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WORLD BANK

COMPREHENSIVE WATER RESOURCE POLICY WORKSHOP

WATER RESOURCE MANAGEMENT: SUDAN

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Summary

1. Sudan is dependent on agriculture as the major sector of the economy. Agricultural sector contributes about 38 percent of GDP, supports the livelihood of about 80 percent of the population and earns about 98 percent of the foreign exchange. The per capita income estimated at US$320 is among the lowest worldwide and registering decline in real terms. The total population is 26 million with annual growth rate of 2.8 percent, whereas the economy is growing only at 2.1 percent over the period 1976-1989.

2. The agricultural sector is composed of four subsectors: (a) irrigated basically from the Nile and its tributaries either by gravity or pumps with a total area of 4 million feddans[1]; (b) mechanized rainfed with a total area of about 6 million feddans; (c) traditional rainfed with a total area of 10 million feddans; and (d) livestock.

3. The shares of irrigated and rainfed subsector vary from one year to another between 45 percent and 55 percent of agricultural GDP, the main factors being the level, duration and timeliness of rainfall. The country has five distinct rainfall zones. The heavy rainfall (800 - 1,000mm) zone in the south, 600 - 800mm Savannah belt, 200 - 400mm light Savannah, less than 200mm semi-desert and the desert. Rainfall, however, is showing a declining trend over

[1] A feddan is 1.04 acres or 0.42 hectares.

the last 30 years and a high variability from one year to another around the mean. The coefficient of variation increased from a low of 0.13 in the 1960s to 0.33 in the 1970s and 0.34 in the 1980s. These trends have direct implications for water resource use and management because of increased crop failures, reduced carrying capacity which leads to overgrazing and decreased levels of recharging which would reduce water tables, draught and desertification.

4. With regard to irrigated agriculture, irrigation water represents the major limiting factor to production. The country has four dams: two on the Blue Nile at Sennar (1925) with a capacity of 0.9 milliard m^3; Roseires (1963) with a capacity of 3.24 milliards m^3; one dam on White Nile at Jebel Aulia (1937) with a capacity of 3.5 milliard m^3 which was essentially designed to supply Egypt with water during the low flow in summer, and was handed over to the Sudan after the construction of the High Dam; and Kashm Elgerba dam (1962) on Atbara River with a designed capacity of 1.3 milliards m^3.

5. These dams are riddled with serious problems:

(a) Siltation is a serious problem. The capacity of Khasm Elgerba Dam was reduced to 45 percent (0.59 milliards m^3) only.

(b) Evaporation losses are high. For example losses from the High Dam are estimated at Aswan guage to be 10 milliards m^3 or 12 percent of total discharge.

(c) Siltation of main irrigation canals of the major irrigation schemes, estimated at 16.7 million m^3 annually whereas the desilting capacity rate is about 10.2 million m^3 leaving silt to accumulate at a rate of 6.5 million m^3 per annum. By 1990, the total backlog of silt is 46.3 million m^3.

(d) The irrigation costs are high, and dam construction is expensive. Pump irrigation is totally dependent on imported inputs in terms of engine pumps, spare parts, pipes and regulatory structures; and foreign exchange is becoming increasingly scarce.

6. Over the years, Sudan failed to continue maintaining the irrigation system. During the 1980s, multinational donors under the leadership of the World Bank invested heavily in rehabilitation of these irrigation schemes. In spite of this, irrigation investments in real terms declined considerably by 40 percent since 1982.

7. Production relationships in the irrigated schemes is based on the parastatal management supply of irrigation water with the technical assistance of the Ministry of Irrigation (MOI), and the imported agricultural inputs (such as fertilizers, insecticides) at cost whereas farmers provide family and hired labor inputs. The farmers then pay land and water charges, in fact deducted from the sale of their produce, mainly cotton. This land and water charge individual accounting system replaced the share cropping joint accounting system on the grounds that the latter had led in

the past to inefficient utilization of water at the field level. With the introduction of the land and water charge system in the early 1980s, agricultural production recovered significantly. One other added reason for this initial success was the improvements in the pricing system. Subsequently the economy became highly distorted and the farmers are being subjected to heavy taxation in lieu of the over-valuation of the national currency. Cotton international prices are converted at an exchange rate of LSd8.3 per US$ whereas the commercial exchange rate is LSd12.3 per US$ and the parallel exchange rate (within the banking system through transfer from one bank account to another) is LSd65 per US$. In addition, the inefficiency in the irrigation system and the alteration of the crop and cropping pattern to achieve objectives of food self sufficiency (implies utilization of resources for production at <u>comparative disadvantage</u>) have resulted in misusing the expensive irrigation water <u>non-optimally</u> and <u>inefficiently</u>. In contrast, a policy in pursuit of <u>food security</u> would ultimately lead to more efficient resource use; if through research per unit resource productivity could be increased and new high yielding varieties could be introduced. In conclusion, economic distortions lead to mismanagement of resources, including the irrigation water.

8. There are competitive uses for irrigation water from dam reservoirs. For example, allocation of additional water for expanded wheat area during the winter (temperate) season means that the area under the cotton crop in the preceding summer season would have to be reduced proportionately. Moreover, this means that

water will have to be released earlier for the production of wheat and in Sudan for the period March - June just before the start of the Blue Nile flow, there would be no generation of hydropower. Not only is cotton production affected, but also electricity supply for industrial housing and service sectors is seriously curtailed jeopardizing the normal functioning of the economy and exerting pressure on foreign currency resources. In fact, it was found that the domestic resource cost (DRC) the opportunity cost of domestic resource use in cotton production to earn one unit of foreign exchange (0.37) is lower than that used to save one unit of foreign exchange from wheat production (DRC for wheat is 0.55).

9. One aspect of environmental hazard associated with irrigation relates to health, specifically water associated diseases such as malaria, schistosomiasis and socio-economic diseases where lack of investments in health services lead to increased health hazards such as increased fly breeding and henceforth epidemics of gastroenteritis, typhoid and trachoma. There is also the pollution from pesticides and fertilizer.

10. Urban centers in Sudan depend for their water supply on surface water (including the Nile for Khartoum, Northern and Central regions) and underground water (especially Eastern, Northern, Kardofar and Darfur). However losses from the system are very high in Khartoum estimated at 62.5 percent and 16 percent in the Central Region, but are around 5 percent and less for other regions. Such losses for Khartoum, the largest urban consumption area are not acceptable.

11. Because of the decline of rainfall and draughts and for reasons associated with profitability of agricultural production in the Northern Region, marked expansion in groundwater exploitation has taken place. There is evidence that the water table has dropped significantly. In Seliem Basin in the Northern Province the water table dropped from about 20 feet to 300 - 400 feet for tubwells irrigation. There is evidence of salination as well. Northern Kardofan and Northern Darfur construction of sporadic, not very well planned artisan wells increased the danger of over-grazing and helped accelerate the pace of desertification.

12. Thirty-two years after the 1959 Nile Water Agreement between Sudan and Egypt, Sudan has not yet utilized its share of 18.5 milliard m^3. Sudan, at present, utilizes about 13 milliard m^3.

Nile Waters Agreement (1959)

Sudan	18.5 milliard m^3
Egypt	55.5 milliard m^3
Evaporation at Nuba Lake	10.0 milliard m^3
	84.0

This discharge came from:

Blue Nile	55 milliard m^3
White Nile	29 milliard m^3
Total	84

White Nile total encatchment is almost equivalent to the Blue Nile at about 53 milliard m^3, but 34 milliard m^3 are lost in the Sud

area. Hence, Janglei Canal was envisaged to reduce evaporation losses. Janglei Canal will only save about 4 milliard m^3 which would be divided between Sudan and Egypt - 2 milliard m^3 for each. The construction was terminated for security reasons though 70 percent complete.

13. The function of institutions in comprehensive water resource management would be to provide services in the following fields:

- Irrigation and drainage
- Urban water supply for human consumption
- Rural water supply for human and animal consumption
- Water conservation and regulation's on water quality
- Investments for increased future supply of water
- Regulatory functions on water demand
- Environmental aspects that aim at the preservation of the ecosystem
- Drought and desertification control
- Public awareness and support for comprehensive policies that aim at optimal water resource use

14. Topologies of institutions:

They vary with:

a) Level of development

b) Natural endowments

c) Nature of the problem

d) Type of government and the socio-economic order

They could be at different levels:

a) National (public such as water boards and irrigation corporations. Regional (provincial, private).

b) Regional such as the Joint Technical Committee for Nile Waters between Sudan and Egypt, better bilateral.

c) International

Lack of broad regional agreement among Nile Basin countries; the Nile Basin has nine countries (Tanzania, Burundi, Rwanda, Uganda, Zaire, Congo, Ethiopia, Sudan and Egypt). There is only the 1959 agreement between Sudan and Egypt. Informally, there is a UNDP project in Uganda in which Uganda, Sudan and Egypt participate in monitoring and data collection, Ethiopia maintains observer status. Sudan and Egypt also cooperate in accordance with the 1959 agreement in joint projects to increase water conservation such as Janglei Canal. There had been extensive exchange of views and detailed studies for power interconnections between Ethiopia and Sudan during 1986 - 1989 in a study under the auspices of the World Bank and Finland.

15. Data and information, research and feedback mechanisms are essential for proper functioning of institutions. Furthermore in a closely interlinked field of water management coordination is vital for resource use.

16. Multidisciplinary approach and variation in technical expertise are prerequisite for optimal resource management.

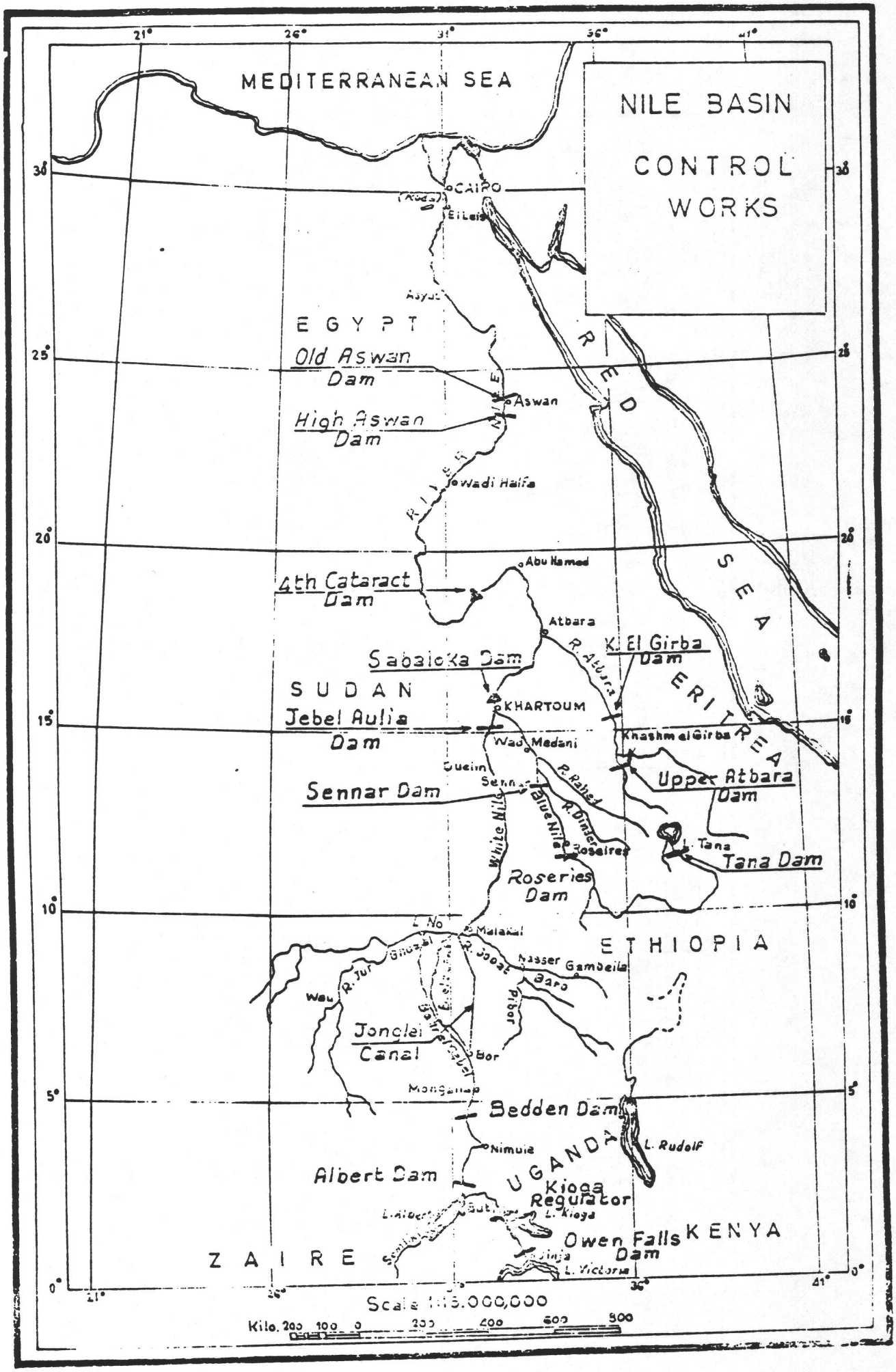

NILE BASIN
CONTROL
WORKS
MEDITERRANEAN SEA
CAIRO
EGYPT
Old Aswan Dam
High Aswan Dam
Aswan
Wadi Halfa
RIVER NILE
RED SEA
Abu Hamed
4th Cataract Dam
Atbara
R. Atbara
K. El Girba Dam
Sabaloka Dam
SUDAN
KHARTOUM
Jebel Aulia Dam
Wad Medani
Khashm el Girba
ERITREA
Sennar Dam
Sennar
R. Rahad
R. Dinder
Upper Atbara Dam
White Nile
Blue Nile
Roseires
L. Tana
Tana Dam
Roseries Dam
ETHIOPIA
Malakal
Gambela
Baro
Wau
R. Jur
Jonglei Canal
Bor
Bedden Dam
Nimule
L. Rudolf
UGANDA
Albert Dam
Kioga Regulator
L. Kioga
Owen Falls Dam
KENYA
ZAIRE
L. Victoria
Scale 1:5,000,000
Kilo. 200 100 0 200 400 600 800

Figure 1

THE NILE BASIN
ANNUAL TOTAL RAINFALL

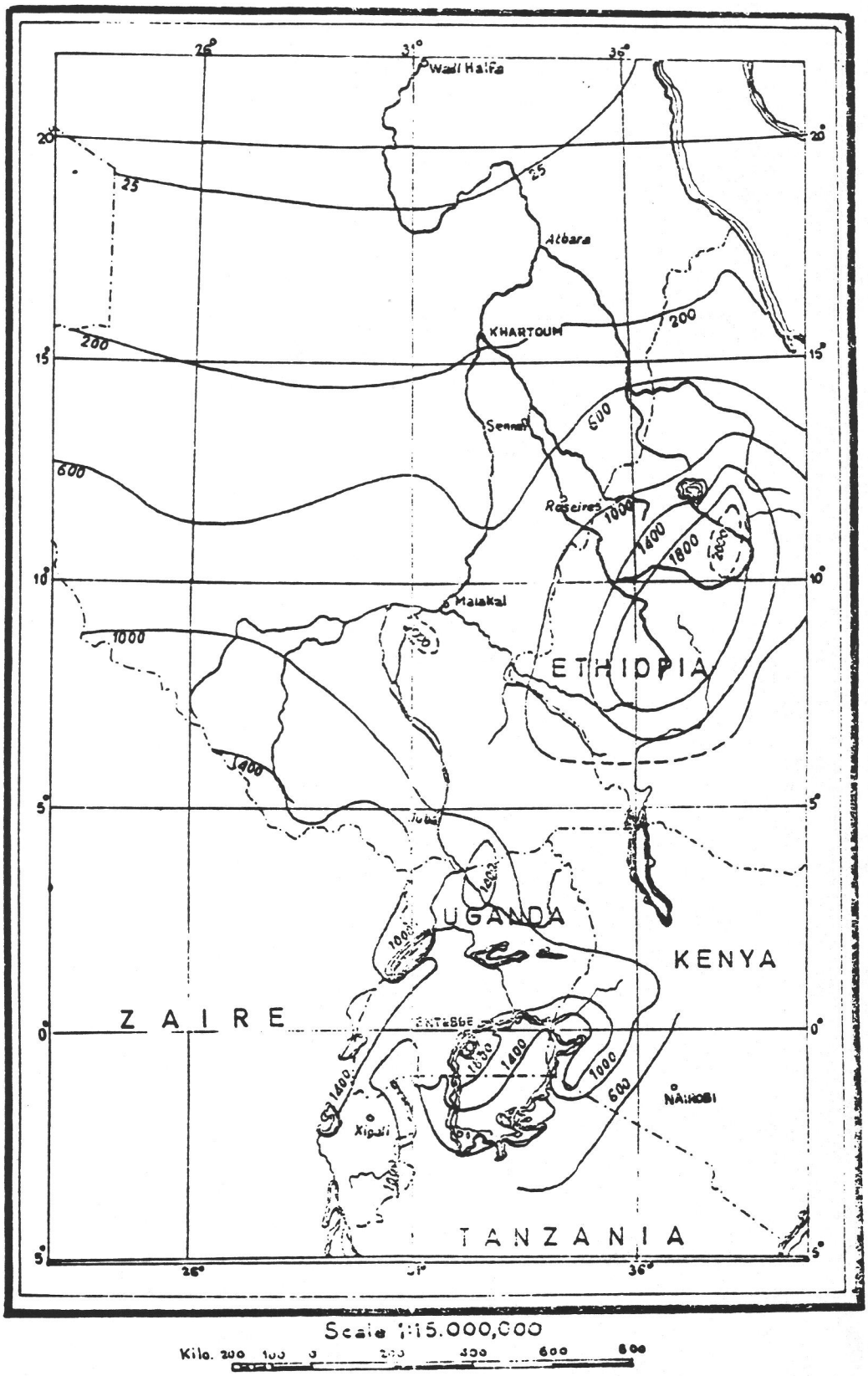


Figure 2

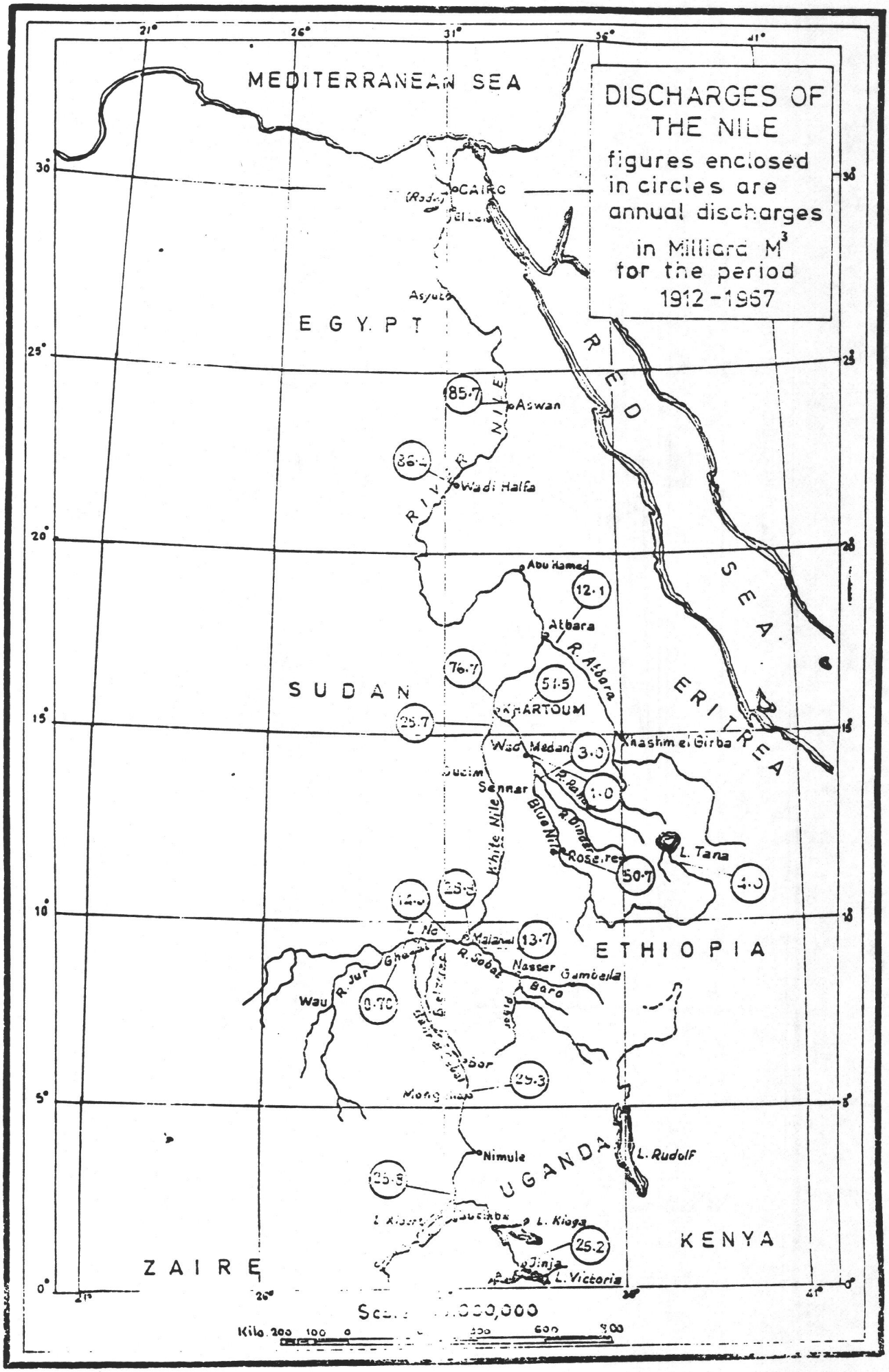
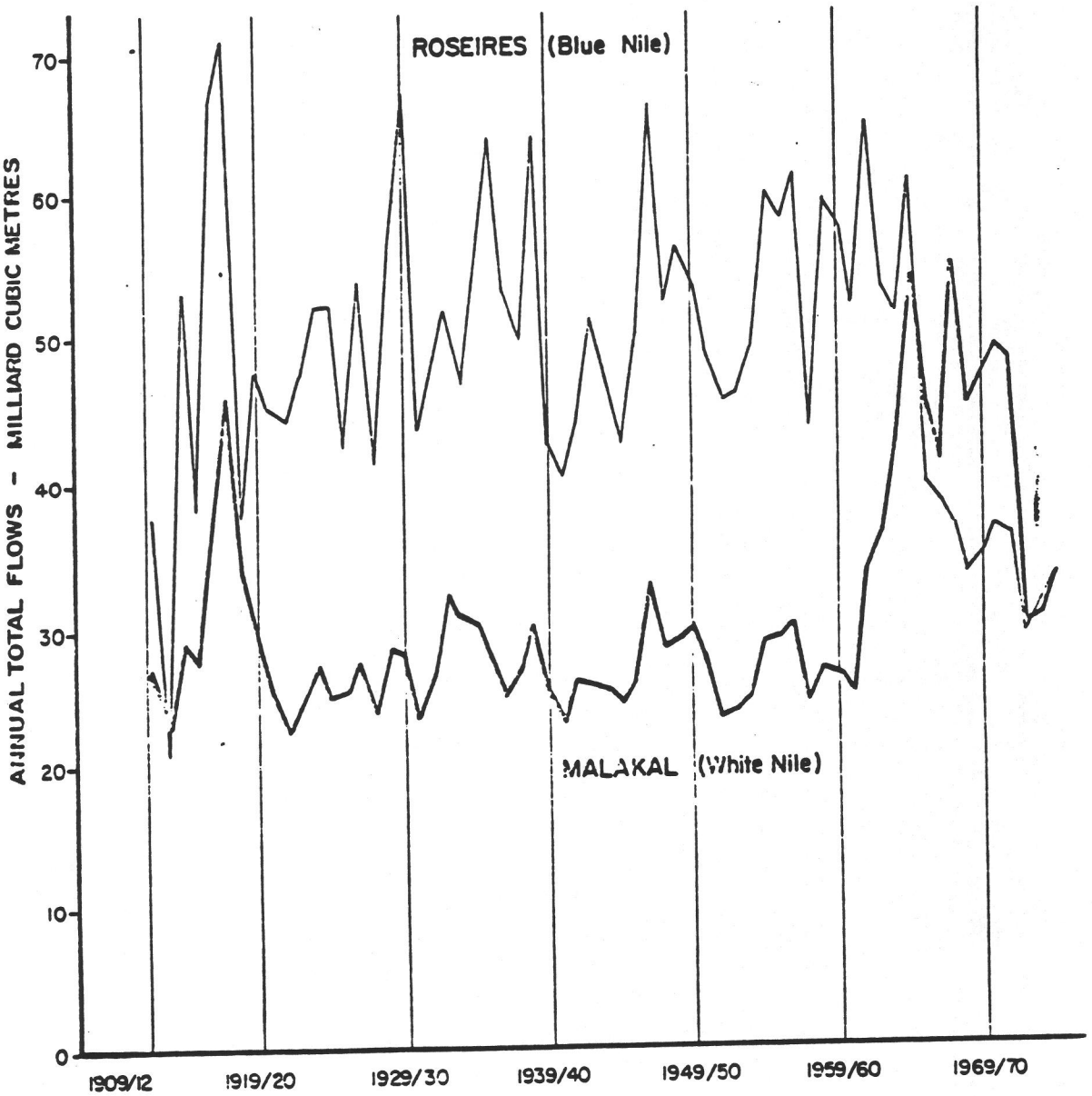

DISCHARGES OF THE NILE
figures enclosed in circles are annual discharges in Milliard M³ for the period 1912-1957
MEDITERRANEAN SEA
CAIRO
EGYPT
RED SEA
ERITREA
SUDAN
ETHIOPIA
UGANDA
KENYA
ZAIRE
Aswan
Wadi Halfa
Abu Hamed
Atbara
KHARTOUM
Wad Medani
Khashm el Girba
Sennar
Roseires
L. Tana
White Nile
Blue Nile
R. Atbara
R. Sobat
Nasser
Gambela
Baro
Wau
R. Jur
Nimule
L. Rudolf
L. Kioga
Jinja
L. Victoria
185.7
36.4
12.1
76.7
51.5
25.7
3.0
1.0
50.7
4.0
14.0
23.4
13.7
0.70
25.3
25.6
25.2
Kilo 200 100 0 500 600 900

Figure 3

Figure 4.



ANNUAL TOTAL FLOWS AT ROSEIRES AND MALA

Figure 5

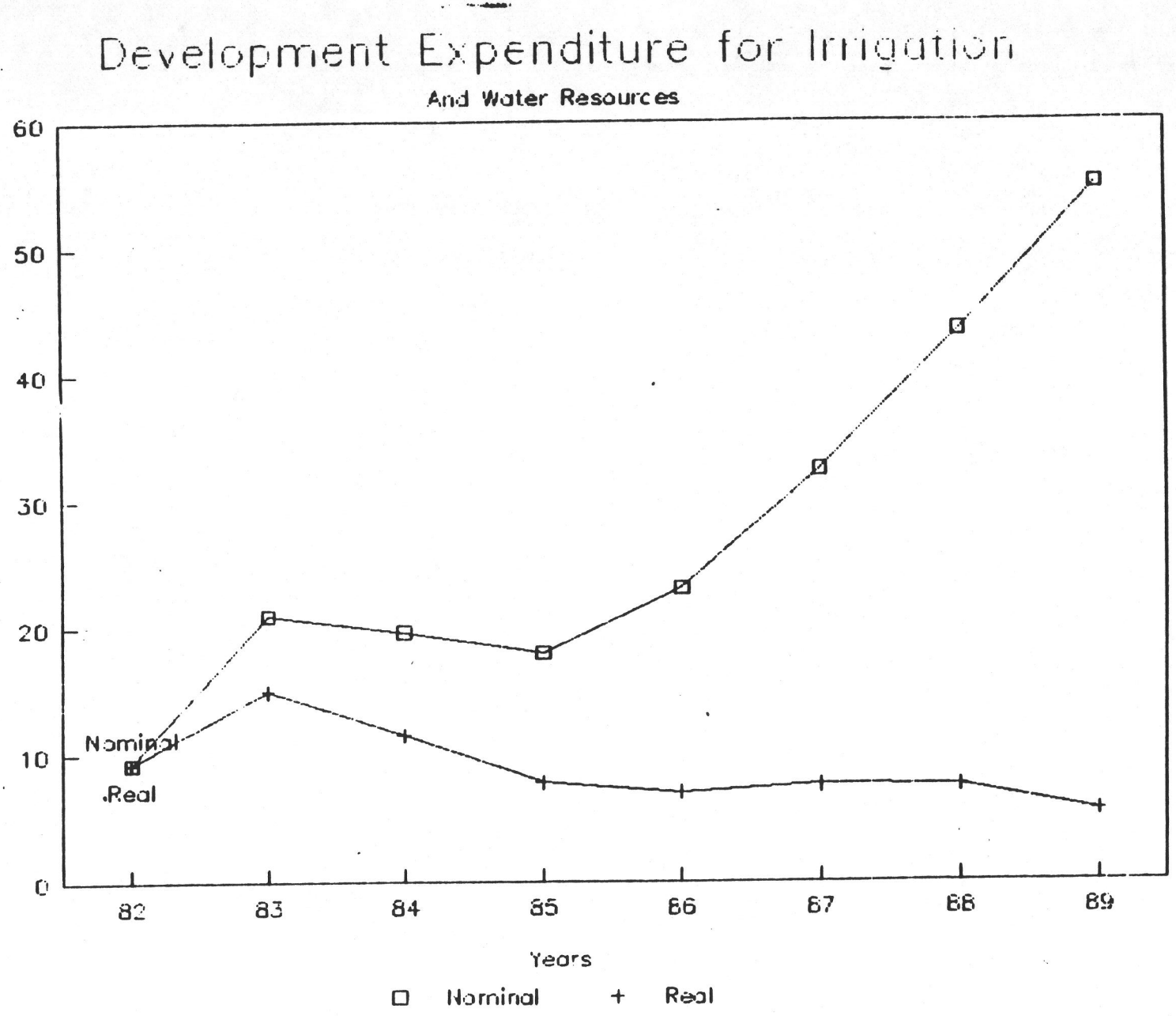

Development Expenditure for Irrigation
And Water Resources
60
50
40
30
20
10
0
LS Million
Nominal
Real
82
83
84
85
86
87
88
89
Years
Nominal
Real

Table 1--Trends in relative share of agriculture GDP components

	1981	1982	1983	1984	1985	1986	1987	Average 1981-87
AGR-GDP[a]	0.38	0.35	0.35	0.31	0.36	0.35	0.31	0.35
Crops	0.59	0.55	0.55	0.57	0.62	0.58	0.52	0.57
Irrigated	(0.41)	(0.60)	(0.63)	(0.75)	(0.56)	(0.55)	(0.67)	(0.60)
Rainfed	(0.59)	(0.40)	(0.37)	(0.25)	(0.44)	(0.44)	(0.32)	(0.40)
Mechanized	(0.25)	(0.14)	(0.14)	(0.07)	(0.21)	(0.24)	(0.12)	(0.17)
Traditional	(0.34)	(0.26)	(0.23)	(0.18)	(0.23)	(0.20)	(0.20)	(0.23)
Livestock	0.33	0.36	0.36	0.32	0.29	0.33	0.38	0.34
Forestry and fishery	0.08	0.09	0.09	0.11	0.09	0.09	0.10	0.09

Source: MFEP data files.

[a] AGR-GDP refers to agriculture's contribution to gross domestic product.

Table [redacted]2--Mean rainfall level and days for selected stations, 1960-1986

Site	Province	Latitude	Longitude	Mean Rainfall	Coefficient of Variation	Mean Days
Gedarif	Kassala	14°02'N	35°24'E	595.9	0.17	54.2
El Fasher	North Darfur	13°38'N	25°20'E	220.9	0.29	29.0
Sennar	Blue Nile	13°33'N	33°37'E	427.0	0.27	34.6
Kosti	White Nile	13°02'N	32°40'E	355.6	0.24	41.3
En Nahud	North Kordofan	12°40'N	28°26'E	352.3	0.27	39.2
Nyala	South Darfur	12°04'N	24°53'E	417.3	0.20	38.6
Roseries	Blue Nile	11°51'N	34°24'E	646.9	0.14	46.7
Kadugli	South Kordofan	10°00'N	29°43'E	681.8	0.20	61.4

Source: Computed from Sudan Meteorological Department (raw data).

Table [redacted]3--Distribution of mean rainfall, average rainy days, and average rain per day, 1960-1986

Site	Mean Annual Rainfall			Average Rainy Days			Average Rain Per Day		
	1960-69	1970-79	1980-86	1960-69	1970-79	1980-86	1960-69	1970-79	1980-86
	(millimeters)			(days)			(millimeters)		
Gedarif	579.1	623.2	543.5	49.7	59.7	50.6	11.7	10.4	10.7
El Fasher	271.9	203.0	168.6	38.9	26.4	18.6	7.0	7.7	9.1
Sennar	461.7	446.2	315.0	37.9	32.3	32.0	12.2	13.8	9.8
Kosti	372.8	391.4	273.0	47.7	41.4	31.0	7.8	9.5	8.8
En Nahud	373.0	349.7	337.9	44.6	37.6	32.8	8.4	9.3	10.3
Nyala	470.1	414.4	367.5	42.8	38.7	33.2	11.0	10.6	11.1
Roseries	727.6	665.5	504.9	59.9	44.6	29.4	12.1	14.9	17.2
Kadugli	748.0	673.5	584.3	58.7	67.4	56.8	12.7	10.0	10.3

Source: Computed from Sudan Meteorological Department (raw data).