EGYPT'S HIGH ASWAN DAM

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ABSTRACT

In the 15 years since water was first stored behind the High Dam at Aswan, ARE, 10 years after the total 133 million acre feet of storage was available and 9 years after the installation of the last turbine the High Dam has proven to be a successful project for the prosperity and well being of the Egyptian people. In spite of this there has been and continues to be adverse reports of the Dam. The charge that the dam would not hold water--it is presently full--and there would be a decrease in cropped area[1/]--cropped area in the "old lands" has increased to 10.9 million acres in the 1970-74 period from 9.4 million acres in the 1950-54 period has been disproven. The other side effects, loss of fisheries, scour of the bed and banks, waterlogging and salinity, aquatic weeds, spread of schistosomiasis, elimination of the brick industry, loss of fertility by loss of sediment being deposited on the land, reservoir filling with sediments in a short time and erosion of the seashore of the delta have all been either proven to be inconsequential, not true or that with available technology carefully used, be overcome.

INTRODUCTION

The High Dam Project at Aswan, Egypt, was completed in 1970 with the installation of the Twelfth Turbine. The first stage was completed and storage of water started in 1964. The dam, which stores almost twice the average annual flow of the Nile, allows the Egyptian people 100 percent control of the Nile River. Its completion has assured the water supply for the 5.8 million acres of the cultivated alluvial lands in the Nile Valley and Delta, can provide water for the development of

1/Cropped area takes into account that some of the cultivated land is cropped two or three times a year.

1.5 to 2.0 million acres of new lands in the desert and has provided for a change of 1 million acres from single crop "basin"[2/] irrigation to multicrop "perennial" irrigation.

Potential annual power generation capacity of the dam is 10 billion kilowatt hours. Because irrigation has first priority on the water, annual power production is less than this potential and Egypt depends on thermal energy for some of its power. Even so, the High Dam furnishes over 50 percent of the electrical power needs of the country and is a significant factor in the industrialization of the country. With its present population of 40 million, Egypt must industrialize to meet the aspirations of her people. Agriculture, although significant to the country (it furnishes 30 percent of the gross national product) cannot provide the necessary jobs for the projected population growth. The projected population growth is to 70 million by the year 2000.

The water from the High Dam meets the navigation needs during drought and will prevent disastrous floods. The average flow in the Nile ranges from a low of 36 million acre feet (AF) to a maximum of 122 million AF with an average of 68.1 million AF. Extreme low flow causes drought, loss of crop production and famine; and extreme high flow causes floods, loss of crop production, famine and loss of life. Since completion of the High Dam there would have been low flow in 1972 and flooding in 1975. Both would have caused the rest of the world to provide food aid to Egypt.

In spite of the many benefits of the High Dam--new energy, assured water supply, increased crop production, navigation and flood control--the dam and reservoir have been subjected to irresponsible, sensational exposes in newspapers and magazines calling it an ecological and financial disaster. The bad press has ranged from, "It won't hold water. . ." "It is presently full. . ." to the "Loss of fertility because mud is no longer deposited on the land. . .". The fertility provided by the annual flood is less than that which would be provided by plowing wheat straw back into the ground.

[2/]"Basin" is Egypt's name for the method of irrigation where bunds (1 to 4 ft high) were built around parcels of land 2 to 100 acres is size. These bunded lands were filled with water when and if the Nile flooded. The water was allowed to stand in the bunds until the flood was over or the soil profile was filled with water, then drained off and a single winter crop was grown.

Most irresponsible has been the claim that Egypt embarked on the construction of the dam with careless disregard and inadequate or no studies of the ecological environmental side effects and still disregards these changes. When the truth is that many ecological and environmental studies were conducted prior to construction utilizing Egyptian scientists and outside experts (Hatem, 1974). Since completion Egypt's engineers are seriously studying and taking remedial measures to offset or remedy adverse side effects of the High Dam.

Any dam on a river, for that matter any change in the ebb and flow of the water in a river system--either by man or by nature--causes a response (change) in the system. These responses, whether good or bad depends on the observer and more particularly whether he has a full belly, are predictable to scientists who have studied the intricacies of rivers and river management. Many an environmentalist will glowingly describe a particular river; for example, the Platte River in Nebraska (Williams, 1978) or the lower Colorado River along the Arizona-California border (Lopez S., 1978) without ever realizing that the river's present condition is the result of the dams and river development upstream. In fact, the lower Nile and the lands adjacent to it all are the results of Egypt's efforts to control and utilize the river from the earliest times. Pharoah Amenemhet in the XIIth Dynasty (about 2000 B. C.) constructed the earliest recorded dam and irrigation project (Brown, 1892, Ibrihiam, 1968, Benedick, 1978). The High Dam is only the last, and by no means the final, step in the evolution of the River Nile.

The benefits of the High Dam are:

1. An assured, adequate and dependable supply of irrigation water for year-round agriculture. This provides for multi-cropping and the potential for three crops instead of one. Increases irrigated areas and yields per acre.

2. Change in cropping season so that crops could be grown during the most favorable season for maximum production. Thus, timing of water for maximum yields.

3. An additional 18 million AF of water that formerly flowed into the Mediterranean Sea. By international agreement, Egypt's share is 6 million AF and Sudan's share is 12 million AF. It is an interesting, but well-proven concept, that downstream storage releases water for use upstream. For example, Lake McConaughy in Nebraska, by providing water for downstream users, either directly or by return flow, who have a

prior right, prevents a call being placed on water being used by upstream irrigators. A call is the process where a downstream user with an earlier water right requires upstream users to stop using water so that he can get his right satisfied. The water for Sudan will help end Egypt's controversy with Sudan for summer water.

The assured increase in water, by utilizing return flow and ground water, will provide sufficient water for agricultural expansion of 2.5 million feddans (1 feddan equals 1.04 acres) (Egypt's Ministry of Irrigation, 1978).

4. Flood control to protect lives, crops and property.

5. Improved year-round navigation.

6. Cheap hydroelectric power. The High Dam potential is 10 million kwh annually but with the assured water supply electrification of the four major barrages (diversion dams) and Old Aswan Dam is another source of electrical power.

In the 15 years since completion of the first phase (1964), many of the benefits have been realized. In fact, Egypt has made significant progress in realizing the potential of the High Dam in a relatively short time. Although storage started in 1964 it was not until 1967 that the full reservoir volume was available and the last turbine was installed in 1970. In addition to construction of the Dam, Egypt changed over 1 million acres from "basin" to perennial irrigation, constructed new or enlarged existing canals, brought over 780,000 acres of desert lands "new lands" under cultivation[3/], started industrialization, constructed the power distribution system, increased the number of universities and the number of students in its universities and at the same time was at war.

The list of ecological disasters (Catalog of Horrors (Benedick, 1978) that have been reported are as follows (references are given in literature cited under High Dam Disaster Reports):

[3/] The development of the new lands has been less than a success. In fact, new land development has not lived up to expectations, but with new and improved technology from the West the desert lands can be made productive and a contributor to gross national product rather than take resources from it.

1. The dam and reservoir would not hold water and it would never fill. Seepage into the nubian sandstone and evaporation losses from the surface would result in a loss of water and millions of acres of land would go out of production.

2. The additional water available year-round would waterlog the land and increase the salinization of the land.

3. Erosion of the Nile riverbed as the result of the release of sediment free water (hungry water) from the dam.

4. The loss of fertility of the old lands in the Nile Valley and delta because they would no longer be inundated with the sediment-laden water during the annual flood.

5. Erosion of the northern shore of the delta resulting from the absence of sediment in the Nile water flowing into the Mediterranean Sea. In fact for all practical purposes the Nile no longer flows into the Mediterranean Sea.

6. Destroy the sardine fishery that existed at the mouth of the two branches of the Nile along the northern coast.

7. The dam and resulting reservoir would increase the occurrence and spread schistosomiasis to epidemic proportions.

8. The lack of sediment in the waters would destroy the brick industry.

9. Aquatic weeds would take over the reservoir and there would be an increase of them in the river and canals.

10. The water in the reservoir would flood the monuments upstream of the dam and downstream of the dam the change in the flow regime of the river and increase in the water table would damage and destroy the monuments.

Although there was some element of truth in some of the critical statements, the dam has not become the ecological disaster as predicted. The few adverse side effects of the dam are either correctable or offset by other benefits. Furthermore, the Egyptian Government and in particular the Ministry of Irrigation has taken the side effects seriously and those that pose significant problems are under study. Many of the studies are being carried out by the Ministry of Irrigation, but the Ministries of Agriculture, Land Reclamation, Industry, Education, Health and Planning are involved. In addition, the Egyptian Academy of Scientific Research and Technology is conducting research on the long-range side effects. Many of the studies were started long before the dam construction started. The studies have been made or are being conducted in collaboration with Ford Foundation, U. S. Agency for International Development, the UNDP, FAO, U. S. Environmental Protection Agency, Colorado State University, University of Michigan, U. S. National Science Foundation, the International Bank for Reconstruction and Development, U. S. Academy of Sciences, U. S. Department of Agriculture, U. S. Department of the Interior, Great Britain, USSR, Netherlands and West Germany.

BACKGROUND

History

Egypt's efforts to control the Nile date back to Pharaohic times. Amenemhet constructed the earliest known dam and irrigation project. Irrigated agriculture is estimated to have started about 5000 B. C. with crops cultivated on the residual moisture left in natural basins after the annual flood. In time these natural basins were probably enlarged and bunds raised to trap additional water. Botzer (1976) concludes that "Artificial irrigation, including deliberate flooding and draining by sluice gates and water contained by longitudinal and transverse dikes was established by the First Dynasty (3200 B. C.). With the change from natural basins to constructed basins and the construction of other irrigation works some form of central government had to develop with rules and regulations. The Step Pyramid, the first of the pyramids, was built for the Pharaoh Zozer about 3400 B. C. after a fairly centralized government had evolved. The Great Pyramids of Giza were build during the Fourth Dynasty around 2500 B. C. This was 1100 years before King Tut. Civilization was very advanced and agriculture was dependent on basin irrigation. About 1785 B. C. a canal was built into the Fayyum area, a depression west of the Nile River (Figure 1). Water was stored in the Fayyum basin for later release. Thus, about 3800 years ago efforts were made to provide some insurance from the year-to-year variations in the Nile's flow.

Egypt's agriculture was the marvel of the ancient world, mentioned in both the Old and New Testaments. Herodotus stated, "The Egyptians. . . obtain the fruits of the field with less trouble than any other people in the World," Herodotus Persian Wars, II, p. 14 as quoted by Benedick

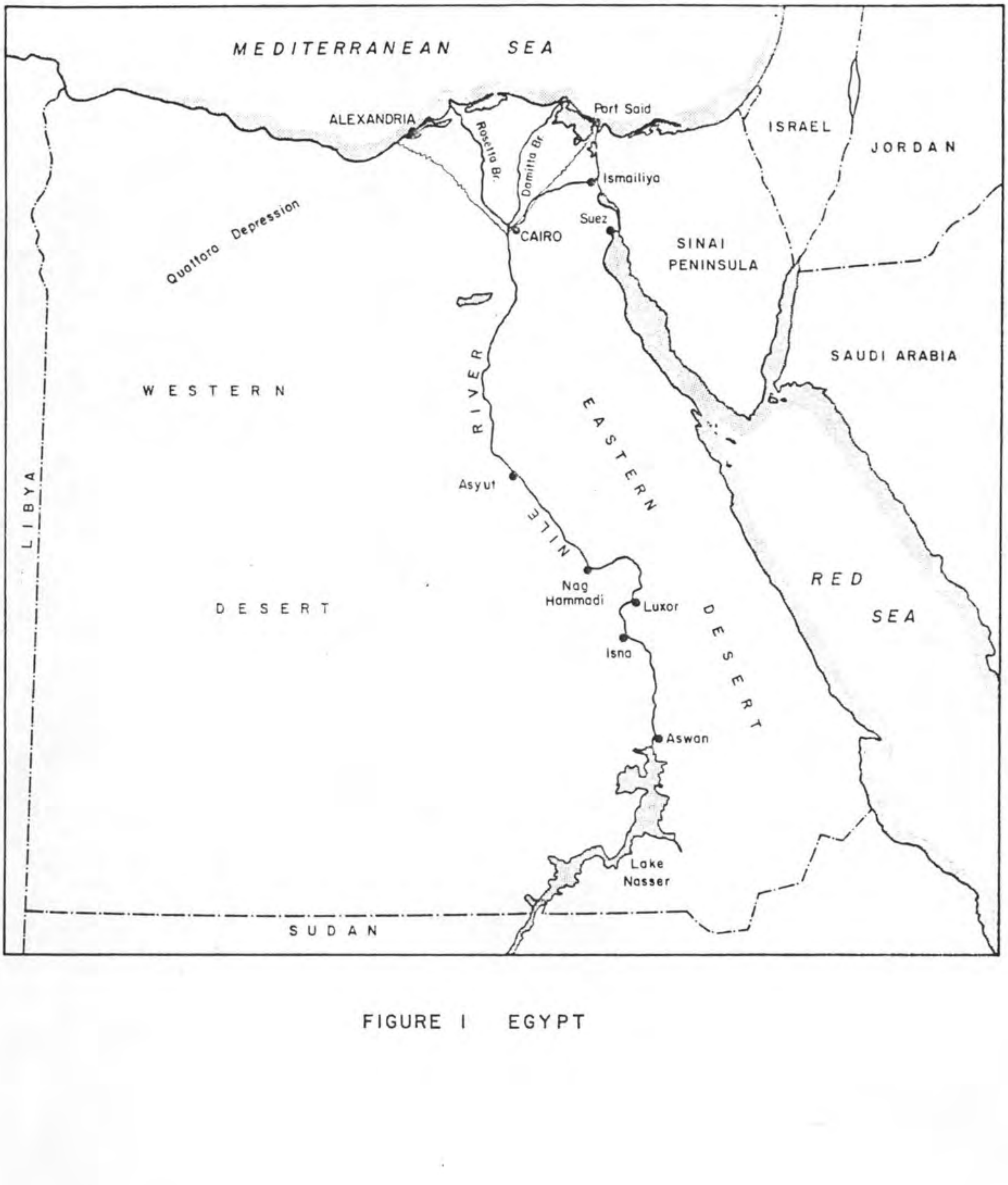

FIGURE I EGYPT

(1978). It was the abundance of the crops provided by the Nile that provided the food and spare time (time not devoted to obtain food and fiber) that allowed the Egyptians the freedom to build pyramids, tombs and temples. The desert also provided them protection from their enemies.

The rapid change from basin to perennial irrigation started about 150 years ago. After the French broke the back of the Mamelukes in 1798 and the Turk Mohamed Ali Pasha (1805-1849) finished the job and established the line that King Farouk was a direct descendent from, barrages across the Nile and canals to distribute the water were built. These canals served to expand the area under "basin" irrigation but they also allowed some irrigation for second crops. The Delta Barrage was built in 1863. The barrage at Assuit was built in 1902, Zifta 1903, Esna 1908, Naji Hamad 1930 and at Edfina 1951. Figure 2 gives a schematic of the irrigation system. Low Aswan was built in 1902 with a capacity of 810-710 AF. Its capacity was increased to 2.3 million AF in 1912 and to 4.5×10^6 in 1933, by the first and second heightening.

With the above construction, Table 1 gives changes in the number of acres in "basin" and perennial irrigation.

Even though there was perennial irrigation and storage of water in old Aswan reservoir, Egypt was still subjected to the variation in flow of the Nile and although there were 1 million acres irrigated perennially, there were years when adequate water was not available. Only by constructing over-year storage could Egypt hope to realize the total potential of the Nile River.

Population

Egypt's present (1979) population is estimated to be 40 million and at the present average annual growth rate the population will be 70 million in the year 2000. Table 2 gives some population statistics. With a population of 40 million, population density for the cultivated area (5.8 million acres) is 4,400 per square mile and with 70 million the density per cultivated acre will be 7,700.

Nile River (Its Water and Land)

The Nile River at 4160 miles in length is certainly the second and perhaps the longest in the world (Hurst, 1952). Its drainage area is 1.15 million square miles. For 1700 miles from the mouth of the Albara River to the sea for all practical purposes the Nile receives no inflow. The last flowing tributary, the Albara River in the Sudan,

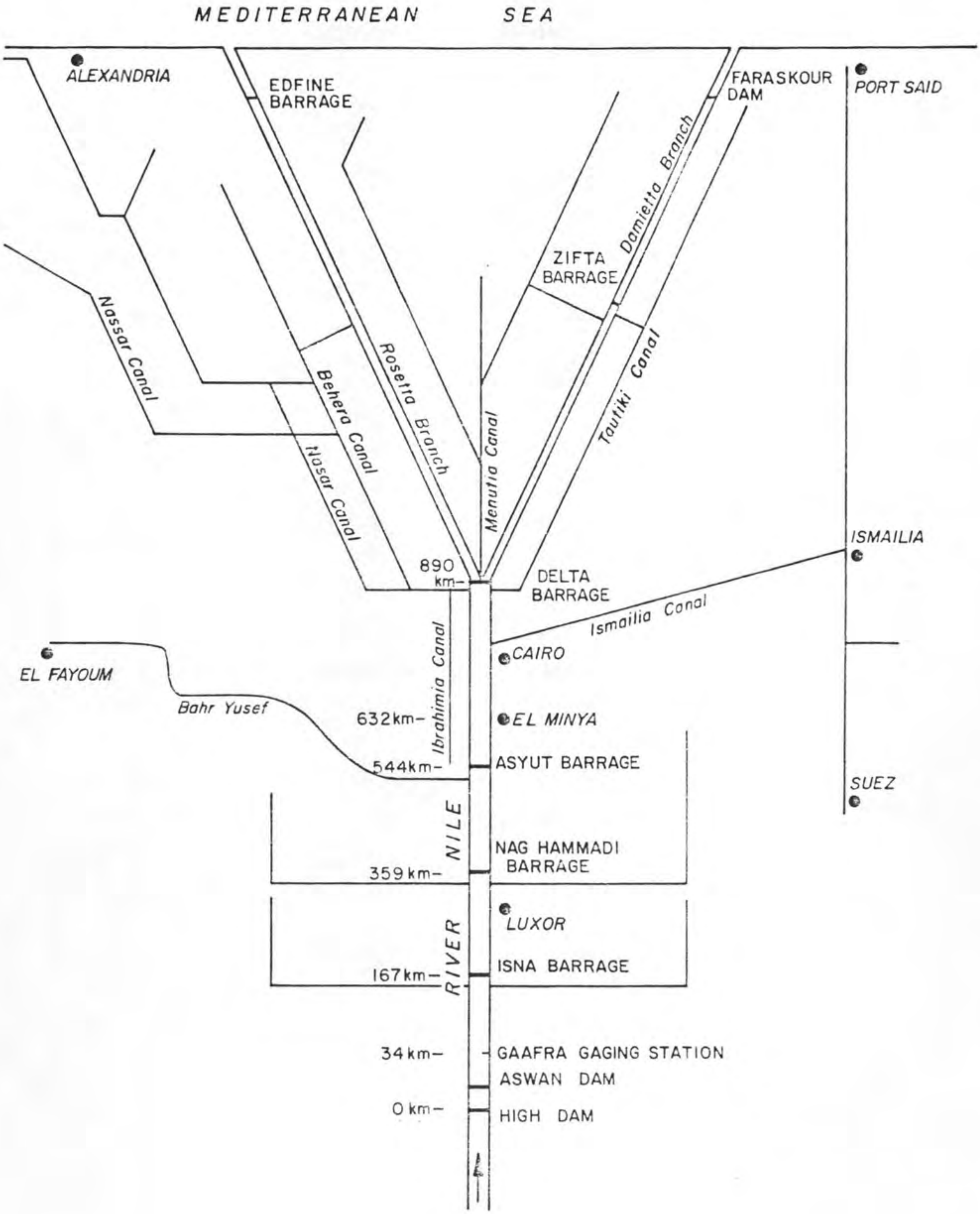

FIGURE 2 SCHEMATIC OF IRRIGATION SYSTEM

contributes 13 percent of the average annual flow. The Blue Nile which drains from Ethiopia contributes 58 percent and the White Nile which comes from Lake Victoria in Equatorial Africa contributes 29 percent. The Blue and White Nile join at Khartoum, Sudan. The average annual flow is 94,100 cfs days or 68.1 million AF. Maximum daily observed flow is 476,000 cfs and the minimum is 35,000 cfs. Maximum average annual flow is 122 million AF and minimum is 36 million AF.

The Nile valley from Aswan to Cairo is 590 miles long and has an area of 3.0 million acres of which 2.3 million acres are cultivated. The Nile Delta from Cairo to the Mediterranean is 130 miles long and has an area of around 5.7 million acres of which 3.5 million acres are cultivated. The total cultivated area is 2.34 percent of Egypt's total land area. It is estimated that about 40,000 acres of land are lost from cultivation each year due to urbanization.

The cropping intensity is such that the 5.8 million acres represents 10.9 million acres of crops or the land is cropped 1.95 times each year. If areas in perennial crops (sugarcane and orchards) are not counted the intensity is 2.00 or 2 crops per acre are grown (El-Tobgy, 1976).

River slope in the Nile valley averages about 0.4 ft per mile (0.000075 ft/ft). Valley width is from 1 to 12 miles.

Land Tenure

After the revolution in 1952 there were three land reform laws. The acts of 1952, 1961 and 1969. These acts limited the amount of land any person or family could own and broke up the large land holdings. The 1952 law limited land ownership to 200 feddans per owner, 1961 law placed a limit of 100 feddans per owner and the 1969 law lowered the limit to 50 feddans per owner and 100 feddans per family unit of husband, wife and minor children. As a result of these laws land was distributed to about 800,000 owners and land holdings changes accordingly. For example, prior to 1952, 94 percent of the landowners had farms of 5 feddans or less and these holdings comprised only 37 percent of the land. In 1965 (the year latest figures are available) 94 percent of the landowners still had farms of 5 feddans or less but these area comprised 57 percent of the land. At the other end of the spectrum in 1952 0.1 percent of the landowners owned over 200 feddans and the area they owned comprised 19.7 percent of the total land area. Whereas in 1965, 0.1 percent had holdings of 100 feddans and they comprised 6.5 percent of the cultivated land (El-Tobgy, 1976).

High Dam

The High Dam has a storage capacity of 133 million AF in Lake Nasser. This is the second largest man-made lake in the world. The Dam is 364 ft (111 m) high, crest elevation is 643.0 ft (196 m) above sea level, cut off wall is 558 ft (170 m) below riverbed, crest length is 12,565 ft (3830 m) and top width is 131 ft (40 m). Sediment inflow into the reservoir is about 120 million tons per year. Dead storage is 24.3 million AF. It will take about 500 years to fill dead storage and sediment start to encroach into the live storage.

Construction started in 1960 with the first phase completed in 1964 (storage volume of 7.7 million AF). In 1967 the entire storage volume of 133 million AF was available and the dam project was completed in 1970 with the installation of the 12 turbines.

Planned storage of water in Lake Nasser is to elevation 600.4 ft (183 m) above sea level and maximum water elevation is to elevation 607 ft (188 m). Minimum elevation of the river downsteam is 344.5 ft (105 m). The lake elevations have continually increased with maximum water surface elevation in Lake Nasser being 418.6 ft (127.6 m) in 1965, 541.0 ft (164.9 m) in 1970 and 559.7 ft (170.6 m) in 1974 (Hatem, 1974). Last year the maximum elevation was 584 ft (178 m) and the reservoir could fill this fall. The emergency spillway spills into the river at this time. But because the Egyptian Government does not want to have any flooding of the Nile, an emergency spillway canal is being constructed at Tushka, 200 miles upstream of the dam and near Abu Simbul. This Tushka spillway will spill any and all excess flood waters (water that would cause the lake elevation to exceed elevation 497 ft (182 m) into the desert. This spillway can spill surplus water this fall (1979) if needed. The construction of the Tushka spillway gives the Egyptian Government the freedom to store water to the maximum design elevation without having to worry about a subsequent flood flow having to go down the Nile.

CRITIQUE OF HIGH DAM

Will Not Hold Water

The likelihood that the dam would never fill and millions of acres of land would have to go out or production because of the loss of water by seepage into the lake bed and evaporation has been thoroughly discredited. Storage of water in the reservoir has continually increased until the reservoir is presently filled. Actual losses have been lower than the estimates (Waterbury, 1974, p. 20; Hatem, 1974, p. 27). The estimated seepage and evaporation losses were given at 10 billion cubic meters (bcm) or 8.1 million AF in the 1959 Nile Water Agreement between Egypt and Sudan. This was prior to the start of construction of the High Dam and refutes the claims of some that these factors were not considered in the design or that research was not conducted until after construction started (Waterbury, 1974, 1977). The total loss of water in the 1969 water year from inflow/outflow analyses was 6.8 million AF. Maximum water level was 512 ft or 88 ft below maximum elevation. Theoretical losses for that year were calculated as 7.95 million AF distributed as 3.27 million AF by seepage and 4.68 million AF by evaporation. The actual losses are significantly below theoretical and the estimated losses that were used in distributing the gain of water between Egypt and the Sudan. The difference between the theoretical and actual measured are probably due to over-estimating the seepage losses because evaporation losses are more subject to calculation.

A factor often overlooked by the critics who question the ability of the dam to hold water (Claire Sterling, 1971, estimated it would take 200 years for the dam to fill) is that seepage loss is bank storage and a significant portion is reclaimed when a lake is lowered. It is interesting that Sterling's estimates were published in 1971 and the reservoir was filling and data were available on actual losses.

The assured increase in water supply has increased the total area of old lands cropped from 9.4 million acres in the 1950-54 period to 10.9 million acres in the 1970-74 period. Actual cultivated area in the "old lands" has remained fairly constant from 1970 to 1974 (El Tobgy, 1976, Table 5) at about 5.8 million acres. There has been a decline in "old lands" cultivated since the 1961 census (6.21 million acres) because of urbanization. The difference between cropped land and cultivated area results from the double and triple cropping of the cultivated land. The increase in cropped land resulted from changing the remaining land under "basin" irrigation to perennial and the addition double cropping that the increased assured water supply allowed.

With the High Dam providing over-year storage crops could be grown when climatic conditions for optimum production prevailed rather than when water was available. Prior to the High Dam, the Nile flooded in the fall of the year and crops were grown during the winter. Summertime, when solar energy and temperatures were optimal for crop production, water even in good runoff years, was either not available or in short supply. The water stored behind old Aswan Dam was only 4.5 million AF. This climatic factor is illustrated by the 72 percent increase in corn yields that occurred with a shift of from 16 percent of the summer cropped areas bring in corn in the 1960-64 period to 78 percent in the 1970-74 period (El-Tobgy, 1976). Total area in corn decreased 8 percent. The increase in yields placed Egypt sixth in grain yield among major corn producing countries.

Rice area which is a major export crop for Egypt (second only to cotton), has doubled since and as a consequence of the High Dam. In 1950-54, 0.42 million acres were in rice. In 1970-74, 0.89 million acres were in rice (El-Tobgy, 1976). The reasons according to El-Tobgy were the available water from the High Dam which allowed for the expansion and a comparative economic analysis showed a change from corn to rice production in the northern delta was advantageous. Corn production in the northern delta had the lowest yields. Rice yields increased 40 percent between the two periods (from 1.5 tons per acre in the 1950-54 period to 2.1 tons per acre in the 1970-74 period). Most of the increase was the result of newer varieties although the assured water also was a contributing factor. Thus the High Dam made possible significant increases in rice and corn yields.

In addition to vertical expansion in crop production there is sufficient additional water for horizontal production increases by bringing in new desert lands ("new lands"). The Ministry of Irrigation estimates that there is 13.5 million AF of water available for horizontal expansion (Minister's Office, 1978). The desert lands are of poor quality. They are low in fertility, have low water holding capacity, contain soluble salts and thus must be developed with care. However, with proper water management, modern irrigation methods (sprinkler, bubble and drip), use of fertilizers and good agronomic practices, these lands can produce record yield as has been shown in the Sand Hills of Nebraska and in the lower Colorado River Basin. Unfortunately, Egypt's efforts in new land development has been less than a spectacular success. Approximately 700,000 acres of new lands have been placed under cultivation but yields are low and salinity and waterlogging problems exist. The major problems are poor design of the delivery system, poor on-farm water management and lack of drainage. These lands will require irrigation methods and technologies that are different than those that are successful in the old lands. The Egyptian Government realizes its problems and is seeking help from FAO and the U. S. to remedy the problem. Regardless of the cost, Egypt must develop the new lands to the extent it has water available. The growth in population requires it. The technology is available--it is just a matter of time and money.

The High Dam not only has increased crop production but its over-year storage capability eliminates wide fluctuations in water supply, floods and droughts. For example, in 1972, without the High Dam, there would have been insufficient water and a third of the cotton and rice crops would have been lost. In 1975 there would have been a major flood with loss of crops and possibly life.

Waterlogging and Salinity

There have been serious waterlogging and salinity problems in the "old lands" as well as the new. These problems have occurred for two reasons; poor on-farm water management and the lack of drains (open and tile). Neither of these are attributable to the High Dam except that it provides the water that is mismanaged either on the farm or by the lack of drains. Drainage problems predate the High Dam. For example, Fox (1951) quotes Sir W. E. Garstin "I do not want more money for reclamation for many years to come. I want money for my drains, and, if I do not get that, we shall have to reclaim our existing irrigation as a great deal of it will have disappeared." Fox also quotes a note by Sir Scott Moncrieff in 1889 that he thought drainage was more important than storage at that time. Some critics cite the High Dam because the evaporation has increased the salt content of the water. However, the water in the Nile is still of excellent quality, TD's of 200 ppm at Aswan and 300 ppm at Cairo. River water with TD's of 800 to 1000 ppm and more are used successfully in the lower Colorado River Basin and Upper Arkansas River Basin.

A major cause of the problem is lack of on-farm water management (Richardson) et al 1976. With water in abundant supply the Egyptian farmer is like any other farmer in the world, "If a little water is good, a lot of water is better."

With the High Dam, there is an abundance of water and the farmer over-irrigates. This has caused the ground water table to come up with the consequences of waterlogging and salinity problems.

Another cause that is advanced by the critics is the concentrated year-round agriculture. But with good water management where only the amount of water needed for evapotranspiration and necessary leaching is applied, with the installation of drains where the water table cannot be controlled by management, and possibly lining of canals that have high seepage rates in the delta, year-round agriculture will not cause waterlogging or salinity problems.

It is advanced that the use of fertilizers and chemicals and the loss of the annual flooding causes the salinity and waterlogging problems. Again with the use of fertilizers and chemicals, it is their misuse and lack of proper on-farm irrigation and irrigation management techniques that is the problem. With proper application rates and proper on-farm water management, little of any of the chemicals will be added to the flow. With regard to the loss of the annual flood leaching the land, proper water management can accomplish the same goal. However, in many areas for this leaching to occur drains will have to be and are being installed. Even with the annual flood, leaching could not occur in many areas because there was poor drainage and many areas were being drained prior to the High Dam.

In conclusion, the High Dam did not cause the salinity and waterlogging problem. The poor management of the new water resource did. However, the problem can be remedied and is.

Erosion of the Riverbed and Bank

The release of sediment-free water from the High Dam has lowered the bed of the river and the change in flow regime has increased bank erosion. These effects were anticipated during the design of the dam, but calculations indicated that with the existing barrages causing backwater upstream and the flat slope of the Nile River (0.4 ft per mile), that it would not be of immediate concern and could be dealt with in time. Measurements made since 1964 confirm that degradation of the bed is not excessive. In a river like the river Nile it is difficult to conclude a certain value for the bed erosion. From the hydrographic survey you can find for example erosion in one five kilometer reach and deposition in the following five kilometer reach and so forth. The drop in the water level can be an indicator of degradation, although, it is the result of bed erosion, bank erosion and change in channel roughness. From the rating curves for the gaging stations downstream (D. S.) of Aswan the following figures (Moatasim, 1979, Gasser et al. 1978) have been determined for the drop in water levels for the period (1964-1978) for $Q = 100\ m \cdot m^3/day$ (40,842 cfs).

At Guafra (34 km D. S. Aswan)	= 40 cm	(1.3 ft)
D. S. Esna Barrage	= 80 cm	(2.6 ft)
D. S. Naga Hamadi Barrage	= 62 cm	(2.0 ft)
D. S. Assuit Barrage	= 35 cm	(1.1 ft)

Most of this change in water surface elevation occurred during construction of the High Dam when sediment was trapped behind the Coffer Dam and the non-regulated high sediment-free flows passed on down the river.

The bed of the river will continue to degrade until it is armor-plated by the coarser faction of the bed material. Studies are continuint to be made to determine how much lower the bed will go until it stabilizes. These studies are going forward with more confidence now that the Tushka Spillway is almost complete and there is no longer the danger of high flows destroying the armorplate.

There is some concern that the lowering of the bed and local scour at Esna and at Naji Hammad Barrages will endanger them. The Ministry of Irrigation is monitoring these barrages very closely. In any event, the Esna Barrage may have to be replaced as it is over 70 years old.

For a time there was concern about having to pass large flows down the Nile to make room for the annual flood. These larger than normal flows might damage the barrages and bridges, in particular Esna and Naji Hammad. With Tushka Spillway, this will not occur.

The construction of the Tushka Spillway has caused concern among some environmentalists because of dumping of water in the Tushka depression. However, the Tushka Spillway is only for flood flows of an infrequent nature. It is doubtful if it ever will spill. The emergency spillway at Hoover Dam in the U. S. has never spilled and it was built over 40 years ago. In addition, although flood discharges are large, the total volume of water is small so that the spills should disappear into the desert sands.

There has even been some concern that the sediment buildup at the upper end of Nasser Lake would block the flow of the Nile and send it into the deserts (Benedick, 1977). Benedick correctly stated that each flood period pushes the sediment deeper into the lake. Reservoirs on rivers with much larger concentrations of coarse sediments than the Nile; for example, Lake Mead on the Colorado, have not had this problem nor is it expected.

With the change in flow regime--no annual high flows and more sustained constant flows--the Nile will establish a new meander pattern in its present river channel. It will erode its banks in some areas and shoal in others. It will take careful monitoring of the river, rip-rapping of the banks when the meandering current attacks them, and dredging of the shallow areas. However, with monitoring and minor action a new regime for the river will be established with no damage to the environment.

The sediments in the Nile pose no immediate danger. It will take 500 years to fill the 24.3 million AF allocated to dead storage.

Loss of Fertility

As another horror story on the High Dam, the loss of fertility to the "old lands" by the trapping of the sediments is often quoted along with the fact that with this loss chemical fertilizers would have to be used. El-Tobgy (1977, p. 33 and 34) carefully examined and destroyed this canard. Eighty-eight percent of the Nile's sediment load went into the Mediterranean. He estimated that only 6,000 tons of potash (k_20), 7000 tons of phosphoric anhydric (p_20_5) and 17,000 tons of nitrogen (N) were added to the land annually. This, for example, represents 6 lb per acre per year of nitrogren. In relation to the fertilizer need for large yields these amounts are insignificant.

More significant to the fertility requirements of the land is the increase in yield through regular availability of an adequate supply of irrigation water, the growing of two or more crops per season and the resulting high levels of production with consequent increases in withdrawals of fertility from the soil. These withdraws require replacement and supply of adequate amounts of the major elements (nitrogen, phosphorous, and potassium) but is probably a major contributing factor to the need for a number of trace elements in recent years. This increased production has an effect many magnitudes greater than the loss of sediment.

With the loss of fertility criticism effectively eliminated, critics now claim the problem is the loss of trace elements (Waterbury, 1977). However, there are not direct cause and effect relationship between the High Dam and lack of minor elements. There is no direct evidence that trace elements were in adequate quantities in the soil prior to the High Dam and that the deficiency did not exist prior to its construction. Furthermore, trace elements can be easily and economically added to the soil. For example, small quantities of zinc added to the nursery or to fields of rice increases yields significantly and economically (Keleg et al 1979).

North Shore Erosion

Some critics of the High Dam have blamed the erosion of the north coast of the delta to the loss of 90 to 100 million tons of sediments that used to be carried into the Mediterranean Sea by the two branches of the Nile. However, very little is understood about the complex process of erosion and sedimentation of the delta. Measurements show a yearly average retreat of the outlets of the Rosetta Branch of 29 meters and the Damietta Branch of 31 meters since 1898. Since Roman times the Mediterranean Sea has risen some two meters (Waterbury, 1977). Much of the Nile's sediment discharge was carried on out into the sea. Although the process is complex and the High Dam impact is debatable, Egypt cannot allow significant erosion of the North Shore. There are solutions--construction of jetties, dikes and sea walls, and maintenance of vegetation on sand dunes. The complex problem is presently under study by an UNDP and Egyptian team.

Loss of Sardines

In the early 1960s about 12,500 tons of sardines were taken annually from the sea and between 1962 and 1971 the sardine catch decreased to 1500 tons (Waterbury, 1977). This decrease has been attributed to the loss of phytoplankton off the shore which formerly was carried there by the Nile. Since the High Dam little if any Nile water reaches the Mediterranean Sea. The loss of the sardine fisheries may have been a consequence of the High Dam. However, there is an expanding fishery in Lake Nasser. Mancy (1977) reported that the fish catch from Lake Nasser has increased from 750 metric tons in 1966 to 16000 metric tons in 1976. In addition, the North Coast fishermen are adjusting in a variety of ways--offshore trawling, cultivating of eels and going beyond Gibralter onto the high seas--to the loss (Benedick, 1978). Also, USAID and others are financing the establishment of commercial fisheries in the northern lakes and Lake Fayyum. As a side effect, the loss of the sardine fishing industry is a small price to pay for the increase in corn and rice yields that resulted from the High Dam. In addition, with aggressive research the lost protein can be replaced by other sources.

Spreading of Schistosomiasis

Schistosomiasis (bilharziasis) is a debilitating diesase that is associated with the tropics and in particular tropical irrigation. The disease cycle is from snails to warm blooded animals back to snails. An infected snail releases into the water thousands of fork-tailed microscopic worms. These worms can bore through the skin of humans in contact with infected water in minutes. In the human host the fluke mature, mate, create cysts in the liver and blood vessels and produce a profusion of eggs which are excreted in the urine and feces. The eggs hatch swimming larvae which enter snails and start the cycle over again. In humans the eggs clog vital organs and the cysts destroy the liver. The disease can be cured but the damage remains. They reduce vigor and the length of life of a man.

The disease can be eliminated by breaking the cycle either by curing man, killing the snails or improved sanitation.

Critics of the High Dam have all speculated that the High Dam would increase and spread the disease. This would occur because of the replacement of "basin" irrigation with perennial. With perennial irrigation the canals would not dry out and the farmer would be in contact with water longer and oftener. Also, there would be more water around.

The recent work of Miller, et al, 1978, has arrived at just the opposite conclusion. Their "...analysis of current and past data indicate a strong decline in overall prevalence of schistosomiasis in the rural population over the past forty years. The data did not show an increase in the overall prevalance of schistosomiasis following construction of the Aswan High Dam. The Nubian population also experienced a decrease in prevalence following relocation, from 15.2% to 7.2%..." The Nubians lived in the area that Lake Nasser would inundate and were moved inland.

This fairly well takes care of the schistosomiasis criticism but whether the High Dam increased or decreased schistosomiasis is not the problem. The problem is to stamp out the disease. The dam provides the resources to do it-flood control, increased food production and cheap electricity. Instead of all the efforts to prove or disprove the problem, additional efforts should be made to stamp out the disease. Egypt needs technical assistance and financial help, not ill-advised criticism.

The increased flow in the ditches and drains that resulted from the extra water provided by the High Dam has decreased the stagnant or slow moving water and should help decrease the snail population. This, coupled with the increase in the economic conditions of Egypt as a result of the High Dam should result in a decrease in schistosomiasis.

The Brick Industry

The brick industry depended on utilizing the sediments that were deposited along the riverbanks for raw materials. Also, adjacent land was used which in effect destroyed it for farming. Insofar as the elimination of the sediments in the flow eliminated the sediment deposits, then it eliminated the brick industry. However, the Egyptian Academy of Science and Technology developed a sand brick that is just as good. Also, concrete blocks can be used. Furthermore, and a more adverse problem, Egyptians are still making bricks by excavating soil and making pits in the farm land adjacent to the river. This destroys essential rich farm land. There are substitute materials (sand) for making bricks and they should be used. Also, brick material could be taken from some of the bars and islands in the Nile and in the process improve river alignment. The dislocations caused by substituting sand for sediments is miniscule compared to the gains provided by the High Dam.

Aquatic Weeds

There has not been an aquatic weed problem on Lake Nasser (Mancy, 1977). The weed problem may have been increased in the canals by the High Dam but only in the areas that changed from "basin" to perennial and in the canals that serve the new lands. Weeds have always been a problem in canals that carry water. After all, that is what canals are for. Because the High Dam provided water for the canals it increased the weed problem. The farmers who were provided the water understand the relation between the water and weeds and the irony of the criticism.

Weeds in the canals and drains must be removed and there are herbicides and mechanical means to do it. The High Dam by contributing to the increased prosperity of the country could provide the resources to pay for cleaning the ditches and drains.

Damage to Monuments

The reservoir inundated some monuments but the major ones such as those at Abu Simbul and the Ptomemeic Temple at Kalobaska were saved by international effort.

There was concern that the increase in ground water elevation, waterlogging of the land and salinity would damage monuments downstream. That the increase in ground water would decrease the bearing capacity of the soil and walls of a temple might collapse. The higher water table would allow salts to move up into the monuments by capillary action. Both of these actions occurred in the past and could occur in the future. However, during flood events temples and monuments were flooded. Portions of the temple at Karnak could be flooded by extreme events and this will no longer occur. Much more research is needed on the action of the water on the monuments and efforts must be made to preserve them. However, it is doubtful that the High Dam has had a significant adverse effect on the monuments downstream and by preventing them from being flooded is a beneficial force.

CONCLUSIONS

Fifteen years after water was first stored behind the High Dam, 10 years after the total 133 million AF of storage was available and 9 years after the installation of the last turbine, it can be conclusively stated that criticism of the High Dam at Aswan, Egypt, as to its benefits, engineering and side effects have been grossly overstated. Construction of the dam, which gives Egypt over-year storage and has the capacity to store almost twice the average annual flow of the Nile, is consistent with a tradition to utilize and harness the Nile that goes back to Pharaohic times.

The dam's objectives of increasing food production, provide cheap electricity and control floods have been met. There are no major adverse side effects that cannot be overcome with the technology and resources presently available.

That does not mean that there are not things to do. The true potential of the dam has not been met. More vertical expansion of agriculture is possible with better water management both on the farm and in the delivery system, subsurface drainage of some of the land and improved seeds and agronomic practice. Horizontal expansion of agriculture has not been a success but the technology is available to successfully develop the desert land. With the projected increase in population this horizontal expansion must be done and done well.

Power production from the dam plays a significant role in the development of the country, but with further studies, careful planning and proper integration of irrigation releases with power needs additional power can be made available from the High Dam. Also, with the almost constant flow of the Nile as the result of the High Dam electrification of the barrages is an economical and viable method to increase power production.

The High Dam has enabled Egypt to increase its corn production by 70 percent, doubled its rice production and prevented a crop failure from the low flow in 1972 and prevented a disastrous flood in 1975. With its present population growth the benefits of the High Dam are a proven necessity. However, the High Dam only buys time for Egypt to get control of its population growth.

The most serious charge against the dam--that it would not hold water and would decrease the irrigated area--has been disproven. The other side effects, loss of fisheries, scour of the bed and banks, waterlogging and salinity, aquatic weeds, spread of schistosomiasis, eliminated the brick industry, loss of fertility by loss of sediment being deposited on the land, reservoir filling with sediments in a short time and erosion of the seashore of the delta have all been either proven to be inconsequential, not true or that with available technology carefully used, be overcome.

Table 1. Acres of "old lands" in "basin" and perennial irrigation.*

	Basin	Perennial	Total
1881	3.7×10^6	1×10^6	4.7×10^6
1890	2.7×10^6	2×10^6	4.7×10^6
1964	1.0×10^6	4.6×10^6	5.6×10^6
1970	0	5.8×10^6	5.8×10^6

*Various sources, but El-Tobgy, 1976, for the 1970 figures.

Table 2. Population statistics.

Date	Population in Millions	Average Annual Growth Rate in Percent	Source
1800	2.5	--	Benedick
1937	16	--	El-Tobgy, p. 8
1947	19	--	El-Tobgy, p. 8
1960	26	2.38	El-Tobgy, p. 8
1966	30	2.54	El-Tobgy, p. 8
1975	38	2.24	El-Tobgy, p. 8
1979	40	2.24	El-Tobgy, p. 8
2000	70	--	El-Tobgy, p. 8

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