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28 November - 2 December 1993
Amman - Jordan

WATER RESOURCES MANAGEMENT, DEVELOPMENT AND UTILIZATION IN EGYPT

Country Paper

Prepared by

Eng. Sarwat H. Fahmy
Former Senior Undersecretary
Ministry of Public Works and Water Resources

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Organized by the
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Water Resources Management, Development and Utilization in Egypt

Introduction:

Egypt with no significant rainfall has been dependent, since the dawn of history, upon the Nile as the main supply for its water

The construction of the High Aswan Dam in 1960's , allowed for storing the Nile average annual inflow of 84 billion cubic meters. After allowing for average annual evaporation and other losses in Lake Nasser, it left an annual net utilizable flow of 74 BCM. The Nile water agreement between Egypt and Sudan in 1959 allocated this resource between them , giving Egypt 55.5 BCM. This represents more than 95 percent of the total developed water resources of the country.

There is modest potential for increasing the resources available at Aswan by canalization of the the White Nile in the Sudd region, thereby reducing losses in the marches. However, work on the Jonglei canal Phase I has been abandoned on account of security problems in southern Sudan, and it is uncertain when work will be resumed. Upon completion of this work, an additional 2 BCM could be available for Egypt.

The Characteristics of the Nile system are determined by the High Dam, which captures the source flow and regulates flow patterns to serve specific demands.

The total net effective rainfall is insignificant to be taken into account, and the context of the Nile basin ground water is not an additional resource since it is recharged from the Nile waters. Outside the basin, the few oases in the western desert and some other areas are capable of economically providing only limited supply of usable waters (mostly non-renewable ground water).
Given the significance of water from the planning point of view, for overall national development, several efforts in recent years have been exerted to test the availability of water supply to satisfy the increasing demands in different uses and all studies indicated that tremendous work is needed for increasing water management, rehabilitation of key structures and concentrated efforts on Operation and maintenance of the Nile system and irrigation network, besides re-cycling of drainage water and municipal and industrial effluents after proper treatment. All these need proper planning, enormous efforts and tremendous investments.

1- Water Resources

1-1 Rainfall

Egypt is a very arid country. Rainfall over most of the country is virtually non-existent. The average annual rainfall seldom exceeds 200 mm along the northern coast, declines very rapidly from these coastal areas to inland and becomes almost nil; south of Cairo.

This meager rainfall occurs in the winter in the form of scattered showers and cannot be depended upon for extensive agriculture production . Irregular but frequent run-off in Sinai constitutes a limited local agriculture or rangeland improvement in Central Sinai or for coastal development project in tourism

There are also some very limited run-off resources in the Red Sea Hills, which have not been fully investigated.

Thus reliable availability of irrigation water is a mandatory condition for agricultural development.

1.2. The River Nile, The Main Water Resources for Egypt:

The River Nile, the second longest river in the world is the principle source of water in Egypt, supplying it with more than 95% of its available water. The ancient Egyptians have given it utmost care and attention starting with King Mena who established the Nile banks for protection from the floods more than 5000 years ago. Since then, the improvement works along the Nile channel have been observed , one following the other, and the irrigation and water distribution constructions have, and are still being, established till our present time.

Modern intervention began with construction of the Delta Barrage north of Cairo, in 1861. The barrage discharge about 70% out of the Rosetta mouth and 30% through the Damietta. The Barrage was the beginning of perennial versus basin irrigation . With the expanded perennial irrigation , several structures have been constructed on the Nile stem namely Esna, Nagh Hamadi and Asuit barrages.
The increased water requirements during the timely season, annual storage has been introduced. The old Aswan Dam was built in 1902 with one billion m^3 storage capacity , then twice heightened, to increase its storage capacity to 2.5 and then to 5 billion cubic meters. In 1937 Egypt built the Gebel Aylia dam, on the white Nile to increase the annual storage capacity needed to meet the increasing timely demands to about 8 billion cubic meters.

Overyear storage was first investigated in the late 1940's to save considerable amounts of Nile waters from being spilled-during the flood season to the Mediterranean. The Nile water agreement of 1959 with Sudan enabled Egypt to construct the High Aswan Dam which was completed in 1968, with a storage capacity 164 billions out of which 32 billions are for dead storage, 40 billion for flood protection, and 92 for live storage to assure long term availability of water for both countries.

According to the 1959 Nile water agreement, the division of the Nile waters traveling north has been defined between both countries , based on the average annual flow of the Nile during the period 1900-1959, which was 84 billion m^3. The average annual evaporation and other losses in H.A.D. lake was estimated at 10 billion m^3, leaving a net usable annual flow of 74 billion m^3. Under the 1959 treaty, 55.5 billion m^3 was allocated to Egypt and 18.5 for the Sudan.

Fig (1) shows the annualized Nile flow at Aswan for the past 115 years. It indicates that the average flow is 84.0 BCM. It also shows the series of low years of drought 1979-1987

Fig (2) shows the annual discharges from the High Dam Lake during the period 1968 to 1990, and the water levels of the lake and the corresponding storage.

There is a potential for increasing the Nile flows at Aswan. Fig (3) is a schematic illustration of the Nile yield and its tributaries max and min yields.

The Joint Egyptian Sudanese Committee has outlined several development programs. The first of which is the construction of the Jonglei Canal. The project was expected to canalize the river channel in the Sudd region in the Southern Sudan and thus reduce the substantial evapotranspiration losses. The construction of phase I of the canal was started in 1979, but had to be abandoned in 1983 due to security problems in the area. Initially, this phase was expected to be completed around the mid 1980's , which would have provided an addition of 4 billion m^3 of water at Aswan to be shared equally by the two countries.

The water lost in the Machar swamps is about 7 billion m^3 annually. Conservation schemes in this sub-basin is expected to yield and average gain of 4.4 billion m^3 at the White Nile or about 4.0 billion m^3 , at Aswan.

The discharge in the streams from Bahr El Ghazal (another sub-basin of the Equatorial Plateau) are about 14.0 billion m^3 in a normal year, of which only an amount of 0.6 billion m^3 reaches the White Nile at Lake Noo and the rest is lost in the swamps. Proposed schemes for conserving the water of Bahr- El-Gazel are expected to yield a saving of 7 billion m^3 annually at Aswan to be equally shared by Egypt and Sudan according to the Nile Water Agreement.

It was anticipated that after completion of Jongolei Canal (Phase I) , a second phase was to follow. This second phase relies on the regulation of the Equatorial Lakes Plateau after the current studies of the Hydrometeorological survey of catchments of lakes Victoria, Kyogo and Muboto Sese-Seco, prove the technical limitation of the necessary storage and regulation. The Hydrometorological Survey is a cooperative program which started in 1968 according to an agreed plan of operation between UNDP WMO, and five reparian countries namely Uganda, Kenya, Tanzania, Sudan and Egypt. The survey aimed at establishing a complete hydromet network covering the whole catchment area of the River Nile, sources from the Equatorial Lakes Plateau.
The data collected from the network along many years helped in completing a water balance study and figured out the gains and losses, formulation of a mathematical model to study the possibilities of storage and regulation, and finally the water resources development potentialities of this catchment area. Cooperation between participating countries continued on this study throughout many years and the other riparian countries namely Rwanda, Burundi and Zaire joined the group, with Ethiopia as observer in the Technical Committee supervising the whole activity . Based on the promising technical cooperation between the nine Nile Basin countries of the Hydrometer Survey Project, it is anticipated that further integrated cooperation could be realized towards the full development of the River Nile . The Jonglei Canal Project (Phase II) was foreseen to divert more water to the Jongolei Canal after doubling its capacity to avoid those waters from being dissipated in the Sudd region through evaporation without any use. The water benefit of this phase was to add 1.5 billion m^3 annually to both Egypt's and Sudan's water shares.
All those planned additions from the pre-planned development projects of upper Nile, besides other projects are now stopped and excluded for many years to come, from Egypt's water resources plans.

1.2.2. Global Climatic Changes and their effect on the River Nile Yield and crisis management

The last decade witnessed a radical change in the annual Nile discharges arriving Egypt. As the annual natural flow diagram shows the sequence of successive years of low floods strting from 1979, till 1988 as a result of drought that effected many areas in Africa and other parts of the world. While the mean annual flow at Aswan is 84 billion cubic meters, it went down to 52 billions as in 1948 and fluctuated around the 70's in other years. The H.A.D. contents gradually decreased, till June 1988 , when the live storage went down to only 7 billion m^3. If not for the very high flood of July and August of 1988, Egypt was to face a severe shortage of water supply, inadequate to satisfy the presuing demands.

The planning sector of the MPWWR, was testing all possibilities and providing alternatives to the decision maker to face the crisis of different magnitude of water shortage, by utilization of the planning tools developed by the Water Master Plan as follows:

- The Dynamic Programming Model was tested to develop alternative possible series of flows
- The water Planning Distribution Model was tested to assist the decision making process of water distribution and allocation under various operating conditions and to quantify the relative crop yield effects of irrigation water shortage.
- The agro-economic Model was investigated to propose alternative cropping patterns under different conditions of water availability and to evaluate the economic effect of different cropping patterns.

A further step was undertaken by the MPWWR to establish with the assistance of USAID , FAO and US weather bureau, the River Nile Forecasting Center, to predict the rainfall pattern on the Upper Nile Catchements and estimate the run-off and water arriving Aswan. It is also considered as the focal scientific point in Egypt to communicate with other international scientific institutes in studying the global climatological changes and work with MPWWR planning sector in advising for crisis management.

1.3 The Ground Water

Ground water in Egypt can be divided into two categories. The first comprises the Nile Valley and Delta System, while the second is the Nubian Sandstone aquiver comprising the Western desert.

The total storage capacity of the Nile Valley aquifer system is about 200 billion m^3, with an average salinity of 800 ppm. Another 300 billion m^3 is the storage capacity of the Delta aquifer . The current annual rate of abstraction of ground water from the valley and Delta aquifers in 3.8 billion m^3 . This can be increased to be equivalent to the safe annual extraction rate from the aquifer system which is currently 4.9 billion m^3

Ground water exists in the Western Desert, generally at great depths. Most recent studies have indicated that this is not a renewable resource. Preliminary studies indicated that it is of acceptable quality with salinity varying between 200 and 700 ppm. Use of this fossil water depends on the cost of pumping, depletion of storage, and potential economic return over a fixed time period. Investigations at New Valley indicate that annually about one billion m^3 of ground water can be used at an economic rate. This will allow irrigation of 150000 acres, of which 43000 are already being cultivated. An additional 190000 acres can be irrigated at the East Ewainat area (southern part of the western desert) on ground water from the deep Nubian Sandstone aquifer. More studies are underway to investigate the ground water potentialities within this regional aquifer. The work is carried out in cooperation with Sudan and Libya. Ground water is available in Sinai in numerous aquifers of varying capacities and qualities, but in general it is believed that it is in very limited scale.

Shallow aquifers in the northern coastal areas are replenished by the seasonal rainfall. The thickness of the aquifer varies between 30 and 150 m and its salinity increases from 2000 ppm up to 9000 near the coast. In the north and central parts of Sinai, ground water aquifers are formed due to recharge by the rain storms falling and collected in the valleys. Deep aquifer with non-renewable water exist in Sinai where wells are drilled to a depth of 1000 m to supply water to domestic use.

The Al-Arish - Rafaa Coastal area in North Sinai has always been of importance. The present extraction rate from the quaternary aquifer at El Arish area is estimated at 52000 m^3/day . This area is facing now a state of quality deterioration in space and time. The system is being exploited and it needs to be safely managed.

The ground water investigations in South SInai included several shallow and deep reservoirs which have a promising potential for development but again of limited scale.

Land Resources

For a very arid country like Egypt, the prime factor which makes land productive is water. Thus an analysis of arable land can be best divided as pre and post - High Aswan Dam (HAD) periods. Fortified by increased and more reliable water availability that was made possible by the construction of this Dam and assisted by technological developments. It has been possible both to intensify cultivation in the old lands and to expand agricultural activities in the new areas. Construction of the HAD basically confirmed the fact that the supply of arable land in Egypt is not necessarily elastic, as was often assumed for countries in the past. Thus nearly 650000 acres out of a total of 805000 acres of land reclaimed between the decade 1960-1970 was made productive directly due to the water released from the HAD.

Table (1) shows changes in arable areas in Egypt during the period 1897-1990

Table 1 changing patterns of population and Arable Land 1987-1990

year	Population millions	Arable Land (Feddans) Total (millions)	Per Capita
1897	9.7	4.9	0.51
1907	11.2	5.4	0.48
1917	12.8	5.3	0.41
1927	14.2	5.5	0.39
1937	15.9	5.3	0.33
1947	19.0	5.8	0.31
1960	26.1	5.9	0.23
1970	3.2	6.7	0.20
1980	42.1	6.8	0.16
1990	55.5	7.2	0.13

It should be noted that between 1907 and 1980, the total arable area increased by only about 1.4 million acres, while populations increased nearly 4 fold, from 11.2 to 42.1 millions. This means that the area of arable land available per person declined by 70% during this 73 year period. The changing patterns of population, total arable and per capita arable land available are shown in Fig (4) which illustrates such changes since 1897 uptill 1990. It is expected that the population in the year 2000 is 68 millions and 100 million in the year 2025. To be able to preserve the per capita arable land to continue to be as it is now 0.13 acres, which is one of the lowest in the world , additional agricultural land has to be developed at a rate of at least 160000 acres a year till the year 2000 and at a rate of 180000 annually afterwards, till the year 2025 . This indicates that the agricultural land has to expand to 8.4 million acres by the year 2000 and to 13 million acres by the year 2025.

The most detailed analysis of land resources of Egypt was completed in 1986 the Land Master Plan (LMP) . This plan concluded that 2.82 million acres of land could be reclaimed by using the Nile waters. In addition another 570000 acres could be reclaimed by using ground water in Sinai, and New Valley . Thus, the total land that could be reclaimed, subject to water availability, was estimated at 3.45 million acres.

The LMP study considered land only for irrigated agriculture. Other uses of land like fisheries, forestry and wildlife habitat were not considered. The LMP study divided potentially reclaimable land into fibe categories depending on one or more land use and management options. These options considered cropπˆng patterns, irrigation and drainage systems and farm types. More than half of the land proposed for reclamation is considered coarse to gravely sands.

The present estimate of cultivated land area in Egypt in 1990 is 7.50 million acres, of which 7.20 millions is in the Nile Valley. From a policy view point, estimates of land loss at present due to topsoil skinning and urban encroachment average 30000 acres per year. It is essential that GOE needs to give urgent attention to reduce the loss of arable land due to urbanization for the following three important reasons. ***First*** with continually increasing population , existing agricultural land areas should not be allowed to be lost. ***Second***, land reclamation is an expensive process, and hence it would be desirable not to lose any additional land areas that are already productive, and then try to compensate that loss by reclamation. ***Third*** often land lost due to urbanization is more productive than the reclaimed land.

Currently, laws exist which are expected to prevent the loss of arable land due to urbanization, However, it should be noted that the prevention of the loss of agricultural land due to urbanization has not been possible in nearly all developing countries as well as in many developed countries.

Land reclamation in Egypt has been practiced over several thousand years. For most of this period, reclamation was practiced primarily in the Nile Valley and the Delta, since land in these areas could be reclaimed with low levels of technology and investment. Tremendous progress was made in land reclamation in the 19th century, at the beginning of which areas cultivated were estimated at 2 million acres of which only 250000 acres could be cultivated in the summer.

By 1848, the area cultivated , had increased to 2.6million acres, by 18800 to 4.7 million acres and by 1900 to 5 million acres . Thus , during the last century , the arable land area increased by 150% or some 3 million acres.

Construction of the High Aswan Dam, significantly increased both the supply and reliability of irrigation water availability. This, in turn allowed considerable expansion of the land reclamation process. Thus between 1960 - 1971 , a total of 912000 acres were reclaimed, much of which was in the Western Delta.

There has been a major policy shift during the 1980's . Government of Egypt (GOE) became disillusioned with the overall performance of the state farms because of their inherent inefficiency , inability to adopt new farming practices quickly, and general lack of development of new farming systems that are more applicable to desert-like conditions. Accordingly, a policy decision was taken to allocate new lands in a varying ration of 60-40% to investors with adequate capital to develop their own farms and the balance, to economically disadvantaged groups like landless farm workers, unemployed graduates, and a small number of retired government personnel.

The land Master Plan study estimated that the investment cost for land reclamation varied from LE 3000 to LE 7000 per acre. In some remote areas, high cost of infrastructure increased the cost to LE 8000

The government has already pledged not to dictate cropping patterns in these areas. Thus many farmers are planting high value crops, probably perennials fruit crops in order to generate sufficiently attractive returns on their initial investments.

With the increasing population base in Egypt, land reclamation at considerable cost must not only retain their productivity but also the production system must be sustainable of the long term. Land can only be productive if water is available for irrigation. With time, larger number of people achieving a better standard of living and higher levels of industrialization, water demands for the municipal and industrial sectors would undoubtedly continue to increase in the future. Since these two sectors are most likely to have higher priority than the agricultural sector in terms of water use, reliable water availability in the future for the reclaimed areas should receive more serious attention. Nevertheless, the share of water to be available for the agricultural sector in Egypt will decline steadily with time in the future. Accordingly, efficiency of water use in Egypt has to be steadily increased over time in order to ensure that all the reclaimed land will continue receiving their share of water in the future on reliable basis.

WATER USE IN EGYPT

The total annual water use in Egypt in 1990 was estimated at 59.2 billion m^3 of which agriculture use accounted for 84%. Industrial, municipal and navigation use accounted for additional 8%, 5% and 3% respectively. Current estimates indicted that the total water use will increase to 69,4 billion m^3 by the year 2000. Percentage of water use by agricultural and municipal sectors will remain almost similar to 1990, but the share of industry will increase by 50%, and navigational use will decline very substantially.

Agricultural Water Use

While in percentage terms, amount of water used for agriculture has declined slowly during the past decade, currently 1990 agriculture accounts for the largest share of water use at 84% or 49.7 billion m^3 per year. This amount does not include an annual estimated loss of 2 billion m^3 due to evaporation from the irrigation system. Annual evapotranspiration losses are estimated at 34.8 billion m^3.

Surface irrigation systems are used in most cultivated lands of the Nile Valley and Delta, the efficiency of which is considered low. Excess irrigation water applications contributes to salinity and high water table problems. The government has launched a national program for irrigation improvement and water management. It should be noted, however, that excess irrigation water contributes to ground water, a good part of which is pumped or partially reused through cycling. All of which bring up the overall water use efficiency to a reasonable value. The measured drainage water out of the system amounted to about 11 billion m^3 during 1990.

For the new land, modern irrigation systems are used. The government does not give any permits for new water to lands unless evidence is given to the use of new irrigation systems (drip or sprinkler)

Domestic Water Use:

The annual domestic water use for 1990 was estimated at 3.1 billion m^3. It is estimated that the present level of distribution losses is 50% . It is assumed that the domestic water use could be held at 3.1 billion m^3 by the year 2000 by reducing distribution losses from 50% to 20%. By the year 2025 this figure could rise to about 5.0 billion m^3.

Industrial Water Use:

The 1990 estimate is based on the extrapolation of the 1980 survey carried out for the Water Master Plan. It is estimated at 4.6 billion m^3 for 1990. By the year 2025, the industrial water requirements will become 5.8 mild m^3 annually.

Navigation Water Use:

From February to September water releases for irrigation are sufficient to maintain water levels in the Nile for navigation. Irrigation demands, however, are not enough during October to January to maintain appropriate navigational level in the river. This period also is the peak tourist seasons, where numerous tourist boats make regular sailing between Aswan and Luxor. At present, some 1.8 billion m^3 of water has to be released during this period to maintain navigational level. Currently the Esna Barrage is being rebuild, which would provide better control of the Nile Water level. It is expected that by the year 2000, annual navigational water requirements could be reduced to only 0.3 billion m^3 by better control of water level and implementation of storage in the northern lakes.

Re-Use of Municipal Waste water

Waste water has been reused indirectly in Egypt for centuries, but the first formal use of waste water was initiated in 1915 in the eastern desert area of Jabal El-Asfar north east of Cairo. After primary treatment , waste water was used for desert agriculture , which has allowed an area of 2500 acres to be cultivated. Since water is the major constrain to the further expansion of agricultural areas, treated waste water must be considered to be a new source of additional irrigation water. As new waste water treatmment plants come on stream in Cairo, and other urban areas, amounts of treated waste water that could be available for agricultural activities would increase steadily during the next three decades. It has been estimated that the total amount of waste water that would be available from the Greater Cairo area, would increase from 0.9 billion m^3 in 1990 to 1.7 billion m^3 in 2000 and 1.93 billion m3 annually by 2010.

Currently , in Egypt , detailed experience on waste water reuse has been somewhat limited. From a policy view point urgent steps are now being taken to establish some major pilot projects on the use of treated waste water, for agricultural production. Some pilot projects would also convince the general population that such practices, as long as they are properly carried out, impose no risk to human and animal health.

Re- Use of Industrial Effluent:

As for industrial waste water, proper treatment of industrial effluent is not properly implemented . While the law 42 for 1982 prohibits non-treated industrial effluent to be returned back to the irrigation and drainage system, the industrial sector has not been able up till now to fully respond to the law because of the very costly treatment process stipulated by the law. The environmental action plan recently designed, is reconsidering the specifications of the industrial return flows to allow for cost effective treatment applications.

As previously mentioned, industrial withdrawals is 4.6 billion m^3 annually , out of which only 1 billion is consumed and the rest is returned back to the system. If properly treated, recycling of at least 2 billion m^3 could be recovered and put to use.

Reuse of Agricultural Drainage Water

Agricultural drainage water in Upper Egypt is discharged back into the river Nile. This slightly affects the quality of the Nile water as its salinity increases from 250 ppm at Aswan to 350 ppm at Cairo. The drainage water in the Nile Delta is of lower quality, and accordingly they are collected through an extensive drainage network.

The total amount of drainage water discharged to the sea depends on many factors; amount of water released at Aswan, cropping patterns and irrigation efficiency. The total amount of drainage water discharge annually has varied from 14 billion m^3 in 1984 to 11 billion m^3 in 1990. The salinity of this water ranges between 1000 and 7000 ppm, about 25% (1984) to 70% 1988 of this water has salinity of less than 3000 ppm (Fig 5) . The effect of reducing the quantity of water released from the HAD will lead to decrease in drainage water quantity and increase of its salinity will occur when the irrigation efficiency is improved both in the conveying system and at the farm level.

Surveys and monitoring of the quality ad quantity of the agricultural drainage water in the Nile Delta have shown that it is possible to reuse part of this water in irrigation, When the salinity is low, the water is used directly , when it is high, it is mixed with fresh canal water. Water with higher salinity or contaminated by municipal and industrial wastes can not be used in irrigation now, but in the near future it will be re-used. Under any circumstances a substantial portion of drainage water must be discharged into the sea to maintain the salt balance in the Nile Delta.

Table (2) Nile Water Flow Downstream HAD and Drainage Water Flowing to sea

Year	Nile Water D.S.HAD billion m^3	Drainage Water billion m^3 --------------- Quantity billion m^3
1984 -85	56.4	14.12
1985 -86	55.52	13.856
1986 -87	55.19	13.027
1987 -88	52.86	11.820
1988 -89	53.24	11.120
1989-90	53.89	11.49

The amount of drainage water presently reused in irrigation is 5.9 billion m^3 annually of which 3.6 billion m^3 is in the Nile Delta, 0.95 billion m^3 in Fayoum, and 1015 billion m^3 returned to the Nile in Upper Egypt. This value is expected to be increased gradually to reach 8.5 billion m^3 by the year 2000. It should be noted that the potential savings from improved water management (e.g. more effecient operation of the system to reduce outflows to the sea as practiced in 1987-88 and 1988-89) and increasing drainage water reuse are not mutually exclusive. There is a real danger that the salinity could increase steadily over the years. Thus , a cautious approach to increasing the use of drainage water, especially in terms of water quality, is likely to be in the long-term interest of the country.

It is expected after putting the environmental action plan into implementation, the expansion in the re-use of drainage water for irrigation will be accomplished. The drainage waters, to lake Burrolos will be used as a result of implementing the project proposed for the storage of winter closure waters in this lake. This means that all drainage waters is planned for its reuse in the coming future.

5- Management of Irrigation Water

Agriculture use comprises 82-84% of the available water resources. The Egyptian economy has traditionally lied heavily on agriculture as a source of growth, both in terms of contribution to GDP as well as a source of employment for a significant part of the Egyptian labor force. Agriculture in Egypt is almost entirely dependent on irrigation ; the country has no effective rainfall except for a narrow band along the northern coastal areas. Consequently, agricultural development is closely linked to the River Nile and its management. The construction of the High Aswan Dam in 1960's allowed for the entire flow of the Nile to be secured with consequent increase in both the reliability which enabled the conversion from basin irrigation in one million acres in Upper Egypt, to perennial irrigation system and availability of irrigation demand for all areas under irrigated agriculture all the year round. The agricultural land base of Egypt consists now of 7.3 million Feddand (about 3.0 million ha) lying within the Nile basin and Delta, and about 200000 feddands (80000 ha) of agricultural land elsewhere(rainfed and in oasis) . This translates to one of the world's lowest levels of per capita productive land availability of 0.13 feddans (o.05 ha) . Of the total area in the Nile basin and Delta, some 5.4 million feddan are old lands, and the remaining 1.9 million feddan are "new" lands reclaimed since 1952 up till now. The total cropped area is presently about 13.3 million fed., giving a cropping intensity of around 180 percent for the country as a whole. The irrigation system is rather a complex system comprising main canals deriving their water directly from the Nile upstream the different locations both in Upper and Lower Egypt to raise the water level to the necessary commanding levels of those main canals. Branch canals divert the irrigation network which comprises some 30300 kilometers, the total length of first, second and third order canals , Fig (6) exclusive of the on-farm irrigation systems.

The ministry of Public Works and Water Resources (MPWWR) , besides other public works and water resources responsibilities, is responsible for all aspects of the irrigation and drainage systems, planning , design, construction, rehabilitation, operation, maintenance and management. To administer this large irrigation system, the Irrigation Department, the largest organizational set-up in the MPWWR, having 22 directories, fifty inspectorates and one hundred and seventy districts is having this large responsibility. (Fig 7) illustrates the organization chart of the ministry.

The MPWWR is undertaking a comprehensive USAID financed program for structure rehabilitation and irrigation system and on-farm improvement and modernization. A complementary program is needed to identify, on large canals command area bases, improvement works that could realize significant rise in the irrigation efficiency and improved water management that could include among other possibilities conversion of on farm flood irrigation into piped improved irrigation whenever it is feasible as well as for the water delivery systems (both branch/secondary canals and pump stations). Significant benefits could be realized from old and old-new lands, where a variety of improvement s of water delivery is possible. Rehabilitation of pumping stations, renovation of water control structures, and improvements in irrigation techniques offer highest returns, safeguarding the capabilities of existing infrastructure through timely maintenance activities or its renewal and improving system efficiency is to be given high priority. The increased capital intensity of the system requires higher level of maintenance funding as well as appropriate techniques and scheduling in order to avoid system deterioration. Inadequate maintenance not only lowers the systems' water use efficiency, but also eventually ends up requiring much higher rehabilitation expenditures. There is thus, a need to ensure that maintenance funding is given high priority and that maintenance is carried out in accordance with acceptable technical standards.

The irrigation improvement program of the MPWWR with USAID is also promoting a farmer level institutional framework, through establishing water user associations on the on-farm level for better sharing of water, with a view to reducing the tail end problems and water wastage, and for improving the on-farm water management. The introduction of an institutional system to provide to farmers an efficient irrigation advisory service is also considered.

The MPWWR started the irrigation improvement program and the modernization of the irrigation system after the WRC completed with USAID a nine year program (1976-1985) to study through applied research in 3 large pilot areas, aiming at identification of existing irrigation problems, propose solution towards raising the irrigation efficiency both of the irrigation system and on the on-farm level.

The results achieved through the intensive studies were used in designing the National Irrigation improvement program under implementation now. The NIIP comprises the following.

- Application of modern irrigation systems in new lands and raising the overall irrigation efficiency from around 70% to 82%. This includes raising the water conveyance and distribution efficiency, as well as the field irrigation efficiency
- Reuse of drainage water for irrigation purpose, on regional basis in conjunction with the available ground water in the same region, taking into account those two sources estimating the water balance and identifying the canal water diversions.
- Development of irrigation canals and properly regulating its waters through the rehabilitation of deteriorated regulating structures and minimizing the losses along the distribution system.
- Prevention of water released during the winter closure period for non-consumable purposes from flowing westerly to the sea.
- As for the on-farm water management:

  Replacement of the mesquas intakes and conversion of the mesquas whenever economically justified to closed conditions or pipeline or to the furrow irrigation long mesquas along with necessary laser land leveling by which on-farm irrigation efficiency could be raised from 55% to more than 80%

  The continuos flow in feeding canals at low levels reduces considerably the waste in irrigation waters.

  Encouraging the night irrigation and prohibiting any flow of irrigation water releases flow to the drains at the canal tail escapes.

  The establishment of water user associations to participate in irrigation water distribution and its management in the on-farm level, leads to better conservation of the water and the irrigation network.

The irrigation management system program of the MPWWR with the USAID comprises nine activities (components) at least four of them are directly dealing with the improved irrigation water management :
These components are:

- The irrigation Improvement Program (IIP)
- The Structural Replacement (SR)
- The Preventive Maintenance (PM)
- The Telemetry (MSM)

Nevertheless, more specific programs are still needed on command area basis of main canals, where priorities should be identified on basis of feasibility studies, to concentrate activities that will lead to raised irrigation efficiency both on the delivery system and on the on-farm levels.
The EWUP (Egyptian Water Use Project) assured through the extended applied research, that beside savings in irrigation water by 10-15%, improved production will also be realized through improved irrigation management.

As has been repeatedly emphasized , the most critical natural resources is water. Demand from various sectors will continue to increase in the next decade and beyond. With limited water supply from the Nile, the only alternative is increased use of available ground water and re-use of drainage water and treated industrial and domestic water effluents.

A related aspect is that of water quality; in this context, the impact of pollution on water availability cannot be over emphasized. This is of importance particularly in the context of ongoing and future re-use of drainage water. Agricultural activities affect water quality through fertilizer, pesticide and other agricultural residues. While reliable data on the quality of surface water and ground water are limited, it is clear, nevertheless, that the extent to which polluted drainage water can be reused throughout the present mechanism of mixing with canal water will have to be carefully monitored to avoid risks. Options for cleaning up of this water including municipal and industrial effluents to remove pollution should be examined, as should the introduction of such practices in agriculture. Dedication of the drainage water for purely agricultural purposes is also being considered for the future.

With increasing re-utilization of drainage water, conservation of this source from being polluted by industrial and municipal effluent should be carefully planned and managed . All drainage waters in Upper Egypt are returned to the system and re-utilized . Plans for expanded re-use of drainage water for irrigation in the Delta calls for augmenting these waters for mixing and re-use to increase by 4.4 to 5.0 million m^3 per year thus only allowing the highly polluted and highly saline drainage water flow to the sea within the amount necessary to preserve the salinity balance.

Besides the MPWWR being engaged in addressing such environmental issues, there is considerable scope for improved coordination with the Egyptian Agency for Environmental Affairs. The agency is presently coordinating the Environmental Action plan for Egypt , which is supported by several donors. This plan will provide a framework for dealing with many of the problems pre-mentioned, including measures for enforcing legislation, institutional responsibilities and economic aspects of environmental preservation.

SUMMARY AND CONCLUSION

Egypt's water resources are getting exhausted because of the rapidly increasing population and the increasing water demands for different uses.

Previous plans considered in the past, the increase of Egypt's water share from the Nile, through the implementation of the Upper Nile Projects. The first of those projects, the Jongolei canal, has been abandoned since November 1983, on account of security problems in the south of Sudan , it is uncertain when work will be resumed in this specific project or in any of the three other projects in the area.

Re-planning to satisfy the increasing demand without increasing the Nile supply, dictated the start of a comprehensive irrigation water management program including improvement and modernization of the irrigation system both in the irrigation network and on-farm level. This program includes rehabilitation of water control structures and pump stations, improvements in irrigation techniques, timely maintenance and other works aiming at increasing the irrigation efficiency to the maximum economically possible value. To carry on this program, many research work has been accomplished and will continue to answer the so many questions arising and to prove through applied research, the viability of each of the different activities incorporated in this program. Training is also becoming more and more active to enable build up the human resources capabilities of the individuals involved in those programs both in public and probate sectors.

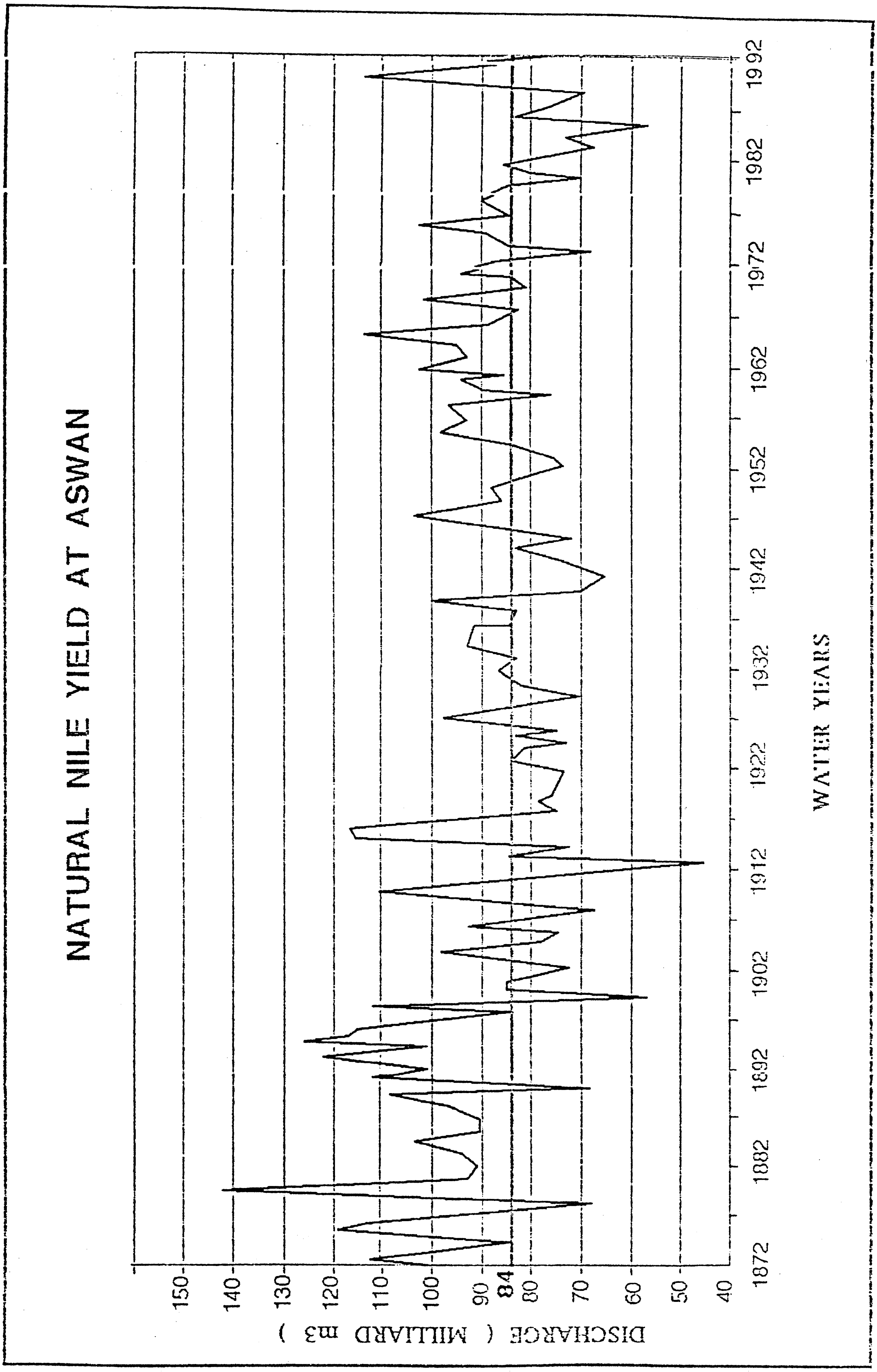
The recycling of drainage water and municipal and industrial effluents to satisfy the pressured demands in irrigated agriculture, in municipal and industrial utilization, as well as other demand indicated the involvement of addressing the related environmental issues. An environmental action plan has been drafted , to provide a framework for dealing with many of related problems, including enforcement, institutional responsibilities and economic aspects of environmental preservations.

The water management programs under implementation are designed towards the year 2000 on the following basis:-

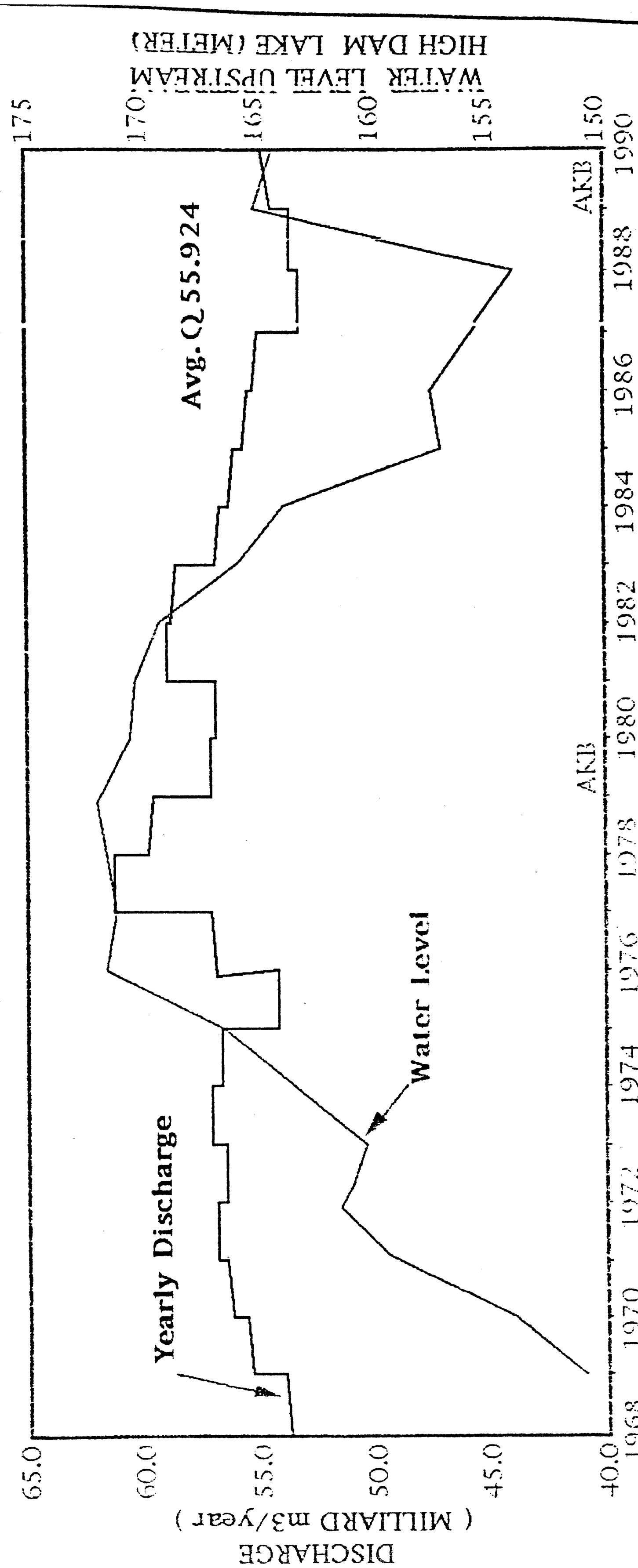
- The irrigation improvement program in old lands in an area of 400000 acres will save one billion m^3 before the year 2000 and expand considerably afterwards to cover all the agricultural lands. Besides the support from USAID , and intensive program will be implemented during the coming five year plan, with funds from IBRD,IDA,KFW and the EEC.
- Re-use of drainage water for irrigation up to 8.5 billion m^3 till year 2000, to be completed. Besides re-cycling of municipal and industrial effluents and storage of water releases during the winter closure period in the Northern lakes has to be accomplished.
- Expanded utilization of the ground water of the valley and the Delta up to 4.9 billion m^3 annually both for irrigation new lands or for drinking purposes..
- Recycling of municipal effluent for restricted irrigation in an area of 200000 acres.
- Expanded utilization of the ground water of the Nubian Sandstone aquifer to irrigate and additional are of 200000 acres.

Planning for water resources towards the year 2025 indicate that satisfying the demands will never become realized unless the upper Nile projects are implemented to increase Egypt's Nile water share by at least 9 billion m^3.

The per/capita annual quota of Nile waters now is 1000 m3, and without implementing the Upper Nile Projects, this share will drop to 603 m3 which is below the proverty datum of the per capita water requirements.

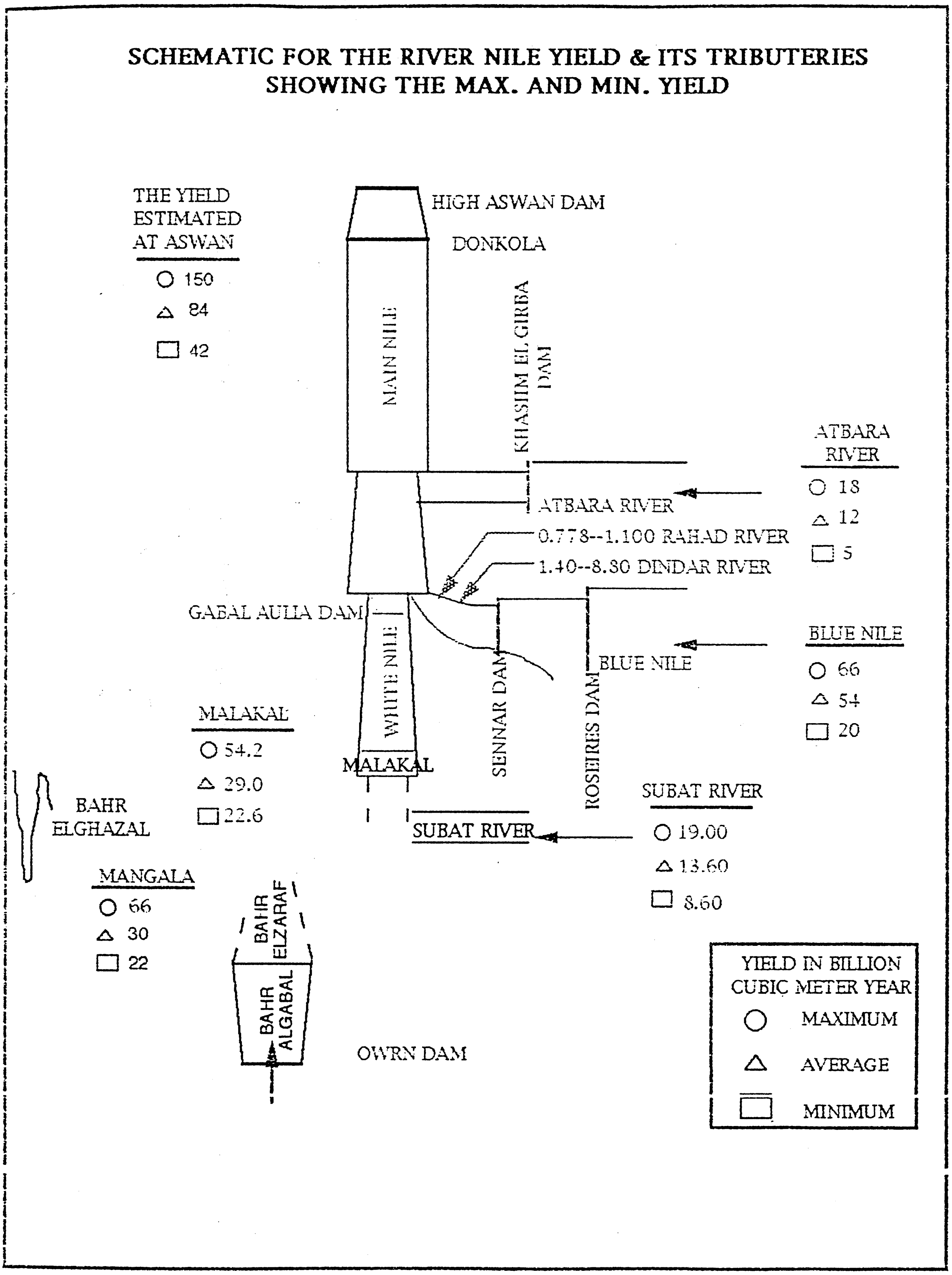

NATURAL NILE YIELD AT ASWAN
DISCHARGE (MILLIARD m3)
150
140
130
120
110
100
90
84
80
70
60
50
40
1872
1882
1892
1902
1912
1922
1932
1942
1952
1962
1972
1982
1992
WATER YEARS

(Fig 1)

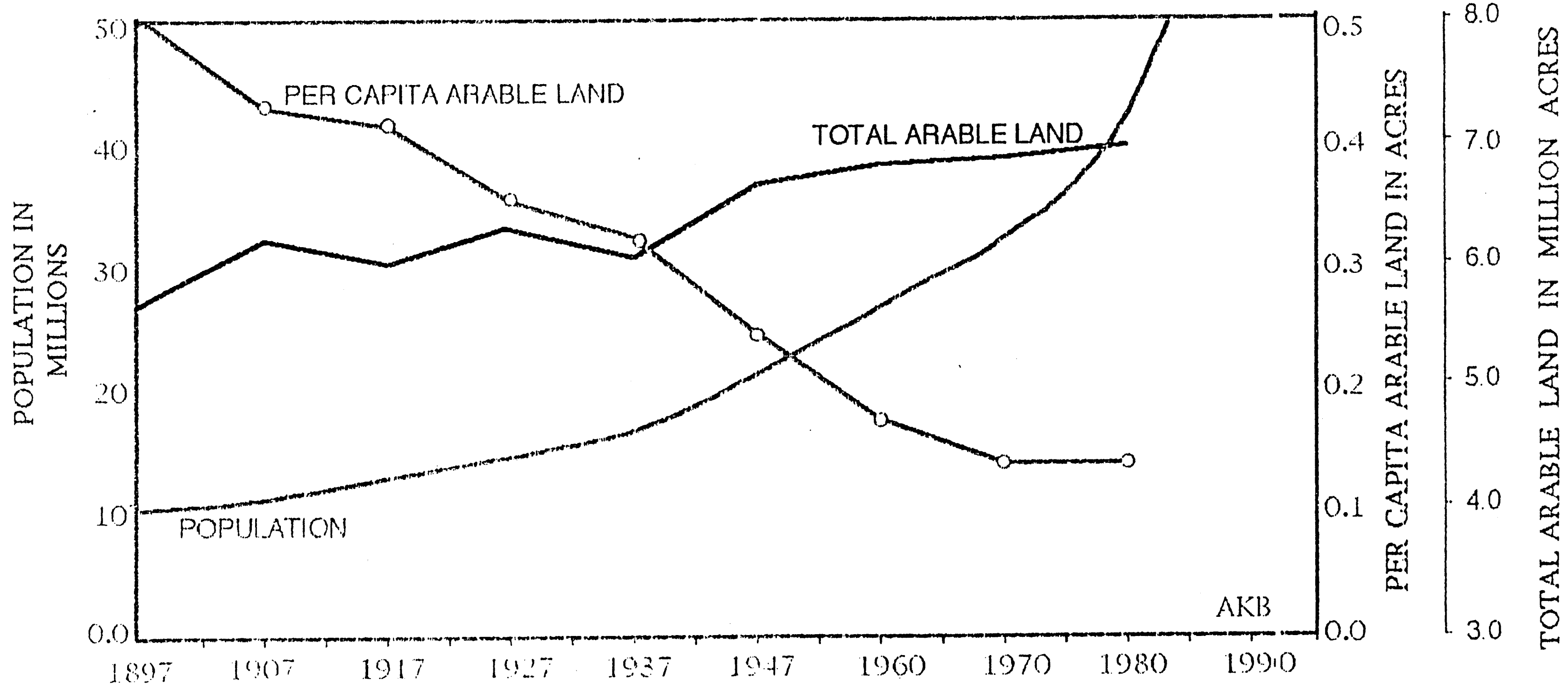


WATER LEVELS (in), and DISCHARGE FROM THE HIGH DAM LAKE (1968 - 1991)

(Fig 2)

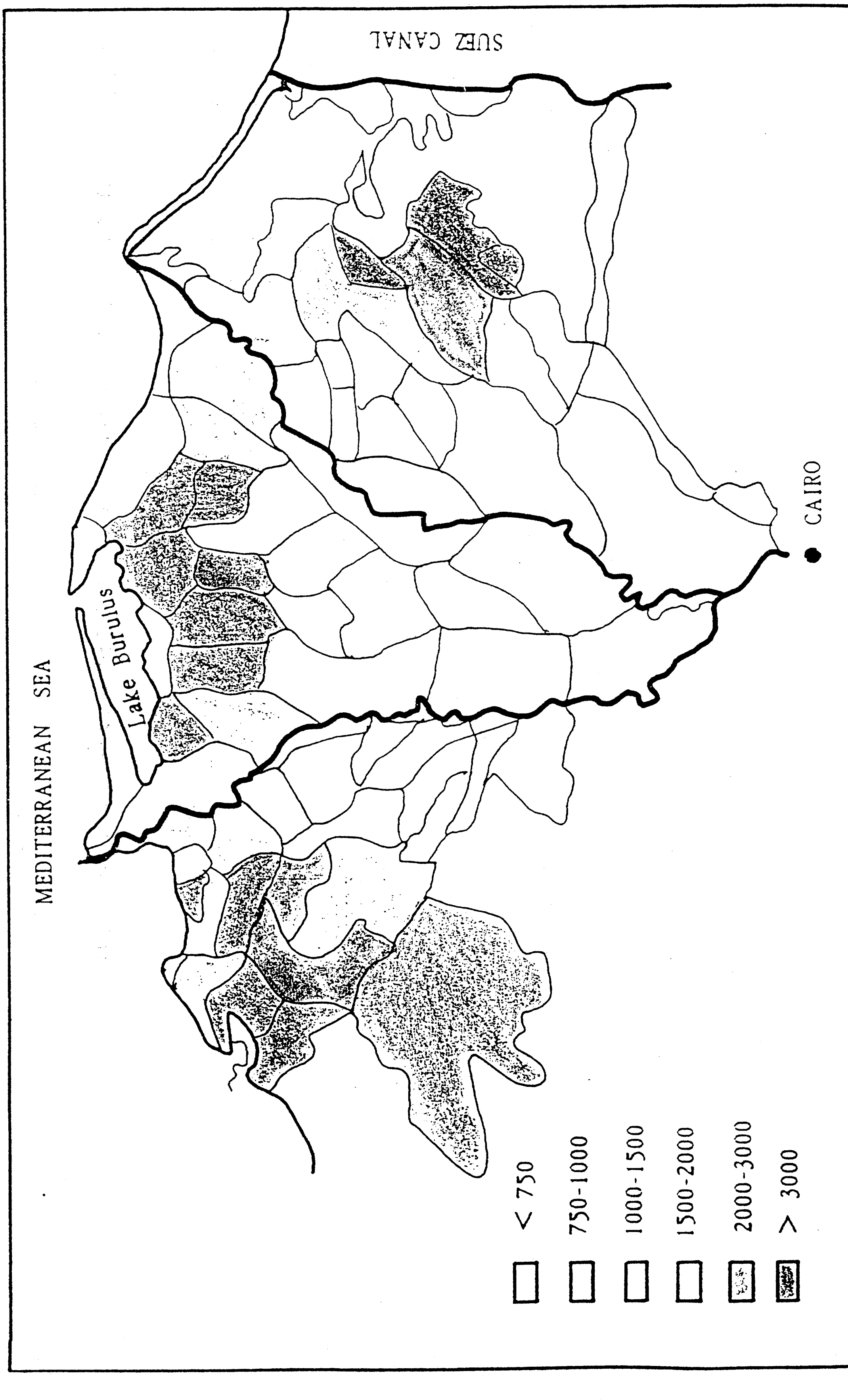

SCHEMATIC FOR THE RIVER NILE YIELD & ITS TRIBUTERIES
SHOWING THE MAX. AND MIN. YIELD
THE YIELD ESTIMATED AT ASWAN
150
84
42
HIGH ASWAN DAM
DONKOLA
MAIN NILE
KHASHM EL GIRBA DAM
ATBARA RIVER
18
12
5
ATBARA RIVER
0.778--1.100 RAHAD RIVER
1.40--8.30 DINDAR RIVER
GABAL AULIA DAM
WHITE NILE
SENNAR DAM
ROSEIRES DAM
BLUE NILE
BLUE NILE
66
54
20
MALAKAL
54.2
29.0
22.6
MALAKAL
BAHR ELGHAZAL
SUBAT RIVER
SUBAT RIVER
19.00
13.60
8.60
MANGALA
66
30
22
BAHR ELZARAF
BAHR ALGABAL
OWRN DAM
YIELD IN BILLION CUBIC METER YEAR
MAXIMUM
AVERAGE
MINIMUM

(FIG 3)



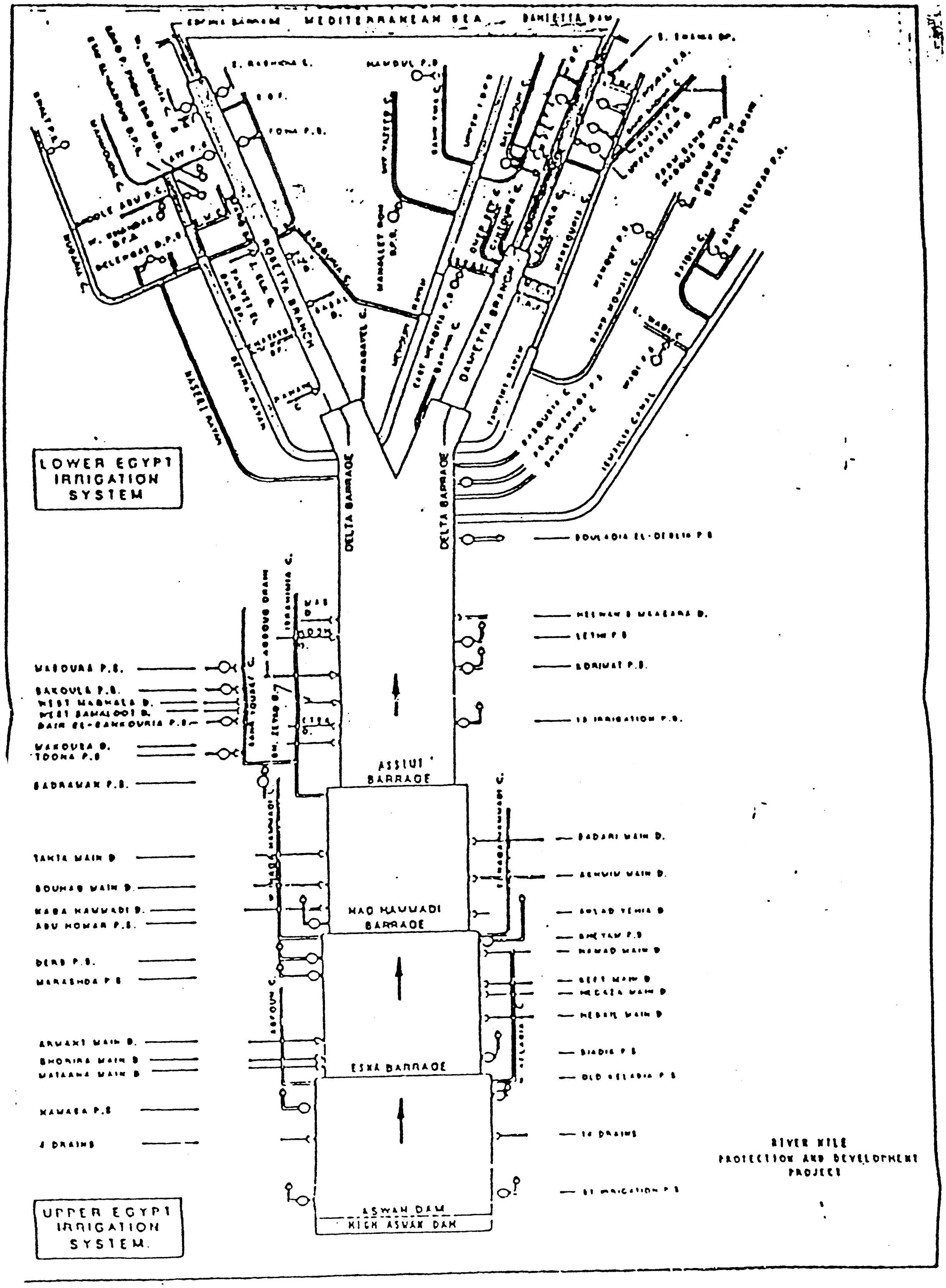
POPULATION AND ARABLE LAND (TOTAL & PER CAPITA) IN EGYPT, 1897 - 1990

(Fig 4)

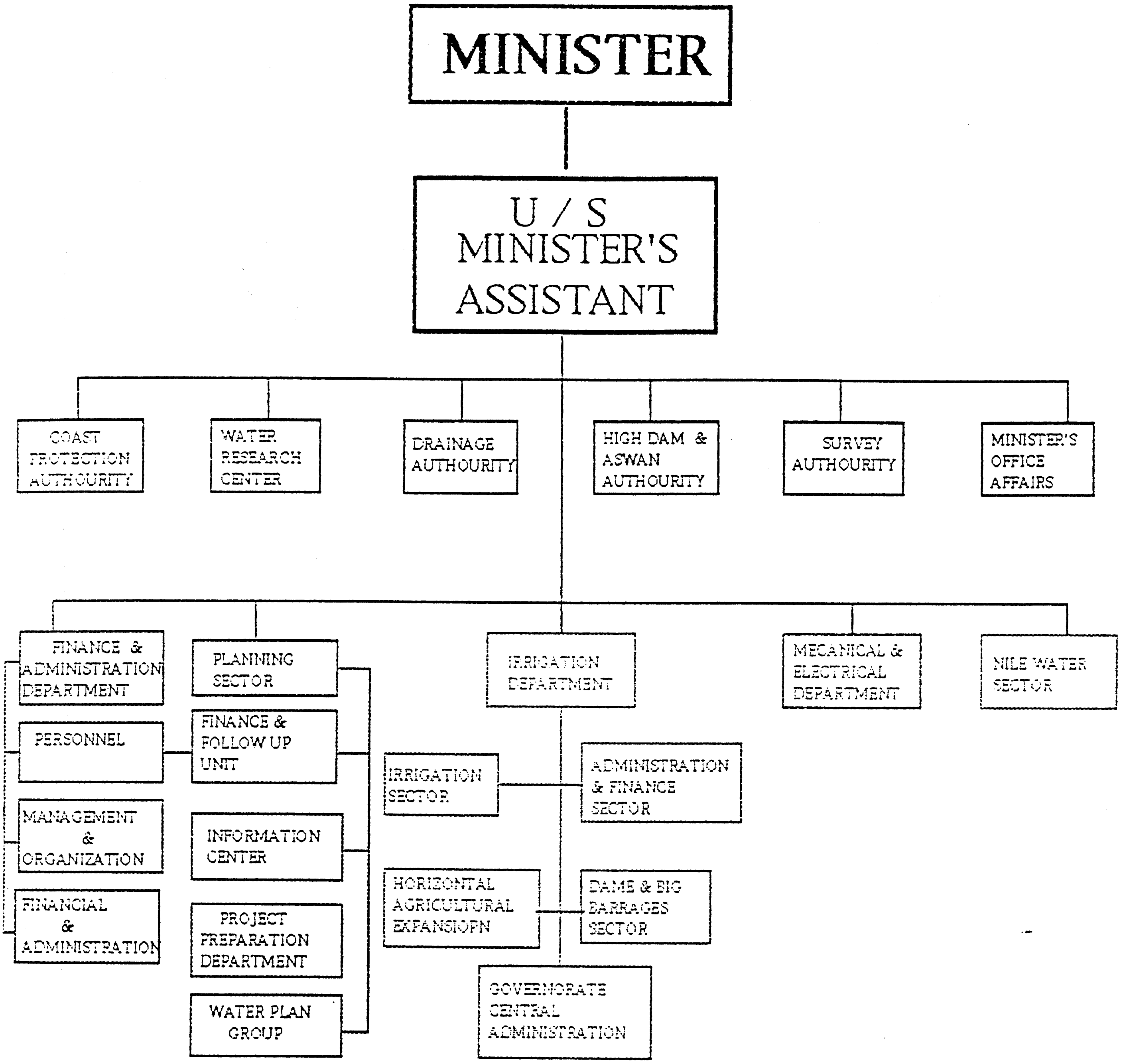


Average Salinity of Drainage Water (ppm) per Catchment

(FIG 5)



(Fig 6) NILE RIVER SYSTEM BARRAGES ,CANALS AND DRAINS



MINISTRY OF PUBLIC WORKS & WATER RESOURCES

(FIG 7)