THE DEMOCRATIC REPUBLIC OF THE SUDAN

MINISTRY OF IRRIGATION & H. E. E.

CONTROL AND USE OF NILE WATERS IN THE SUDAN

Khartoum June 1975

THE DEMOCRATIC REPUBLIC OF THE SUDAN

MINISTRY OF IRRIGATION & H. E. E.

CONTROL AND USE OF NILE WATERS IN THE SUDAN

Khartoum June 1975

Printed by
KHARTOUM UNIVERSITY PRESS
P. O. Box 321, Khartoum
The Democratic Republic of the Sudan

CONTENTS

THE CONTROL AND USE OF NILE WATERS IN THE SUDAN

1. INTRODUCTION :

The World to-day witnesses a tremendous increase in population and a genuine effort to raise the standard of living of mankind at large. The utilization of water resources constitutes an important step towards the realization of economic prosperity as rivers have tremendous potentials for agricultural development, generation of hydro-power, domestic use of water, industrial uses and fisheries.

In order to achieve these objectives it is indeed necessary to carry out conservation and control works. Water is a valuable natural commodity similar to any other natural commodity except that it has a characteristic of its own. Minerals like iron, gold or bauxite, if not exploited to-day, can always be mined in the future. On the other hand, water flowing in rivers if not utilized today, will waste into the sea without recovering its value again. It is estimated that one milliard of water released from Lake Victoria will provide approximately two million sudanese pounds annually for Uganda if the whole hydro-power potential of Victoria Nile is developed. If this same milliard is not utilized for agriculture in the Sudan and is left to flow northwards, the Sudan will lose about eight million pounds annually. From the above it is evident that the control and conservation of the Nile will yield a tremendous wealth to the Countries concerned. Before going into details it is not out of place to give a short descriptive account of the Nile and its tributaries.

2. *Description of the Nile Basin :*

The most distant source of the Nile is River Luvironza, a tributary of the Kagera river which flows in Lake Victoria, the second largest freshwater Lake in the World. This Lake straddles the equator on the East side of Africa between Longitudes 29° and 36° East and latitudes 1° North and 4° South. The general shape of the catchment is an open trough, running from North to South. An important feature of the whole basin is the prevalence of swamp land. Poor drainage, coupled with climatic conditions favourable to vegetation growth, have produced swamp conditions in many areas. Swamps are found throughout a wide range of elevation from high altitudes peat swamps at Kigezi to the fringe swamps along the shores of the Lakes. Along both the North and the South shores of the Lake, swamps occur at the head of every inlet in a much indented coastline. The major rivers create large areas of swamps in their own deltas.

The Kagera and Mara rivers provide examples of delta swamps. The dominant permanent swamp vegetation in most areas are the papyrus, the long grass and the water lilies and water chesnuts. Particulars of the Lake and its catchment can be summarised as follows :—

Area of basin	—	262,000 km2
Area of Lake	—	67,000 km2
Mean depth of Lake	—	40 m
Average annual evaporation	—	1120 mm.
Average annual rainfall	—	1200 mm.

Out of Lake Victoria emerges Victoria Nile at Jinja which runs in a well defined channel for 70 Kilometres from its exit interrupted by a series of rapids before it enters into lake Kioga a little distance from Namasagali. Kioga is generally a shallow lake and its maximum ever recorded depth is about 7 metres. The areas of open water and swamps are 1760 km2 and 4510 km2 respectively.

Its basin lies between latitudes 0°30′ and 3°30′ and longitudes 31° 30′ E and 34° 50′ E. Kioga receives the drainage from the high land North of Lake Victoria watershed and from the slopes of mounts Elgon and Debasin. The outlet of the Lake is at Masindi Port after which Victoria Nile runs as a sluggish river before it is interrupted by another series of rapids till it passes over Murchison falls after which it broadens till it ends in a swampy delta at Lake Albert. This Lake receives a good deal of water from the Semliki river which emerges from Lake Edward and is fed by tributaries coming from the western slopes of the Ruwenzori along its way to Lake Albert. Lake Albert is about 5300 km2 with an average rainfall of 810 mm. and an annual evaporation of 1200 mm. It is worth mentioning at this juncture that the total fall between Lake Victoria and Lake Albert is about 514 metres and the fall between Lake Edward and Lake Albert is about 300 metres. These tremendous falls give an idea of the hydro-power potential which can be exploited. Out of Lake Albert emerges Albert Nile which flows North-ward through a flat plain which is in fact an extension of Lake Albert as far as Nimule in the Uganda – Sudan frontier. At Nimule, the river plunges once more through a narrow rocky gorge in a series of rapids known as the Fola rapids and from Nimule northward the river is generally known as Bahr El Jebel. Twenty kilometres North of Numile River Aswa flows into Bahr El Jebel. Between Nimule and Rajaf the river drops 153 metres in a distance of 156 kilometres. North of Mongala the river enters the great swamps of the southern Sudan. The distinctive feature of the river from here on is this border of marshland gradually increasing in width until, after passing through the Aliab valley where it is several miles across, it enters the Sudd region.

Here, the main channel of the river, supplemented by numerous side channels is narrow and winds its way in a serpentine course through the thick vegetation of the swamps which extends for miles on either side. At one point water is taken off through artificial cuts into Bahr El Zeraf which rejoins the main channel below and is joined by Bahr El Ghazal which drives its water from the west in a different catchment, but its contribution is negligible and the river, now called the White Nile, takes a sharp turn to the East. It is first joined by Bahr El Zeraf and then a few miles down-stream by the Sobat river flowing in from the East deriving its water from the Ethiopia highlands and hence from a catchment area different from that of the main river. After this the White Nile leaves the Sudd area and turns North again while the bordering swamps and marshland begin to narrow being confined by high land on either bank to a width of about one mile. It then flows slowly northward until it joins the Blue Nile at Khartoum.

The Blue Nile basin lies on the Northern side of the Ethiopian plateau between latitudes 8° and 12° 30′ North and Longitudes 34° 30′ East. The rains falling in this basin feed Lake Tana and the tributaries joining the Blue Nile between Lake Tana and Roseries for a distance of 900 kilometres. The area of Lake Tana is about 3000 km^2 with an elevation 1800 metre a.m.s.

The drop between Tana and Khartoum is about 1470 metres. The average contribution of Lake Tana to the Blue Nile is about 4 milliard M^3 annually which is about 7% of the total flow of the Blue Nile. On its way to join the White Nile, the Blue Nile is joined by rivers Dinder and Rahad inside the Sudan.

After Khartoum the river is named the Main Nile. It is joined by River Atbara. After this the river meanders through the great

Desert and is not fed any more by any tributary until it flows into the Mediterranean Sea.

3. HYDROLOGY OF THE NILE :

(1) *Flow Discharges* :—

The Nile is one of the most remarkable and the second longest river in the World. The length of its course from the most remote source near Lake Tanganyika to the sea is about 4000 miles. Its rival in length is the Mississipi-Missouri river which is about 4200 miles long.

With regard to volume of flow, it is exceeded by many rivers. The Amazon in Latin America has an annual flow of 2500 milliard M^3 and the Congo has an annual flow of 1250 milliard M^3 as compared with the Nile having an average annual flow of 84 milliard M^3, measured at Aswan. This flow constitutes only 6% of the total amount of rain falling in the Nile basin. The Nile is known for its marked seasonal and annual variations. The variation in discharge is illustrated by the fact that more than 80% of its annual flow occurs from August to October and only 20% occurs during the remaining nine months. It is also interesting to note that the annual discharge of the Nile for the year 1913–1914 was 41 milliard M^3 as compared to 151 milliard M^3 in 1878 – 1879 while the average annual flow for this century is 84 milliard M3. The percentage contribution of the main tributaries of the Nile is as follows :—

Blue Nile	59%
Sobat	14%
River Atbara	13%
Bahr El Jebel	14%

Or in other words 85% of the flow of the Nile comes from the Ethiopian Plateau and only 15% comes from East Africa. During flood time the percentage contribution of the tributaries is as follows :—

Blue Nile	68%
River Atbara	22%
Sobat	5%
Bahr El Jebel	5%

Or in other words during flood 95% of the water comes from the Ethiopian highlands and only 5% comes from East Africa.

During the low period 60% of the Water comes from Ethiopia and 40% from East Africa.

The low contribution of the White Nile to the Main Nile is attributed to the great amount of water which is wasted by evaporation in the swamps while the Ethiopian Plateau acts efficiently for draining the water to the Nile.

These figures are very important when we come to consider the conservation and control works of the Nile.

The White Nile is characterised by its relatively uniform flow as compared to the Blue Nile and Atbara River. Its average seasonal variation at Malakal for the period 1912–1962 ranges from 525 M^3/Sec. to 1215 M^3/Sec. as compared to the average variation of the Blue Nile at Roseires for the same period which ranges from 125 M^3/sec. to 6200 M^3/sec.

These seasonal variations are important from an irrigation point of view; as the marked difference of flows in the Blue Nile between the flood period and the low period necessitates storage; while the rather uniform flow of the White Nile makes annual storage for irrigation unnecessary.

(ii) *The Sediment Problem of the Nile :*

The silt carried annually by the Nile is about 110 million tons as measured in Egypt. This silt content is much less than that carried by other rivers i.e. the Mississipi (150 million tons), the Colorado (260 million tons) and the Yellow River (2,000 million tons). The average suspended matter of the Nile during flood is 1600 p.p.m. and the maximum is about 5400 p.p.m.

The Rivers flowing from the Ethiopian Plateau, especially the Blue Nile and River Atbara, are the main source of silt in the Nile. The White Nile carries relatively less silt. This is due to the fact that most of its silt is deposited, on its way, at the Lakes, swamps and marshes through which the White Nile flows.

The estimated annually suspended matter of the Blue Nile is 140 million tons. Silt measuremets nof the Blue Nile in 1955 had shown that during the flood the silt load varried from 7,000 p.p.m to 4,000 p.p.m. Its mechanical analysis had indicated that sand constitutes about 45%, silt about 15% and clay about 40%.

The annual sediment load of River Atbara is about 8 million tons. The grain size analysis of the sediment samples from River Atbara indicated that sand is 52%, silt is 15% and clay is 18%;

rather similar to the Blue Nile.

Silt has influenced considerably the designs and operations of dams built on the Nile as well as irrigation canals.

The design of High Aswan Dam allows for a dead storage of 30 milliard M^3 to cater for the arrest of 60 million M^3 of silt carried annually by the Nile and assuming a life time of 500 years for the reservoir. The Roseires reservoir will lose its capacity of approximately 3 milliard M^3 at an average rate of about 15 million M^3 per year.

Sennar Dam which was built in 1925 had by now lost about 25% of its 1 milliard capacity. Khashm el Girba dam, which was completed in 1961 was losing its capacity at an average rate of 50 million M^3 per year during the period 1964–1973. However this enormous siltation is attributed mainly to the working arrang ement of the dam. The new regulation is expected to reduce the annual siltation to 5 million M^3 per year.

On the other hand the irrigation canals in the Sudan are cleared annually of the silt accumlated in its beds in spite of the fact that the annual storage dams are filled after the flood water laden with silt water has passed away. This clearance is costing millions of pounds annually.

(iii) *Quality of Nile Waters :—*

The chemical composition of the Nile waters varies from one tributary to the other. The soluble salts are available in the quantities shown below :—

	Parts per Million.
Lake Victoria	80
Victoria Nile	100
Lake Edward	670
Lake Albert	590
Lake Tana	170
Albert Nile	160
Blue Nile at Khartoum	130
White Nile at Khartoum	140
Nile at Cairo.	170

The quality of the water of the Blue Nile and the White Nile varies from class C_1 S_1 during the flood to C_2 S_1 after the recession of the flood. The Blue Nile waters are slightly saline during most of the months of the year except in May and June when the salinity rises to a medium level. The White Nile waters are also slightly saline except in April, May and June. Generally speaking the White Nile waters are compartively more saline than the Blue Nile waters during most of the months except in July and August when the salinity of the waters are equal.

With regards to direct sodicity, the waters of the two rivers contain little sodium which is not deterimental to plant growth. This is verified by the fact that the maximum sodium absorption ratios are on the average 1.96 for the White Nile in December and 1.44 for the Blue Nile in August.

With regards to Residual Sodium Carobonate (RSC) the Blue Nile waters contain a safe amount of bicarbonates all the year round whereas the White Nile waters contain rather an unsafe amount of bicarbonates in June, a marginal amount in May and a safe amount during the other months.

In general, data available on the chemical composition of the Nile waters show a low soluble content, a high Ca/Na ratio and a low percentage of sodium, which classify the waters as excellent for irrigation purposes according to the classification given by the U.S. Salinity Laboratory.

4. NILE CONTROL :—

Before the present century irrigation in Sudan was confined to the inundated basins in the Northern Province and to the patchy areas which were irrigated by Sagias (Water Wheels) and Shaduf. Irrigation by pumps was introduced to the Country in the early years of this century.

By 1919 areas irrigated by pumps was only 38,500 feddans. Perennial irrigation was introduced earlier in Egypt. By 1890, the area under perennial irrigation in Egypt was 2,900,000 feddans which consumed the whole of the natural flow of the Nile during the low period from January to July. The basin areas at that time were 2 million feddans. In order to meet further expansion in irrigation development in Egypt and Sudan it was necessary to construct annual storage dams which would be replenished by the flood water tobe released during the period of shortage. Aswan dam was built in 1904 with an initial storage of 1 milliard M^3 and was further heightened in 1912 and 1938 to provide 5 Milliard M^3 of stored water.

Jebel Aulia dam was also built by Egypt in 1937 on the White Nile South of Khartoum with a net storage capacity of 2.5 milliard M^3 of water. These works enabled Egypt to proceed with its agricultural development without difficulty.

In 1920 the Egyptian Government appointed the Nile control commission to advise on the ultimate needs of Egypt and the Sudan and to propose the projects which would make available irrigation water to meet the agricultural expansion in the two Countries. The Commission recommended, among other things the construction of Sennar Dam across the Blue Nile in the Sudan to irrigate the Gezira plains. The initial idea was to construct only a barrage to a level that commands 100,000 acres. But with the incidence of an extremely low flood in 1914 and with the introduction of long staple cotton for agriculture which needs water up to April the idea of the barrage was changed to a proper dam with ample storage. The dam was built in 1925. Its regulation was governed by the 1929 Nile Water Agreement which was concluded in the form of exchange of notes between Egypt and Britain. According to that Agreement the natural flow of the Nile during the restricted period (January-July) was reserved to the use of Egypt. During this period Sudan was allowed to draw water from Sennar storage.

Sennar dam enabled Sudan to develop the Gezira scheme (1,000, 000 feddans) and to expand in the pump schemes along the main Nile and its tributaries : The developed area in 1963 was 1.4 million feddans with a consumption of 4 milliard M^3 of water.

By 1961 the Sudan started to realize the need for more irrigation development and was faced with the imposed restriction on the use of the Nile waters.

Studies for the possibility of constructing a dam on the Blue Nile at Roseires started. In 1952 Egypt was contacted for the approval of raising Sennar dam by one metre and Jebel Aulia Dam on the White Nile by 10 cms, to enable the Sudan to draw an extra 200 million M^3 of water during the restricted period to meet its agricultural expansion.

After independence Sudan embarked on the development of Managil Project,an extension to the Gezira scheme of approximately 800,000 feddans. As the Sudan was not allowed to draw from the natural flow of the Nile after January and as the storage available at Sennar reservoir was already utilized for other areas, Egypt agreed to allow the Sudan to store 850 million M^3 at Jebel Aulia reservoir temporarily, as a virtual storage to enable Sudan to withdraw from the Blue Nile the same amount during the restricted period provided the same amount was released from Jebel Aulia reservoir. This arrangement was the only way left for the Sudan to enable it go ahead with its agricultural development without impairing the rights to Egypt established by 1929 agreement.

This adverse situation of restricting the Sudan from having a free hand in the use of water was resolved by the establishment of the over-year storage of High Aswan Dam and by the conclusion of the 1959 Nile Waters Agreement between Egypt and the Sudan. According to the agreement the Sudan share of Nile Waters increased from 4 milliard M^3 to 18.5 milliard M^3, as measured at Aswan, out of an annual average flow of 84 milliard M^3. Sudan was allowed to construct storage works on the Nile which it considers essential for the utilization of its share. The construction of Khashm El Girba dam on river Atbara, a storage capacity of 1.3 milliard M^3 which started in 1960, was completed in 1966. The dam is at present irrigating 450,000 acres of land. At the same time Roseires dam on the Blue Nile was built in 1960 and completed in 1966.

The dam has an initial storage capacity of 3 milliard M^3 and an ultimate capacity of 7.6 milliard M^3 which can be made available by raising the dam an extra 10 metres. The two dams will enable the Sudan to utilize the share of Nile waters. Plans are being drawn at present to get the maximum use out of Roseires Dam and to study the possibility of constructing the second Phase of the Roseires Dam.

5. IRRIGATION :—

Irrigation is required for agriculture where ever the rainfall is deficient during the whole or part of the period of growth of the crops to be cultivated – From this point of view the Sudan may be divided into three regions.

In the Northern Sudan from the Egyptian boundary to about latitude 16°, the mean annual rainfall, less than 100 mm., is so deficient and irregular that it must be disregarded in any reliable scheme of agriculture.

The second region embracing most of the Central Sudan, lies roughly between 100 mm. and 500. mm. isohytes. Here, in years of average to good rainfall, rain crops can be grown in the northern portion of the area only on a limited scale, but further south with a fair degree of certainty, though still with wide variations in annual extent and yield, depending on the incidence of rainfall. But since the rainy season is short, the crops grown are limited to various varieties of millet and other quick maturing crops. Crops with a period of growth extending into or through the winter months such as long-staple cotton, legumes, wheat and of course fruit and garden crops, can only be grown on irrigated lands.

In the third region, south of latitude 12°, the mean annual rainfall ranges from 500 to over 1200 mm. and generally speaking, this suffices for all cultivation, though from time to time a season of comparative drought seriously affects the crop in areas and yields. Here irrigation is only needed on a small scale during the dry season from December to April.

Irrigation in the Sudan may be mainly classified as follows, according to the method used and the source of supply :—

(a) Systematic irrigation by gravity from the river.
(b) Systematic irrigation, fed by pumps from the river.
(c) Basin irrigation in the Northern and Neel Provinces along the Main Nile.
(d) Flush irrigation in the delta of the river Gash by inundation canals and in the delta of River Baraka at Tokar by natural flooding.

All these types of irrigation except the flush irrigation on the Gash and Baraka and the small area watered from wells, depend for their supplies of water on the Nile and its tributaries.

(1) GRAVITY IRRIGATION :—

The gravity irrigation schemes are the Gezira and the Managil which are supplied with water from Sennar dam on the Blue Nile and Khashm El Girba which is supplied with water from Khashm El Girba dam on the Atbara River. Detailed description of these projects are given below :—

(i) *The Gezira Scheme* :—

The Gezira scheme, approximately one million feddans extends along the western side of the Blue Nile north of Sennar to the southern boundary of Khartoum Province. It is a natural extension to the land forming a triangle north of the Sennar-Kosti railway, having a gross area of 5 million feddans. It may be described as a vast plain with a few isolated rocky hills near its southern boundary, but like many plains, it is by no means uniform in level, though the slopes for the most part are so gentle as to be hardly visible. A block of relatively high land stretches northwards from Sennar-Kosti railway to a point near Managil Town which is known as the Managil Ridge. Another main ridge less prominent extends from Sennar to south of Khartoum, roughly parallel with the general line of the Blue Nile and about 3 to 15 kilometres from it. From these higher lands secondary ridges slope westwards and northwestwards towards the White Nile.

The soil of the Gezira, with its high clay content, has the merit, from an irrigation point of view that it is very impervious to water and thus seepage losses from Canals are low.

Rainfall is limited to the months June to September and on the average ranges from 170 mm south of Khartoum to 450 mm. at Sennar.

The total of individual years may very from 30 per cent below to 50 per cent above the average.

The history of irrigation of the Gezira scheme dates back to 1904 when Sir William Garstin, of the Public Works of Egypt published his comprehensive report on the basin of the Upper Nile.

Originally a barrage on the Blue Nile at Sennar was proposed in 1908 to hold up the water-level some 7.8 m only, i.e. to about mean flood level, and for a canal system to irrigate some 500 thousands feddan gross, North and West of Medani, on which the main crop would be wheat.

By this time it had become apparent that long-staple cotton grew best as a flood-time and winter crop, sown about July and watered until March. In 1913 there had occured the lowest Nile flood in the last 200 years. The Blue Nile discharges in the early part of 1914 were correspondingly low, and after further studies it was realised that in such years Egypt might require all the natural flow at Sennar.

By 1918 the whole project had been reconsidered and it was decided to build the dam to full height from the start. The building of the dam and the canalization of the first 300,000 feddans area of the Gezira started in 1919 and completed in 1925.The area was gradually increased until the whole area of the Gezira scheme was completed during the fifties.

The canal system of the Gezira includes the Main Canal and branch canals-of total length of 320 kilometres, major distributaries of 640 kilometres length and Minor Canals totalling about 3200 kilometres.

The main and branch canals and the major distributaries are carrier channels, so aligned on the ridges and elevated land as to command, the whole area. In them the water flows steadily, day and night, throughout the lengths.

The minor canals generally take off from the Majors. Their function is to feed directly to the water courses from which the fields are irrigated and they are designed in such a manner that water is stored by night in the different reaches and released during the day to the fields.

Originally the scheme was operated in the form of a triple partnership, between the Government, the two allied concession Companies and the tenant cultivators. In 1950 the scheme was nationalised and since then the scheme is operated on a dual partenership between the Government and the tenants.

In the early days of the scheme each tenant was alloted with 30 feddans plot which was grown with crops adopting a six course rotation. This rotation was : Cotton 10 feddans; Lubia 5; Dura (Sorghum) 5; resting 10. The position of the Dura and Lubia plots was reversed in the following cycle. From 1933 onwards the rotation was replaced by an eight course rotation. Holdings were increased to 40 feddans, and the cropping adopted is : Cotton-resting resting-cotton-resting-dura-lubia or resting.

After independence intesification and diversification of the crops in the scheme were considered, resulting in the introduction of wheat and ground nuts; thus increasing the cropping intensity to 75%.

(ii) *The Managil Extension* :—

The Managil extension adjoins the Gezira scheme and lies to the south-west. A gross area of some 800,000 Fds. was developed in four phases. All canals have been designed on a six-course rotation, i.e. two third of the area will be under crop at one time. Water for phase (1) is provided from the existing pool on the Main

Canal at Km. 57 by a branch 40 cumecs capacity.

For the remaining area, the Main Canal is duplicated from Sennar to Km. 57 with a 186 cumecs capacity and a second canal branch with a capacity of 118 cumecs is dug parallel to the first. At Sennar a new head regulator is provided with 11 sluice gates each 3m. wide and 5.m3. high. These are replicas of those in the old Main Canal head regulator.

The length of the Managil extension, as in the Gezira area, has resulted in significant climatic variation within its boundaries. In the north the rainfall per annum averages about 250mm. with an eight month dry period and in the south the rainfall is noticably heavier ranging from 300mm. to 500 mm. per annum with a six to eight month dry period.

The Managil soil is heavy alkaline clay with low permeability.

The crops grown are cotton, ground nuts, dura, lubia and wheat.

(iii) *Khashm El Girba Scheme : —*

Khashm El Girba irrigation scheme lies on the western side of River Atbra, having an area of 450,000 feddans. The scheme was constructed in five phases, starting in 1962 and ending in 1969.

The first Phase of 175,000 feddans was developed for the settlement of the thirty thousand inhabitants, in Halfa district in the Northern part of the Country, whose land was inundated by High Aswan dam reservoir. This phase also includes a 33,000 feddans area planted with sugar cane and is supplying the 60,000 ton sugar factory.

The crops grown are short staple cotton, wheat and ground-nuts.

The Main Canal takes off Khashm El Girba dam and runs for 26 kilometres northward before it commands the area. Three branch canals run through the scheme with series of regulators from which major and minor canals take off.

(iv) *The Rahad Irrigation Project :—*

The Rahad Project, which is under construction, 25 km. wide and 130 km. long lies along the east bank of the Rahad River about 160 km. southeast of Khartoum. The area is semi-arid. Rainfall occurs only from late June to early October. Annual rainfall varies from 350 mm. in the northern part of the Project to 650 mm. in the south. Temperatures are highest in April, 42°C, and lowest in January, 13°C.

The Project area is a flat alluvial plain, almost bare in the north with low bushes and small trees in the south. The general slope is 0.5 m. per Km. to the west.

The soils are similar to those of the Gezira. They are very deep, cracking, self mulching clays, with high-water holding capacities but low permeability. When dry, the deep cracks permit very rapid initial intake of water but the soil swells on wetting, sealing cracks and becoming almost impermeable. Salinity and internal drainage difficulties ordinarily arise when soils of this type are irrigated. In spite of the fact that water movement is extremely low, it is sufficient to leach salt into the subsoil and maintain a satisfactory salt balance. Moreover, the waters of the Blue Nile and the Rahad are of such excellent quality that it should be possible to irrigate for so many years before salt level affects seriously crop production.

The Project is the development of irrigated agriculture on a net area of about 300,000 feddans using water pumped from the Blue Nile at Meina, some 200 km. downstream from Roseires dam. The Pumping capacity is 105 M^3/sec. The water flows into a supply canal, 84 km. long carrying water from Meina and passing under the Dinder River through a siphon and discharging it over an out-fall on the Rahad river. A barrage across the Rahad, 6 km.. downstream the fall will be constructed to maintain the commanding level in addition to a head regulator which will pass water to the irrigation scheme through a 100 M^3/sec Main Canal.

The Rahad Project will adopt an intensive rotation. Selected is a six course rotaion : Cotton-Groundnuts Cotton-Groundnuts Cotton-fallow. One year in six the land would be fallow to allow for mechanical control particularly nut grass, other weeds and possible insects, and to permit periodic land levelling. Long furrow irrigation in which water would be siphoned to 150 or 300 mm. furrows by plastic tubes, is recommended. This system facilitates mechanisation and increases efficiency of field irrigation by about 5%.

The estimated cost of the Project is about 120 million pounds. The economic rate of return would be about 16%. 14,000 tenant cultivators will settle in the Project, each having a 24 feddan plot. The Tenant average annual gross income, at full development is estimated to about 400 Sudanese Pounds.

The Project is scheduled to be completed in 1978.

(2) *Irrigation by Pumps.*

Irrigation by Pumps drawing water from the rivers was introduced into the Sudan early in the present century in a small scale. It has since steadily developed, and now takes an important place in the economic life of the Sudan. At present the total irrigated area by Pumps is 1400,000 Feddans of which 600,000 Feddans are along the Blue Nile, 500,000 Feddans are along the White Nile and 300,000 Feddans are along the Main Nile. Early development of irrigation by Pumps has been on the Main Nile from the Egyptian boundary to Khartoum and on the White Nile from Khartoum to Kosti especially after the construction of Jebel Aulia dam which helped in the reduction of the pumping lift.

On the long stretches of the river formed by the White Nile and the Main Nile there are no areas of good land sufficiently large at such levels as to justify a barrage or a weir across the river for free flow irrigation as in the Gezira. Therefore all irrigation must be by lift – pumps or persian wheels.

The irrigated areas are well distributed over this vast extent of country, since each scheme is a self – contained unit.

Development of irrigation by pumps came later along the Blue Nile because of its enormous variations in discharge and levels between high flood and low river.

Practically pump irrigation is precluded on the Atbara because of the complete drying up of the river after February.

From an agricultural point of view there is no fundamental difference between the irrigation on a large free-flow scheme and that on a pump scheme. In most cases it is convenient to run the pumps from 12 hours to 18 hours per day only and thus night watering is avoided.

When siting a pump house it is necessary to look for deep water close to the bank at all stages of the river, permancy of banks not subjected either to erosion or silting, steep slopes of banks to shorten lengths of suction and delivery pipes, high ground to avoid canalisation in high banking and a location immediately adjoining the irrigable area.

Most of the pump sites, with a few exceptions, satisfy the above mentioned requirements.

Generally speaking where conditions are reasonably good the capital cost per feddan of land canalised in a pump scheme, including the pumping equipment, is comparable with that of a large free-flow scheme. The annual running costs of a pump scheme per feddan are considerably higher, and therefore crops grown must be such as will produce an adequate return.

After the nationalization of the Pump schemes along the Blue Nile and White Niles, the Government thought of grouping the existing schemes according to their proximity, thus reducing the operation costs and improving the pumping sites which will be selected in accordance with engineering practice. In addition the grouping will reduce the number of pumping stations and stand-by units.

The Government is also planning for the electrification of these pump schemes.

Assuming the peak crop factor to be 30 M^3/day, the pumps are working for 18 hours and the pumping lifts are 14m. and 4.m. for pumps along the Blue Nile and the White Nile respectively. The power required is estimated to be 0.08 KW and 0.02 KW per cropped feddan for the Blue Nile and the White Nile respectively.

The total power required if the whole area is cropped is expected to be in the range of 45,000 KW which may be provided from Roseires hydro-power station whose potential installed capacity is 210,000 KW

(3) *Basin Irrigation* :—

In basin irrigation the water is poured into a depression – "the basin" – and then, after the land is sufficiently soaked, returned to the river.

Basin irrigation exists in the depressions adjacent to the Main Nile in the Northern Province. Eleven basins in the Shendi area, ranging from 2,000 to 8,000 feddans each, can be expected to water an area ranging from 6,000 feddans to 41,000 feddans depending on the flood.

Further north in Dongola area nine basins exist ranging from 3,000 feddans to 25,000 feddans. The areas which are watered yearly vary from 5,000 feddans to 70,000 feddans. The basins are mainly cropped with millet, chickpea, beans and lupins.

The cycle of irrigation in the basins is simple. On arrival of the flood at a suitable level the feeder canal is opened and the basin allowed to fill to good irrigation level. This level is generally considered to be that which covers the land to an average depth of from 70 cms to 1 metre. After ho'ding this level for as nearly as possible 30 days, the water is released as the river level falls by opening the drain.

The success of basin irrigation depends on the flood. The relative level of the basin lands and the river water in flood must be such that the basin can be filled, and the flood must hold these levels long enough to cover the period required for filling.

No detailed data are available for the required water in the basin, but discharge observations in some basins indicate a requirement from 6,000 to 8,000 M^3 per feddan.

The Government has planned for the conversion of the basins into pump schemes to guarantee a regular supply of water, irrespective of the flood conditions. Already Kiteiyab basin, having an area of 9,000 feddans is converted to a pump scheme. Work is progressing for the conversion of the Sayal basin.

The conversion is expected to enable full utilization of these fertile lands of the basins.

(4) *Flush Irrigation :—*

Flush irrigation is the simplest form of irrigation, being merely a single soaking of the land during the season of high flood. The success of the method depends on the absorption capacity of the soil. The method has the merits of simplicity and of covering the land with a deposit of fertilizing silt. Its disadvantages are that it depends on adequate flood levels, and that as compared to systematic irrigation it generally gives lower yields of crops and needs more water per feddan.

The outstanding examples of this type of irrigation are in the deltas of Gash and Baraka rivers in the eastern part of the Country.

The Gash river is in flow usually from July to late September. Its flow is torrential and highly variable; it may increase from a mere trickle to a high spate of 800 M^3/sec. within a day. The total discharge has varied from 140 million M^3 to about 1,250 million M^3. The water is heavily silted up to 1 part in 60.

The Gash Delta streches well over 106 kilometres with a general slope of about 1 : 1000.

The area irrigated for cultivation ranges from 40,000 to 60,000 feddans each year, according to the flood.

On the other hand the Baraka is even more torrential and irregular than the Gash. During a spate the rate of discharge may be enormous, approaching 1,200 M^3/Sec. From the head of the delta, 50 kilometres from the coastline, the waters flow in no really permanent channels; large changes in course may occur during a single flood or even a single spate. Only a part of the whole delta is irrigated in any one year even if the total flood is a large one. The average area irrigated every year is about 60,000 Feddans.

(5) *Utilization of the Nile Waters for Irrigation :—*

According to the 1959 Nile Waters Agreement the Sudan is entitled to 18.5 milliard M^3 as measured at Aswan (20.35 milliard M^3 in Sudan); while Egypt is entitled to 55.5 milliard M^3. The remaining 10 milliard M^3 from the average Nile flow is allowed for evaporation losses in High Aswan Dam.

The Sudan is at present committed to irrigation schemes and projects which consume about 18 milliard M^3 annually. The details are shown below :—

		in area Million Fed.	Consumption (MM^3)
(1) Areas along Blue Nile		2.960	11,980
(2) Areas along White Nile		0.620	2,860
(3) Areas along Main Nile		0.420	1,600
(4) Areas along River Atbara		0.500	1,860
Total	=	4.500	18,300

The Sudan is planning to develop in the near future Projects having areas of about 3 million feddans expected to consume about 10 milliard M^3 of water. The details are as shown below :—

	Area (Million Feddan)	Consumption (MM^3)
1. Upper Atbara	0.600	2,200
2. Kenana Sugar Project.	0.080	0,800
3. South Khartoum	0.100	0,200
4. Rahad Second Phase	0.520	2,000
5. Kenana (Gravity irrigation)	0.800	2,600
6. Renk – Jelhak Sugar Project	0.200	1,000
7. Jonglei Irrigation Project	0.200	0,300
8. Pengko Project.	0.500	0,750
Total	3.000	9,850

Form the above figures it is evident that the Sudan will ultimately be faced with shortage of water amounting to at least 8 milliard M^3 per year.

Therefore it becomes necessary to increase the yield of the Nile to meet this shortage by implementing the conservation projects for the reduction of the water losses in the vast swamps in the Southern Region of the Country.

(6) *Conservation Projects for the Increase of the Nile Yields.*

It is stipulated in the 1959 Nile Water Agreement that joint efforts by both Sudan and Egypt should be exerted to prevent water losses in the swampy regions of southern Sudan to increase the Nile yield for use in agricultural expansion in the two Countries. It is also agreed that the Sudan jointly with Egypt shall carry out projects for this purpose. The net water benefit shall be divided equally between the two Countries and each shall contribute equally to the costs.

The total estimated losses of the Equatorial Nile is about 45 milliard M^3 per year. Bahr El Jebel and Bahr El Zeraf basin is losing through evaporation and over – spilling about 14 millliard M^3, Bahr El Ghazal about 12 milliard M^3 and Sobat and Mashar marshes about 19 milliard M^3

Preliminary hydrological studies indicate that it is possible to reclaim about 7 milliard M^3 from Bahr El Jebel, 7 milliard M^3 from Bahr El Ghazal and 4 milliard M^3 from Sobat and Mashar, giving a total of 18 milliard M^3.

Sudan and Egypt are at present embarking on the first phase of Bahr El Jebel project for the increase of the Nile yield by digging a canal at Jonglei with a capacity of 20 million M^3/day and length 280 kilometres circumventing the swamps and flowing into Sobat River near its confluence with the White Nile. This canal is expected to yield 4 milliard M^3 of water annually.

The second phase of this project is linked with over – year storage in the Equatorial Lakes.

As for the other projects, hydrological and engineering investigations are being carried out to collect the necessary data which will enable the proper planning of the conservation projects necessary to increase the yield of the Nile.

(7) HYDRO - ELECTRIC POWER :—

Hydro – electric potential is the only local source of commercial energy in the Sudan.

At present hydro – power is developed at Roseires dam, Khashm El Girba dam and Sennar dam. The power station at Roseires is provided with seven turbines, each will have a maximum output of 30 MW providing an ultimate installation of 210 MW. At present three turbines are installed and are in operation. The power is transmitted to Khartoum over a 220 KV overhead transmission line. The power station located at Sennar dam has two units of 7.5 MW each and is also transmitted to Khartoum over a 110 KV transmission line. The third power station is at Khashm El Girba dam having a 13 MW capacity.

Apart from the present power installations, major possibilities of development exist in the 168 Km. stretch of Bahr El Jebel from Nimule to Juba, in which the river drops by about 162m, Jebel Aulia Dam on the White Nile south of Khartoum, the Sabaloka Gorge and the third, the fourth and the fifth cataracts on the Main Nile.

It is estimated that the expected installed capacities of these sites is 1605 MW detailed as below :—

	Planned Capacity (MW)	Installed capacity. (MW)
1. BLUE NILE.		
(a) Roseires	210	90
(b) Sennar	30	15
2. BAHR EL JEBEL.		
Nimule – Juba	500	–
3. WHITE NILE		
Jebel Aulia.	25	–
4. THE MAIN NILE.		
a) Sabaloka	107	–
b) Berber (5th Cataract)	250	–
c) Merowe (5th Cataract)	250	–
d) Third cataract	200	–
5. RIVER ATBARA.		
a) Khashm El Girba	13	13
b) Upper Atbra	20	–
Total	1605	118

It is estimated that the total annual energy production from all those sites, when fully developed, would be of the order of 8,000 GWH, as compared to 400 GWH from 118 of existing hydro - electric generating capacity which is limited by present market and other constraints.

Hydro - electric installations on the Nile operate under modest heads ranging from 6 m to 36 m. During periods of reservoir draw - down and high flows, their effective heads are greatly reduced.

The existing Sennar and Roseires dam power stations lose about 40% of their normal capacity in this period. Therefore thermal back up is required for the optimum utilization of hydro - electric potential. As the existing dams are built primarily for irrigation purposes, coordination with the power authorities is maintained, in view of the effect of irrigation releases on reservoirs levels and the amount of water that is utilized during critical periods.

The Sudan has at present an energy consumption of 50 Kg. of petroleum equivalent per capita which is below the average for Africa (62 Kg). The imported oil supplies 96% of the total energy and hydro - electricity the balance.

In order to increase the energy consumption of the Country to meet its industrial development and as the price of imported fuel is shooting high, the Government is at present considering seriously the development of hydropower potential of the Country.

(8) NAVIGATION :

At present there are regular river services on the Main Nile, almost all the year round, from Kerma to Karima as well as on the White Nile from Khartoum to Malakal and on Bahr El Jebel from Malakal to Juba. In the past there were recorded local and seasonal services on the Sobat - Baro system, on the Blue Nile from Suki to Roseires and on Bahr El Ghazal from Lake No to Wau.

Thus a navigable network of 3,000 kilometres long is considered workable, being attended by about 50 tugs or ships and 200 barges. The annual carrying capacity of river transport today is about 200,000 tons compared to about 400,000 tons required capacity.

The Navigation along the Main Nile from Dal Cataract to Kerma and from Karima to Khartoum is difficult because of the existence of rapids and cataracts. The situation is similar along Bahr El Jebel south of Juba to the Uganda border.

The Navigation along the Nile from Kerma to Karima is occassionally interrupted when the flow of the Main Nile falls below 90 million M^3/day.

The Navigation along the Blue Nile from Khartoum to Sennar is not possible during the summer period as the flow of the river drops considerably to the extent that the depth of the river and the existence of sand islands do not permit any traffic.

As River Atbara is a torrential river which runs dry from February to May, navigation is not possible.

On the main trunk route from Juba to Kosti, when steamers operate all the year round, difficulties arise in the reach from Juba to Terakeka. Generally navigation difficulties in the low season are due to insufficient depth, sand banks which are increasing year by year. The criteria is a guage – reading at Juba of 13.20m, which corresponds to 11.3m at Mongala and a discharge of 51 million M^3 per day. North of Malakal on the White Nile difficulties are also encountered near Jebel Ahmed Agha, El Zelit rocks and at Abu Zeid ford where there are obstacles in the form of shallows and rocks when the discharge is low. In addition to the above – mentioned navigation difficulties, the growth of the water Hycinth along the White Nile and Bahr El Jebel is creating tremendous difficulties to the traffic. The Government is at present spending about half a million pounds yearly to clear the waterway from this acquatic plant.

9. INTERNATIONAL ASPECTS OF THE NILE :

As mentioned before, the Egyptian Government issued in 1920 a comprehensive review of the whole programme of the development of the Nile under the title of the Nile Control.

The survey forcast the water need of Egypt as 50 milliard M^3 and that of the Sudan as 6 milliard M^3. The projects necessary to provide the quantities of water required were Jebel Aulia reservoir on the White Nile south of Khartoum, Sennar reservoir on the Blue Nile, a reservoir on the Upper Blue Nile, Lake Albert reservoir and Sudd channel project and Nag Hammadi Barrage in Egypt.

The proposals were subjected to sharp crtisicism in Egypt. As a result the Egyptian Government appointed in 1920 a Commission comprising a nominee from India as Chairman, a nominee from the University of Cambridge and a nominee of the Government of U.S.A. to advise on these projects. The Commission endorsed the proposals to construct Gezira, Jebel Aulia reservoir and Nag Hamadi. It also estimated the ultimate water requirement for Egypt as 58 Milliard M^3 but as to the rights of Sudan the majority of the Commission were unable to fix its requirement due to lack of data. However Mr. H.T. Cory, the U.S.A. Member proposed that the yet unassigned waters should be divided between Egypt and Sudan according to the prospective irrigable lands in each Country.

As Agreement could not be reached the Egyptian Government decided in May 1921 to postpone all irrigation projects awaiting agreement on the political future of Sudan.

In January 1925, a new Commission was formed consisting of a representative of the Egyptian Government, a representative of the British Government, the Dutch Engineer Canter Cremers. The Commission was assigned with the task of examining and proposing the basis on which irrigation in the Sudan can be carried out without detriment to Egypt natural and historic rights.

The 1929 Nile Water Agreement was based on the Commission recommendations.

The Agreement specified that save with the previous agreement of Egypt no works should be constructed or measures taken, on the Nile or its tributaries or on the Lakes from which it flows, in the Sudan or in territories under British administration, which would affect the flow of the river in such a way as to cause prejudice to the interests of Egypt.

The Agreement had also governed the distribution of Nile Waters between the Sudan and Egypt supplemented by detailed working arrangements. The Agreement stipulated that the natural flow of the river and its tributaries should be reserved for the benefit of Egypt from January to Mid-July subject to certain pump irrigation rights in the Sudan covering 61,000 feddans. In order to protect this established irrigation, the Sudan's further requirement during the low flow period was to be made entirely from Sennar storage.

With regards to the Blue Nile The United Kingdom Government had agreed with Ethiopia in 1904. According to that agreement Ethiopia undertakes not to construct any works on the Blue Nile or its tributaries which may obstruct the flow without the prior consent of the Sudan Government.

In 1935, agreement was reached between Egypt and Sudan on a dam project to yield 2.7 milliard M^3 of overyear storage in Lake Tana. The 1935 agreement was modified in 1946 to cater for increasing over-year capacity in Lake Tana to 30 milliard M^3 guaranteeing an annual discharge not less than 3.5 milliard M^3. However no agreement has been reached yet with Ethiopia in this respect.

In 1932 an agreement was reached between Sudan and Egypt, under which Jebel Aulia reservoir has been constructed and operated to give additional water supplies to Egypt. The dam which is 45 Km. from Khartoum on the White Nile has a gross content of 3.5 milliard M^3; but after allowing for evaporation the net content is 2.5 milliard M^3. The Egyptian Government paid the necessary compensation for all the areas inundated by the reservoir.

In 1946, the Egyptian Government formulated a revised comprehensive scheme of development for the Nile to meet the expected future needs for both Egypt and the Sudan. The scheme appeared in volume VII, one of the series of the "Nile Basin" titled as "The future conservation of the Nile".

The recommended projects were : Lake Tana project, enlarged to provide over – year storage , and flood protection, the Equatorial Nile Project, including over – year storage in Lake Victoria and Albert with Jonglei Canal and a reservoir on the Main Nile at the 4th. Catract in the Northern Sudan with a capacity of 8 milliards M^3 for flood protection and annual storage.

This scheme of development was studied by the Sudan Government, in particular the Equatorial Lakes project. Modifications and remedial measures were suggested. No further action was taken.

In 1949 agreement was reached by Egypt and Britain on the construction of Awen dam, at the outlet of Lake Victoria, which was completed in 1954. The power station at the dam produces some 150,000 KW. In this connection it has been agreed that the rate of flow from the Lake is not to fall below a minimum of 44 million M^3 daily for power and that otherwise amounts will be released as may be desirable in the interest of irrigation below the dam. This operation has established control over a range of 3 metres; thereby providing a total capacity of 200 milliard M^3. The Egyptian Government in return paid the necessary compensation for the flooding around the Lake as well as that part of the cost of the dam which is necessitated by the rise of the Lake level.

In 1952 agreement was reached between Sudan and Egypt on the raising of Sennar reservoir by one metre, assistance by the Sudan for the construction of the 4th. Cataract dam and the drawing of 200 million M^3 of water during the restricted period by means of raising Jebel Aulia reservoir by 10 cms.

At the end of 1952 Egypt proposed the Aswan High Dam to provide an over year storage capacity of 157 milliard M^3. At the same time the Sudan planned for its agricultural expansion by embarking on the construction of the Roseires dam.

Since then negotiations between Sudan and Egypt were conducted with the purpose of agreeing on the apportionment of the Nile waters. But no - results were achieved until in 1959 when the Nile Water Agreement was signed by the two Countries.

According to the agreement, the net benefit from Aswan High Dam reservoir shall be divided between the two Republics at the ratio of 14½ milliard M^3 for Sudan and 7½ milliard M^3 for Egypt, so long as the average river yield remains in the future within the limits of the average yield of 84 milliard M^3 at Aswan. In effect the share of Sudan shall be 18.5 milliard M^3 and that of Egypt shall be 55.5 milliard; leaving 10 milliard M^3 to cater for evaporation losses in the Aswan High Dam reservoir.

It was also stipulated in the agreement to establish a Permanent Joint Technical Commission to draw plans for the increase of the Nile Yield, to supervise the execution of these projects and to draw up the working arrangement for any works to be constructed on the Nile. With regards to the other riparian Countries, the two Countries agree that they shall jointly consider and reach a unified view regarding their claims, and if the said consideration results in acceptance of alloting an amount of the Nile water, the accepted amount shall be deducted from the shares of the two Countries.

During the sixties several informal technical meetings were held between the representatives of the Sudan, Egypt and the Eas

African Countries to discuss the question of the Nile Waters rights of the East African Countries and to agree on patterns of regulation of the Equatorial Lakes to cope with the unprecedented high levels of the Lakes. The meetings resulted in the agreement on the necessity to conduct joint Hydrological studies of the Lakes and its catchments.

Following a joint request by the East African Countries, Sudan and Egypt to the special Fund of the United Nations, the Hydro-meteorological Survey for the catchments of Lakes Victoria, Kyoga and Albert was initiated in 1967 with W.M.O. as an executing agency. Brundi and Rawanda joined the Project at a later stage.

The objectives of the Project were the collection and analysis of hydrometeorological data of the catchments of the Lakes in order to study the water balance of the Upper Nile. The data collected and the study are expected to assist the Countries in the planning of water conservation and development and to provide the ground work for inter - Governmental Cooperation in the storage, regulation and use of the Nile.

The first Phase of the Project was successfully completed in 1975.

Subsequently the Participating Countries agreed with U.N.D.P. to implement the second phase of the Project for a period of three years.

The objectives of the second phase are, among other things, the formulation of a mathematical model representing the Upper Nile system to help in the future development of the Nile water resources and the evolving of various patterns of regulation of the Lake singly and as a system taking into consideration optimum benefits of the riparian countries.

10. ORGANIZATION :—

In accordance with the Republican Order No (334) dated 1974 concerning the establishment of Ministeries, the objectives of the Ministry of Irrigation and Hydro-Electric Energy are, in general, the control, regulation and development of the water resources of the Country and, in particular, the planning and implementation of irrigation and hydro-electric projects.

The history of the Ministry dates back to 1920, when it was initially established as a department of irrigation within the organizational structure of the Egyptian Irrigation service in the Sudan.

In 1925 the department was independent of the Egyptian Irrigation service and was made responsible for the maintenance and operation of the Irrigation systems in the Gezira and the Gash Scheme.

In 1956 the department was developed to become the Ministry of Irrigation and Hydro electric Power.

The Ministry is at present assigned with the following tasks. :—

(i) To develop, improve, maintain and operate the irrigation schemes.

(ii) To implement projects for the increase of the yield by the water resources available in the Country with the object of meeting the water requirement needed for agricultural expansion as well as improving the irrigation techniques in the Country.

(iii) The beneficial use of the share of Sudan in Nile Waters and the pursuance of studies for the increase of Nile Yield.

(iv) The development of hydro-power potential for industrial and domestic use.

To achieve the above functions the organization set up of the Ministry of Irrigation and Hydro electric power has been devised as follows :—

(i) *Minister's Office :—*

To assist the Minister in the follow up of the Ministerial tasks assigned to him and to conduct Ministerial routine activities.

(ii) *Planning and Follow up Unit :—*

This unit is concerned with the formulation of the final plans for the water resources projects, their construction programmes, cost estimates and the submission thereof to the National Planning Council for approval and embodying in the National development plan.

The said unit follows up, evaluates and reports on the progress of the implementation of the approved Projects.

(iii) *The Under Secretary :—*

The Under Secretary is designated with the overall responsibility regarding the technical, administrative and financial activities and to ensure the best performance of all the duties levied on the Ministry of Irrigation and hydro-electric power.

(iv) *Water Resources and Projects Directorate :—*

The functions of this Directorate comprise the following :—

(a) The hydrological survey of the Nile and tributaries and the formulation of projects for the water resources development and for the increase of the Nile Yield projects – the drawing up of plans for the best utilization of the Sudan's share of the Nile waters.

(b) Conducting of water resources studies in the proposed National Hydraulic research and experimental station.

(c) Investigating, designing and constructing irrigation, hydro-power and river training projects.

(d) Maintenance, operation and management of dams for the Nile Control with the object of meeting the irrigation and hydro-electric power requirements.

(e) Production of hydro-electric power for industrial and domestic uses.

This directorate is composed of the following departments :

1. Nile Waters Department.
2. Projects Department.
3. Dams and Nile Control Department.
4. Hydro-Electric Power Department.
5. Hydraulic Research Department.

(v) *The Irrigation Affairs Directorate Functions :—*

1. Technical, administrative and financial superintendence of all the existing irrigation services.
2. Installation, maintenance and operation of the electrical and mechanical equipment required for the irrigation projects, dams and pumping stations.

(vi) *The Administrative and Financial Affairs Department :—*

The main function of this Department is to manage all personnel, financial accountancy, stores, purchasing and training affairs. This Department is composed of two sections, one for the financial affairs and the other for the administrative affairs.

COMMISSIONS AND CORPORATIONS.

1. THE PERMANENT JOINT TECHNICAL COMMISSION FOR NILE WATERS :—

In accordance with the 1959 Nile Water Agreement for the full utilization of the Nile Waters between Egypt and Sudan, the Permanent Joint Technical Commission for Nile Waters has been established comprising equal numbers of Members from both sides. The Sudanese Panel discharges the following functions within the frame-work of the Permanent Joint Technical Commission for Nile Waters :—

(a) Sponsoring the studies necessary for the Projects of the increase of the Nile Yield and implementation of the Projects approved by the two Governments.

(b) Drawing up the working arrangements of all works constructed on the Nile within and outside the Sudan borders, in agreement with the concerned specialists of the Countries in which such works are constructed, and the supervision of the implementation of the said working arrangements.

(c) Drawing up the necessary arrangements to be adopted by the Riparian Countries of the Nile Basin to prevent the occurrence of any harm or damage on any of the said countries in case of droughts, and catastrophic floods and the submission of such arrangements for approval by the respective Governments.

(d) Conducting negotiations with the other Riparian Countries on their Nile Waters demands and submitting recommendations to the concerned Governments.

(e) Technical superintendence of the Nile gauging which is undertaken by the concerned authorities of the Riparian States.

(f) Participation in the periodical meetings held by the Permanent Joint Technical Commission for Nile Waters and other Committees concerned with the Nile Waters Affairs.

2. THE EARTHMOVING AND IRRIGATION WORKS PUBLIC CORPORATION :

This Corporation has been established in accordance with the Republican Order No 15 for the year 1974 issued on 21st. July 1974. The Corporation is presided over by a full time Chairman of the Board of Directors to perform the following functions :—

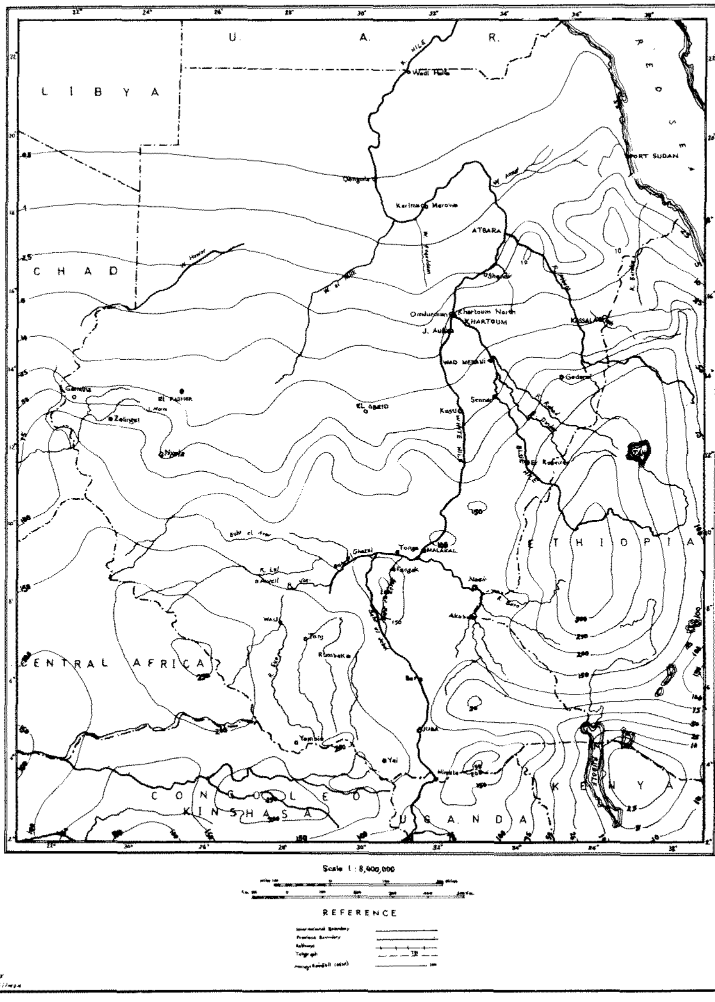
The Corporation, under the supervision of the Minister of Irrigation, undertakes all or some of the following tasks whether directly or indirectly and as a principal agent, or sub-agent and whether with or without participation of a local or external body and whether for the central Government or otherwise :—

(a) Execution of any excavation work for Irrigation Projects and maintenance works in the existing projects and any similar excavation works such as dredging.
(b) Construction of irrigation and hydroelectric power establishments.
(c) Dealing in materials and equipment necessary for the attainment of its objects and making available all its requirements thereof.
(d) Establishment and administration of the necessary Workshops.

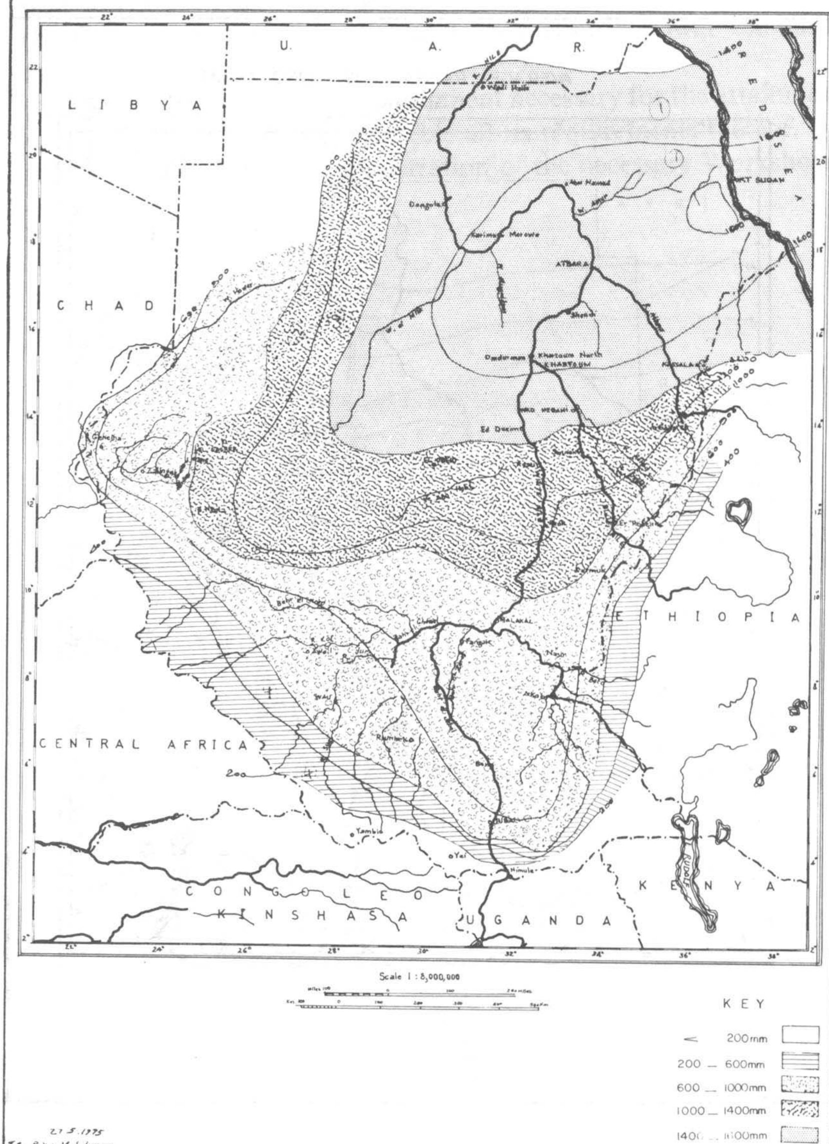
AVERAGE RAINFALL 1931-1960 (MM)

SUDAN

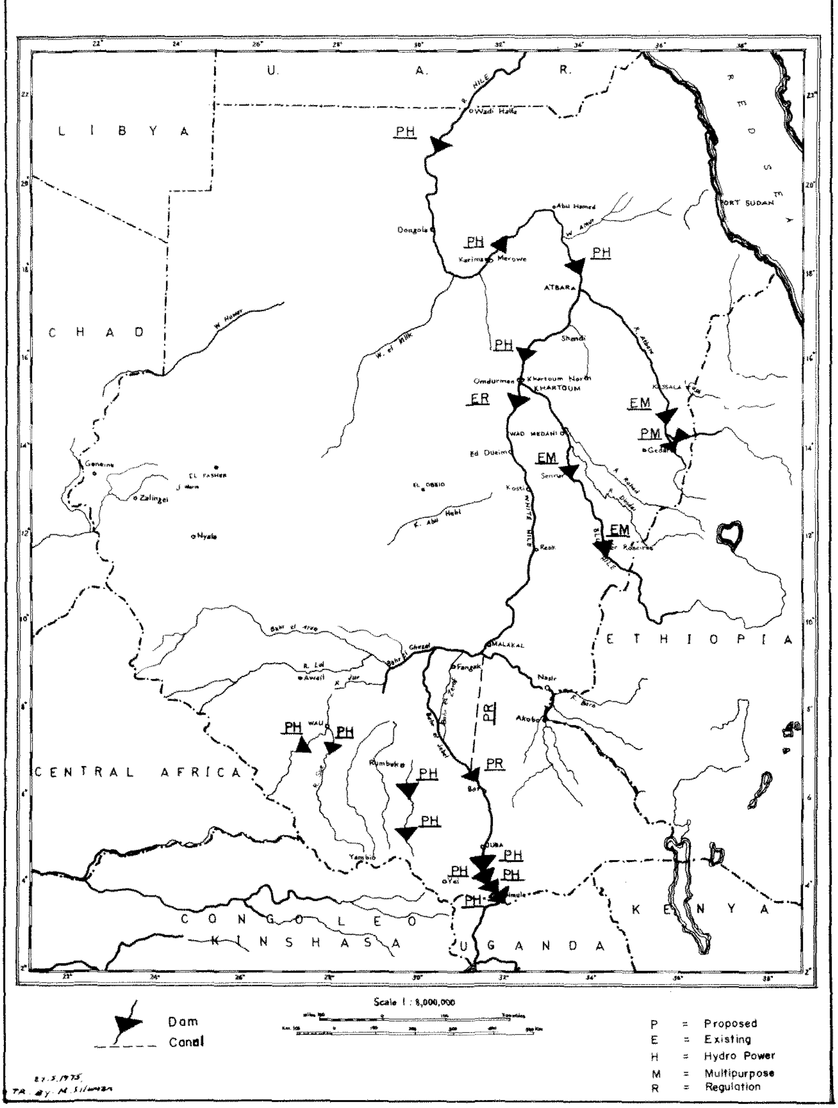
JUNE



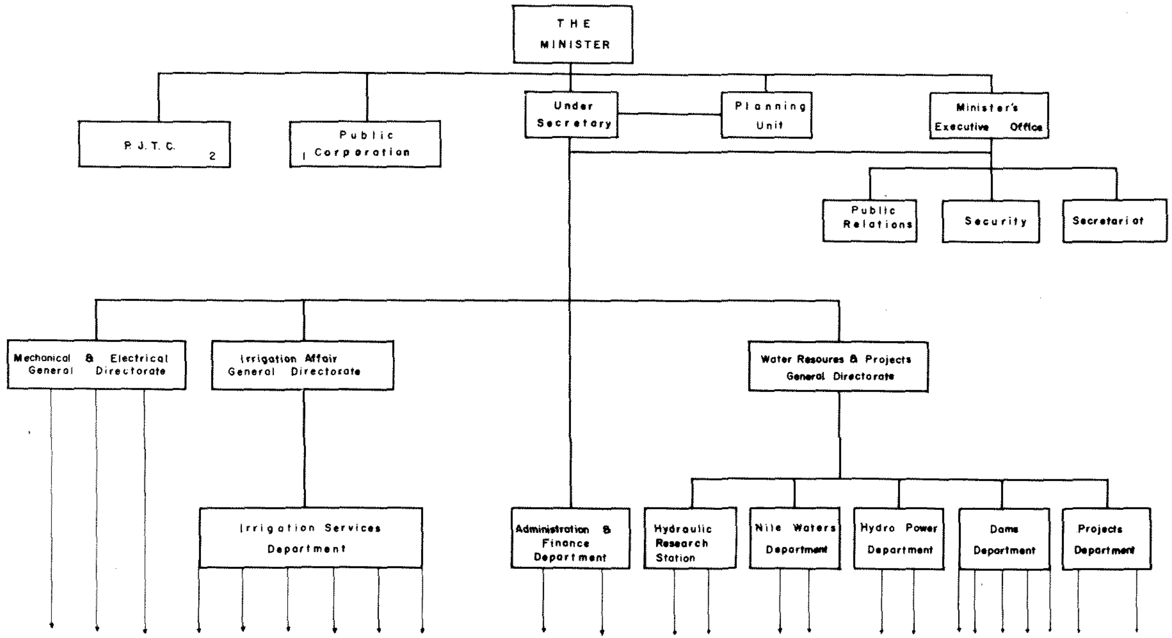
WATER DEFICIT IN THE SUDAN



WATER CONTROL WORKS ALONG THE NILE IN THE SUDAN

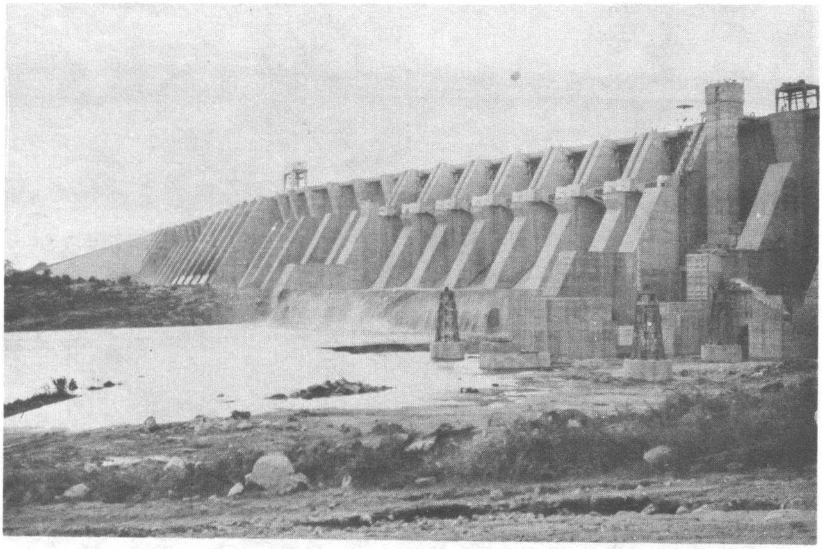


MINISTRY OF IRRIGATION AND HYDRO– ELECTRIC ENERGY ORGANIZATION CHART

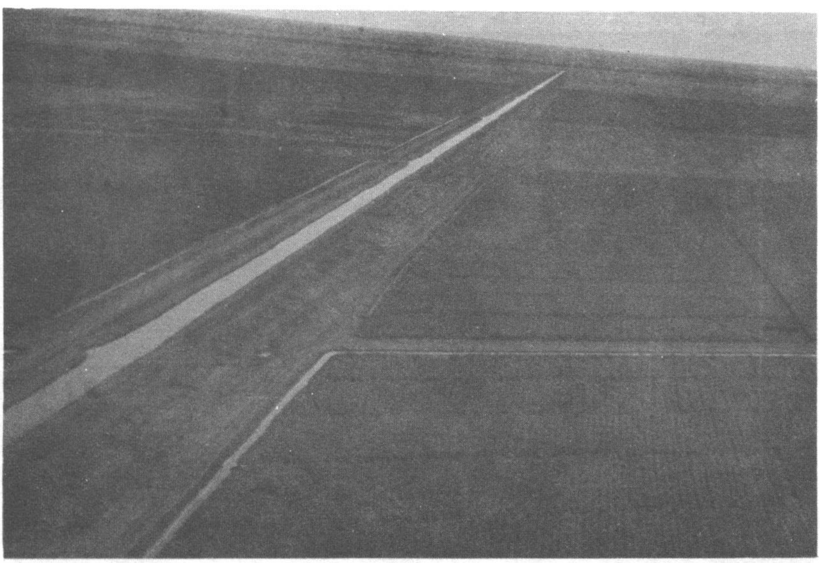


1_ The Earth Moving And Irrigation Works Public Corporation

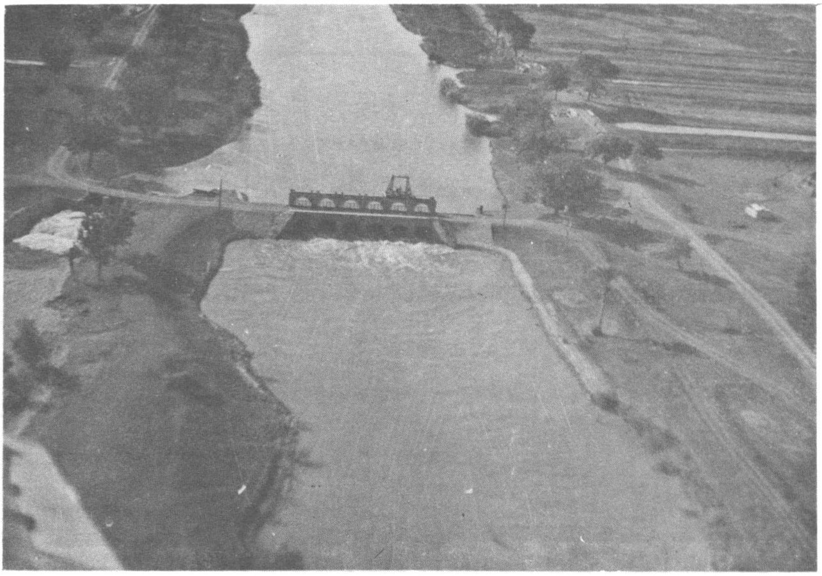
2_ The Permanent Joint Technical Commission For Nile Waters.



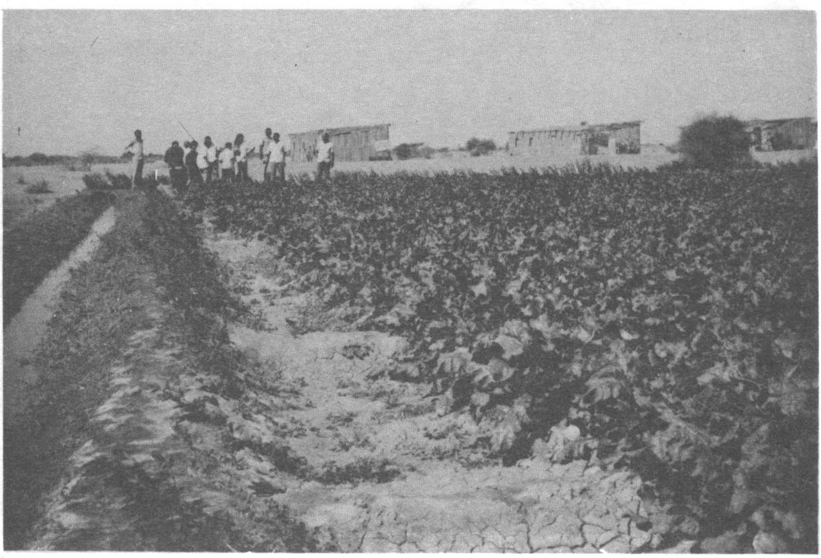
Roseires Dam



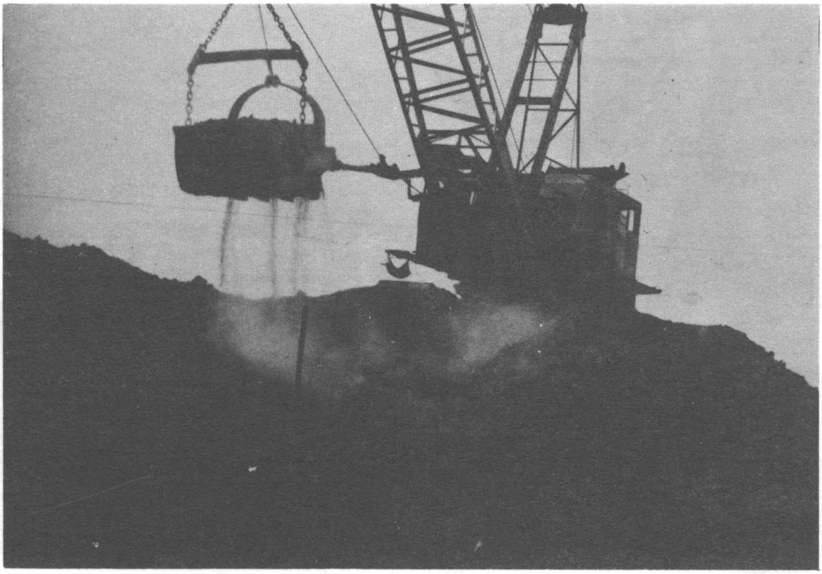
Canalization



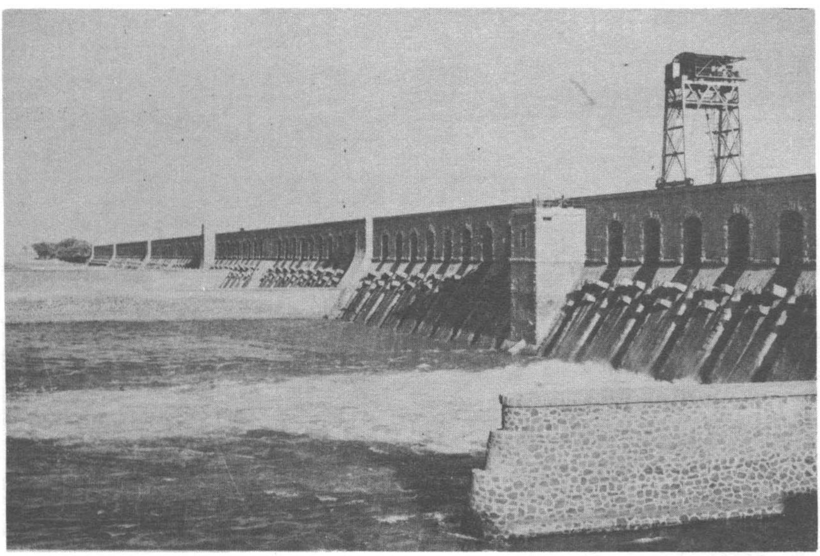
A Head Regulator



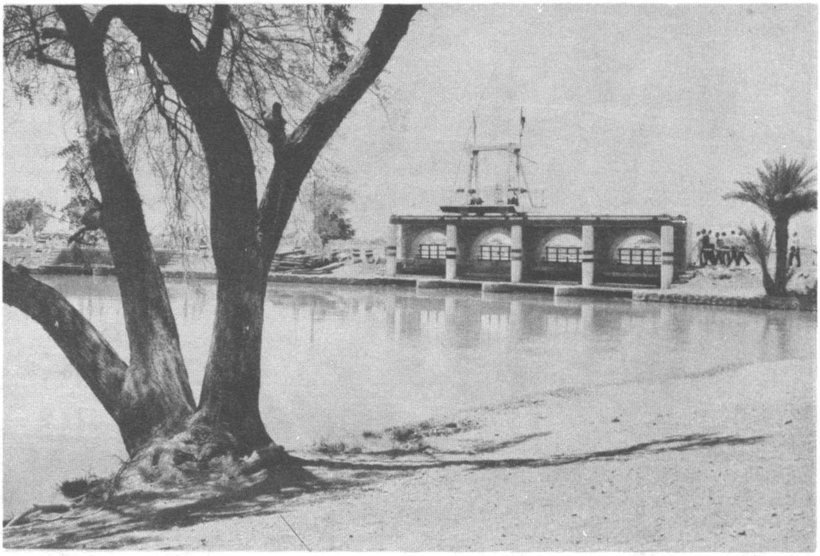
Irrigated Cotton



A Dragline Excavating a Canal



Sennar Dam



A Head Regulator in a Main Canal

Canalization

Printed by Khartoum University Press

Cover designed by Omer El Amin Shibir