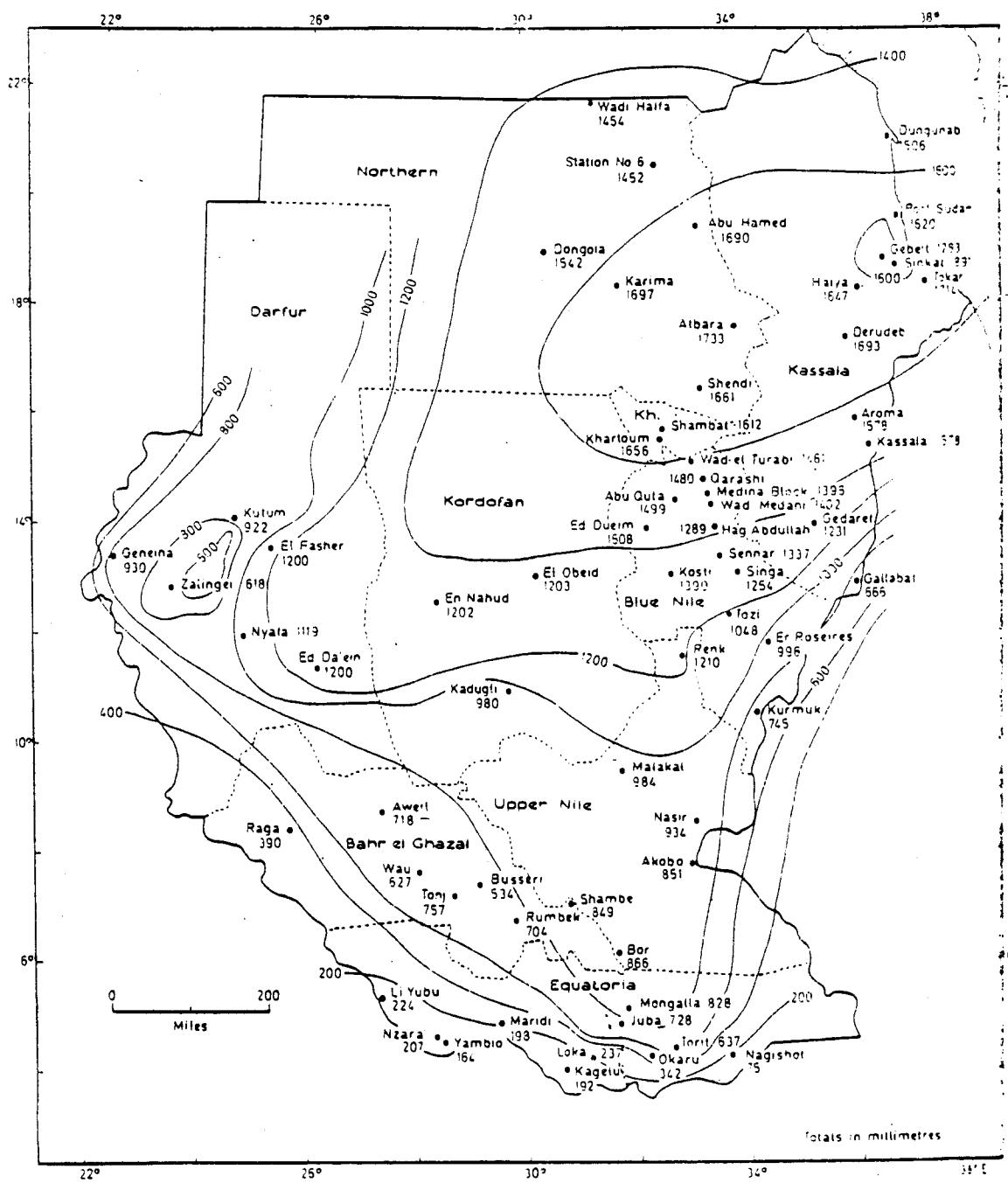


Figure 4. Annual Water Deficits

Source: Oliver. 1969.

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

| | Result. Directions from True N. | | | | Relative Steadiness per cent | | | |
|--------------|---------------------------------|---------------|---------------|---------------|------------------------------|---------------|---------------|------|
| | 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 | 83 | 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

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 agriculture¹ | 78 | 1979 |

Sources: U.S. AID. 1980.

¹World Bank. 1981.



Figure 1. Provincial Boundaries, 1976

Source: Waterbury. 1979.

Table 2. Population, Urbanization and Growth by Province

| | 1973 Popula- tion (000's) | Annual Growth Since 55/56 | 1973 | | Annual Growth Since 55/56 | Percent Urban ¹ | | |
|---------------------------|------------------------------------|------------------------------------|--|-------------|------------------------------------|----------------------------|-------------|--|
| | | | Urban Popula- tion ¹ (000's) | 1955- 56 | | 1964- 66 | 1973- 74 | |
| <u>Northern Provinces</u> | | | | | | | | |
| 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 | 300 | 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 | <u>2,140</u> | <u>2.7</u> | <u>177</u> | <u>6.5</u> | <u>4.3</u> | <u>6.5</u> | <u>8.5</u> | |
| Total Northern | 11,733 | 2.6% | 1,747 | 5.8% | 8.4% | NA | 14.9% | |
| <u>Southern Provinces</u> | | | | | | | | |
| 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 | <u>792</u> | <u>-.7</u> | <u>57</u> | <u>9.7</u> | <u>1.2</u> | <u>1.7</u> | <u>7.9</u> | |
| Total Southern | 3,025 | .6% | 147 | 9.6% | 1.0% | NA | 4.9% | |
| Total Sudan | 14,758 | 2.1% | 1,894 | 6.0% | 6.4% | 8.3% | 12.3% | |

¹Urban 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)

| | <u>Khartoum</u> | <u>Omdurman</u> | <u>North</u> | <u>Khartoum</u> | <u>Greater Khartoum</u> | <u>Port Sudan</u> | <u>El Obeid</u> | <u>Juba</u> |
|---------------------------|-----------------|-----------------|--------------|-----------------|-----------------------------|-----------------------|---------------------|-------------|
| 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 | 45 | 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 | 320,413 | 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.

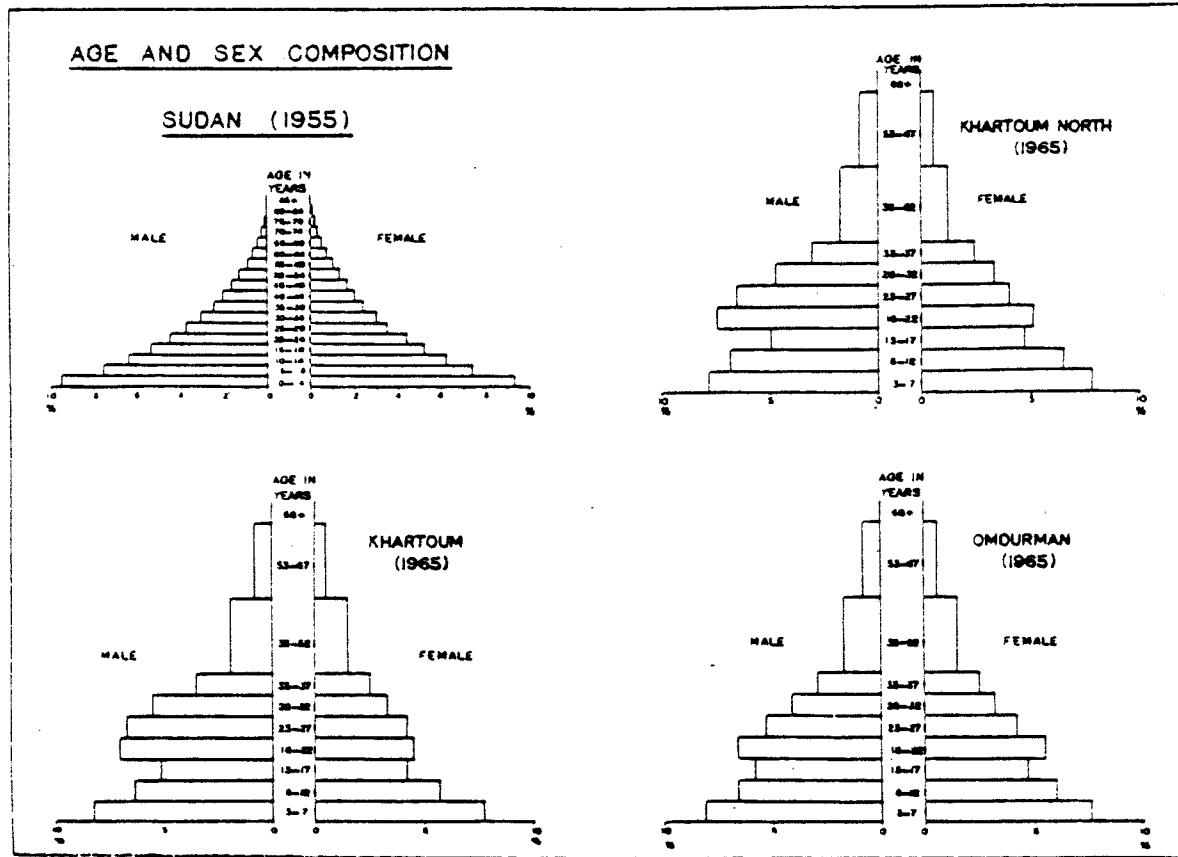


Figure 2. Age and Sex Structure

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 | 54.6 | 0.6 | 36.3 | 96.9 | 68.0 | 81.0 | 1.7 |
| Beja | 0.2 | 0.1 | 0.1 | 0.1 | 0.4 | 0.4 | 0.4 | 0.4 | 0.1 |
| Nuba | 0.1 | 0.1 | 41.7 | 0.5 | 0.5 | 0.4 | 0.4 | 0.4 | 0.1 |
| Darfurian | 7.9 | 2.5 | 0.1 | 0.1 | 11.1 | 0.8 | 2.7 | 0.1 | 0.1 |
| West African ¹ | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Nubian | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 | 0.2 | 0.1 |
| Fung | 4.8 | 0.1 | 0.1 | 0.1 | 0.6 | 0.6 | 0.6 | 0.6 | 1.6 |
| Zande | 0.4 | 0.1 | 0.1 | 0.1 | 23.8 | 0.1 | 0.1 | 0.1 | 0.1 |
| Bongo-Baku | 1.5 | 0.1 | 0.1 | 0.1 | 3.0 | 0.1 | 0.1 | 0.1 | 0.1 |
| Ndogo-Sore | 2.9 | 0.1 | 0.1 | 0.1 | 2.5 | 0.1 | 0.1 | 0.1 | 0.1 |
| Moro-Madi | 0.1 | 0.1 | 0.1 | 0.1 | 10.2 | 0.1 | 0.1 | 0.1 | 0.1 |
| Dinka | 87.4 | 0.1 | 0.1 | 0.1 | 0.3 | 0.1 | 0.1 | 0.1 | 25.4 |
| Nuer | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 62.2 |
| Luo | 4.8 | 0.4 | 0.1 | 0.1 | 4.9 | 0.1 | 0.1 | 0.1 | 13.8 |
| Lango ² | 0.1 | 0.1 | 0.1 | 0.1 | 31.3 | 0.1 | 0.1 | 0.1 | 0.1 |

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

² Includes Bari, Lotuko and Toposa.

Source: Nelson, et al. 1973.

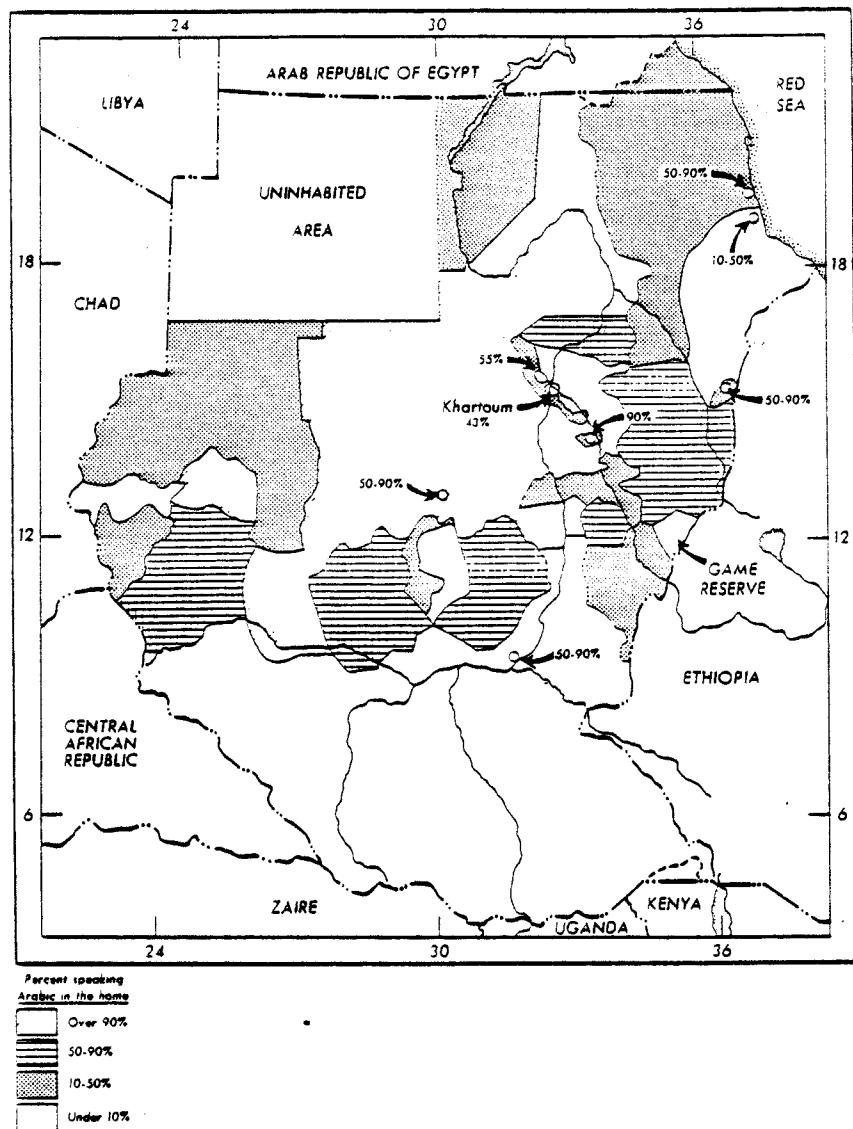


Figure 3. Use of Arabic Language, 1972

Source: Nelson et al. 1973.

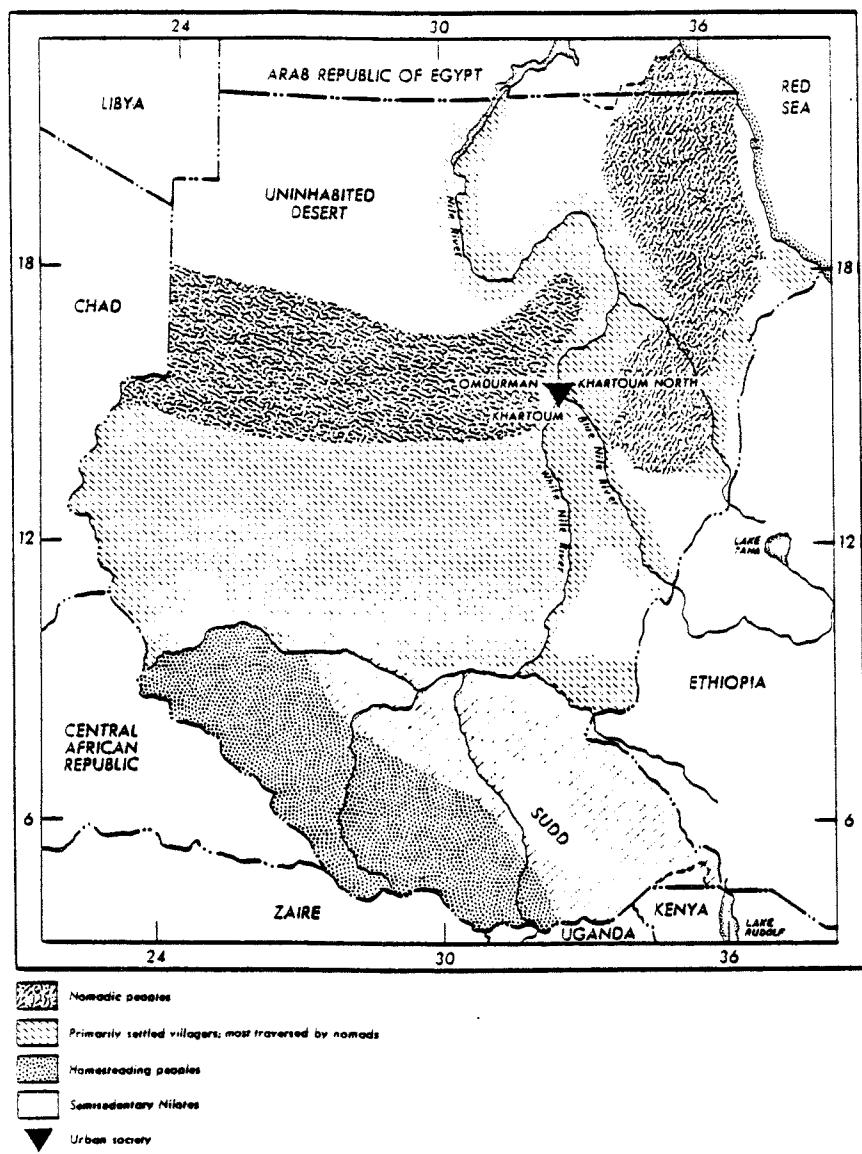


Figure 4. Predominant Patterns of Social Organization

Source: Nelson et al. 1973.

Table 5. Schistosomiasis - Cases and Deaths

Source: Hasseeb et al. 1972.

Table 6. Incidence of Diarrhoeal Diseases

| Age | Gastro-Enteritis & Other Diarrhoeal Diseases | Bacillary & Amoebic Dysentery | 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 3. SMALL POX, HEPATITIS, AND 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 |
| Sanitary 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

Table 1. World Bank Economic Data Sheet

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 | 11258.0 | 12533.0 | 12832.0 | 13138.0 | 13451.0 | 13772.0 | 14100.0 | 14484.0 |
| GDP by industrial origin | | | | | | | | | | At current factor cost |
| Agriculture | .. | .. | 294.8 | 314.6 | 249.8 | 276.0 | 292.8 | 298.4 | 358.2 | 393.4 |
| Mining | .. | .. | 0.4 | 0.4 | 2.7 | 2.9 | 3.4 | 2.8 | 2.9 | 3.3 |
| Manufacturing | .. | .. | 24.2 | 39.3 | 52.9 | 58.0 | 60.8 | 71.0 | 87.6 | 90.3 |
| Construction | .. | .. | 32.2 | 33.6 | 34.5 | 31.5 | 35.8 | 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 | 185.0 | 186.0 | 194.7 | 133.8 | 140.4 |
| Public administration and defense | .. | .. | 40.0 | 68.7 | 58.6 | 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 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| Manufacturing | .. | .. | .. | .. | .. | 108.1 | 118.7 | 108.3 | 123.6 | 134.6 |
| Construction | .. | .. | .. | .. | .. | 70.2 | 84.3 | 75.8 | 83.9 | 80.9 |
| Electricity, gas, and water | .. | .. | .. | .. | .. | 20.6 | 28.8 | 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 costs | .. | .. | .. | .. | .. | 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 |
| 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 | 1018.4 |
| Private consumption | .. | 364.0 | 456.1 | 573.2 | 534.0 | 577.8 | 631.8 | 681.8 | 676.5 | 787.8 |
| General government consumption | .. | 21.2 | 30.7 | 63.2 | 93.6 | 105.2 | 112.1 | 132.8 | 147.7 | 159.0 |
| Gross domestic investment | .. | 15.7 | 46.2 | 62.9 | 75.6 | 73.0 | 80.8 | 85.1 | 95.8 | 99.8 |
| 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 | 1190.0 |
| Factor payments to abroad (net) | .. | -1.8 | -3.5 | -7.1 | -9.6 | -8.8 | -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 |
| Imports of goods and N.F.S. | .. | .. | 171.8 | 247.9 | 318.6 | 249.3 | 284.2 | 253.0 | 218.5 | 259.8 |
| 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 | 1262.8 |
| 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 | 283.5 | 287.3 | 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 | 89.8 |
| 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 |
| 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 | 98.3 | 88.2 | 95.1 | 100.0 | 95.7 |
| Implicit GDP deflator | .. | 60.8 | 65.0 | 78.0 | 77.4 | 88.0 | 88.0 | 90.0 | 100.0 | 102.9 |
| Foreign exchange rate | .. | .. | 0.348 | 0.348 | 0.348 | 0.348 | 0.348 | 0.348 | 0.348 | 0.348 |

a. 1960. 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 | 1980-80 | 1980-70 | 1970-77 | |
|--------------------------------------|---------|--------------------|---------|--------------------|--------------------|--------------------|---------|-------------------|--|
| Average annual growth rate (percent) | | | | | | | | | |
| 14837.0 | 15220.0 | 15612.0 | 16015.0 | 16461.0 | 16919.0 | 1.9 | 2.3 | 2.6 | (Total, midyear, thousands) |
| (millions of Sudanese pounds) | | | | | | | | | |
| 401.5 | 436.1 | 516.4 | 585.3 | 640.5 | 838.7 | 57.5 ^a | 45.3 | 40.4 ^d | Agriculture |
| 3.5 | 3.7 | 4.1 | 4.6 | 11.9 | 11.8 | 0.1 ^a | 0.2 | 0.3 ^d | Mining |
| 84.0 | 91.3 | 107.2 | 138.3 | 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 | 18.6 | 20.9 | 43.0 | 43.8 | 4.3 ^a | 3.6 | 2.3 ^d | Electricity, gas, and water |
| 84.7 | 92.2 | 74.8 | 89.4 | 159.9 | 167.3 | 7.4 ^a | 7.2 | 7.8 ^d | Transport and communications |
| 242.1 | 263.1 | 271.5 | 354.4 | 248.3 ^b | 273.4 ^b | 10.2 ^a | 18.0 | 21.1 ^d | Trade and finance |
| 152.7 | 165.9 | 127.9 | 151.2 | .. | .. | 7.8 ^a | 10.4 | 13.3 ^d | Public administration and defense |
| 12.8 | 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 | 1968.1 | 100.0 ^a | 100.0 | 100.0 | GDP at factor cost |
| 46.3 | 50.3 | 52.6 | 88.8 | 104.4 | 122.9 | 4.4 ^a | 4.4 | 5.3 | Net indirect taxes |
| 1098.2 | 1192.6 | 1248.2 | 1510.8 | 1778.9 | 2091.0 | 104.4 ^a | 104.4 | 105.3 | GDP at market prices |
| (millions of Sudanese pounds) | | | | | | | | | |
| 413.2 | 500.1 | 480.4 | 585.3 | 545.3 | 536.0 | .. | .. | 6.2 | Agriculture |
| 135.6 | 103.8 | 129.4 | 160.9 | 180.7 | 193.1 | .. | .. | 6.6 | Mining ^c |
| 71.4 | 66.9 | 101.4 | 73.4 | 80.7 | 94.3 | .. | .. | 5.7 | Manufacturing |
| 26.4 | 26.9 | 17.7 | 21.0 | 22.0 | 23.3 | .. | .. | -4.7 | Construction |
| 98.7 | 101.8 | 109.3 | 100.3 | 108.6 | 116.1 | .. | .. | 1.5 | Electricity, gas, and water |
| 283.1 | 293.8 | 316.3 | 369.3 | 398.2 | 419.3 | .. | .. | 8.1 | Transport and communications |
| 212.2 | 213.7 | 220.9 | 200.6 | 201.9 | 244.2 | .. | .. | 1.3 | Trade and finance |
| .. | .. | 103.3 ^f | .. | .. | .. | .. | .. | .. | Public administration and defense |
| 1240.6 | 1307.0 | 1478.7 | 1510.8 | 1535.4 | 1626.3 | .. | .. | 5.4 | Other branches |
| 1240.6 | 1307.0 | 1478.7 | 1510.8 | 1535.4 | 1626.3 | 5.5 | 1.3 | 5.4 | GDP at factor cost ^d |
| 1240.6 | 1307.0 | 1478.7 | 1510.8 | 1535.4 | 1626.3 | .. | .. | .. | Net indirect taxes |
| 1240.6 | 1307.0 | 1478.7 | 1510.8 | 1535.4 | 1626.3 | .. | .. | .. | GDP at market prices |
| (millions of Sudanese pounds) | | | | | | | | | |
| 1091.8 | 1184.9 | 1235.8 | 1491.3 | 1742.4 | 2051.7 | 99.7 ^h | 99.3 | 98.8 | GDP |
| -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 | 1248.2 | 1510.8 | 1778.9 | 2091.0 | 100.0 ^b | 100.0 | 100.0 | GDP |
| 134.2 | 195.0 | 306.8 | 418.6 | 454.0 | 519.5 | .. | 13.8 | 20.9 | Imports of goods and N.F.S. |
| 125.8 | 172.0 | 159.5 | 179.3 | 242.3 | 272.3 | .. | 12.5 | 12.8 | Exports of goods and N.F.S. |
| 1106.6 | 1215.6 | 1393.5 | 1750.1 | 1988.6 | 2338.2 | 98.1 ^h | 101.3 | 108.1 | Total resources |
| 889.5 | 944.9 | 983.7 | 1277.3 | 1440.5 | 1784.2 | 86.1 ^h | 79.9 | 80.6 | Private consumption |
| 141.0 | 165.5 | 180.5 | 207.8 | 231.4 | 255.0 | 5.5 ^h | 11.1 | 13.7 | General government consumption |
| 78.1 | 105.2 | 229.3 | 265.0 | 318.7 | 319.0 | 6.5 ^h | 10.3 | 13.8 | Gross domestic investment |
| (millions of Sudanese pounds) | | | | | | | | | |
| 1233.7 | 1299.2 | 1466.0 | 1491.3 | 1506.0 | 1595.4 | .. | 1.3 | 5.2 | GDP |
| -6.9 | -7.8 | -12.7 | -19.5 | -29.4 | -30.9 | .. | .. | .. | Factor payments to abroad (net) |
| 1240.6 | 1307.0 | 1478.7 | 1510.8 | 1535.4 | 1626.3 | 5.5 | 1.3 | 5.4 | GDP |
| 220.0 | 270.8 | 374.1 | 418.6 | 407.0 | 447.0 | .. | 1.7 | 12.0 | Imports of goods and N.F.S. |
| 187.8 | 215.0 | 184.4 | 179.3 | 237.3 | 192.5 | .. | 6.6 | -0.1 | Exports of goods and N.F.S. |
| 1272.8 | 1362.8 | 1688.4 | 1750.1 | 1705.1 | 1880.8 | .. | 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 | 207.8 | 186.6 | 202.3 | .. | 12.1 | -4.8 | General government consumption |
| 147.1 | 178.2 | 271.0 | 265.0 | 278.2 | 246.2 | .. | -1.3 | 9.5 | Gross domestic investment |
| (millions of Sudanese pounds) | | | | | | | | | |
| 76.1 | 105.2 | 229.3 | 265.0 | 316.7 | 319.0 | 100.0 ^h | 100.0 | 100.0 | As percentage of GDI |
| 61.3 | 74.5 | 71.6 | 6.2 | 70.5 | 32.5 | 125.4 ^h | 80.1 | 32.8 | Gross domestic investment |
| -14.8 | -30.7 | -157.7 | -258.8 | -246.2 | -286.5 | 25.4 ^h | -19.9 | -67.2 | Gross national savings (excluding net current transfers from abroad) |
| 63.7 | 75.3 | 78.8 | 22.0 | 77.5 | 39.5 | .. | .. | 35.4 | Net balance of goods and services |
| 115.0 | 132.6 | 167.2 | 207.2 | 210.8 | 248.0 | 4.5 | 2.8 | 15.3 | Gross national savings (including net current transfers from abroad) |
| 104.3 | 120.8 | 153.7 | 177.4 | .. | .. | -0.9 | 2.3 | 13.5 ^d | Consumer price (or retail price) index |
| 108.7 | 112.0 | 103.6 | 122.9 | 142.1 | 158.0 | .. | 3.7 | 6.3 | Wholesale price index |
| (annual average) | | | | | | | | | |
| 0.348 | 0.348 | 0.348 | 0.348 | 0.348 | 0.348 | .. | .. | .. | Implicit GDP deflator |
| (annual average) | | | | | | | | | |
| 0.348 | 0.348 | 0.348 | 0.348 | 0.348 | 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 1961-65 | AVERAGE WEIGHT 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 |
| CORN | 42 | 17 | 37 | 25 | 25 | 36 | 48 | 48 | 55 | 53 | 50 |
| MILLET | 63 | 303 | 460 | 325 | 365 | 368 | 434 | 444 | 403 | 468 | 46 |
| SORGHUM | 47 | 1,256 | 1,529 | 2,153 | 1,300 | 1,654 | 1,702 | 1,744 | 2,026 | 1,900 | 2,017 |
| PULSES | 97 | 176 | 200 | 200 | 200 | 190 | 71 | 74 | 77 | 80 | A2 |
| CASSAVA | 16 | 120 | 174 | 134 | 134 | 140 | 90 | 82 | 130 | 131 | 130 |
| ONIONS | 56 | 50 | 70 | 70 | 70 | 70 | 100 | 21 | 34 | 35 | 35 |
| COTTON | 656 | 157 | 252 | 237 | 240 | 239 | 223 | 226 | 113 | 156 | 203 |
| COTTONSEED | 60 | 308 | 472 | 460 | 465 | 465 | 432 | 421 | 210 | 291 | 370 |
| PEANUTS, IN SHELL | 119 | 256 | 351 | 394 | 515 | 314 | 544 | 931 | 827 | 850 | 1,021 |
| SESAME SEED | 149 | 165 | 297 | 271 | 290 | 245 | 234 | 233 | 238 | 248 | 245 |
| ORANGES | 52 | 5 | 7 | 7 | 7 | 7 | 20 | 41 | 42 | 43 | 44 |
| DATES | 98 | 41 | 50 | 50 | 50 | 50 | 42 | 102 | 105 | 106 | 109 |
| MEATS | 349 | 79 | 110 | 120 | 120 | 120 | 300 | 327 | 350 | 360 | 372 |
| MILK | 60 | 1,774 | 1,870 | 1,880 | 1,880 | 1,880 | 1,350 | 1,312 | 1,328 | 1,376 | 1,412 |
| 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 | 452.3 | 452.3 |
| LIVESTOCK | 134.0 | 150.6 | 154.7 | 154.7 | 154.7 | 154.7 | 192.8 | 211.9 | 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 | 669.9 | 669.9 |
| TOTAL FOOD | 313.8 | 403.5 | 430.6 | 408.8 | 395.1 | 455.3 | 509.9 | 507.4 | 523.1 | 561.9 | 544.1 |
| INDICES OF PRODUCTION | | | | | | | | | | | |
| CROPS | 100 | 149 | 153 | 146 | 141 | 147 | 165 | 134 | 148 | 179 | 160 |
| TOTAL AGRICULTURE | 100 | 137 | 141 | 136 | 132 | 144 | 149 | 140 | 150 | 167 | 151 |
| TOTAL FOOD | 100 | 129 | 137 | 130 | 126 | 145 | 162 | 142 | 167 | 179 | 173 |
| PER CAPITA AGRICULTURE | 100 | 116 | 119 | 112 | 107 | 114 | 122 | 106 | 111 | 121 | 114 |
| PER CAPITA FOOD | 100 | 111 | 116 | 117 | 102 | 115 | 126 | 122 | 123 | 130 | 123 |
| INDEX OF POPULATION 1961-65 POPULATION = 12,000,000 | 100.0 | 116.2 | 119.7 | 121.1 | 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 | V | Dura* Q | V | Millet Q | V | Groundnuts Q | V | Sesame Q | V | Gum Arabic Q | 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

| | <u>Urban</u> | <u>Total Sudan</u> |
|--|--------------|--------------------|
| Agriculture | 140 | 18% |
| Mining and quarrying | 1 | - |
| Manufacturing | 90 | 12 |
| Electricity, gas and water | 19 | 2 |
| Construction | 38 | 5 |
| Wholesale, retail trade, restaurants and hotels | 107 | 14 |
| Transport, storage and communications | 80 | 11 |
| Financing, insurance real estate and business services | 4 | 1 |
| Community, social and personal services | 229 | 30 |
| Not adequately classified | 53 | 7 |
| 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% |

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

| | Narrow Concept | | | Broad Concept | | |
|----------------------|----------------|--------|--------|---------------|--------|--------|
| | Male | Female | Total | Male | Female | Total |
| <u>Low Estimate</u> | | | | | | |
| 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 |
| <u>High Estimate</u> | | | | | | |
| 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% |
| | High | 15.6% | 11.7% | 89% | 85% | 88% |

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 (£S1,120,000 in 1976).

† Excluding exports of camels (£S2,420,000 in 1971).

PRINCIPAL COMMODITIES
(£S '000)

| IMPORTS | 1977 | 1978 | 1979 | EXPORTS | 1977 | 1978 | 1979 |
|---------------------------|---------|---------|---------|--------------------------------|---------|--------|--------|
| Sugar . . . | 13,440 | 18,930 | 20,470 | Animals . . . | 4,538 | 8,310 | 7,102 |
| Tea . . . | 6,551 | 17,398 | 6,185 | Cotton, long-staple . . . | 100,044 | 71,200 | 93,658 |
| Coffee . . . | 1,695 | 5 | 1,598 | Cotton, others . . . | 31,518 | 33,723 | 57,602 |
| Wheat . . . | 6,490 | 8,825 | 22,007 | Cottonseed . . . | 2,717 | 1,697 | 1,635 |
| Textiles . . . | 28,232 | 37,360 | 26,723 | Cottonseed cake and meal . . . | 4,767 | 2,664 | 13,524 |
| Footwear . . . | 160 | 88 | 50 | Sorghum (Durra) . . . | 28,503 | 20,725 | 9,956 |
| Sacks and jute . . . | 3,577 | 4,544 | 5,300 | Groundnuts . . . | 2,927 | 3,773 | 4,307 |
| Fertilizers . . . | 3,370 | 433 | 5,969 | Groundnut cake and meal . . . | 3,138 | 7,479 | 3,556 |
| Machinery . . . | 125,619 | 111,955 | 100,796 | Groundnut oil . . . | 13,007 | 13,996 | 18,247 |
| Tyres . . . | 6,509 | 9,657 | 11,173 | Gum arabic . . . | 4,301 | 3,900 | 3,680 |
| Petroleum products . . . | 44,354 | 49,953 | 71,889 | Hides and skins . . . | 10,258 | 19,182 | 6,278 |
| Pharmaceuticals . . . | 10,156 | 14,527 | 10,581 | Sesame seed . . . | 2,182 | 1,330 | 1,325 |
| Iron and steel . . . | 8,327 | 8,750 | 8,759 | Sesame cake and meal . . . | 34 | 1,225 | 460 |
| Transport equipment . . . | 39,659 | 57,510 | 70,956 | Sesame oil . . . | | | |
| Metal manufactures . . . | 20,759 | 32,855 | 42,217 | | | | |

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 | 2,100 |
| 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 | 8,465 |
| 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 | 708 | 349 | 49 |
| Italy . . . | 16,754 | 24,573 | 19,725 | 28,376 | 27,159 | 30,672 |
| Japan . . . | 39,989 | 29,317 | 30,445 | 17,960 | 16,578 | 16,278 |
| Netherlands . . . | 10,705 | 14,085 | 8,417 | 5,829 | 4,988 | 3,259 |
| Poland . . . | 1,351 | 1,516 | 4,274 | 5,036 | 4,782 | 2,959 |
| U.S.S.R. . . . | 1,943 | 839 | 397 | 7,948 | 6,859 | 10,481 |
| 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
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- Table 8. Limnological characteristics of swamp rivers
- Table 9. Recharge Estimates and Transmissibility Calculations in Kordofan
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- Figure 3. Reference map of Darfur Kordofan border area (for Table 12)
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- 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 | 1 |
| Magnesite | 213-214 | 2 |
| 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.

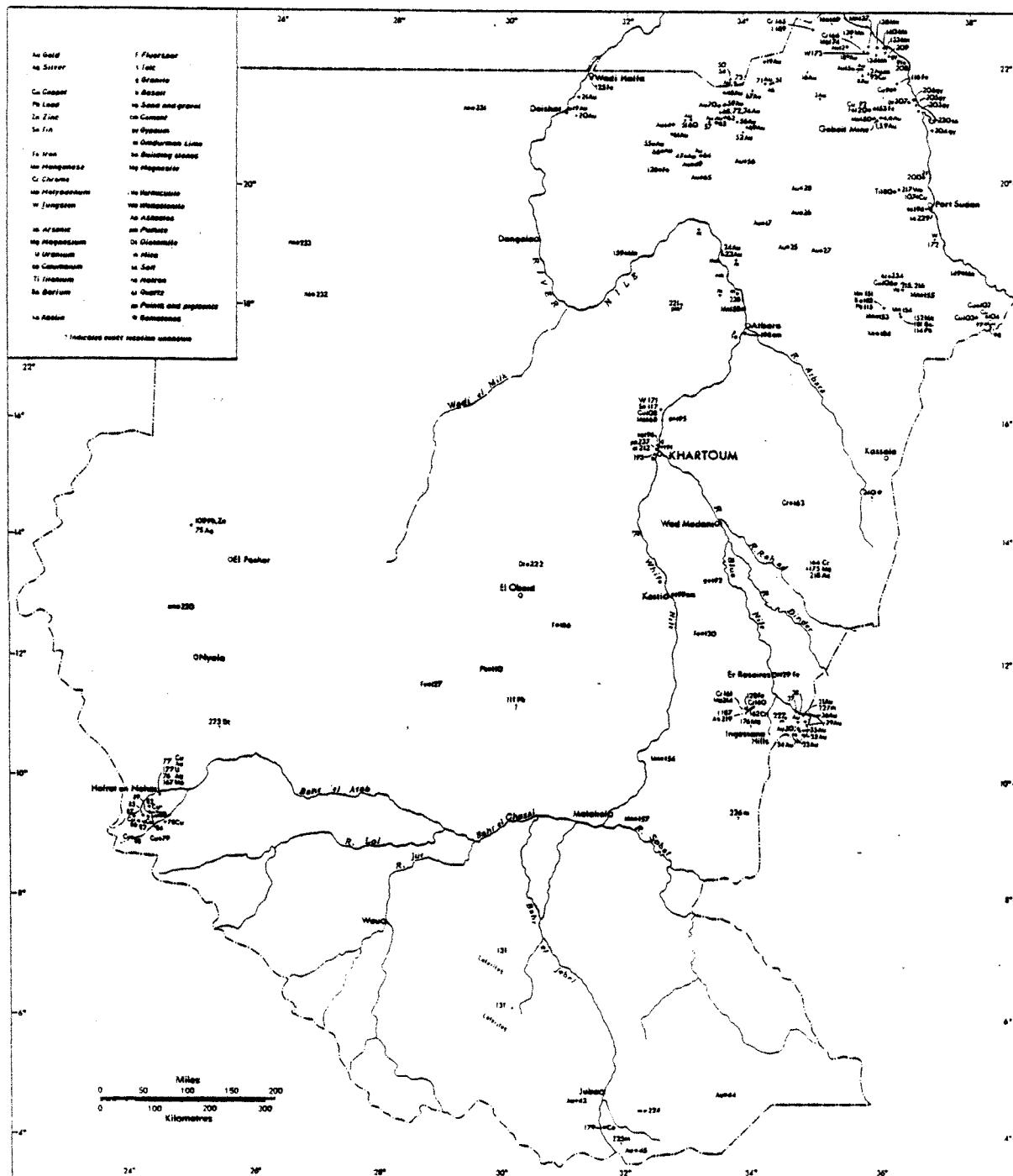


Figure 1. Mineral Locality Map, Sudan

Source: Whiteman. 1971.

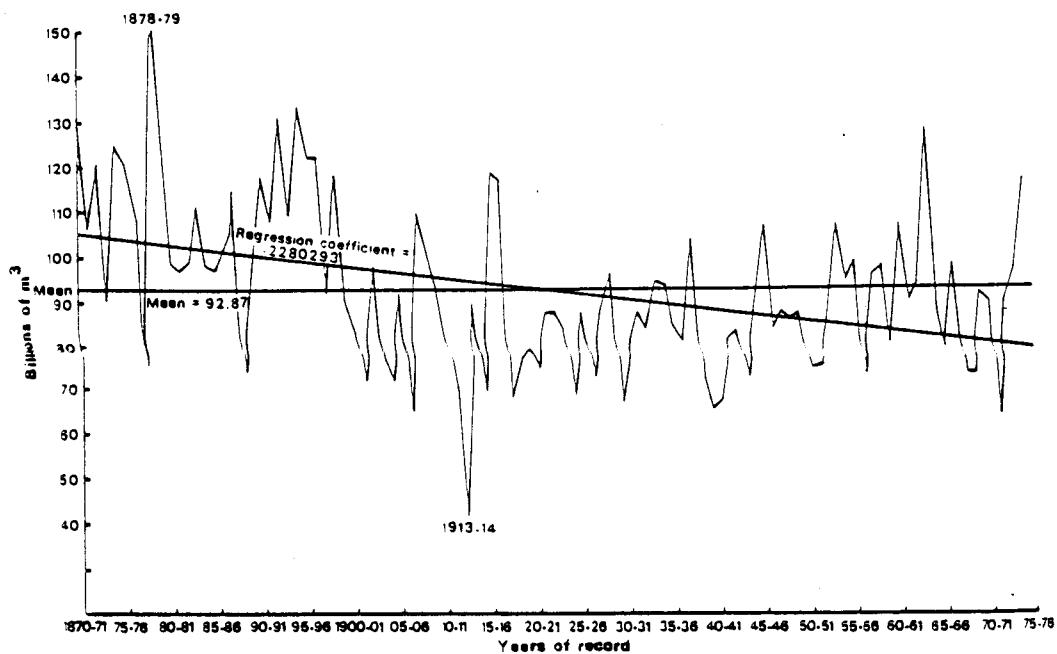


Figure 2. Natural Yield of the Nile at Aswan by Hydrologic Year, 1870/71-1975/76

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) | | | |
|--------------------------------|-----------|--|------|-------|---|-------|----------|-------|
| | | Min. | Mean | Max. | Mean | | Absolute | |
| | | | | | 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 | 2.8 | 4.5 | 9.1 | 9.4 | 16.0 | 4.7 | 29.2 |
| Swanips 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 Tumaniat . | 1911-34 | 46.2 | 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 |
| Mulakal | 73 | 12 |
| White Nile at Mogren | 63 | 10 |
| 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 | Mon-galla: Total Mills m ³ | 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 | 8 |
| 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 | 8 |
| 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 | June 11-20 | 8 |
| 1917 | 55 810 | Oct. 1-10 | Mar. 11-20, 1918 | 16 | Mar. 21-31 | July 11-20 | 10 |
| 1918 | 47 130 | Jan. 1-10 | Apr. 1-10 | 9 | Apr. 1-10 | 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 | 16 820 | Oct. 11-20 | Dec. 21-31 | 7 | May 1-10 | July 1-10 | 8 |
| 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 | 28 030 | June 1-10 | Aug. 11-20 | 7 | Dec. 21-31 | Feb. 21-20 | 6 |
| 1928 | 26 600 | 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. | 48 | 120 | - 74 | 100 | - 74 |
| Oct. | 50 | 77 | - 19 | 100 | - 19 |
| Nov. | 94 | 12 | - 82 | 100 | 82 |
| Dec. | 131 | 3 | 128 | 90 | 115 |
| | 1112 | 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 m ³) | 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 0.65 m/sec- | 388.3-386.2 0.02- | About 400-383 0.085 m/km |
| Current | Bor 1.13 m/sec L. No 0.61 m/sec | 0.61 m/sec | 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* | Trans- | | CO ₂ (mg/l) | Oxygen (mg/l) | % satura- tion |
|----------------|---|--------------------------|------|---|---------------------|---------------------------|------------------|----------------------|
| | | | | Conduc- tivity (μmho/ cm, 20°C). | par- ency (m) | | | |
| 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 |
| | | Talling, June 1954 | 7.2 | 255 | 0.53 | 17.0 | 0.8 | 10 |
| Near Shambe | 1210 | 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 |
| | | Chadwick, Apr. 1961 | — | 340 | — | — | — | — |
| River Post 70 | 1283 | Gay, March 1958 | — | 350 | — | — | — | — |
| River Post 59 | 1340 | Gayed, Dec. 1961 | — | 170 | — | — | — | — |
| River Post 30 | 1480 | Talling, Jan. 1949 | — | — | — | — | — | — |
| River Post 12 | 1583 | Talling, Jan. 1954 | 7.8 | — | 0.45 | — | 2.45 | 43.5 |
| | | Talling, Dec. 1954 | 7.15 | 202 | 0.58 | 14.5 | 4.50 | 55 |
| | | Talling, Jan. 1954 | 7.8 | — | 0.45 | — | 5.00 | 64 |
| | | 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 |
| At Lake No | 1633 | 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 |
| | | 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 |
| At Khor Atar | 1745 | 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 |
| | | Pyle, June 1949 | — | — | — | — | 3.23 | 58 |
| At Sobat Mouth | 1756 | Talling, Febr. 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 | 18.0 | 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 |
| | | Pyle, Jan. 1949 | — | — | — | — | 4.7-5.3 | 48-61 |
| | | 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) | Sat (%) |
| Entrance of Jur | 0 | Jan. 1954 | 6.8 | — | — | — | — |
| L. Ambadi | 6 | Jan. 1954 | 6.4-6.9 | 40 | 2.50 (to bottom) | In reeds 1.3-1.8 Open water 7.5-8.0 | 15-21 83-95 |
| Nyakong | 15 | Jan. 1954 | 6.4-6.6 | — | 1.80 | Reeds 2.6-3.1 open w. 4.4-3 | 30-40 50-52 |
| Wangkai | 53 | Jan. 1954 | — | — | 2.50 | — | — |
| Bentiu | 103 | Jan. 1954 | 7.0 | 175 | 1.12 | 4.6 | 53 |
| | | Apr. 1961 | 6.6 | 225 | — | — | — |
| | | Dec. 1962 | — | 100 | 1.60 | 5.4 | 65 |
| River Post no. 5 | 178 | Jan. 1954 | 7.5 | — | 1.10 | 5.7-6.3 | 70-78 |
| River Post no. 1 | 198 | Jan. 1954 | 7.5 | — | 1.20 | 6.0 | 75 |
| Mouth of Ghazal into L. No | 203 | Dec. 1953 | 7.5 | — | 1.04 | 4.9-5.8 | 58-70 |
| Lake No | — | Dec. 1953 | 8.4 | 200 | 0.47 | 8.5-9.0 | 110-120 |

Source: Rzoska. 1974.

C. Bahr el Zeraf and Sobat

| Site | Distance from origin (km) | Date | pH | Conductivity | Transparency (m) | Alkalinity (N 10 ⁻⁴) | Oxygen | | Cl ⁻ (mg/l) | SiO ₂ (mg/l) |
|-----------------------|---------------------------|------------|---------|--------------|------------------|-------------------------------------|---------|---------|---------------------------|----------------------------|
| | | | | | | | (mg/l) | Sat (%) | | |
| Zeraf River | | | | | | | | | | |
| Zeraf cuts | 60 | Dec. 1960 | 7.5 | 245 | 0.70 | 92 | 3.2 | 28 | — | — |
| Downstream diff. site | 200 | Jan. 1954 | 7.6-7.9 | — | — | 160 | 4.8-5.0 | 55-57 | — | 10 |
| | | | 7.8 | — | — | 160 | 5.4 | 61 | — | — |
| River Post 5 | 268 | Feb. 1954 | — | — | 0.65 | — | — | — | — | — |
| 15 km from mouth | 278 | Jan. 1954 | 8.0-8.4 | — | 0.55 | 166 | 5.6-5.9 | 65-69 | — | 8 |
| 5 km from mouth | 287 | Dec. 1961 | 7.1 | 370 | — | — | — | — | — | — |
| Mouth | 293 | Jan. 1961 | 8.0 | 350 | 0.85 | 150 | 4.4 | 52 | — | — |
| Sobat River | | | | | | | | | | |
| Near mouth | Over 200 | Dec. 1949 | — | — | — | 4.7-5.3 | 48-61 | — | — | — |
| | | Dec. 1953 | 7.4 | — | 0.35 | 34 | 6.0 | 70 | 3 | 22 |
| | | Dec. 1954 | 6.8 | 112 | 0.35 | 15.2 | 3.4 | 44 | 0.06 | 26 |
| | | Dec. 1956 | -- | 125 | — | — | — | — | — | — |
| | | March 1958 | — | 120 | — | — | — | — | — | — |
| | | June 1961 | 7.8 | 110 | 0.45 | 50.0 | 4.5 | 53 | 0.15 | — |
| | | Dec. 1961 | 7.3 | 280 | — | — | — | — | — | — |
| | | Feb. 1964 | 6.8 | — | 0.55 | — | 4.3 | 52 | — | — |
| | | May 1964 | 7.15 | — | 0.30 | 47 | 6.2 | 81 | — | — |

Source: Rzoska. 1974.

Table 9. Recharge Estimates and Transmissibility Calculations in Kordofan

A. Formations in Southwestern Kordofan

Central Kordofan - Wadi Elghalla

| | |
|---|---|
| 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 = $2820 \times 640 \times .34$ | = 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 | |
| $= \frac{543 \times 10^6 \times 30}{100}$ | = <u>16.3×10^7 gals/day</u> |
| | = <u>.25 in/yr or 6 mm/yr</u> |

Using the ground water equation

$$Q = T I L$$

$$T = \frac{16.3 \times 10^7 \times 1100}{150 \times 5280 \times 1} = \underline{\underline{200,000 \text{ gals/ft/day}}}$$

Source: Ishag. 1965.

B. Nubian Aquifer in Northern Kordofan

| | |
|--|----------------------------------|
| Average annual rainfall (from fig. 7) | = 200 mm/year |
| Amount of runoff | = 50 mm/year |
| | = .16 ft/year |
| Catchment area, 20 miles radius | = 1250 square miles |
| Volume of runoff = $1250 \times 640 \times .16$ | = 12.8×10^4 acre ft/yr. |
| $= \frac{12.8 \times 10^4 \times .39}{1000}$ | = 114×10^6 gals/day |
| Percentage of recharge increment from total runoff | = 40% |
| Total (Q) or volume of recharge | = 45.6×10^6 gals/day |
| | = .07 inch or 1.5 mm/yr. |

Using the ground water equation

$$Q = T I L$$

$$T = \frac{45.6 \times 10^6 \times 5280}{300 \times 5280 \times 1} = 150,000 \text{ gals/ft/day}$$

Source: Ishag. 1965.

C. Umm Ruwaba Aquifer in Eastern Kordofan

Northern Nuba Mountains - Khor Abu Habil

| | |
|--|--------------------------------|
| Average annual rainfall (from fig. 7) | = 600 mm/year |
| Amount of runoff | = 200 mm/year |
| | = .67 ft/year |
| Catchment area, 30 miles radius | = 2820 square miles |
| Volume of runoff = $2820 \times 640 \times .67$ | = 1.2×10^5 acre ft/yr |
| $= \frac{1.2 \times 10^5 \times .39}{1000}$ | = 1068×10^6 gals/day |
| Percentage of recharge increment from total runoff | = 30% |
| Total (Q) or volume of recharge | |
| $= \frac{1068 \times 10^6 \times 30}{100}$ | = 32×10^7 gals/day |
| | = .4 inch or 10 mm/yr. |

Using the ground water equation

$$Q = T I L$$

$$T = \frac{32 \times 10^7 \times 700}{200 \times 5280 \times 1} = 210,000 \text{ gals/ft/day}$$

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 |
| 601 | 1 | 601 | 29.58 | 1.11 | 2.92 | 28.47 ft. |
| 602 | 2 | 301 | 29.35 | 0.88 | 3.15 | |
| 604 | 4 | 150 | 29.18 | 0.71 | 3.32 | |
| 607 | 7 | 86.70 | 29.14 | 0.67 | 3.36 | Q = 250 gpm. |
| 610 | 10 | 61.00 | 29.09 | 0.62 | 3.41 | |
| 613 | 13 | 47.15 | 29.00 | 0.53 | 3.50 | |
| 618 | 18 | 34.30 | 28.93 | 0.46 | 3.57 | |
| 623 | 23 | 27.08 | 28.83 | 0.36 | 3.67 | |
| 631 | 31 | 20.35 | 28.68 | 0.21 | 3.82 | |
| 640 | 40 | 16.00 | 28.64 | 0.17 | 3.86 | |
| 645 | 45 | 14.10 | 28.60 | 0.13 | 3.90 | |
| 650 | 50 | 13.00 | 28.57 | 0.10 | 3.93 | |
| 660 | 60 | 11.00 | 28.54 | 0.07 | 3.96 | |
| 670 | 70 | 9.60 | 28.51 | 0.04 | 3.99 | |
| 680 | 80 | 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 draw-down | Transmis-sivity = Cs x 2000 gpm/ft. |
|-----------------------------|------------------------------------|-----------------|---------------|--|-------------------------------------|
| Garb El Gash B. H. No. 1834 | Municipality | 250 | 4.03 | 61 | 122,000 |
| Garb El Gash B. H. No. 1834 | Municipality | 250 | 4.50 | 55.55 | 111,000 |
| Tukrof West | Mohamed Kider Dunbalab B. H. No. A | 210 | 2.00 | 105 | 210,000 |
| " | Mohamed Kider Dunbalab B. H. No. B | 200 | 5.00 | 40.00 | 80,000 |
| " | Mohed. Osman Wagie | 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. Babiker Atta | 180 | 10.00 | 18 | 36,000 |

Source: Saeed. 1968.

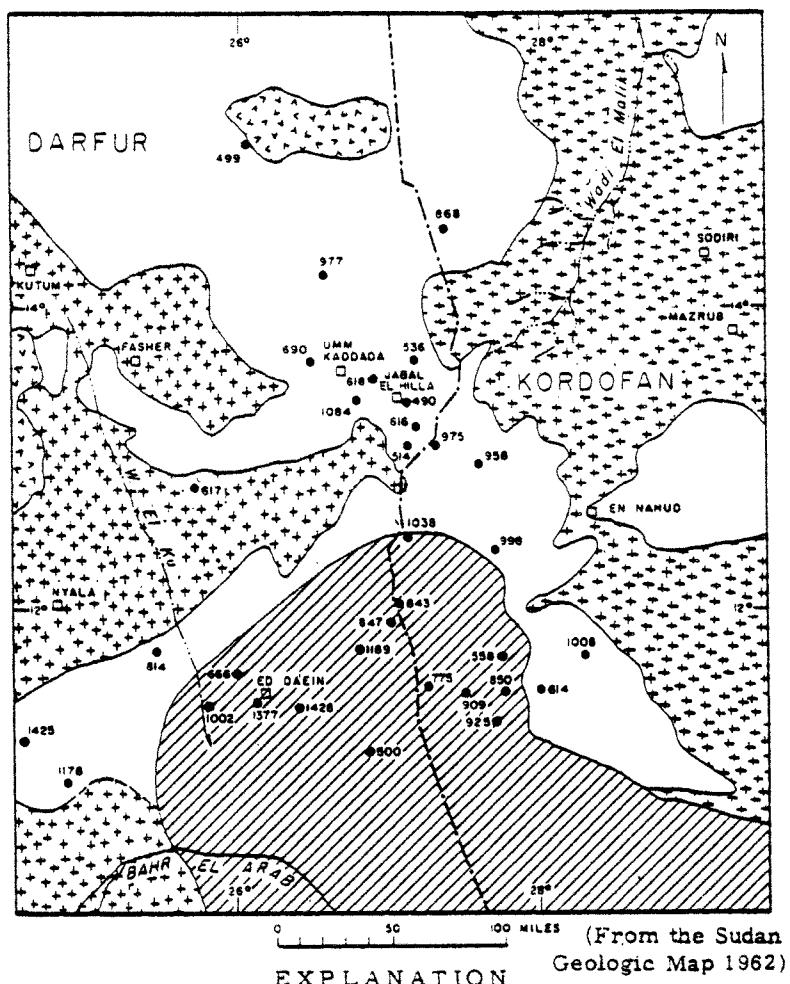


Figure 3. Reference Map of Darfur Kordofan Border Area (for Table 12)

Source: Karkamis. 1966.

Table 12. Chemical Analyses of Groundwater in Darfur and Kordofan

| Bore Hole Number | 490 ppm | 499 ppm | 500 ppm | 514 ppm | 536 ppm | 558 ppm | 514 ppm | 516 ppm |
|-------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|
| Silica | 20 | 24 | 6 | 30 | 20 | 20 | 10 | 50 |
| Calcium | 120 | 40 | 28 | 28 | 40 | 40 | 19 | 464 |
| Magnesium | 66 | 15 | 10 | 16 | nil | 15 | 25 | 570 |
| Sodium | - | - | - | - | nil | 45 | 103 | 2663 |
| Bicarbonate | - | - | - | - | - | 182 | 407 | 536 |
| Chloride | 1164 | 21 | 21 | 121 | .5 | 60 | 14 | 4060 |
| Sulphate | 1144 | 2 | 13 | 99 | nil | 30 | 10 | 2750 |
| Nitrate | 25 | 0.25 | nil | .32 | nil | nil | 2.9 | 5.8 |
| Fluoride | 1.9 | 0.44 | .96 | 6.5 | nil | .48 | 0.6 | .28 |
| Total dissolved solids | 3872 | 208 | 235 | 452 | 150 | 330 | 430 | 11620 |
| Hardness as CaCO ₃ | 40 | 12 | 8 | 90 | 100 | 160 | 150 | 3300 |
| 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 | 40 | 25 | 40 | 30 | 10 |
| Calcium | 18 | 17 | 86 | 33 | 12 | 73 | 54 | 39 |
| Magnesium | 4 | 4 | 49 | 17 | 6 | 14 | 8 | 14 |
| Sodium | 135 | 24 | 139 | 49 | 53 | 89 | 57 | 66 |
| Bicarbonate | 257 | 84 | 280 | 290 | 256 | 256 | 231 | 232 |
| Chloride | 24 | 26 | 216 | 4 | 16 | 72 | 26 | 32 |
| Sulphate | 40 | ndl | 100 | 20 | 10 | 53 | 58 | 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 | 240 | 166 | 156 |
| pH (Lab.) | 7.5 | 7.0 | 7.2 | 8.3 | 8.4 | 7.8 | 7.9 | 8.3 |

Table 12. Continued

| Bore Hole Number | 568 ppm | 909 ppm | 958 ppm | 975 ppm | 977 ppm | 998 ppm | 1002 ppm |
|-----------------------------|---------|---------|---------|---------|---------|---------|----------|
| Silica | 15 | 8 | 10 | 15 | 10 | 5 | 10 |
| Calcium | 27 | 28 | 40 | 18 | 13 | 33 | 78 |
| Magnesium | 9 | 8 | 3 | 8 | 5 | 12 | 21 |
| Sodium | 10 | 38 | 41 | 23 | 25 | 17 | 146 |
| Bicarbonate | 122 | 207 | 219 | 109 | 85 | 150 | 207 |
| Chloride | 16 | 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 | 180 | 200 | 240 | 120 | 90 | 220 | 600 |
| Hardness as CaCO_3 | 104 | 104 | 134 | 80 | 52 | 130 | 284 |
| pH (Lab.) | 7.2 | 7.8 | 8.2 | 8.1 | 8.1 | 8.0 | 7.9 |

Table 12. Continued

| Bore Hole Number | 1008 ppm | 1038 ppm | 1084 ppm | 1169 ppm | 1176 ppm | 1377 ppm | 1425 ppm | 1428 ppm |
|-----------------------------|----------|----------|----------|----------|----------|----------|----------|----------|
| Silica | 10 | 8 | 10 | 14 | 50 | 10 | 6 | 22 |
| Calcium | 21 | 45 | 24 | 59 | 69 | 34 | 61 | 65 |
| Magnesium | 12 | 17 | 26 | 13 | 7 | 10 | 10 | 14 |
| Sodium | 11 | 29 | 66 | 75 | 81 | 47 | 33 | 75 |
| Bicarbonate | 110 | 232 | 171 | 293 | 378 | 267 | 244 | 390 |
| Chloride | 8 | 22 | 92 | 28 | 20 | 10 | 4 | 30 |
| Sulphate | 19 | 19 | 29 | 72 | 38 | 14 | 10 | 19 |
| Nitrate | 1.3 | 1 | 3 | 3 | nil | .5 | .7 | .7 |
| Fluoride | .3 | .7 | 1 | .3 | .4 | .4 | .7 | .4 |
| Total dissolved solids | 100 | 240 | 340 | 360 | 290 | 280 | 250 | 460 |
| Hardness as CaCO_3 | 100 | 100 | 168 | 20 | 202 | 128 | 144 | 218 |
| pH (Lab.) | 8.3 | 8.3 | 8.0 | 8.0 | 8.3 | 8.0 | 8.3 | 8.3 |

Source: Karkamis. 1966.

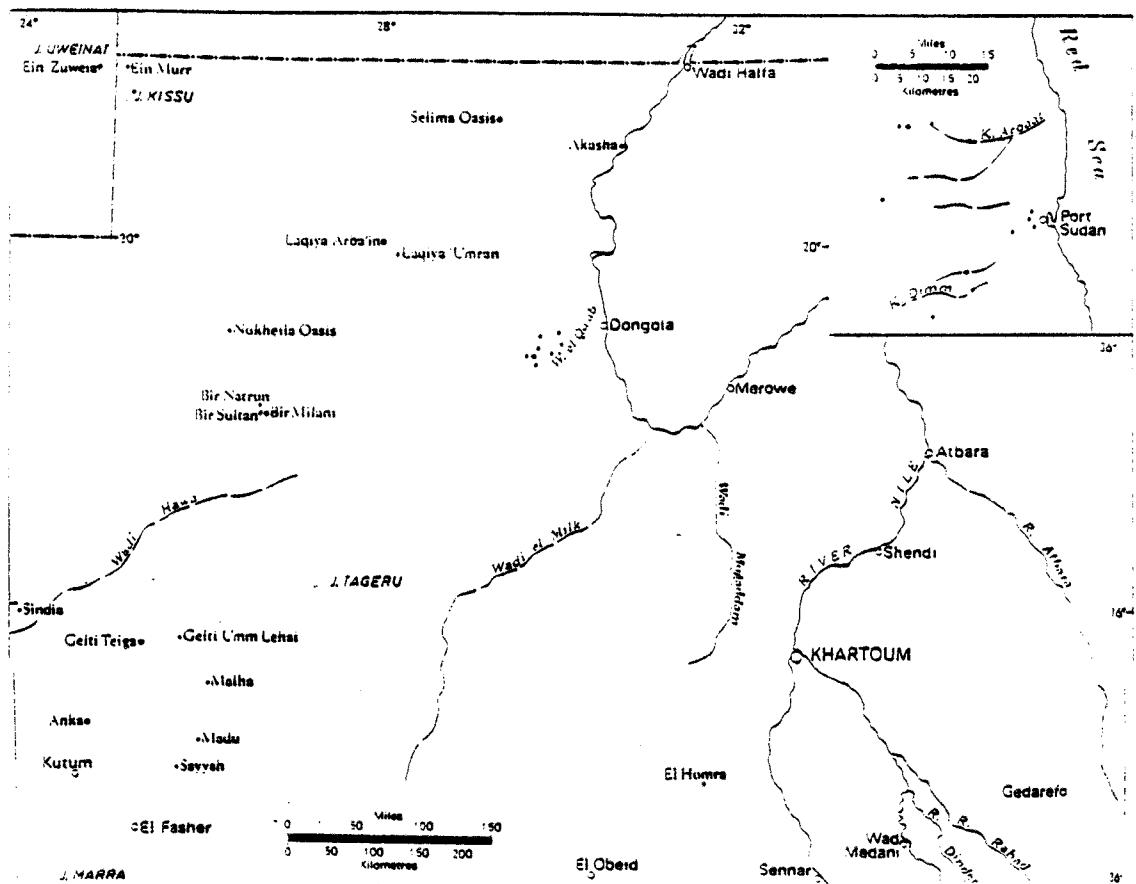


Figure 4. Wells and Oases of the Northern Sudan

Source: Whiteman. 1971.

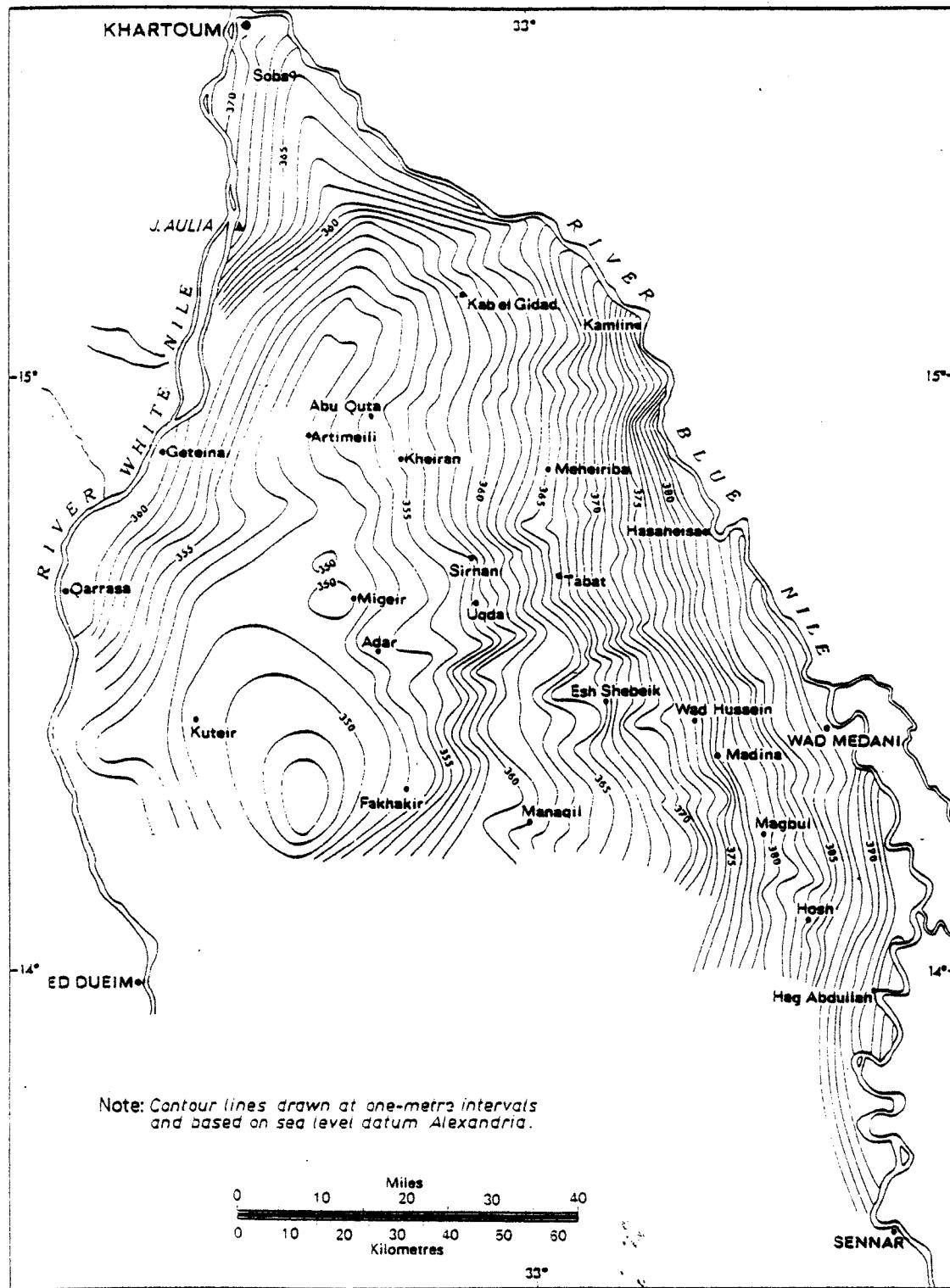


Figure 5. Standing Water-Level Contour Map, El Gezira

Source: Whiteman. 1971.

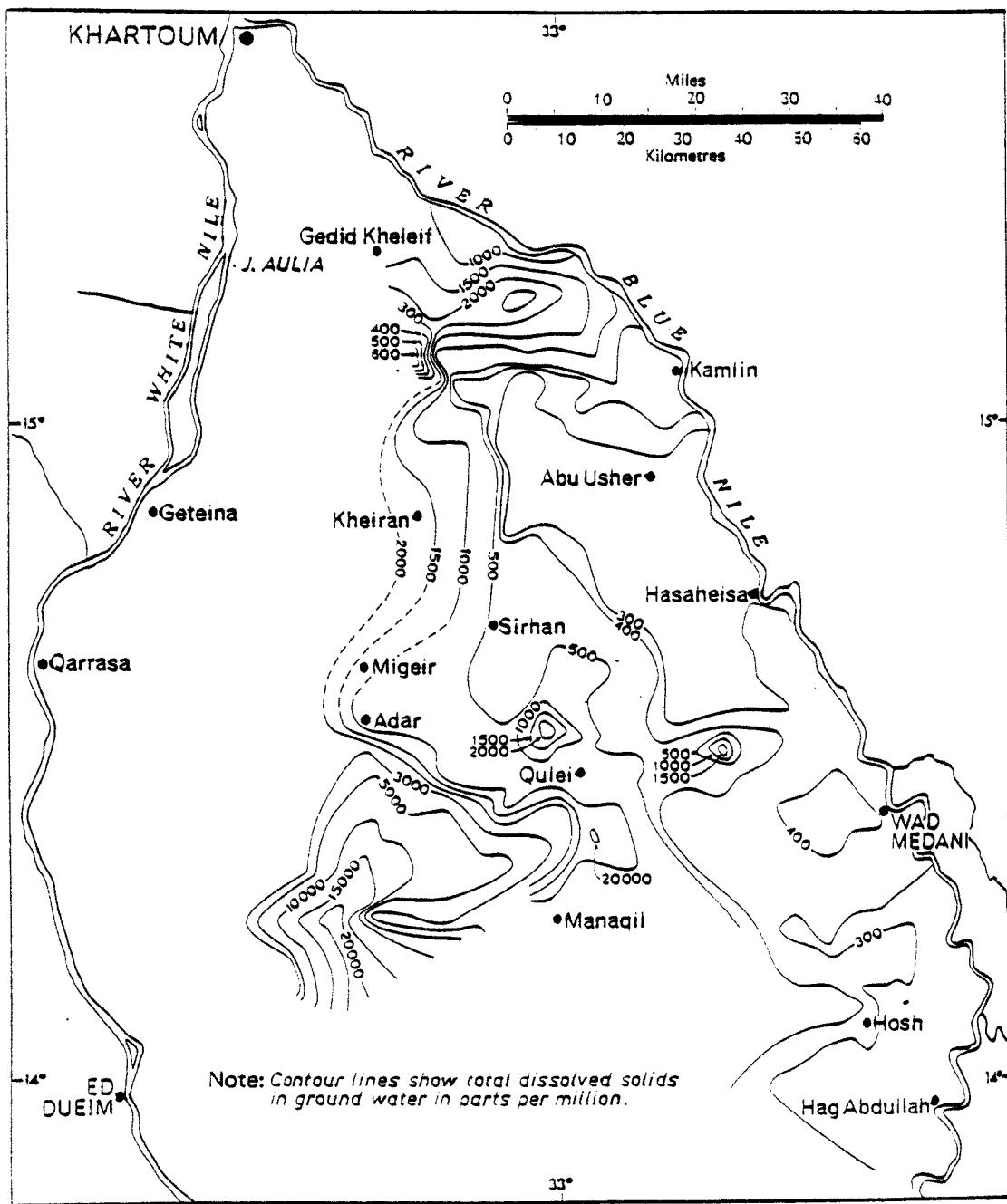


Figure 6. Total Dissolved Solids , El Gezira (p.p.m.)

Source: Whiteman. 1971.

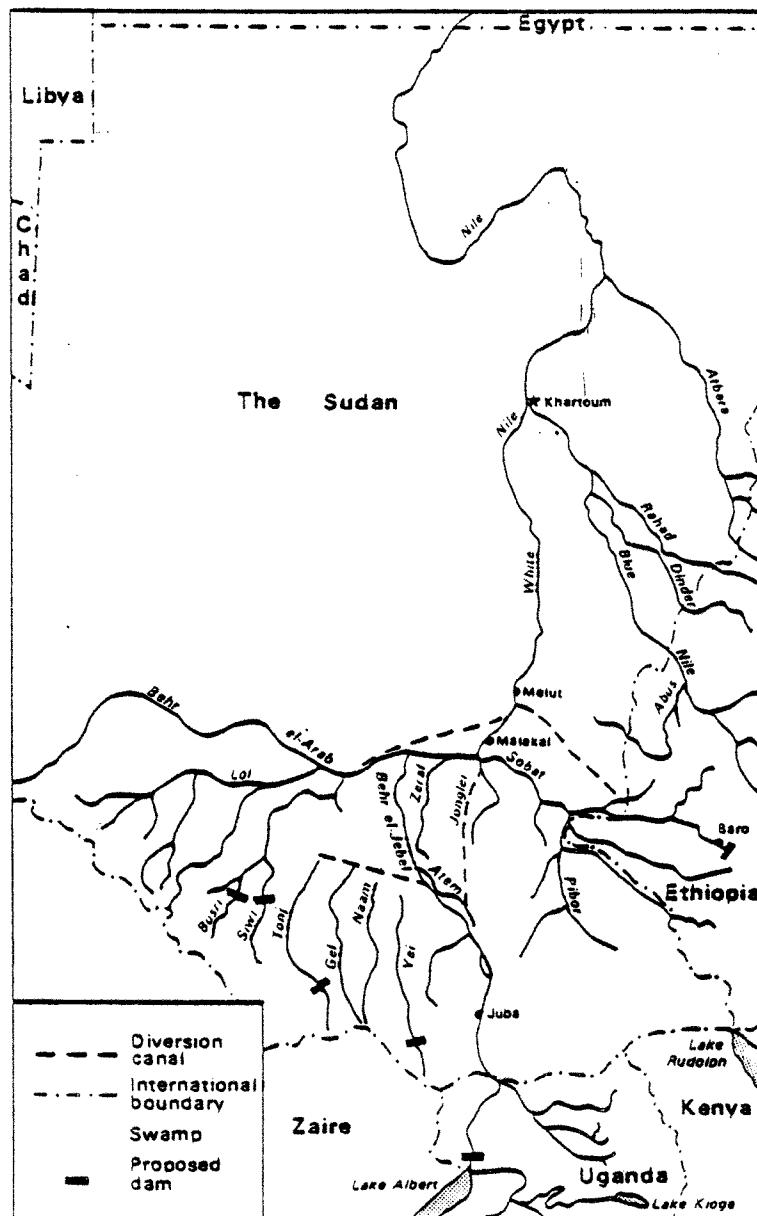
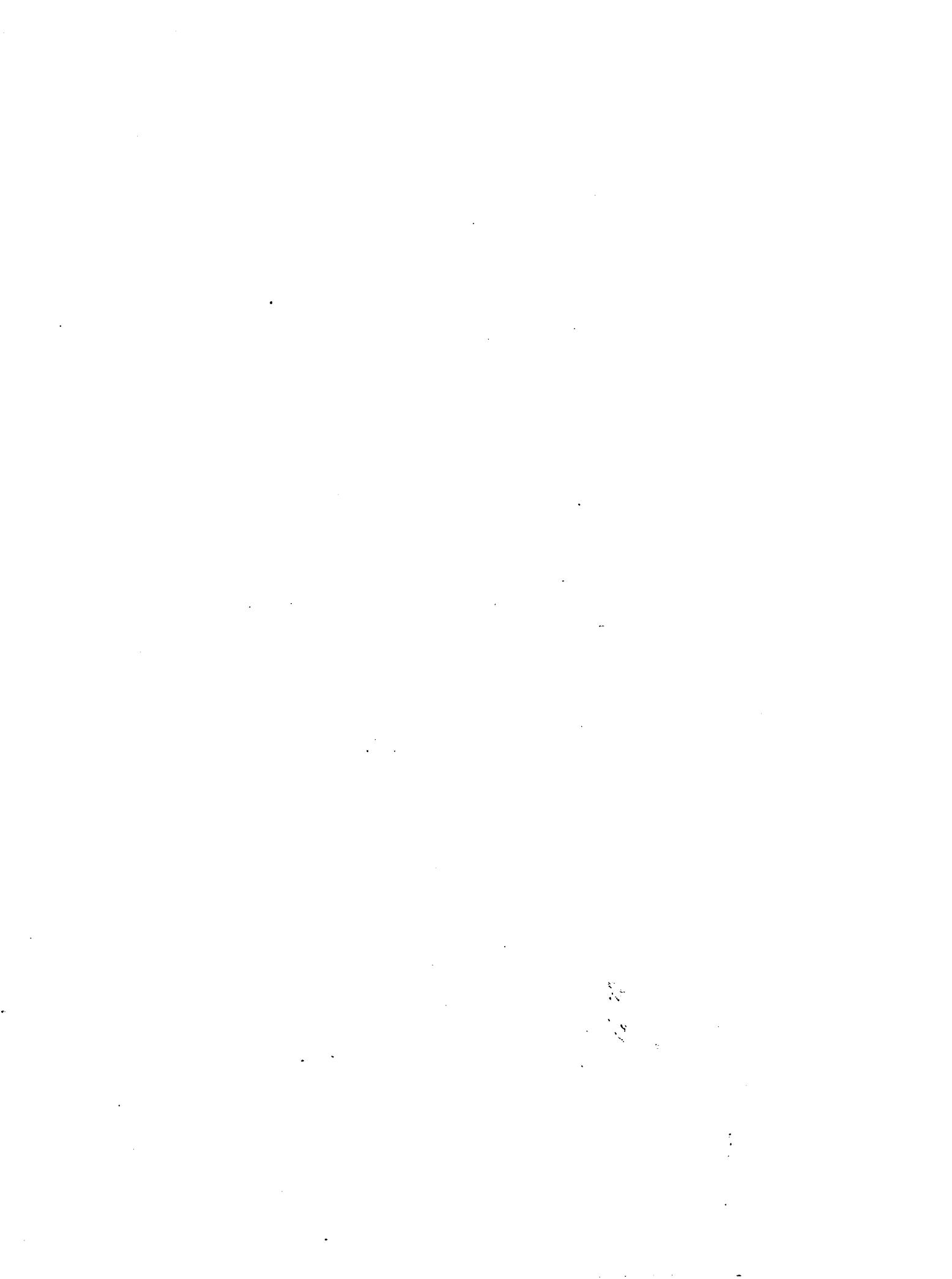


Figure 7. Proposed Upper Nile Projects

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

Table 1. Temperature Data of a Khartoum Soil

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

| Month | J | F | M | A | M | J | J | A | S | O | N | D |
|---------------|------|------|------|------|------|------|------|------|------|------|------|------|
| Depth in cm | | | | | | | | | | | | |
| 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 | 38.4 | 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 | J | F | M | A | M | J | J | A | S | O | N | D |
|----------------|----|----|---|---|---|---|----|-----|-----|----|----|----|
| Station | | | | | | | | | | | | |
| Sennar . . . | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 11 | 9 | 6 | 5 | 4 |
| Singa . . . | 7 | 4 | 2 | 1 | 0 | 0 | + | 35 | 46 | 29 | 17 | 11 |
| Rosieres . . . | 19 | 12 | 4 | 1 | 0 | 0 | 28 | 115 | 127 | 83 | 51 | 32 |

Source: Buursink. 1971.

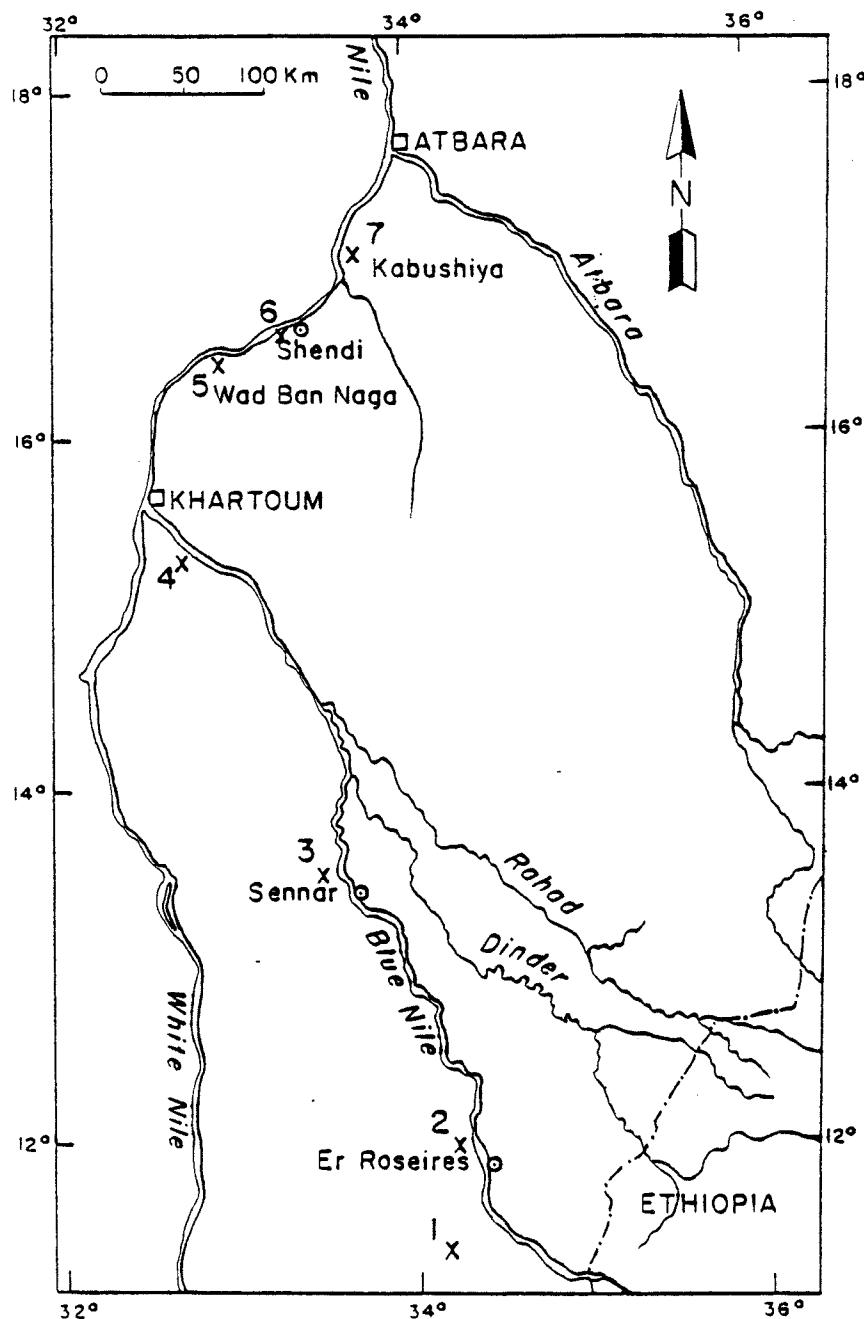


Figure 1. Reference Map for Location of Soil Profiles

Source: Buursink. 1971.

Table 3. Selected Soil Profiles along Nile

| <u>Sample</u> | <u>Site</u> | <u>Landform</u> | <u>Vegetation</u> |
|---------------|-------------|--------------------|--|
| 15 | 1 | Foot of inselberg | Few <u>Dalbergia melanoxylon</u> , few <u>Acacia mellifera</u> |
| 16 | 1 | Foot of inselberg | Dominant <u>Acacia mellifera</u> , very few <u>Acacia seyal</u> , very few <u>Balanites aegyptiaca</u> |
| 21 | 2 | Nile terrace | Sparse <u>Hyphaene thebaica</u> , <u>Calotropis procera</u> , and short grass cover |
| 22 | 2 | Nile levee | Few <u>Balanites aegyptiaca</u> , <u>Adansonia digitata</u> , <u>Acacia seyal</u> |
| 32 | 3 | Nile levee | Sparse <u>Acacia seyal</u> |
| 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 <u>Acacia tortilis</u> |
| 71A | 7 | Lower Nile terrace | Sparse grass |
| 77 | 7 | Upper Nile terrace | None |

Source: Bursink. 1971.

Laboratory Data Profile No. 15

| Depth, cm | Horizon | % | Particle size distribution (μ) % | | | | | |
|--------------|---------|----|--|------------|-----------|----------|------|-----------|
| | | | >2 mm | | sand | | silt | |
| | | | 2000— 200 | 200— 50 | 50— 20 | 20— 2 | <2 | 2— 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 % | 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 | | | | Exch. Na % | Saturation extract, soluble (meq/l) | | | E.C. mmhos per cm |
|-------------------------|--------------------------------|------|------|-----|------------------|--|----|----|-------------------------|
| | Sum | Ca | Mg | K | | Ca | Mg | Na | |
| 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) | | | | | | | | | | E.C., mmhos per cm |
|---------------------------------------|-----|---|-----|-----|--------|-----------------|------------------|----|-----------------|--------------------------|
| cations | | | | | anions | | | | | |
| Ca | Mg | K | Na | Sum | Sum | CO ₃ | HCO ₃ | C1 | SO ₄ | NO ₃ |
| 0.2 | 0.2 | t | t | 0.4 | 0.4 | — | 0.4 | t | t | 0.1 |
| 0.1 | 0.1 | t | 0.1 | 0.3 | 0.2 | — | 0.3 | t | t | 0.1 |
| 0.1 | 0.1 | t | 0.1 | 0.3 | 0.1 | — | 0.1 | t | t | 0.1 |
| 0.1 | 0.1 | t | 0.1 | 0.3 | 0.2 | — | 0.2 | t | t | 0.1 |
| 0.1 | 0.1 | t | 0.1 | 0.3 | 0.4 | — | 0.4 | t | t | 0.1 |
| 0.4 | 0.4 | t | 0.2 | 1.0 | 1.2 | — | 1.2 | t | t | 0.2 |

Laboratory Data Profile No. 16

| Depth, cm | Horizon | % | Particle size distribution (μ) % | | | | | |
|--------------|---------|----|--|------|------|------|------|----|
| | | | sand | | silt | | clay | |
| | | | 2000- | 200- | 50- | 20- | <2 | 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 | 9.3 | 13.1 | 66.0 | |

| B.D. (g per cc) | Organic matter C % | 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 | | | | | Exch. Na % | Saturation extract, soluble (meq/l) | | | E.C. mmhos per cm |
|-------------------------|--------------------------------|------|------|-----|-----|------------------|--|----|----|-------------------------|
| | Sum | Ca | Mg | K | Na | | Ca | Mg | Na | |
| 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 | | | | |

| Waterextract 1:5, soluble (meq/100 g) | | | | | | | | | | E.C., mmhos per cm | |
|---------------------------------------|-----|---|-----|-----|--------|-----------------|------------------|-----|-----------------|--------------------------|-----|
| cations | | | | | anions | | | | | | |
| Ca | Mg | K | Na | Sum | Sum | CO ₃ | HCO ₃ | C1 | SO ₄ | NO ₃ | |
| 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 | % | Particle size distribution (μ) % | | | | | | |
|--------------|---------|---|--|------------|-----------|----------|------|-----------|------|
| | | | sand | | silt | | clay | | |
| | | | 2000- 200 | 200- 50 | 50- 20 | 20- 2 | <2 | 2- 0.2 | <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 ₂ O ₃ | Fe ₂ O ₃ | TiO ₂ | CaO | MgO | K ₂ O | 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 % | CaCO ₃ equiv. % | Gypsum % | pH 1 : 5 | Clayminerals | | | | | |
|--------------------------|-----------------------------|----------------------------------|-------------|-------------|--------------|----|----|-----|----|---|
| | | | | | Mt | Mi | Vm | Chl | K | Q |
| | | | | | C/N | | | | | |
| 1.34 | 1.41 | 13 | 3.8 | 8.3 | xxxxx | t | | | xx | t |
| 1.32 | 0.98 | 13 | 4.9 | 8.4 | xxxxx | t | | | xx | t |
| 1.47 | 0.90 | | 3.8 | 8.5 | xxxxx | t | | | xx | t |
| 1.27 | 0.83 | | 4.6 | 8.5 | xxxxx | t | | | xx | t |
| 1.26 | 0.62 | | 4.7 | 8.5 | xxxxx | t | | | xx | t |

| Cation exch. cap. | Extractable cations, meq/100 g | | | | Exch. Na % | Saturation extract, soluble (meq/l) | | | E.C. mmhos per cm |
|-------------------------|--------------------------------|------|-----|-----|------------------|--|----|----|-------------------------|
| | Sum | Ca | Mg | K | Na | Ca | Mg | Na | |
| 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) | | | | | | | | | | E.C. mmhos per cm | |
|---|-----|---|-----|-----|--------|-----------------|------------------|-----|-----------------|-------------------------|-----|
| cations | | | | | anions | | | | | | |
| Ca | Mg | K | Na | Sum | Sum | CO ₃ | HCO ₃ | Cl | SO ₄ | NO ₃ | |
| 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 | % | Particle size distribution (μ) % | | | | | | | | |
|--------------|---------|---|--|------|------|-----|------|-----|------|--|--|
| | | | > 2 mm | | sand | | silt | | clay | | |
| | | | 2000- 200 | 200- | 50- | 20- | <2 | 2- | <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 | 17.9 | 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) | | | | | | | | | | | E.C., mmhos per cm |
|---|-----|---|-----|-----|-----|-----------------|------------------|-----|-----------------|-----------------|--------------------------|
| cations | | | | | | anions | | | | | |
| Ca | Mg | K | Na | Sum | Sum | CO ₃ | HCO ₃ | Cl | SO ₄ | NO ₃ | |
| 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 ₂ O ₃ | Fe ₂ O ₃ | TiO ₂ | CaO | MgO | K ₂ O | 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 |
| 73.1 | 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 % | CaCO ₃ equiv. % | Gypsum % | pH 1 : 5 | Clayminerals | | | | | | |
|--------------------------|-----------------------------|----------------------------------|-------------|-------------|--------------|-----|----|-----|---|---|--|
| | | | | | Mt | Mi | Vm | Chl | K | Q | |
| | | | | | % | C/N | | | | | |
| 1.59 | 0.24 | 13 | — | 6.5 | xxxxx | | | | x | x | |
| 1.62 | 0.14 | 12 | — | 6.2 | xxxxx | | | | x | x | |
| 1.93 | 0.23 | 12 | — | 6.9 | xxxxx | t | | | x | t | |
| 1.92 | | — | | 7.7 | xxxxx | t | | | x | t | |
| 1.74 | | — | | 8.4 | xxxxx | t | | | x | t | |
| 1.81 | | — | | 8.5 | xxxxx | t | | | x | t | |
| 1.84 | | — | | 8.8 | xxxxx | | | | x | t | |
| | | — | | 8.8 | xxxxx | | | | x | t | |

| Cation exch. cap. | Extractable cations, meq/100 g | | | | | Exch. Na % | Saturation extract, soluble (meq/l) | | | E.C. mmhos per cm |
|-------------------------|--------------------------------|------|-----|-----|-----|------------------|--|----|----|-------------------------|
| | Sum | Ca | Mg | K | Na | | Ca | Mg | Na | |
| 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 | — | | | | |

Laboratory Data Profile No. 32

| Depth. cm | Horizon | ">% > 2 mm | Particle size distribution (μ) % | | | | | |
|--------------|---------|---------------|--|------|------|------|------|------|
| | | | sand | | silt | | clay | |
| | | | 2000+ | 200- | 50- | 20- | 2- | 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 % | CaCO ₃ equiv. % | Gypsum % | pH 1:5 | Clayminerals | | | | | |
|--------------------------|-----------------------------|----------------------------------|-------------|-----------|--------------|-----|----|-----|---|---|
| | | | | | Mt | Mi | Vm | Chi | K | Q |
| | | | | | % | C/N | | | | |
| 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 | | | | Exch. Na % | Saturation extract, soluble (meq/l) | | | E.C. mmhos per cm |
|-------------------------|--------------------------------|------|-----|-----|------------------|--|----|----|-------------------------|
| | Sum | Ca | Mg | K | Na | Ca | Mg | Na | |
| 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) | | | | | | | | | | E.C. mmhos per cm | |
|---|-----|-----|-----|------|--------|-----------------|------------------|-----|-----------------|-------------------------|-----|
| cations | | | | | anions | | | | | | |
| Ca | Mg | K | Na | Sum | Sum | CO ₃ | HCO ₃ | Cl | SO ₄ | NO ₃ | |
| 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 |

Laboratory Data Profile No. 33

| Depth, cm | Horizon | % | Particle size distribution (μ) % | | | | | |
|--------------|-------------|-----|--|------------|-----------|----------|------|-----------|
| | | | > 2 mm | | sand | | silt | |
| | | | 2000- 200 | 200- 50 | 50- 20 | 20- 2 | <2 | 2- 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 | |
| +2- 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 % | CaCO ₃ equiv. % | Gypsum % | pH 1 : 5 | Clayminerals | | | | |
|--------------------------|-----------------------------|----------------------------------|-------------|-------------|--------------|----|----|-----|---|
| | | | | | Mt | Mi | Vm | Chl | K |
| | | | | | C/N | | | | 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 | | | | Exch. Na % | Saturation extract. soluble (meq/l) | | | E.C. mmhos per cm |
|-------------------------|--------------------------------|------|------|-----|------------------|--|----|----|-------------------------|
| | Sum | Ca | Mg | K | Na | Ca | Mg | Na | |
| 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) | | | | | | | | | | E.C. ₅ mmhos per cm |
|---|-----|---|-----|--------|------|-----------------|------------------|-----|-----------------|--------------------------------------|
| cations | | | | anions | | | | | | |
| Ca | Mg | K | Na | Sum | Sum | CO ₃ | HCO ₃ | G1 | SO ₄ | NO ₃ |
| 0.2 | 0.1 | t | 1.4 | 1.7 | 1.6 | — | 1.6 | t | t | 0.2 |
| 0.1 | 0.1 | t | 1.8 | 2.0 | 1.7 | — | 1.7 | t | t | 0.2 |
| 0.1 | 0.1 | t | 1.9 | 2.1 | 1.9 | 0.1 | 1.8 | t | t | 0.3 |
| 0.2 | 0.1 | t | 4.7 | 5.0 | 4.9 | — | 2.3 | 1.0 | 1.6 | 0.9 |
| 4.6 | 2.7 | t | 9.3 | 16.6 | 18.4 | — | 1.1 | 0.7 | 16.6 | 2.6 |

Laboratory Data Profile No. 41

| Depth, cm | Horizon | % | Particle size distribution (μ) % | | | | | | |
|--------------|---------|---|--|------------|-----------|----------|------|-----------|------|
| | | | sand | | silt | | clay | | |
| | | | 2000- 200 | 200- 50 | 50- 20 | 20- 2 | <2 | 2- 0.2 | |
| 0- 10 | A1 | — | 14.9 | 37.6 | 22.0 | 8.2 | 17.3 | 2.4 | 14.9 |
| 10- 55 | IIC1h | — | 1.6 | 10.8 | 26.7 | 26.3 | 32.6 | 5.6 | 27.0 |
| 55-105 | IIC1 | — | 0.8 | 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 ₂ O ₃ | Fe ₂ O ₃ | TiO ₂ | CaO | MgO | K ₂ O | 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/N | CaCO ₃ | Gypsum | pH | Clayminerals | | | | | |
|--------------------------|------------------------|-----|-------------------|--------|-------|--------------|----|----|-----|----|---|
| | | | equiv. | % | 1 : 5 | 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 | Extractable cations, meq/100 g | | | | Exch. Na % | Saturation extract. soluble (meq/l) | | | E.C. mmhos per cm |
|--------|--------------------------------|------|------|-----|------------------|--|-----|----|-------------------------|
| | Sum | Ca | Mg | K | | Ca | Mg | Na | |
| exch. | | | | | | | | | |
| Sum | 16.8 | 19.0 | 15.1 | 2.9 | 1.0 | t | — | — | |
| Ca | 12.0 | 13.9 | 28.5 | 4.9 | 0.5 | t | — | — | |
| Mg | 31.7 | 34.7 | 28.9 | 5.3 | 0.4 | 0.1 | 0.3 | — | |
| K | 35.8 | 37.4 | 31.2 | 6.0 | 0.1 | 0.1 | 0.3 | — | |

| Cation | Waterextract 1 : 5, soluble (meq/100 g) | | | | ions | | | | | E.C., mmhos per cm | |
|--------|---|-----|-----|-----|------|-----------------|------------------|-----|-----------------|--------------------------|-----|
| | cations | | | | ions | | | | | | |
| Ca | Mg | K | Na | Sum | Sum | CO ₃ | HCO ₃ | Cl | SO ₄ | NO ₃ | |
| 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 | % | Particle size distribution (μ) % | | | | | | | |
|--------------|---------|---|--|------|------|-----|------|-----|------|------|
| | | | 2 mm | | sand | | silt | | clay | |
| | | | 2000+ | 200- | 50+ | 20- | 2+ | 2- | 0.2+ | 0.2- |
| | | | 200 | 50 | 20 | 2 | <2 | 0.2 | <0.2 | <0.2 |
| 0- 10 | A11 | 8 | 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 | 29.4 | 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 | 35.0 | 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 ₂ O ₃ | Fe ₂ O ₃ | TiO ₂ | CaO | MgO | K ₂ O | 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 | 3.8 | 0.8 | 2.5 | 0.5 | 1.3 | 3.2 | 225 | 12.5 | 655 | 20.5 | 775 | 49.5 |
| 72.4 | 9.3 | 3.0 | 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 cc) | Organic matter C %" | CaCO ₃ equiv. " | Gypsum equiv. " | pH 1:5 | Clayminerals | | | | | |
|--------------------------|------------------------------|----------------------------------|-----------------------|-----------|--------------|----|----|-----|----|---|
| | | | | | Mt | Mi | Vm | Chi | K | Q |
| | | | | | C/N | | | | | |
| 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 | | | | | Exch. Na % | Saturation extract. soluble (meq/l) | | | E.C. mmhos per cm |
|-------------------------|--------------------------------|------|-----|-----|-----|------------------|--|----|----|-------------------------|
| | Sum | Ca | Mg | K | Na | | Ca | Mg | Na | |
| 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 | CN | SO ₄ | NO ₃ |
| 0.3 | t | t | 0.1 | 0.4 | 0.5 | 0.1 | 0.4 | t | t | t |
| 0.4 | t | t | 0.2 | 0.6 | 0.6 | t | 0.4 | 0.2 | t | t |
| 0.2 | t | 0.1 | 0.6 | 0.9 | 0.8 | t | 0.8 | t | t | t |
| 0.2 | t | 0.1 | 0.7 | 1.0 | 0.9 | 0.2 | 0.7 | t | t | t |
| 0.2 | t | 0.1 | 0.7 | 1.0 | 0.9 | 0.2 | 0.7 | t | t | t |
| 0.2 | t | 0.1 | 0.7 | 1.0 | 0.9 | 0.2 | 0.7 | t | t | t |

Laboratory Data Profile No. 51

| Depth, cm | Horizon | % | Particle size distribution (/) % | | | | | | clay |
|--------------|---------|-----|----------------------------------|------|------|------|------|-----|-------|
| | | | > 2 mm | | sand | | silt | | |
| | | | 2000- | 200- | 50- | 20- | < 2 | 0.2 | ≤ 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 | 12.0 | 6.7 | 40.8 | | |
| 86-110 | IIC4 | 0.6 | 37.6 | 30.9 | 1.3 | 1.3 | 8.9 | | |
| 110-150 | IIC5 | 0.6 | 25.2 | 35.2 | 4.7 | 9.5 | 25.4 | | |
| 150-170 | IIC6 | 0.6 | 18.5 | 42.6 | 7.7 | 8.5 | 22.7 | | |

| Elemental composition | | | | | | | | | | | | | |
|-----------------------|--------------------------------|--------------------------------|------------------|-----|-------|------------------|---------------------|----|----|----|----|----|----|
| SiO ₂ | Al ₂ O ₃ | Fe ₂ O ₃ | TiO ₂ | CaO | MgO | K ₂ O | Loss on ignition | Ba | Co | Mn | Ni | Sr | Zn |
| weight percentages | | | | | | | | | | | | | |
| 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 | 880 | 51.5 | 342 | 50.0 | | | | | | | | |
| 310 | 16.5 | 380 | 31.0 | 324 | 25.0 | | | | | | | | |

| B.D. (g per cc) | Organic matter C | 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 | | | | | Exch. Na % | Saturation extract. soluble (meq/l) | | | E.C. mmhos per cm |
|-------------------------|--------------------------------|------|-----|-----|-----|------------------|--|----|----|-------------------------|
| | Sum | Ca | Mg | K | Na | | Ca | Mg | Na | |
| 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) | | | | | | | | | | E.C. mmhos per cm |
|---------------------------------------|-----|-----|-----|-----|--------|-----------------|------------------|-----|-----------------|-------------------------|
| cations | | | | | anions | | | | | |
| Ca | Mg | K | Na | Sum | Sum | CO ₃ | HCO ₃ | Cl | SO ₄ | NO ₃ |
| 0.4 | 0.1 | 0.1 | 0.1 | 0.6 | 1.0 | — | 0.9 | t | 0.1 | t |
| 0.3 | 0.1 | 0.1 | 0.1 | 0.6 | 0.7 | — | 0.6 | t | 0.1 | t |
| 0.2 | 0.1 | t | 0.1 | 0.4 | 0.6 | — | 0.4 | 0.1 | 0.1 | t |
| 0.1 | t | t | 0.8 | 0.9 | 1.0 | — | 0.8 | 0.1 | 0.1 | t |
| t | t | t | 0.8 | 0.8 | 0.8 | — | 0.6 | 0.1 | 0.1 | t |
| | | | | | | | | | | 0.2 |

Laboratory Data Profile No. 67

| Depth cm | Horizon | | Particle size distribution (μ) % | | | | | | | |
|-------------|---------|---|--|------|------|------|------|------|------|-------|
| | | | > 2 mm | | sand | | silt | | clay | |
| | | | 2000+ | 200- | 200- | 20- | 20- | < 2 | 2- | < 0.2 |
| 0- 16 | Bt1 | | — | 29.9 | 33.7 | 13.5 | 2.6 | 20.3 | 3.4 | 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 | g | 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 ₂ O ₃ | Fe ₂ O ₃ | TiO ₂ | CaO | MgO | K ₂ O | Loss on ignition | Ba | Co | Mn | Ni | Sr | Zn |
| weight percentages | | | | | | | | | | | | | |
| 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 | — | — | — | — | — | |
| 73.4 | 6.0 | 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 % | CaCO ₃ equiv. % | Gypsum % | pH 1:5 | Clay minerals | | | | | |
|--------------------------|-----------------------------|----------------------------------|-------------|-----------|---------------|------|----|-----|---|---|
| | | | | | Mt | Mi | Vm | Chl | K | Q |
| | | | | | C/N | | | | | |
| 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 | | | | Exch. Na % | Saturation extract, soluble (meq/l) | | | E.C. mmhos per cm |
|-------------------------|--------------------------------|------|-----|-----|------------------|--|------|------|-------------------------|
| | Sum | Ca | Mg | K | | Ca | Mg | Na | |
| 17.5 | 18.6 | 11.0 | 2.1 | 0.5 | 5.0 | 28.6 | 3.9 | 1.0 | 74.8 |
| 20.6 | 26.8 | 10.0 | 2.8 | 0.3 | 9.7 | 47.1 | 24.8 | 12.2 | 282.6 |
| 12.8 | 16.3 | 6.6 | 1.5 | 0.2 | 8.0 | 62.5 | 15.1 | 3.6 | 208.7 |
| 15.3 | 17.8 | 5.9 | 1.9 | 0.2 | 9.8 | 64.1 | 8.0 | 2.5 | 150.0 |
| 30.4 | 30.6 | 7.0 | 4.5 | 0.4 | 18.7 | 61.5 | 1.0 | 0.8 | 65.2 |
| | | | | | | | | | 7.2 |

| 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 |
| 0.1 | t | t | 3.8 | 3.9 | 4.1 | 0.6 | 0.7 | 2.5 | 0.2 | 0.1 |
| 0.3 | 0.1 | t | 14.1 | 14.5 | 14.0 | 0.2 | 0.9 | 11.9 | 0.1 | 0.9 |
| 0.2 | t | t | 10.1 | 10.3 | 10.1 | 0.2 | 0.8 | 4.2 | 4.7 | 0.4 |
| 0.1 | t | t | 8.0 | 8.1 | 7.4 | 0.3 | 0.4 | 3.4 | 3.2 | 0.1 |
| 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 | % | Particle size distribution (μ) % | | | | | | | | |
|--------------|---------|---|--|------------|-----------|----------|------|-----------|-------|--|--|
| | | | > 2 mm | | sand | | silt | | clay | | |
| | | | 2000- 200 | 200- 50 | 50- 20 | 20- 2 | < 2 | 2- 0.2 | < 0.2 | | |
| 0- 25 | A1 | — | 0.5 | 6.1 | 7.8 | 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 ₂ O ₃ | Fe ₂ O ₃ | TiO ₂ | CaO | MgO | K ₂ O | 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 | 32.5 | 375 | 80.5 |
| 53.7 | 17.1 | 9.2 | 1.6 | 3.3 | 1.1 | 1.2 | 6.8 | 295 | 38.5 | 1120 | 72.0 | 318 | 98.5 |
| 53.7 | 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 % | 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 | | | | | Exch. Na % | Saturation extract, soluble (meq/l) | | | E.C. mmhos per cm |
|-------------------------|--------------------------------|------|-----|-----|------|------------------|--|-----|-------|-------------------------|
| | Sum | Ca | Mg | K | Na | | Ca | Mg | Na | |
| 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) | | | | | | | | | | E.C. mmhos per cm | |
|---|-----|-----|------|------|--------|-----------------|------------------|-----|-----------------|-------------------------|-----|
| cations | | | | | anions | | | | | | |
| Ca | Mg | K | Na | Sum | Sum | CO ₃ | HCO ₃ | Cl | SO ₄ | NO ₃ | |
| 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 |
| 8.8 | 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 |

Laboratory Data Profile No. 77

| Depth, cm | Horizon | % >2 mm | Particle size distribution (μ) % | | | | | |
|--------------|---------|------------|--|------------|-----------|----------|------|-----------|
| | | | sand | | silt | | clay | |
| | | | 2000- 200 | 200- 50 | 50- 20 | 20- 2 | <2 | 2- 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 ₂ O ₃ | Fe ₂ O ₃ | TiO ₂ | CaO | MgO | K ₂ O | 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/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 | | | | Exch. Na % | Saturation extract, soluble (meq/l) | | | E.C. mmhos per cm |
|-------------------------|--------------------------------|------|-----|-----|------------------|--|----|----|-------------------------|
| | Sum | Ca | Mg | K | Na | Cu | Mg | Na | |
| | - | - | - | - | - | - | - | - | |
| 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 |

| 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 | | |
| 0.1 | t | t | 0.2 | 0.3 | 0.7 | — | 0.5 | 0.1 | 0.1 | 0.1 | |
| 0.1 | t | t | 0.9 | 1.0 | 1.2 | — | 0.5 | 0.4 | 0.1 | 0.3 | |
| 1.0 | 0.2 | t | 1.6 | 2.8 | 3.4 | — | 0.3 | 2.0 | 0.3 | 0.8 | |
| 1.0 | 0.3 | t | 1.4 | 2.7 | 3.4 | — | 0.3 | 1.8 | 0.8 | 0.5 | |

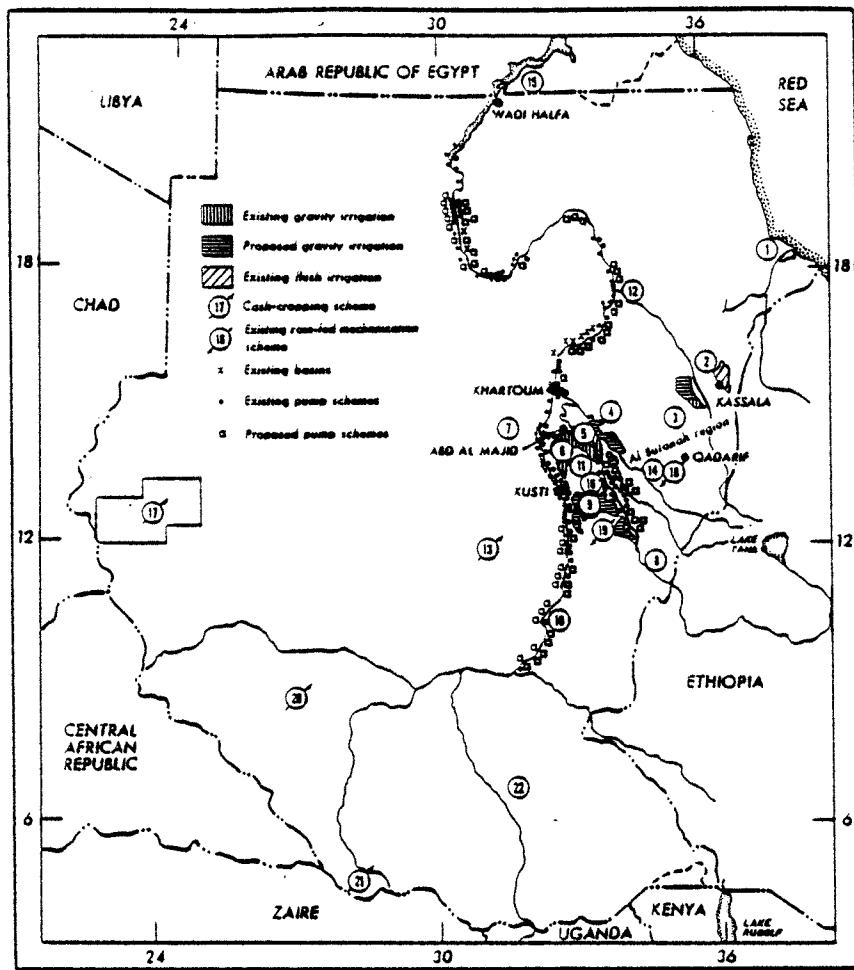


Figure 2. Location of Principal Improvement Schemes,
Existing and Proposed, Sudan, 1971

Source: Nelson et al. 1973.

Appendix VI

Vegetation

Figure 1. Vegetation Regions of Sudan

Table 1. Vegetation of Khartoum Province

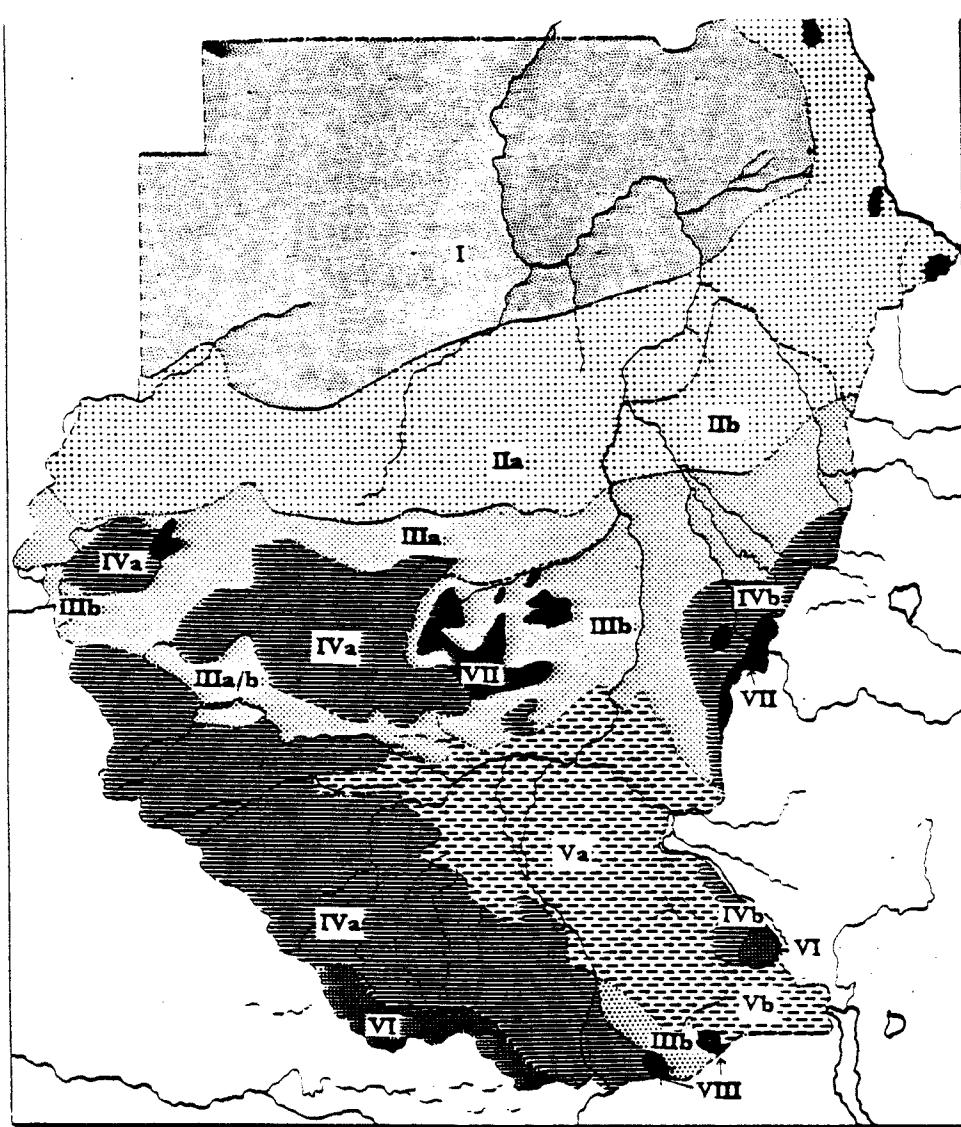
Figure 2. Vegetation Map of the Fung

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. Schematic Diagrams of Vegetation in the Jebel Marra Region



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

Semi-desert scrub and grassland
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.
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 *Schoenfeldia gracilis* and *Sethia ischaemoides* as the dominant grasses.

Thorn savanna and scrub
on sandy soils: average rainfall 280 to 450 mm. *Acacia senegal* is the dominant tree with *Aristida sieberana* and *Eragrostis* spp. as the dominant grasses.
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 *Schoenfeldia gracilis*, *Cymbopogon* spp. and *Brachiaria obtusiflora*.

IV Deciduous savanna woodland
A on latosols: average rainfall 450 to 1300 mm. *Combretum glutinosum*, *Inga sessilis leiocarpus*, *Terminalia brownii*, *Albizia amara* subsp.

sericeophylla, *Khaya senegalensis* and *Isoeortinia 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 *Inga sessilis 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. sieberana* 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. aucheri* var. *quinqueplumus*), *Bothriochloa insculpta*, etc., among the more important grasses, with thickets of *Acacia mellifera* also present.

VI Lowland forest: average rainfall over 1000 mm. Consisting of small relic forest areas *Laboni*, *Talanga*, *Azza* and *Aloma*. *Celosia zeyheri*, *Chrysophyllum albidum*, including areas derived from forest, *Zygia*, *Vitex doniana*, *Terminalia glabra*.

VII Hill vegetation: regarded as isolated savanna and woodland vegetation; hill slopes in areas where similar ones are no longer to be found in the surrounding lowlands.

VIII Montane vegetation: upland areas of temperate and tropical species that are known from similar upland areas in

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

* Species recorded with no indication of frequency.

the Eastern Sandy Desert Plains

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

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

| | | | | | | | Presence % |
|--|---|---|---|--|--|--|------------|
| Herbs | | | | | | | |
| <i>Enneapogon brachystachys</i> (Jaub. & Spach) Stapf. | a | c | a | | | | 100 |
| <i>Aristida mutabilis</i> Trin. & Rupr. | a | c | a | | | | 100 |
| <i>Aristida funiculata</i> Trin. & Rupr. | c | c | c | | | | 100 |
| <i>Eragrostis ciliaris</i> (All) Link ex Vign. Lut. | o | c | r | | | | 100 |
| <i>Boerhavia diandra</i> L. | r | c | - | | | | 67 |
| <i>Aristida adscensionis</i> L. | - | r | c | | | | 67 |
| <i>Indigofera arenaria</i> A. Rich. | r | - | r | | | | 67 |
| <i>Aristida hirtigluma</i> Steud. ex Trin. & Rupr. | a | - | - | | | | 33 |
| <i>Eragrostis tremula</i> Hochst. ex Steud. | o | - | - | | | | 33 |
| <i>Heliotropium stellatum</i> Willd. | r | - | - | | | | 33 |
| <i>Tephrosia vicioides</i> A. Rich. | r | - | - | | | | 33 |
| <i>Cymbopogon excavatus</i> (Hochst.) Stapf.? | r | - | - | | | | 33 |
| <i>Schoenfeldia gracilis</i> Kunth. | - | c | - | | | | 33 |
| <i>Boerhavia diffusa</i> var. <i>viscosa</i> (Choisy) Cuf. | - | c | - | | | | 33 |
| <i>Tragus paucispina</i> Hack. | - | o | - | | | | 33 |
| <i>Tragus berteronianus</i> Schult. | - | - | r | | | | 33 |
| <i>Eragrostis pilosa</i> (L.) Beauv. | - | - | r | | | | 33 |

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

| | | | | | | | | Presence % |
|--|------|----|------|----|----|------|---|------------|
| Trees and shrubs | | | | | | | | |
| <i>Acacia nubica</i> Benth. | d | o | d | o | r | d | - | 100 |
| <i>Acacia ehrenbergiana</i> Hayne. | c | d | c | o | d | - | - | 83 |
| <i>Capparis decidua</i> (Forsk.) Edgew. | c | r | a | c | o | - | - | 83 |
| <i>Ziziphus spina-christi</i> (L.) Willd. | o | r | c | - | c | - | - | 67 |
| <i>Calotropis procera</i> (Ait.) Ait. f. | - | - | a | r | - | r | - | 50 |
| <i>Acacia tortilis</i> (Forsk.) Hayne. | - | a | - | - | - | - | a | 33 |
| <i>Mauria crassifolia</i> Forsk. | - | - | - | r | - | - | - | 17 |
| Undershrubs and herbs | | | | | | | | |
| <i>Schouwefeldia gracilis</i> Kunth. | va | va | c-la | d | va | c | - | 100 |
| <i>Eragrostis pilosa</i> (L.) Beauv. | c-la | a | o | c | a | c | - | 100 |
| <i>Dactyloctenium aegyptium</i> (L.) Beauv. | r | o | c-la | c | r | r | - | 100 |
| <i>Eragrostis cilianensis</i> (All.) Link ex Vign. Lut. | c | c | r | - | c | c | - | 83 |
| <i>Aristida hordeacea</i> Kunth. | c | r | r | - | o | c | - | 83 |
| <i>Aristida mutabilis</i> Trin. & Rupr. | r | a | r | - | c | va | - | 83 |
| <i>Aristida adscensionis</i> L. | c | - | c-la | c | c | c | - | 83 |
| <i>Panicum turgidum</i> Forsk. | - | c | c | r | c | c | - | 83 |
| <i>Aristida funiculata</i> Trin. & Rupr. | c | c | - | - | o | a | - | 67 |
| <i>Chloris virgata</i> Sw. | c | - | - | o | va | r | - | 67 |
| <i>Indigofera hochstetteri</i> Bak. | r | r | - | - | r | o | - | 67 |
| <i>Cyperus rotundus</i> L. | - | - | c | la | r | c | - | 67 |
| <i>Corchorus depressus</i> (L.) Christens. | r | - | - | - | o | c-la | - | 50 |
| <i>Solanum dubium</i> Fresen. | c | - | - | o | - | r | - | 50 |
| <i>Boerhavia diandra</i> L. | - | - | - | o | r | r | - | 50 |
| <i>Cenchrus biflorus</i> Roxb. | o | - | - | - | - | o | - | 33 |
| <i>Cassia italica</i> (Mill.) Lam. | o | - | - | r | - | - | - | 33 |
| <i>Sesbania macrophylla</i> Harms ex Phillips & Hutch. | r | - | - | o | - | - | - | 33 |
| <i>Tribulus terrestris</i> L. | - | r | r | - | - | - | - | 33 |
| <i>Echinachloa colonum</i> (L.) Link. | - | - | - | r | c | - | - | 33 |
| <i>Cymbopogon excavatus</i> (Hochst.) Stapf.? | - | - | - | - | c | c | - | 33 |
| <i>Enneapogon brachystachys</i> (Jaub. & Spach) Stapf. | - | - | - | - | r | o | - | 33 |
| <i>Dichanthium annulatum</i> (Forsk.) Stapf. | la | - | - | - | - | - | - | 17 |
| <i>Celosia argentea</i> L. | r | - | - | - | - | - | - | 17 |
| <i>Kuhnia caespitosa</i> Schnizl. | r | - | - | - | - | - | - | 17 |
| <i>Crotalaria saltiana</i> Andr. | r | - | - | - | - | - | - | 17 |
| <i>Trianthema sedifolia</i> Vis. | - | - | c-la | - | - | - | - | 17 |
| <i>Cassia senna</i> L. | - | - | o | - | - | - | - | 17 |
| <i>Tragus paucispina</i> Hack. | - | - | r | - | - | - | - | 17 |
| <i>Panicum hygrocharis</i> Steud. | - | - | - | c | - | - | - | 17 |
| <i>Ipomoea verticillata</i> Forsk. | - | - | - | c | - | - | - | 17 |
| <i>Digera alternifolia</i> (L.) Aschers. | - | - | - | r | - | - | - | 17 |
| <i>Hibiscus obtusilobus</i> Gürke. | - | - | - | r | - | - | - | 17 |
| <i>Indigofera stenophylla</i> var. <i>latifolia</i> A. Rich.? | - | - | - | r | - | - | - | 17 |
| <i>Corchorus tridens</i> L. | - | - | - | - | o | - | - | 17 |
| <i>Euphorbia granulata</i> var. <i>glabrata</i> (Gay) Boiss. | - | - | - | - | r | - | - | 17 |
| <i>Indigofera viscosa</i> Lam. | - | - | - | - | r | - | - | 17 |
| <i>Indigofera cordifolia</i> Heyne ex Roth. | - | - | - | - | r | - | - | 17 |
| <i>Limeum viscosum</i> (non Fenzl) Broun & Massey... | - | - | - | - | r | - | - | 17 |
| <i>Boerhavia diffusa</i> var. <i>viscosa</i> (Choisy) Cuf. | - | - | - | - | - | o | - | 17 |
| <i>Cenchrus prieurii</i> (Kunth) Maire. | - | - | - | - | - | o | - | 17 |
| <i>Trianthema crystallina</i> (Forsk.) Vahl. | - | - | - | - | - | o | - | 17 |
| <i>Fagonia parviflora</i> 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 % | | | | | |
|-------------------------------------|---|---|---|---|-----|--|---|---|------|---|-----|
| | f | d | o | d | 100 | r | - | - | cod. | o | 50 |
| <i>Acacia ehrenbergiana</i> | f | d | o | d | 100 | r | - | - | cod. | o | 50 |
| <i>Acacia nubica</i> | c | c | o | c | 100 | d | - | - | - | d | 40 |
| <i>Acacia tortilis</i> | - | - | - | - | 0 | r | d | d | cod. | a | 100 |
| <i>Calotropis procera</i> | a | c | r | - | 75 | - | - | - | - | - | 0 |
| <i>Capparis decidua</i> | a | - | c | c | 75 | o | - | - | - | r | 40 |
| <i>Ziziphus spina-christi</i> | 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 | f | d | o | c | r | - | cod. | o | 50 |
|--|---|---|----|---|---|---|------|---|----|
| <i>Capparis decidua</i> (Forsk.) Edgew..... | r | - | r | r | - | - | - | - | 50 |
| <i>Acacia ehrenbergiana</i> Hayne..... | - | r | - | r | - | - | - | - | 33 |
| <i>A. laeta</i> R. Br. ex Benth..... | r | - | - | - | - | - | - | - | 17 |
| <i>Cadaba rotundifolia</i> Forsk..... | - | r | - | - | - | - | - | - | 17 |
| <i>C. farinosa</i> Forsk..... | - | - | r | - | - | - | - | - | 17 |
| <i>Ziziphus spina-christi</i> (L.) Willd..... | - | - | - | r | - | - | - | - | 17 |
| Undershrubs and herbs | f | d | o | c | r | - | cod. | o | 50 |
| <i>Aristida adscensionis</i> L..... | d | d | a | c | c | - | - | - | 83 |
| <i>Aristida mutabilis</i> Trin. & Rupr..... | o | o | a | d | - | a | - | - | 83 |
| <i>Eragrostis pilosa</i> (L.) Beauv..... | c | c | c | c | a | - | - | - | 83 |
| <i>E. ciliatissima</i> (All) Link ex Vign. Lut..... | c | c | c | r | - | o | - | - | 83 |
| <i>Buerhavia diandra</i> L..... | - | o | r | - | r | r | - | - | 67 |
| <i>Schoenoplectus gracilis</i> Kunth..... | o | o | c | - | - | - | - | - | 50 |
| <i>Panicum turgidum</i> Forsk..... | - | r | r | r | - | - | - | - | 50 |
| <i>Cassia senna</i> L..... | r | r | - | - | r | - | - | - | 50 |
| <i>Aerva tomentosa</i> Forsk..... | o | o | - | - | - | - | - | - | 33 |
| <i>Abutilon fruticosum</i> Guillm. & Perrott..... | r | r | - | - | - | - | - | - | 33 |
| <i>Euphorbia granulata</i> Forsk. var <i>glabrata</i> (Gay) Boiss..... | r | r | - | - | - | - | - | - | 33 |
| <i>Solanum dubium</i> Fresen..... | r | r | - | - | - | - | - | - | 33 |
| <i>Aristida hordeacea</i> Kunth..... | - | - | r | r | - | - | - | - | 33 |
| <i>Chloris prieurii</i> Kunth..... | - | - | o | - | c | - | - | - | 33 |
| <i>Euneapogon brachystachyus</i> (Jaub. & Spach) Stapf..... | - | - | - | o | - | a | - | - | 33 |
| <i>Aristida funiculata</i> Trin. & Rupr..... | - | - | - | o | - | c | - | - | 33 |
| <i>Indigofera hochstetteri</i> Bak..... | - | - | - | r | r | - | - | - | 33 |
| <i>Eragrostis tremula</i> Hochst. ex Steud..... | - | - | - | - | c | o | - | - | 33 |
| <i>Blepharis edulis</i> (Forsk.) Pers..... | - | - | la | - | - | - | - | - | 17 |
| <i>Tetrapogon spathaceus</i> (Hochst.) Hack..... | - | - | r | - | - | - | - | - | 17 |
| <i>Citrullus colocynthis</i> (L.) Schrad..... | - | - | r | - | - | - | - | - | 17 |
| <i>Sporobolus humifusus</i> var <i>cordifolius</i> Stapf ex Massey..... | - | - | r | - | - | - | - | - | 17 |
| <i>Trianthema crystallina</i> (Forsk.) Vahl..... | - | - | c | - | - | - | - | - | 17 |
| <i>Tragus paucispina</i> Hack..... | - | - | - | r | - | - | - | - | 17 |
| <i>Echinochloa colonum</i> (L.) Link..... | - | - | - | - | r | - | - | - | 17 |
| <i>Cenchrus pennisetiformis</i> Steud. & Hochst.... | - | - | - | - | r | - | - | - | 17 |
| <i>Dactyloctenium aegyptium</i> (L.) Beauv..... | - | - | - | - | r | - | - | - | 17 |
| <i>Aristida hirtigluma</i> Steud. ex Trin. & Rupr..... | - | - | - | - | - | a | - | - | 17 |
| <i>Tephrosia vicioides</i> A. Rich..... | - | - | - | - | - | - | r | - | 17 |
| <i>Indigofera arenaria</i> A. Rich..... | - | - | - | - | - | - | r | - | 17 |
| <i>Heliotropium strigosum</i> Willd..... | - | - | - | - | - | - | r | - | 17 |
| <i>Cymbopogon excavatus</i> (Hochst.) Stapf?.... | - | - | - | - | - | - | r | - | 47 |

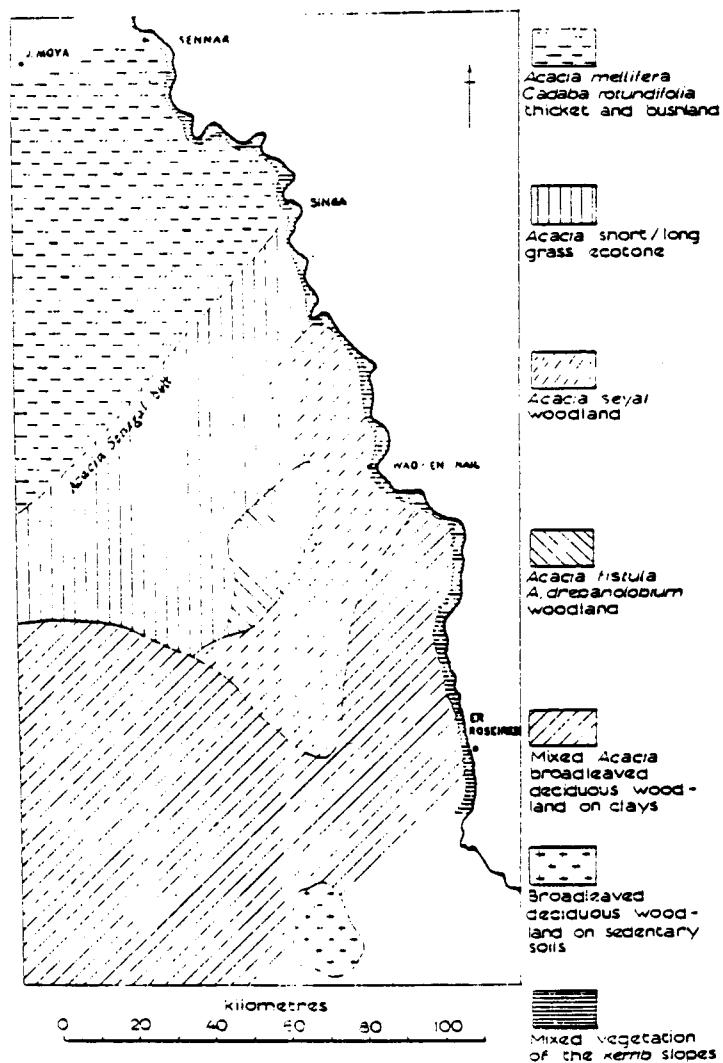


Figure 2. Vegetation Map of the Fung (Scale 1:2,000,000)

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

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

Gramineae

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

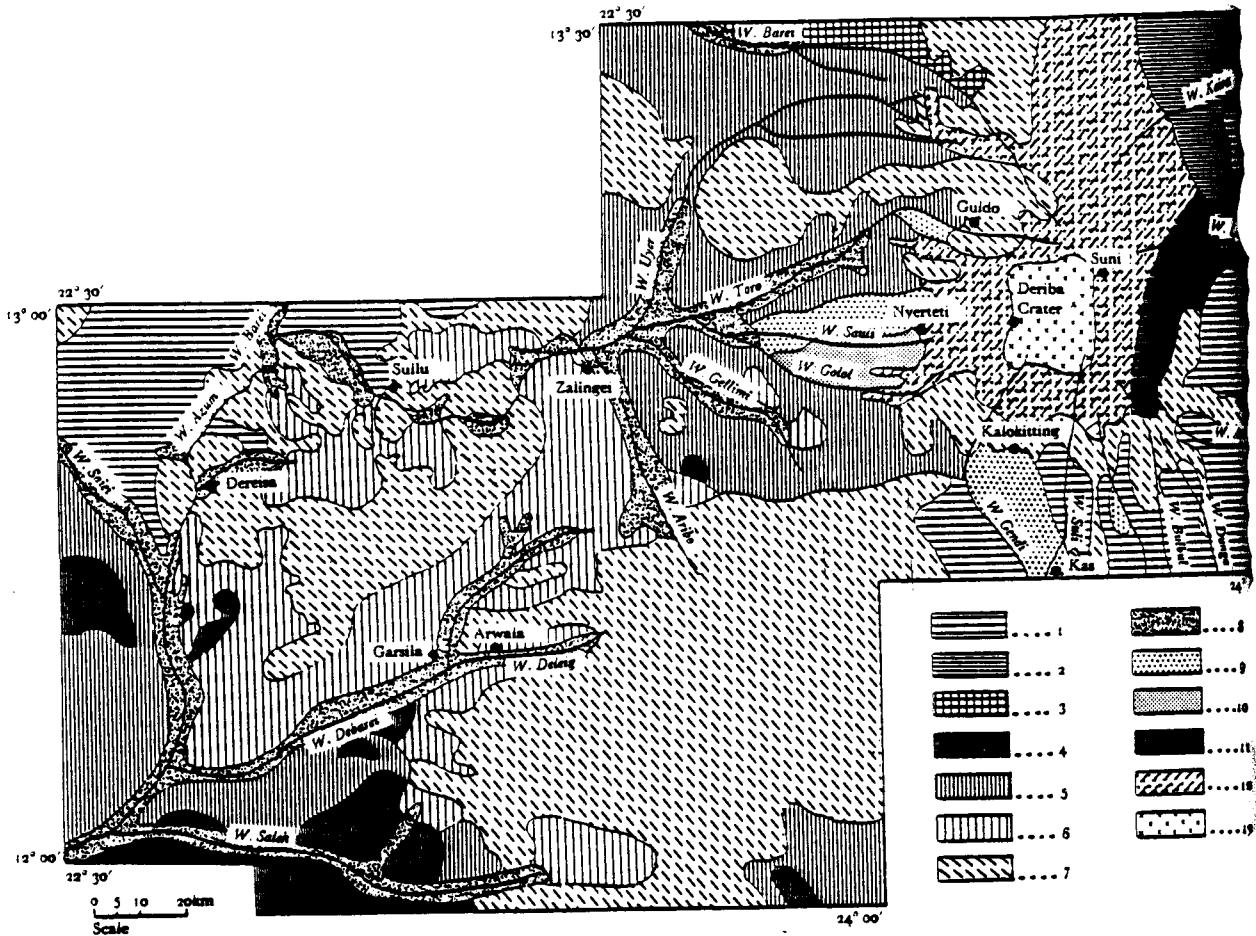
Table 2. Continued

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

Table 2. Continued

| | |
|---|------------------|
| <i>Rhynchosia minima</i> (L.) DC. var. <i>prostrata</i> Harv. | Papilionaceae |
| <i>Sclerocarpus africanus</i> Jacq. ex Murr. | Compositae |
| <i>Sida alba</i> L. | Malvaceae |
| <i>Solanum incanum</i> L. | Solanaceae |
| <i>S. nigrum</i> L. | Solanaceae |
| <i>Stemodia serrata</i> Benth. | Scrophulariaceae |
| <i>Striga gesnerioides</i> (Willd.) Vatke. | Scrophulariaceae |
| <i>S. hermonthica</i> (Del.) Benth. | Scrophulariaceae |
| <i>Striga</i> sp. | Scrophulariaceae |
| <i>Tenagocharis latifolia</i> (D. Don.) Buchen. | Burmanniaceae |
| <i>Tephrosia bracteolata</i> Guillemin. et Perrott. | Papilionaceae |
| <i>T. uniflora</i> Pers. | Papilionaceae |
| <i>Thunbergia annua</i> Hochst. ex Nees. | Acanthaceae |
| <i>Tragia</i> ? <i>cannabina</i> L.f. ex Cooke. | Euphorbiaceae |
| <i>Trianthema pentandra</i> L. | Ficoidaceae |
| <i>T. portucaleastrum</i> L. | Ficoidaceae |
| <i>Tribulus terrestris</i> L. | Zygophyllaceae |
| <i>Trichodesma</i> ? <i>africanum</i> (L.) Lehm. | Boraginaceae |
| <i>Vahlia digyna</i> (Retz.) Kuntze. | Saxifragaceae |
| <i>Vernonia kotschyana</i> Schultz Bip. | Compositae |
| <i>V. pauciflora</i> (Willd.) Less. | Compositae |
| <i>Vicoa leptoclada</i> (Webb) Dandy. | Compositae |
| <i>Vigna pubigera</i> Bak. | Papilionaceae |
| <i>V. vexillata</i> (L.) Benth. | Papilionaceae |
| <i>Withania somnifera</i> (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 Dereesa
 - Combretum glutinosum*-*Guiera senegalensis* on Nubian sandstone, 5 km W of Garsila

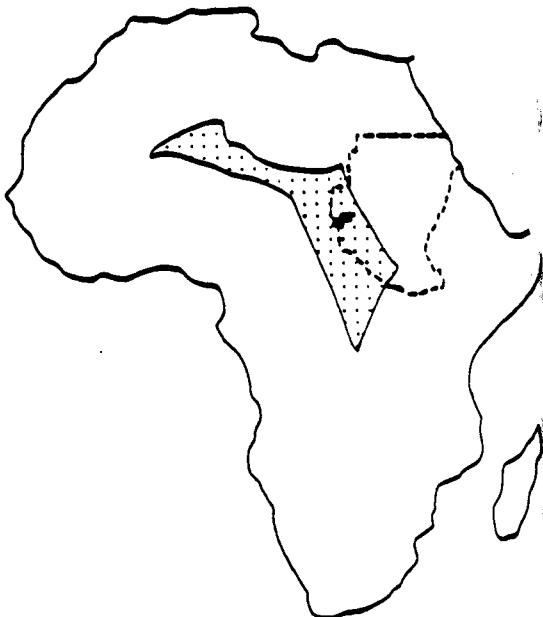


Figure 3. Sketch Map of the Vegetation in the Jebel Marra Region

Source: Wickens. 1976.

Table 3. Classification of Vegetation in the Jebel Marra Region

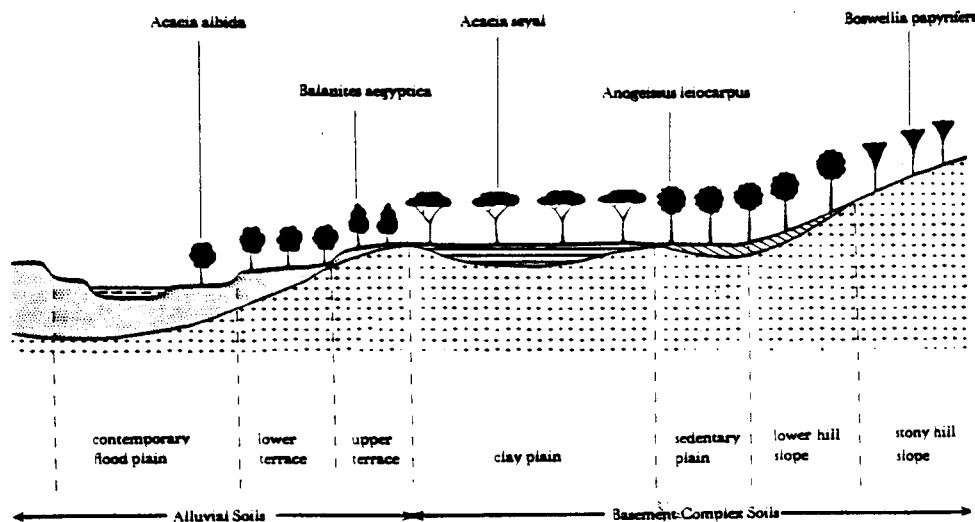
| Formation-type | Formation | Sub-formation | Association |
|--------------------|-------------------------|--|---|
| Tropical thornland | Thorn scrub | <i>Acacia mellifera</i> thornland | i. <i>Acacia mellifera - Commiphora africana</i> on indurated soils. ii. <i>Acacia mellifera</i> on hill soils of the basement complex. iii. <i>Acacia mellifera</i> hill thornland on volcanic soils of the Jebel Marra massif. |
| | Thorn savanna | <i>Acacia senegal</i> thorn savanna | i. <i>Acacia senegal - Combretum glutinosum</i> on aeolian sand. |
| | | <i>Acacia seyal - Balanites</i> thorn savanna | i. <i>Acacia seyal - Balanites</i> on clay soils. ii. <i>Acacia seyal - Anogeissus</i> on basement complex soil mosaic. |
| | Thorn woodland | <i>Acacia albida</i> thorn woodland | i. <i>Acacia albida</i> on piedmont ash soils. |
| | | Riparian woodland | i. <i>Acacia albida</i> on alluvial soils. ii. <i>Balanites aegyptiaca</i> on alluvial soils. |
| | Savanna woodland | <i>Combretum - Albizia - Terminalia</i> savanna woodland | i. <i>Combretum glutinosum - Guiera senegalensis</i> on Nubian sandstone soils. ii. <i>Combretum glutinosum - Terminalia laxiflora</i> on piedmont ash soils. |
| | | <i>Anogeissus leiocarpus</i> savanna woodland | i. <i>Anogeissus leiocarpus</i> on lowland basement complex soils. ii. <i>Anogeissus leiocarpus - Boswellia papyrifera</i> on hill soils of the basement complex. iii. <i>Anogeissus leiocarpus</i> hill savanna on volcanic soils of the Jebel Marra massif. |
| Tropical forest | Lowland forest | Gallery forest | <i>Trema-Syzygium</i> 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.

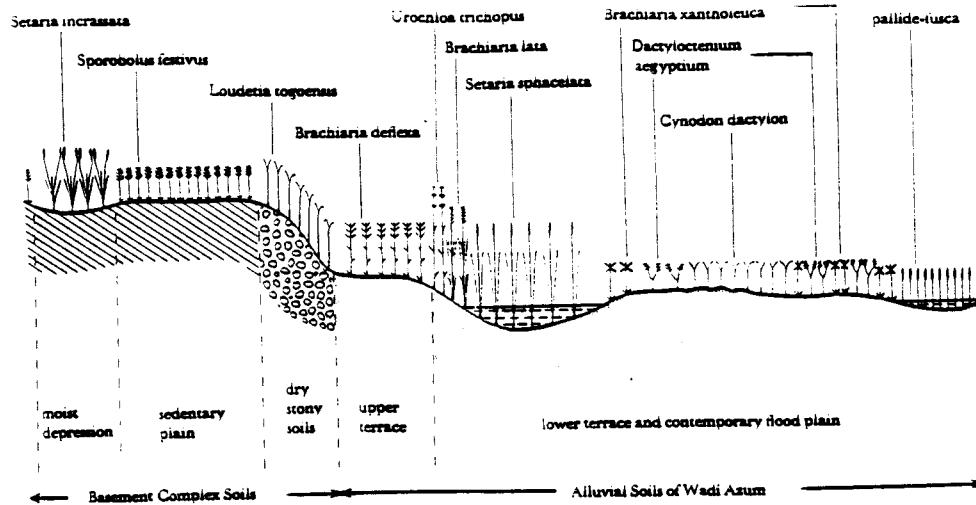
Figure 4. Schematic Diagrams of Vegetation in the Jebel Marra Region

- 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.

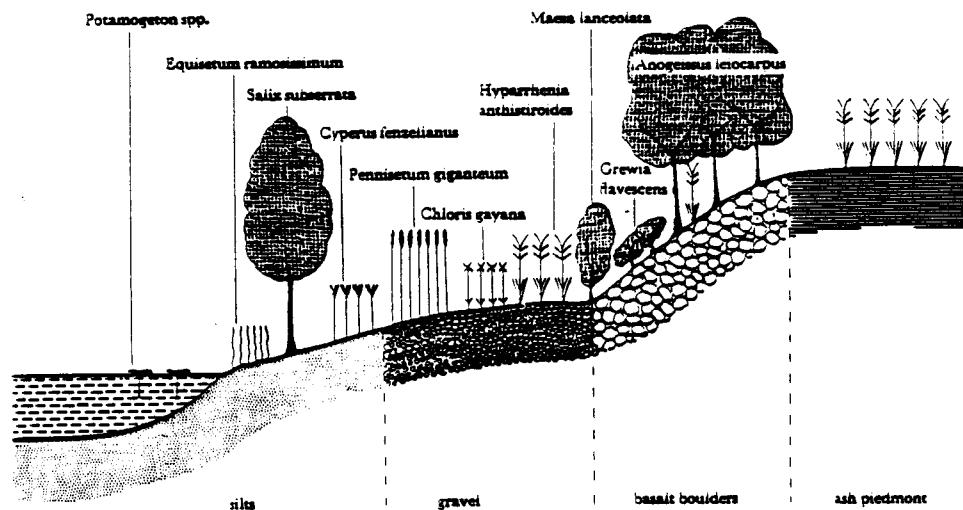
Source: Wickens. 1976.



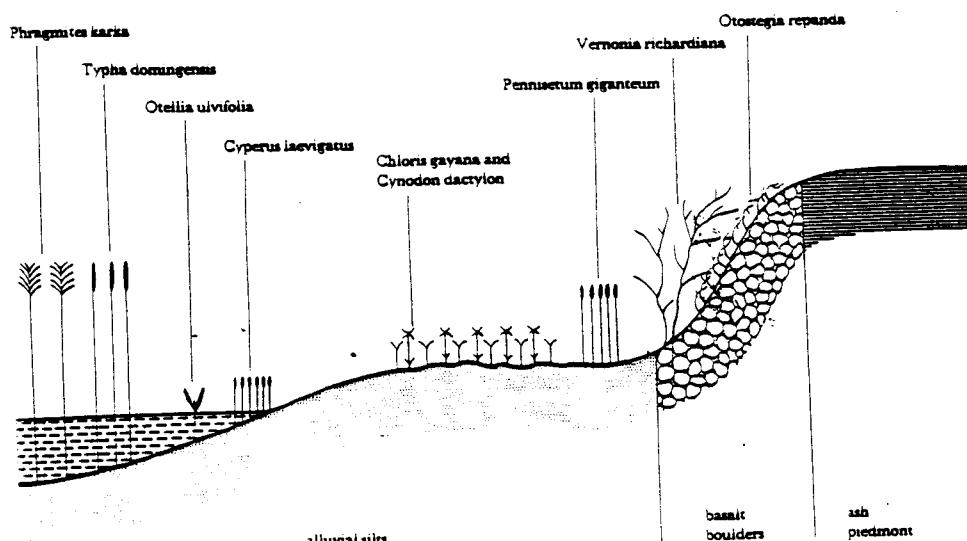
A. Zalingei Area



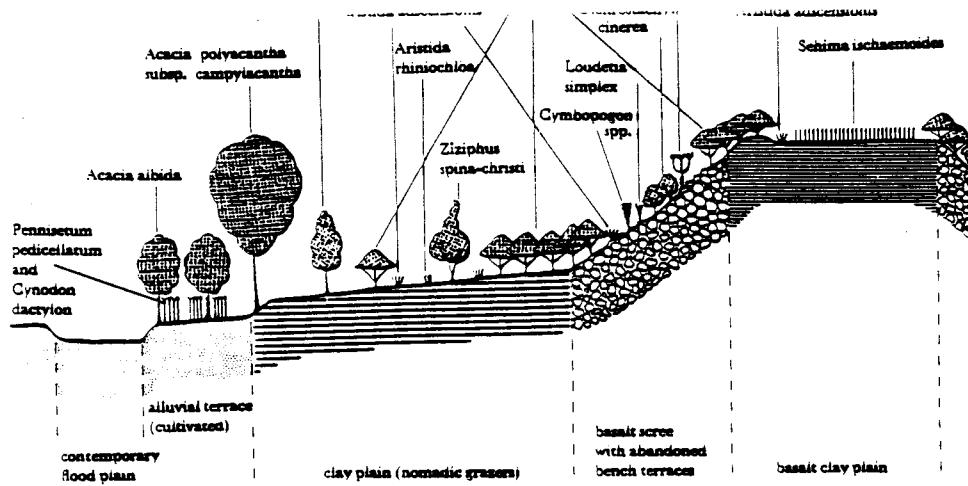
ansect from Basement Complex to Alluvial Soils at Adjakari, near Zalingei



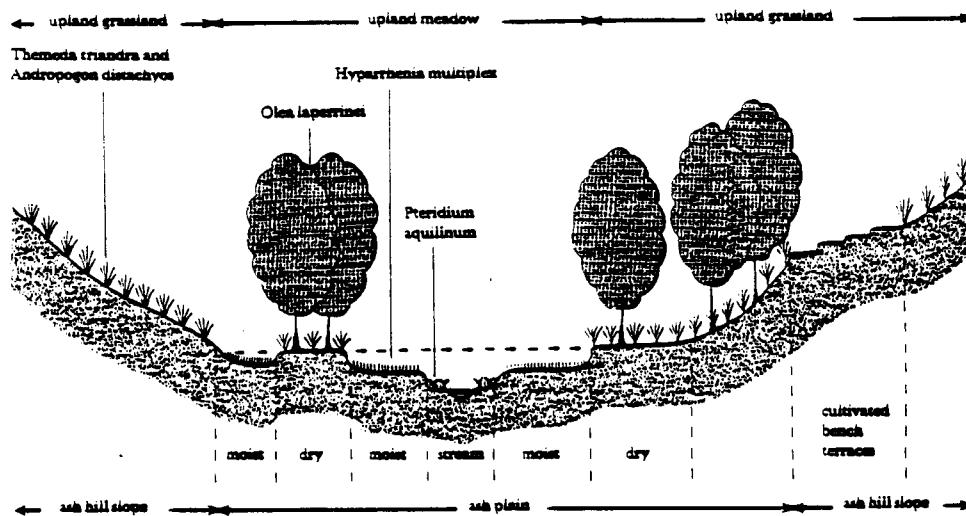
C. Riparian Vegetation near Nyertete



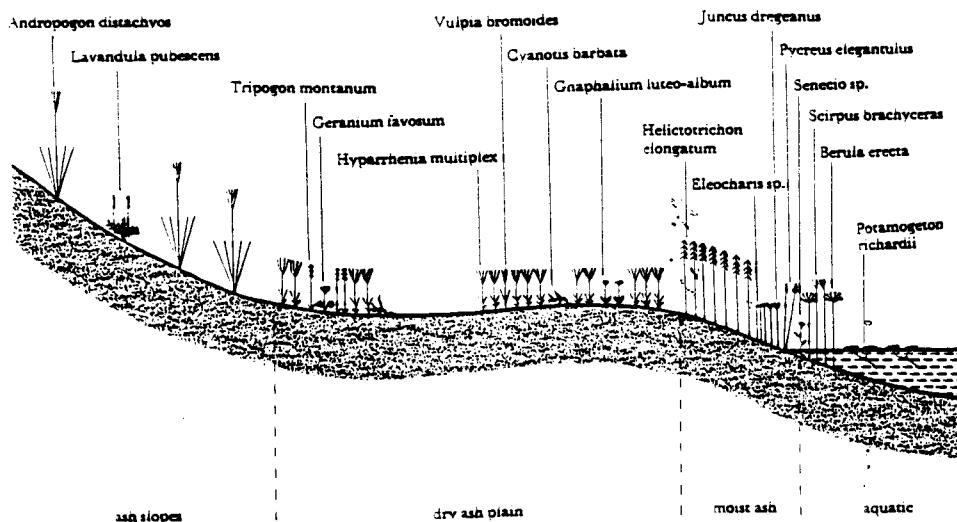
D. Riparian Vegetation near Kibi-Wadi Keira



E. Transect across Jebel Tia



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



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

Table 1. Mammals of Sudan

Ereinaceidae

Atelerix pruneri
Paraechinus aethiopicus

Macroscelididae

Elephantulus fuscipes
E. rufescens

Soricidae

Crocidura bicolor
C. butleri
C. hedenborgiana
C. hildegardeae
C. marita
C. nyansae
C. pasha
C. sericea
C. turba

Galagidae

Galago senegalensis

Cercopithecidae

Papio doquera
Cercopithecus aethiops
C. mitis
Erythrocebus patas
Colobus polykomos

Manidae

Manis temminckii

Leporidae

Poelagus marjorita
Lepus capensis
L. victoriae

Sciuridae

Tamiscus emini
Heliosciurus gambianus
Euxerus erythropus

Cricetidae

Lophiomys imhausi
Gerbillus bottai
G. lowei
G. mackilliqini
G. muriculus
G. principulus
G. stigmonyx
G. watersi
G. aqaq
G. sudanensis
G. hancillus
G. pyramidum
G. rosalinda
Tatera benvenuta
T. flavipes
T. macropus
T. robusta
T. soror
Taterillus congicus
T. emini
Desmodilliscus braueri
Meriones libycus
Psammomys obesus

Muridae

Grammomys macmillani
Oenomys hypoxanthus
Myomys cunninghamei
Dasyurus incomitus
Aryicanthis niloticus
Lebinthomys barbarus
L. dunni
L. lynesi
L. macculus
L. striatus
Aethomys kaiseri
Mastomys kulmei
M. natalensis
Praomys albipes

| | |
|-----------------------------------|-----------------------------|
| <u>P. butleri</u> | Canidae |
| <u>P. fumatus</u> | |
| <u>P. stella</u> | |
| <u>P. tullbergi</u> | |
| <u>Mus bellus</u> | |
| <u>M. musculoides</u> | <u>Canis adustus</u> |
| <u>M. tenellus</u> | <u>C. aureus</u> |
| <u>M. triton</u> | <u>C. mesomelas</u> |
| <u>Lophuromys aquilus</u> | <u>Vulpes pallida</u> |
| <u>L. sikapusi</u> | <u>V. ruppellii</u> |
| <u>Acomys albigena</u> | <u>Fennecus zerda</u> |
| <u>A. cahirinus</u> | <u>Lycaon pictus</u> |
| <u>A. hystrella</u> | |
| <u>A. intermedius</u> | |
| <u>A. lowei</u> | |
| <u>A. percivali</u> | |
| <u>A. wilsoni</u> | |
| <u>Cricetomys gambianus</u> | Mustelidae |
| <u>Dendromus mesomelas</u> | |
| <u>D. pumilis</u> | <u>Ictonyx striatus</u> |
| <u>Steatomys aquilo</u> | <u>Poecilicitis libyca</u> |
| <u>S. gazellae</u> | <u>Mellivora capensis</u> |
| <u>S. thomasi</u> | <u>Lutra maculicollis</u> |
| <u>Otomys orestes</u> | |
| | Viverridae |
| Gliridae | |
| <u>Graphiurus murinus</u> | <u>Genetta genetta</u> |
| <u>G. orobinus</u> | <u>G. tigrina</u> |
| | <u>Civettictis civetta</u> |
| | <u>Herpestes sanguineus</u> |
| | <u>Dologale dybowskii</u> |
| | <u>Mungos mungo</u> |
| | <u>Ichneumia albieanda</u> |
| | Hyaenidae |
| Dipodidae | |
| <u>Jaculus jaculus</u> | <u>Proteles cristatus</u> |
| | <u>Crocuta crocuta</u> |
| | <u>Hyaena hyaena</u> |
| Hystricidae | |
| <u>Atherurus turneri</u> | Felidae |
| Thryonomyidae | |
| <u>Thryonomys gregorianus</u> | <u>Felis caracal</u> |
| <u>T. swinderianus</u> | <u>F. libyca</u> |
| | <u>F. serval</u> |
| | <u>Panthera pardus</u> |
| | <u>P. leo</u> |
| | <u>Acinonyx subatus</u> |
| | Drycteropodidae |
| Bathyergidae | |
| <u>Cryptomys ochraceocinereus</u> | <u>Orycterus sp.</u> |

Elephantidae

Loxodonta africana

Procaviidae

Heterohyrax brucei
Procavia habessinica
P. ruficeps

Equinae

Equus asinus
E. burchellii

Redunca bohor
Hippotragus equinus
Oryx damman
Addax nasomaculatus
Damaliscus korrigum
Alcelaphus buselaphus
Ourebia ourebi
Rhynchoragus guentheri
Gazella dorcus
G. leptoceros
G. rufifrons
G. thompsonii
G. dama
G. granti
G. soemmerringii
Capra ibex

Rhinocerotidae

Source: Setzer. 1956.

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

Table 2. Vertebrates Listed by the IUCN Red Data Books.

Mammalia (1978), Amphibia and Reptilia (1975)

| ADDAX | | | |
|------------------------------------|---|--------|---------|
| Order | ARTIODACTYLIA | Family | BOVIDAE |
| | <i>Addax nasomaculatus</i> (Blainville, 1816) | | |
| 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 Majabat-al-Koubra, 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 Uebnat 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 Halfa 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. (8; 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 Edébe 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 Bocté, Djourab, Moudri and southern Air. (16; 5; 13) Jones (7) saw two addax and a further six dead ones, in the area north of Arlit in 1973. 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 Abbès in the years 1920-1922; in the Fanezrouft area the last direct observation was in 1960, although Dupuy (3) found old tracks in 1964. Some addax remain in the area between the Adrar des Iforas and 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 Majabat-al-Koubra where Mondj in 1960, counted 363 tracks in a traverse of 15 km. Present reports show a considerable reduction in numbers. Trotter (1972) and Chech regions of the Meyye, and Majabat-al-Koubra. They may also still occur in the Djebel Tinefert and the Tamezna. Tunisia: The last addax were killed about 1865 (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 | Watery 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 Majabat-al-Koubra, Chad's Oued Rime-Ouedi Souf, and the Oued Ghadames, there is no effective protection. | | |

- CONSERVATION MEASURES PROPOSED** Establishment of effectively policed reserves in certain areas where addax still remain reasonably common, including the Majabat-al-Koubra in Mauretania, the Teneïza area of Mali, Niger and Aktria, the Bilma-Tenïza area of Niger and the Edébi-Houari-Houar regions of Chad and Sudan. (6) Establishment of a centrally placed guard post from which camel patrols could operate throughout the year, in the Oued Rime-Ouedi 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)
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Code: 19-128-16-1 v

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 Beunen (15), and it should be noted that *E. africanus taeniatus* (von Iltz 1861) is used for much of *E. a. somalicus* (e.g. *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 in pure form, but several recent reports could refer to it: from the southwest corner of the Nubians, north of Tibesti-Tinmedi, in northern Chad (15; I.R. Grimwood 1976, pers. comm.) and a small herd in the Daciyet el Meiva saltmarshes, the northern edge of the Great Libyan sand sea. (11; E.J. Hufnagl 1965, pers. comm.; H. Klingel 1972, pers. comm.) *E. a. somalicus*: 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. carniolicus*: Formerly from Tolar 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 Beunen (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°31'N and between 40°30' and 42°E. The total population was estimated at a maximum of 2000 head, but noted that 3000 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 Abie. In Somalia, the populations near Las Anod and at Gobidbo 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.K. Bally 1967, pers. comm.; A.M. Simonetka 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. (11)

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 populations 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. somalicus*) is Claus Pohle, Tierpark Berlin. DDK 116.

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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 race 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 northern Russia westwards to Syria and Palestine, and thence 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 100 in Zambia, 200 in Mozambique, 50 in Malawi, 200 in Botswana, 400 in Rhodesia, 1500 in South West Africa, 100 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, 100 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 man-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. Game laws have been passed, Ranching interests in Kenya, Tanzania, Malawi, Zambia, Rhodesia and Angola. Man has, however, often - too often - been the chief threat to the cheetah. The cheetah occurs in less than half the parks and reserves

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 rapidly, 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 ranch and communites 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.

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Family PONGIDAE

Order PRIMATES

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, to savannas in others 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 or 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 intrusions 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, Bouronville calculated approximately 12,500 chimpanzees within a 90,000 km² area of Uganda during 1964; Kortland estimated that there were 'return' 10 chimpanzees per km² in the Zaire Reserve; van Lawick-Goodall suggests > 15 per km² in the Gombe Stream of Tanzania; and Leybold 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 Sahelian 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 Zaire. 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 Zaire, in the Queen Elizabeth Park in Uganda, in Niokolo Koba, Senegal, the Niama and Niari Reserves of the Ivory Coast, the Mount Cameroon and Douala Edea Reserves in Cameroun, and Mbariziya 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 captive primates, are strongly urged. Substantial financial support from research

REMARKS Usually single infants are born (gestation period approximately 255 days) at intervals of 2½ to 4 years, depending on infant mortality, which is high owing to disease and human predation. Maternity is reached between 6 and 8 years and the potential life span extends beyond 40 years.

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AFRICAN ELEPHANT

Loxodonta africana (Blumenthal, 1797)

| Order | PROBOSCIDEA | Family | ELEPHANTIDAE |
|---------------------------|---|---------------------|--|
| <u>STATUS AND SUMMARY</u> | 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 - ivory, some-nat over 100,000, for example, must have died to supply the 1976 African ivory exports. In the longer term the main threat is contraction of the elephant's range due to expanding human populations. Protected by law in most countries and found in many national parks, however protected as usual. | <u>POPULATION</u> | Data collected by the IUCN/SSC African Elephant Specialist Group in the first systematic enquiry into elephant numbers and trends throughout Africa, suggests that in 1976 there were not less than 1.3 million elephants spread over 14-16 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 25 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, Kenya has a highly endangered population drop, this being the only recent evidence that the species still exists, and elsewhere in West Africa little more than relic's survive in isolated forest patches (12). In Kenya, total elephant numbers estimated by the IUCN Elephant survey in 1977 were 65,000-5,000 (an independent survey of the Kenya Rangeland Ecological Monitoring Unit (KREMU) provided an estimate of about 60,000 (12)). This is less than half the population estimated by the Kenyan Department in 1973 (11). In Uganda the elephant population declined from 14,000 to just over 2,000 between 1971 and 1973, and still did so. Declines have also been reported in Ruwenzori National Park (10). Although Kenya and Uganda have provided the best documentation, similar declines are believed to | <u>DISTRIBUTION</u> | Africa south of the Sahara. In early Neolithic time, 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). |

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 (1; 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; 11); (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 these averages were generally valid 1976 exports would represent 112,000 elephant. Recent data suggest, however, that the ivory trade may be selecting heavier ivory by deliberately cutting 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 these averages were generally valid 1976 exports would represent 112,000 elephant. Recent data suggest, however, that the ivory trade may be selecting heavier ivory by deliberately cutting 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 these averages were generally valid 1976 exports would represent 112,000 elephant.

Ac must also be borne in mind that only a fraction of the ivory from natural

Africæ, 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/WF 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.

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SLENDER-HORNED GAZELLE OR LODER'S GAZELLE

Gazelle leptoceros (Cuvier, 1842)

Order ARTIODACTYLA

Family BOVIDAE

TORA HARVESTER

Alcelaphus buselaphus toro (Gray, 1873)

Family BOVIDAE

Order ARTIODACTYLA

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 Fayoum, 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. Lavauzen'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. Mammal 14: 10-108.2. Dekeyser, P.J. (1955): Les mammifères de l'Afrique Noire Française. Baker: IFAN Institutions AFR.3. Ellerman, D.R. & Morrison-Scott, T.C.S. (1951): Checklist of Palearctic and Indian mammals 1926-1946. London: British Museum (Nat. Hist.).4. Flower, S.S. (1942): 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.ORYX HARVESTERAlcelaphus buselaphus toro (Gray, 1873)

Family BOVIDAE

Order ARTIODACTYLA

STATUS Endangered because of excessive hunting and habitat degradation. Believe 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. Fortes 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. (2)REMARKS Normally a single young is born after a gestation period of 214 to 212 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 Hartbeest. Biol. Con. 3(2): 147-148.
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LEOPARD

Panthera pardus (Linnaeus, 1758)

Order CARNIVORA

Family FELIDAE

STATUS Vulnerable. Exterminated from large parts of its former range and depopulated elsewhere. In some areas persecution and loss of habitat have taken a severe toll; at least five geographic rates 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, Namibia and 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 uiombo woodland and 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 uiombo biome will be little affected by human activities except for the 10-15 per cent which constitute alluvial floodplains or "dambos" drainage systems. In South Africa thick thornbush in the Kruger Park and an abundance of impala prey permit densities of two leopards 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, uiombo woodland, savanna and rocky areas with heavy or scattered vegetation to the high, cold regions of the Hindu-Kush, 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 ecosystems 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 Wild. Magaz. Assn. 2(1): 9-16.

Action has been taken 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 internal national trade in Endangered Species of Wild Fauna and Flora, 1973. Trade in these animals between acceding nations is subject to severe restriction, trade in 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 replace a sustained-yield offtake. In Africa much severe penalties are required to deter poaching and preventive killing by livestock owners.

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SCIMITAR-HORNED ORYX

Oryx dammah (Cretzschmar, 1826)

Order: ARTIODACTyla

Family: BOVIDAE

DISTRIBUTION: Formerly throughout the Sahelian zone north and south of the Sahara from Spanish Sahara, Mauritania 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 Mauritania and the Sudan. (1; 6; 9; 11; 13; 14)

POPULATION: Very unlikely that any still exist in Egypt, in spite of old reports of the possibility that some animals may migrate into the Gébel '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 5'000 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'Azawak. Algeria: Oryx have been observed in the Ahaggar and near In Aouza but these are believed to be migrants from Adrar des Iforas (Mali) and Aïr and Ténéré in Niger. (3) Mali: Probably still occur in the Ténéré and also west of the Adrar des Iforas. (6) Upper Volta: Now thought to be extinct. (M. Baumel 1975 pers. comm.) Mauritania: Mondal (1958) recorded two oryx northeast of Oudai Achim in 1957. In 1959 the two oryx killed in the region of Tazizkar Bay have been the last in the country. If any do still exist, the Nema-Gualata 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 unrestricted in most countries in which this species occurs. It receives little effective protection in most of Niger, Mali, Mauritania and Sudan. Although officially protected by law in Sudan it is still sought by big game hunters. In Chad, a reserve, the Oued Riué-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 Oued Riué-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)

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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), Bonyoro (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); Sodan: 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 Quanda-Gubingo 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); Cameroon: 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 of savanna 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 1 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 zoos collections (41 bred in captivity) (22).

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SOUTHERN SQUARE-LIPPED RHINOCEROS

Ceratotherium simum cottoni (Lydekker, 1908)

| Order | PERISSODACTYLA | Family | RHINOCHEROTIDAE |
|---|----------------|--------|-----------------|
| information is needed on distribution and numbers if conservation and management are to be properly planned and implemented. | | | |
| <u>STATUS AND SUMMARY</u> 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 than 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. | | | |
| <u>DISTRIBUTION</u> 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 Arai Game Reserve and Kabslega 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). | | | |
| <u>POPULATION</u> 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 (11) 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 Shambae Reserve and adjoining areas south of the Sudd (2). Chad: extinct (1; 14). | | | |
| <u>HABITAT AND ECOLOGY</u> 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). | | | |
| <u>THREATS TO SURVIVAL</u> Pouching for its horn which in Asian countries is considered to have aphrodisiac properties. Disturbances arising from military operations (3; 11; 14). | | | |
| <u>CONSERVATION MEASURES TAKEN</u> 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 info: cannot be had. 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 Shambae Reserve in the Sudan. | | | |
| <u>CONSERVATION MEASURES PROPOSED</u> 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 | | | |

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.

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Crocodilus niloticus Laurenti, 1768

Order CROCOVYIA

Family CROCODYLIDAE

Lycosa pictus (Temminck, 1820)

Family CANIDAE

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 "I" 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.

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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. (1) 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; persistent 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 to predation on the domestic animals. Uncommon in the Oued Rime-Oued Achim faunal reserve in Chad (4). (2) Newby 1976, pers. commun.)

HABITAT Open or wooded savanna. Have been observed at the summit of Mt. Kilimanjaro and on Mt. Kenya above 2100 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)

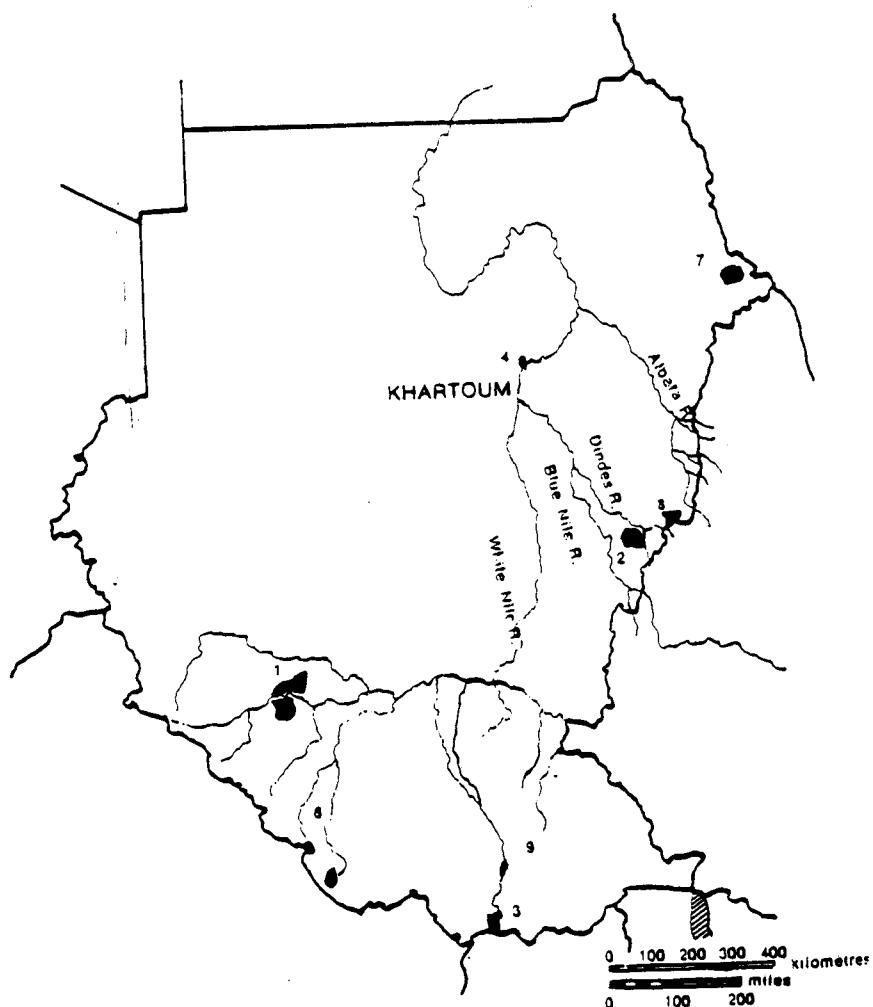
CONSERVATION MEASURES PROPOSED They should be given full protection of the law; control measures should be carefully supervised and eased wherever possible.

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.

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SUDAN



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.

I. 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 *Taurtragus 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 *Synacerus 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 area 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 harveyanum*.

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. Burna 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 Nil 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 measures taken for their control; control cost money which the less developed countries do not have.

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 break 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. FRESHWATER

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 *Eichornia 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 mosquitoes, snails, crocodiles and poisonous snakes. In addition, much water is lost by evaporation 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 (Finances) 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.¹
2. Salination of soil will become a problem because of the increasing use of fertilizers.
3. Sheet erosion and gullying due to resettlement of mountain dwelling tribes on roads and hill sides.

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 soil and Barren Land (Rationalization) 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 (Rationalization), 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.

D. ADMINISTRATION

1. Ministry of Irrigation and Hydro-Electricity.
2. Land Use and Rural Water Development Board.

E. FAUNA (INCL. FISHERIES)

A. PROBLEMS

1. Changes in Natural habitat have reduced the population of wild animals. The mud dams 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 Sumatran gaur is an example of this.
3. Communal hunting accounts for much loss of wildlife. The communal explanation of leopards has resulted in an explosion in the Baloum population which has begun very destructive 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 leather work". Uncalculated trade in crocodile skins accounts for the disappearance of the crocodiles 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 lower financial returns.
5. Insufficient staff for control operations including for example, the collection of elephant tusks for auction.

B. POLICY

1. There are serious attempts at protection of the valued 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 animals 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.

E. 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 Scimitaring Gacelle, among others.
2. Constant retreat of the forest line due to shifting cultivation and overstocking of domestic animals around scarce water points.
3. See Sec. II (4) A.

B. POLICY

1. It is intended to designate 5% 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.
3. Forest 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.

F. NON-RENEWABLE RESOURCES

A. PROBLEMS

B. POLICY

C. LEGISLATION
D. ADMINISTRATION

B. REGULATION OF NOISE

A. PROBLEMS

Noise pollution in the urban centers.¹

B. POLICY

C. LEGISLATION

The Road Traffic Ordinance, 1948. An Ordinance to provide for the licensing, taxation and control of road traffic. Includes regulations regarding the use of silencers while in towns and villages.

D. ADMINISTRATION

B. 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

B. HAZARDOUS SUBSTANCES

A. PROBLEMS

1. Atomic energy and radioactive materials are used in medical application, the condition of equipment and protection devices is inadequate.
2. Increasing use of fertilizers has caused corrosion of powerline towers. Included in these fertilizers are ammonium sulphate and urea.
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

Inufficient development projects.¹

B. POLICY

C. LEGISLATION

D. ADMINISTRATION

2. HUMAN SETTLEMENTS AND HOUSING

A. PROBLEMS

1. Overcrowded settlements. Squatters squat at 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

1. Increasing use of fertilizers has caused corrosion of powerline towers. Included in these fertilizers are ammonium sulphate and urea.
2. The use of herbicides to control water hyacinth is a constant threat to crops on irrigated land, especially cotton.¹

B. POLICY

4. PROTECTED AREAS

A. PROBLEMS

B. POLICY

In addition to these 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.

6. 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

Inufficient 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.³
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.

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2. Paper, The Role of Wildlife in Social and Economic Development of the Southern Sudan, Malak and Kuadwo, Sudan Veterinary Association, (presented at Southern Social and Economic Development Conference, Juba, Sept. 1970).
3. The Statesman's Yearbook 1972-1973.
4. Ed. John Paxton, Macmillan Press, London, 1972.
4. U.N. List of National Parks and Equivalent Reserves. IUCN International Commission on National Parks, Brussels, 1971.

Appendix IX
U.S. AID Projects in Sudan

Source: U.S. AID Computer Data Files

COUNTRY/BUREAU
PROJECT NUMBER
PROJECT TITLE
PROJECT SUMMARY

SUDAN
650001000
SUDAN - EXTENSION EDUC TRAIN FOR HUMAN RESO

OPERATIONAL PROGRAM GRANT SUPPORTS CONTRACT WITH WORLD EDUCATION TO PROVIDE ADVISORY ASSISTANCE TO AHPAD UNIVERSITY COLLEGE FOR WOMEN (AHPAD) TO ESTABLISH THE CAPABILITY TO TRAIN WOMEN TO DELIVER INTEGRATED WOM-FOURAL EXTENSION EDUCATION TO POOR ADULTS (MAILY WOMEN) IN URBAN AND RURAL AREAS. AHPAD STAFF AND STUDENTS WILL BE TRAINED IN NEEDS ASSESSMENT, LEARNED 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. A PHASE ONE ACTIVITIES WILL BEGIN WITH WORKSHOPS TO STUDY INSUFFICIENCIES OF OTHER EXTENSION DELIVERY AGENCIES IN ORDER TO AVOID THOSE MISTAKES IN DESIGNING AHPAD'S STRATEGY. COURSES ON THE PROCESS, TECHNIQUES, AND STRATEGIES OF EXTENSION EDUCATION WILL BE CLOSELY INTEGRATED WITH EXTENSION ACTIVITIES 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 AHPAD 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, AND DESIGN

EVALUATING PROCEDURES FOR THESE SELF-HELP AND INCOME-GENERATING ACTIVITIES. AT MID-TERM, 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 GATHER SYSTEMATIC FEEDBACK IN ALL ASPECTS OF THE PROJECT. ANOTHER WORKSHOP TO ASSESS PROJECT EXPERIENCES WILL BE HELD AT TERM'S END. PHASE TWO WILL INCORPORATE REVISIONS DEDICATED NECESSARY BASED ON SUCH EVALUATIVE INPUT.

COUNTRY/BUREAU
PROJECT NUMBER
PROJECT TITLE
PROJECT SUMMARY

SUDAN
650001100
NORTHERN SUDAN PRIMARY HEALTH CARE I

GRANT IS PROVIDED TO THE GOVT OF THE SUDAN TO IMPLEMENT A PRIMARY HEALTH CARE PROGRAM (PHCP) IN THE NORTHERN REGION WHICH IS COMMUNITY-BASED, SPECIFICALLY DESIGNED TO REACH THE RURAL POOR & NOMADS, AND NELIES ON COMMUNITY PARTICIPATION. THE COMPONENTS OF THE PHCP INCLUDE: 1) COMMUNITY HEALTH WORKERS (CHW'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 40,000 PERSONS; 3) A LOGISTICS/SUPPLY SYSTEM WHICH WILL PROVIDE EQUIPMENT, DRUGS & SUPPLIES TO THE CHW'S, NELIES'S & PHCU'S; 4) A HEALTH & AGRI INFORMATION SYSTEM WHICH WILL COLLECT DATA ON THE HEALTH PROBLEMS, SERVICES DELIVERED & SUPPLIES UTILIZED AT THE PHCU. AID WILL FUND TECHNICAL ASSISTANCE, TRAINING, COMMODITIES, AND CONSTRUCTION OF PHCU'S IN SUPPORT OF THE ABOVE COMPONENTS. 3A 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 GOVT NATIONAL HEALTH PROGRAMS, AND A DESCRIPTION OF OTHER DOMESTIC 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 NAIIL 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 & OWNER HEALTH PROGS. STRAINING FINANCED BY GRANT INCLUDES: 1) LONG-TERM US TNG IN STTS, PUBLIC HEALTH & LOGISTICS/RIGHT FOR 3 MOH COUNTERPARTS, SHOT-TRNG US TNG IN UNSPECIFIED AREAS FOR 12 MOH PERSONNEL, SHOT-TRNG 3RD COUNTRY TNG IN PUBLIC HEALTH FOR 36 DEPUTY & ASSISTANT HLTH COMMISSIONERS; 2) 10-DAY REORIENTATION SESSIONS ON THE PHCP FOR 4120 PROVINCIAL SUPERVISOR ULTRA PERSONNEL AND 20 10-DAY REPAIRSER COURSES FOR 1120 CHW'S & 35 PHCU'S WILL ALSO BE CONSTRUCTED.

COUNTRY/BUREAU
PROJECT NUMBER
PROJECT TITLE

SYDAW
650001800
BLUE MILK AGRICULTURAL DEVELOPMENT
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 DAIMPED PRODUCTION SUB-SECTOR OF SUDAN. THE PROJECT WILL INVOLVE 2,500 FARM FAMILIES AND 3,300 NOMAD FAMILIES WITHIN BLUE MILK PROVINCE. THE INTEGRATED SERVICE SYSTEMS DEVELOPED, HOWEVER, WILL BE SUITABLE FOR APPLICATION OVER LARGER AREAS DURING FOLLOW-ON PROJECTS. MAJOR COMPONENTS INCLUDE AGRICULTURAL MECHANIZATION, IMPROVEMENT OF AGRONOMIC PRACTICES, LIVESTOCK MANAGEMENT, COOPERATIVES, AND CREDIT. 2A BLUE MILK 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 SHENIMA. ORGANIZATION 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 VEHICULATION TRAILLS FARM WILL BE ESTABLISHED AT THE BASC TO IMPROVE AGRONOMIC PRACTICES RELATING TO SESAME AND SORGHO 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 SHENIMA. SPILLOT NOMAD GRAZING ASSOCIATIONS WILL BE ORGANIZED AS A VEHICLE FOR INTRODUCING IMPROVED PRACTICES WITH RESPECT TO ANIMAL HEALTH, PRODUCTION, AND RANGE MANAGEMENT. SPANNER SERVICES AND CREDIT WILL BE CHANNELLED 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 ASSURE 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
PROJECT NUMBER
PROJECT TITLE

SUDAN
650001900
PRIMARY HEALTH CARE PROGRAM
PROJECT GRANT IS PROVIDED TO THE INT'L 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 WITH WORKERS (CWHS) & 1120 SUPERVISORY MEDICAL ASSISTANTS. A TOTAL OF 56 ONE-WEEK REFRESHMENT COURSES INVOLVING 1660 CWHS & 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 RAMPPOWER 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 BOH COUNTERPART. THE PROJ TEAMS WILL RECEIVE TECH ADMINISTRATIVE SUPPORT FROM THE AMERICAN MEDICAL & RESEARCH FOUNDATION, INC.'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 CWH TRNG CENTERS, THREE LANDROVERS TO SIX PROVINCIAL HLTH DEPTS, 600 BICYCLES FOR CWHS & THEIR SUPERVISORS, FOUR GRINDING MILLS TO BE USED BY RESIDENTS WHILE VISITING DISPENSARIES, AND VARIOUS INSTRUCTIONAL & BUILDING SUPPLIES.

COUNTRY/BUREAU
PROJECT NUMBER
PROJECT TITLE
PROJECT SUMMARY

SUDAN
65002000
WESTERN SUDAN AGRICULTURAL RESEARCH
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 A RESEARCH CENTER, OFFICES, LABORATORIES, A DOCUMENTATION CENTER, A CONFERENCE ROOM, AND STAFF HOUSING. THE RESEARCH STATIONS WILL CONSIST OF OFFICES, FIELD LABORATORIES, PARK 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 FLOOR GR 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 TECH PLANNING & EVAL ADVISOR, AN ARCHITECT/PLANNER, A DEPUTY PROJ DIRECTOR, A SOCIOLOGIST, A PARK AGIT ECONOMIST AND A LIVESTOCK/CROP PRODUCTION SYSTEM SPECIALIST. EIGHTY MAN-DAYS OF SHORT-TERM ASSISTANCE WILL ALSO BE PROVIDED BY QSAID. USAID WILL ALSO FINANCE OVERSEAS TRNG FOR 26 SUDANESE PARTICIPANTS (6PHD CANDIDATES, 5 MS CANDIDATES, AND 17 MSc DEGREES CANDIDATES) AND ALL OPERATIONAL COSTS. IBRD & THE GOS WILL FINANCE CONSTRUCTION COSTS.

COUNTRY/BUREAU
PROJECT NUMBER
PROJECT TITLE
PROJECT SUMMARY

SUDAN
65002100
SUDAN--SOUTHERN HUMANPOWER DEVELOPMENT
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 BUBBEK; 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 AIMAG AND DIVIV OF JOBA-DAT NUMBER 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 BUBBEK 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 BUBBEK WILL ALSO BE FORMULATED AND IMPLEMENTED WITHIN THE AIMAG DEPT OF RESEARCH AND EXTENSION. THE AGRICULTURAL TRAINING CENTER WILL ALSO BE USED AS A CENTER FOR FIELD TRAINING, AND SUPPORT COOPERATING FARMERS, COOPERATIVES, AND SOCIETIES.

COUNTRY/BUREAU
PROJECT NUMBER
PROJECT TITLE
PROJECT SUMMARY

SUDAN
650002601

WADI HALFA COMMUNITY DEVELOPMENT: WATER SUPPLY
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 1900 POPULATION OF 30,000. THE GRANT WILL SUPPORT THE COST OF PUMP EQUIPMENT. A NEW LAKESHORE PUMP WILL BE INSTALLED ON A FLOATATION 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 POULING 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 HELPAED 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, FEDDING 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 THERE BE INSTALLED ON A FLOATATION PLATFROM 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. NEW CONCRETE TANKS ARE COMPLETED. GULLS SUBPROJECT ADDS TWO DIESEL ENGINES TO THE BUSTLING SYSTEM, WHICH MILL COST APPROXIMATELY 760 POUNDS (CURRENCY) PER ANNUN 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
PROJECT NUMBER
PROJECT TITLE
PROJECT SUMMARY

SUDAN
650002602

WADI HALFA COMMUNITY DEVELOPMENT: YOUTH TRAINING
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 AGRICULTURE, 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 VERIFIY 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 TURRI PARENTS WILL WORK ON SMALL PLOTS TO GROW THEIR OWN VEGETABLES. THE PLOTS WILL BE ON TWO SECTIONS OF THE PARM (LAKESHORE AND INLAND IRRIGATION). EACH OF 50 FARMERS, 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. PROMOCRE WILL BE MARKETED THROUGH THE COMMUNITY'S COOPERATIVE SOCIETY WITH TECHNICAL SERVICES OF THE OM-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
PROJECT NUMBER
PROJECT TITLE
PROJECT SUMMARY

SUDAN
650002603
WADI HALFA COMMUNITY DEVELOPMENT
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 ISLAND FROM THE LAKESHORE AREA. THE SOIL AT THIS SITE IS OF HAVING ALL 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 GROUNDWATER AT RECOVERABLE DEPTHS, THE AREA OF POTENTIALLY ARABLE LAND WILL BE INCREASED. THE TWO CULTIVATION AREAS (LAKESHORE AND INLAND) WILL COMBINE UNDER COMMON MANAGEMENT AND CONTROL, WITH COOPERATIVE CROP TRIALS TAKING PLACE SIMULTANEOUSLY. A DANDO 400 TIPS DOUBLE 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. OTHERS 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 FEDDAMS. THE BIG WILL BE USED FOR FURTHER WATER EXPLORATION ON ALTERNATIVE SITES ALONG THE LAKE WHERE THE GEOLOGICAL STRUCTURE IS FAVORABLE. IT WILL ALSO BE USED TO EXPAND THE SANITATION SCHEME TO CLIP WITH THE NEEDS OF THE EXPANDING POPULATION.

COUNTRY/BUREAU
PROJECT NUMBER
PROJECT TITLE
PROJECT SUMMARY

SUDAN
650002604
WADI HALFA COMMUNITY DEVELOPMENT: SANITATION
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 REPLACE UNSANITARY METHODS. THE DANDO 400 TIPS MOBILE PEACUSION DRILLING RIG USED FOR BOREHOLE IRRIGATION ALSO WILL BE USED TO DRILL A SERIES OF "LOAD 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 MUD-BRICK, AND WITH CORRUGATED IRON ROOFS. A TAP WILL PROVIDE WATER FOR PERSONAL HYGIENE. THE TOWN COUNCIL WILL UNDERTAKE CONSTRUCTION AND MAINTENANCE OF 40 OF THESE SIMPLE STRUCTURES. TO ENSURE MAXIMUM POSSIBLE HEALTH BENEFIT TO THE COMMUNITY, A PROGRAM OF PUBLIC EDUCATION WILL BE DESIGNED. THREE CHANNELS OF COMMUNICATION WILL BE USED: A) INFORMATION DISSEMINATED THROUGH THE DISSEMINATION THROUGH THE PEOPLE'S COUNCIL TO COMMUNITY LEADERS; B) INFORMATION TO THE GENERAL PUBLIC THROUGH POSTERS/FLEERS; C) INFORMATION TO THE GENERAL PUBLIC THROUGH POSTERS PLACED IN ALL PUBLIC PLACES. HEALTH EDUCATION WILL BE IMPLEMENTED IN COOPERATION WITH THE SENIOR MEDICAL OFFICES AND THE PUBLIC HEALTH OFFICES IN WADI HALFA.

COUNTRY / BUREAU
PROJECT NUMBER
PROJECT TITLE
PROJECT SUMMARY

SUDAN
50002605

WADI HALPA COMMUNITY DEVELOPMENT EDUCATIONAL PROGRAM GRANT (OPG) TO INTERNATIONAL VOLUNTARY SERVICES (IVS) WILL SUPPORT A SIX-PART COMMUNITY OPERATIONAL PROJECT IN WADI HALPA, SUDAN. UNDER THE FIFTH SUBACTIVITY, IVS WILL SUPPORT CATHOLIC RELIEF DEVELOPMENT PROJECT IN WADI HALPA. SUDAN. UNDER THE SUDAN MINISTRY OF HEALTH TO INITIATE A PROGRAM OF HEALTH AND 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 HALPA. 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 NURSE WILL HAVE BEEN TRAINED IN NUTRITION EDUCATION, AND ON COMPLETING HER TRAINING WILL SUPERVISE THE PROGRAM DAY TO DAY. HALPA SCHOOL TEACHERS WILL ATTEND A FOUR-MONTH COURSE IN NUTRITION EDUCATION. THE TOWN'S MEDICAL OFFICER WILL ASSIST THE PUBLIC HEALTH NURSE FULL-TIME. EACH CHILD WILL BE EXAMINED AND WEIGHED. CHILDREN AND THEIR MOTHERS WILL VISIT THE CENTER AT LEAST ONCE A MONTH. EACH CHILD WILL BE EXAMINED AND WEIGHED ON A PARTICULAR DAY. THE NURSE WILL RECORD WEIGHTS FOR ALL CHILDREN ATTENDING THE CENTER ON A PERTICULAR DAY. THE NURSE WILL RECEIVE PRIVATE CONSULTATIONS TO LEARN THE CHILD'S HEALTH STATUS AND WHAT CORRECTIVE STEPS ARE NECESSARY TO ENSURE A CHILD'S GROWTH. CHILDREN WILL BE IMMUNIZED AGAINST INFECTIOUS DISEASES WHEN VACCINES ARE AVAILABLE AND TREATED FOR PROBLEMS. SERIOUSLY ILL CASES WILL BE TRANSFERRED TO THE HEALTH CENTER PHYSICIAN. A GROUP LECTURE ON A MONTHLY BASIS WILL BE GIVEN TO ALL MOTHERS BY THE NUTRITION EDUCATOR. SUPPLEMENTARY FOODS (TWO KILOS OF NON-FAT 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 HALPA IS 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/BOUREAU
PROJECT NUMBER
PROJECT TITLE
PROJECT SUMMARY

SUDAN
650003001

RURAL HEALTH SUPPORT
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) - 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 4,063 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.S. Fund for Population Activities program to integrate BCH services into the PHCP, 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 kit.

COUNTRY/BUREAU
PROJECT NUMBER
PROJECT TITLE
PROJECT SUMMARY

SUDAN
650003002
RURAL HEALTH SUPPORT

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. WHO 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 RMH 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 RMH 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
PROJECT NUMBER
PROJECT TITLE
PROJECT SUMMARY

SUDAN
650003600
SOUTHERN ACCESS ROAD

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 Binisus Commercial Access standards. Construction will include 48 minor structures (36 in Sudan) and 8 major structures (seven in Sudan), including 11 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 Lokichokio 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 60 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
650010000
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 COMP. BRIEFLY 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 FARMANTS WITH NECESSARY INFRASTRUCTURE. SUBSTANTIAL FUNDING BY IDA AND KUWAIT DEVELOPMENT FUND. PROJECT IS IMPLEMENTATION OF SUCCESSFUL GEZIRA PROJECT.

COUNTRY/BUREAU
SUDAN
PROJECT NUMBER
650010300
PROJECT TITLE
SOUTH REGION AGR REHABILITATION DEVEL
PROJECT SUMMARY
IVS PROVIDES PERSONNEL FOR FOODCROPS DEVELOPMENT SUBPROJECT, LIVESTOCK MARKETING AND SAVVY SUBJECT OF BROADER WORLD BANK AGR BUREAU DEVEL PROJECT IN SOUTHERN SUDAN. FOODCROPS COMPONENT INCREASES FOOD PRODUCTION BY MULTIPLICATION AND SALE OF IMPROVED SEEDS. CROP TRIAL 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 INCREASEM OFFTAKE FROM REGIONAL HERD BY PURCHASING ANIMALS FOR WHICH BUYERS CANNOT BE FOUND. EXPERIENCE, DATA LEAD TO PROPOSALS FOR MARKETING PROGRAM.

Appendix X
Supplementary Bibliography

- 1. Climate**
- 2. Geology, Minerals, Soils**
- 3. Flora and Fauna**
- 4. Water Resources and Management**
- 5. Land Use and Agriculture**
- 6. Public Health, Socio-Economic Aspects,
Development**

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