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THE ENVIRONMENTAL IMPACTS OF THE ASWAN HIGH DAM

by

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The Aswan High Dam, or "Sadd-el-Aali", is this huge rockfill type of dam which was built across the River Nile, about 6.5km. south of the old Aswan Dam. It has created in front of it a huge man-made lake which extends in Egypt for almost 350km. under the name Lake Nasser, and in the Sudan for about 150 km. under the name Lake Nubia.

The environmental impacts of this dam have attracted a good deal of attention, inspite of the fact that they are the same kind of impacts which accompany big dams and their man-made lakes. Before dealing with these impacts we refer to some of the facts about the River Nile, and its development programmes which ended by the construction of the High Dam.

River Nile Hydrology

The discharge of the River Nile is subject to wide seasonal variations. About 80% of the total annual discharge falls in the flood season, from August to October, the remainder is spread over the rest of the year. About 85% of this annual discharge originates in Ethiopia, and 15% in the lake plateau in Central Africa. In this plateau rises the White Nile, which is the main source of water to the Nile Valley during the low period of the summer. This "Summer Water" was the limiting factor in the expansion of perennial irrigation in Egypt. Any increase in the cultivated area required a corresponding increase in the Summer Water, and this used to be obtained by storing flood water to be utilized during the low period. This is the "annual storage" of water, that is the storage of "untimely water" in the days of surplus, and releasing it as "timely water" in the days of shortage.

The first application of annual storage on the Nile came with the building of the Aswan Dam in 1902 with a capacity of about one billion cubic metres. This Dam was heightened twice: the first was completed in 1912, just ten years after the completion of the original Dam, to raise its capacity to 2.5 billion cubic metres. The second heightening was completed in 1934, and it doubled the capacity of the Dam to just over 5 billion cu. m.

Following the Aswan Dam, two other dams were built in the Sudan; Gabal Awlia, for the benefit of Egypt, and Sennar for the benefit of the Sudan.

Apart from the seasonal variation in the discharge of the Nile, the total annual discharge is subject to wide fluctuations from year to year. The year 1878 saw the highest discharge on record, with 154 billion cu. m., and the year 1913 witnessed the lowest discharge with only 42 billion cu.m. As an explanation to these wide fluctuations it was assumed that the quantities of rainfall follow a cycle of 100 years, with 50 years of heavy rains and 50 years of less rainfall. This was supported by observations of the mean discharge at Aswan. Thus the short term sub-annual storage would be inadequate in low years for the irrigation of the land under cultivation, and that under reform. The long term storage is the solution, and this came to be called "century storage". In good years a reserve will be built up to be used in poor ones. Such long-term reservoir should have a very wide area. Lake Victoria was proposed for "century storage" because of its very wide surface area which is about 67,000 sq. km., so the required capacity for the long term storage could be ensured by raising its level only a few metres. However, Lake Victoria reservoir would be of little use to Egypt, as the bulk of the flood-water flows a long way downstream. Thus full control of Nile water could only be realized by creating the long-term reservoir on the river itself. A suitable location was found, about 6.5km south of the Aswan Dam, where the Aswan High Dam was built creating a huge man-made lake, Lake Nasser.

The execution of the Aswan High Dam was preceeded by very extensive feasibility studies. It was a scheme of colossal dimensions, calling for heavy expenses and envisaging such far-off objectives, while at the same time entailing side effects which transcends the limits of the local areas. Local and foreign expertise was called upon to study the proposed project and to compare it with other alternatives, and it was finally decided to build the High Dam, which was completed in 1968.

Some data about the High Dam

The Aswan High Dam is 111 m. above the river bed, and the construction material used to build it is about 43 million cubic metres of granite rock, sand and other building materials. The total length of the dam at its crest is 3830 m., its width at the base is 980 m., and at the crest only 40 m.

The Dam closes the river at about 6.5 km. upstream of the old Aswan Dam, and the flow of the river is diverted into a side canal. The diversion canal is an upstream and downstream open canal. The central part of this canal consists of six tunnels, each of 15 m. diameter. At the downstream end of the tunnels there are twelve electric units capable of generating 2.1 million kilowatts.

Environmental impacts of the High Dam

The Aswan High Dam has caused major ecosystem modifications in the immediate vicinity, and at far away localities.

Some of these modifications were immediate changes:

a. Terrestrial system changing into aquatic system, with the enundation of vast areas of land, which, though rather thinly populated, but it caused the relocation of people from their traditional homes to new ones. It also anundated land rich in historical monuments, which had to be dismantled and moved to other higher localities.
Foremost amongst these is Abu Simbel Temple.

b. Riverine system changing into lacustrine, namely the changing of about 500 km. of the River Nile into a huge water reservoir extending across the borders of Egypt into the Sudan. This vast man-made lake is the second largest in the world, exceeded only by Lake Bratisk in the Soviet Union. The Egyptian portion of the reservoir is lake Nasser, and the Sudanese portion is Lake Nubia.

The following table gives some key note information about Lakes Nasser and Nubia:

	Lake Nasser only	Total Reservoir
Length	292 km	540 km
Surface area at elev. 160 m.	2,585 km^2	3,057 km^2
" " at elev. 180 m.	5,248 km^2	6,216 km^2
Volume at elev. 160 m.	55.6 km^3	65.9 km^3
" " " 180 m.	132.5 km^3	156.9 km^3
Shoreline length at 160 m.	5,380 km.	6,027 km
" " at 180 m.	7,844 km.	9,250 km

Mean width at elev. 160 m.	8.9 km.	7.1 km
" " at elev. 180 m.	18.0 km.	12.5 km
" depth at elev. 180 m.	25.2 m.	25.2 m
Maximum depth at elev. 180 m.	130.0 m.	130.0 m.

The total volume of the reservoir includes about 30 km^3 dead storage to contain the silt expected to deposit in the lake over more than 500 years.

The live storage in the reservoir is used to guarantee a constant annual draft of 84 billion cu. m. of water, of which 55.5 billions will be for the benefit of Egypt, and 18.5 billions for the Sudan. The remaining 10 billion cu. m. are estimated lost by evaporation and seepage.

c. Changes in the regime of water quantity and quality. The flow of water which used to vary from 220 to 14,000 cu. m./sec. is now regulated between 930 and 2,600 cu.m./sec to meet the irrigation requirements. This meant stopping the release to the Mediterranean of huge quantities of water which amounted, in some years, to 100 cu. km.

These ecosystem modifications caused by the Dam and its man-made Lake, have various impacts on the environment in the wide sense of the word and spreads through human, biologic, atmospheric, hydrologic and earth crust components of the environment.

These impacts are of vital importance to Egypt, and they are studied by a number of ministries according to their interests and specializations: the Ministry of Irrigation and Agriculture, Ministry of Social Affairs and Ministry of Public Health. There are other scientific agencies which deal with these impacts in a more integrated manner. Foremost amongst these is the Academy of Scientific Research and Technology, which, together with the above ministries and other scientific agencies in the country and abroad, deal with the impacts in an integrated manner.

The major environmental impacts are:

1. Siltation in the Lake

Each year the large amount of silt and suspended matter which the Nile used to either deposit on the soil in the valley, or to carry all the way to the sea, is now deposited in the reservoir. Sedimentation results are needed to determine the effect on the reservoir capacity, and the pattern of the build up of the river delta created in the Sudan. Before damming the Nile, the suspended matter passing Aswan ranged

between 100 - 150 million tons per year. During the first years of storage (1964 - 1967) the silt deposited along the whole length of the reservoir, and the turbid water reached the High Dam. In 1969 it reached only a point within 100 km. upstream of the Dam.

Observations during the few years since the complete damming of the river show that siltation in the reservoir results in the loss of about 60 million cu. m. of its capacity every year. Thus the dead storage capacity of 30 cu. km. will be filled, as calculated before, in about 500 years. However, it is expected that turbid water would, in the future, flow throughout the whole length of the reservoir, and deposition will be reduced.

As a result of this siltation in the reservoir, clean water is now flowing through the river causing erosion to the river bed and banks, and, to some extent, to existing installations along the Nile. One solution to this problem is the construction of a number of barrages to reduce the speed and force of the clear water. These barrages would be utilized for power generation. The other solution adopted by the ministry is spilling water into a depression located to the west of the lake i.e. Toshka Depression.

A far away effect of this siltation in the reservoir is the erosion of the Nile Delta, one thousand kilometres away. This Delta used to build up during the flood season with the silt carried to the Mediterranean, compensating for any losses which resulted from the winter waves the year before. This shore erosion of the Delta is studied by the Academy to find out the best methods for the protection of the Delta.

The loss of the silt has affected the soil which used to build up every year by nutritions material. Studies are being carried out to assess the actual nutritive value of the silt and to find the trace elements present in order to compensate for all this by using fertilizers.

Again the silt is utilized for making bricks which are dried, fired and used as building bricks. This silt used to be dredged from canals during clearing operations. With the absence of this silt, researches have succeeded in utilizing sand for making sand building bricks. Yet the costs of dredging of the canals has been reduced.

2. Hydrometeorological changes in the reservoir vicinity.

The creation of the reservoir has an impact on the local weather conditions, mainly because of the evaporation of water from the surface. Since evaporation is directly proportional to surface area, it has become

an important factor as the lake is filling to its capacity. It was calculated that the raising of the water level by 20 m. (from 160 to 180 m.), has doubled the lake surface (from 2950 sq. km. to 6118 sq. km.) which is accompanied by an increase in evaporation rate from 6 cu. km. to 10 cu. km. of water annually.

Agricultural development in the region, as well as the lakeshore ecology, depend on air temperature and humidity.

3. The reservoir shoreline ecology

The creation of Lake Nasser in the desert area has an effect on the marginal land surrounding the lake. Parts of the coastal zones are flooded each year and receive certain amounts of silt depending on their slope and locations.

On the other hand, the coastal zones will contribute to the mineral enrichment of the lake. There is an input of nutrients and organic matter into the lake from the flooded shoreline.

4. Water Quality in the Lake

As a direct result of the long impoundment of water in the reservoir, changes in water quality will take place: physical, chemical and biological. These changes will have direct effects on the river water quality.

Lake thermal stratification was found to take place during the summer. This has significant effects on the physics, chemistry and biology of the lake water. The stagnant water layer at the bottom of the lake represents a condition where the biological decomposition of organic matter completely removes dissolved oxygen which cannot be replenished. As a result, anaerobic biological populations takes over and start to reduce nitrates to nitrites and ammonia. This is followed by sulphate reduction which results in the formation of H_2S.

These physicochemical interactions will have the following results:

a) The absence of oxygen will have effects on the lake fisheries.

b) The anaerobic biosynthesis will result in the formation of such gases as CH_4 and H_2S which will interfere with water use.

c) The anaerobic waters withdrawn from the reservoir by the turbines, together with their content of H_2S, might have corrosive action.

5. Water quality in the River

In so far as Egypt is concerned, since the construction of the High Dam, the River Nile has a new source, which is Lake Nasser. Water quality, fauna and flora are all mainly dependent on Lake Nasser ecosystem. The interactions which occur in the Lake have dominant effects on the river ecosystem and its multipurpose water use; municipal water supply, industrial water supply, irrigation, fishery, etc. Thus the impacts of Aswan High Dam on the water quality of the Nile extend to the Mediterranean.

The river ecosystem is undergoing rapid changes in river morphology and water quality, and excessive production of vegetation and floating plants. These changes, and others, are the results of a number of factors, all related to the High Dam and the closing up of the two branches of the Delta:

a) The river carries downstream a considerable amount of the biomass generated in the Lake.

b) The river receives, and keeps, huge amounts of organic and mineral materials from agricultural drainage, underground percolation and sewage discharge. All this goes to affect the river eutrophication.

c) The water flow has a dominant effect on river eutrophication, causing problem of aquatic vegetation.

A comprehensive river survey and monitering program is carried out to provide data on various aspects of river ecosystem. This data will constitute the basis for formulation of water quality models which are mandatory to construct a logical and rational framework to aid in deriving strategies for river management.

So far we have discussed the impacts of the dam on the lake and the vicinity, and the impacts along the river.
There are other impacts of the dam which include both the lake and the river. These are the human impacts: social, public health and agricultural.

6. Social Impacts

The primary social impacts associated with the High Dam and Lake Nasser are considered to be the following:

a) Population displacement from the Nubian Valley which is now covered by water. In 1964 the Egyptian

government completed the relocation of about 50,000 Nubians from their homeland to new homes with new environment.

b) New fishing communities moved to the lake with the development of lake fisheries.

c) New agricultural practices are now followed by farmers who are shifting from basin to perennial irrigation. Instead of only one crop, they have now two or three crops which have to be attended to, with the result that they have to stay on their land all the time. This is affecting their mode of living.

d) The construction of the High Dam has resulted in industrial expansion in certain regions of Egypt, resulting from the availability of more power.

e) The construction of the dam has created employment opportunities to thousands of workers. The project has also helped in the training of certain cadres of persons, and helped in solving the problems of shortage of skilled labourers in certain fields.

7. Public Health Impacts

An assessment of the impact of the Aswan High Dam on public health in Egypt has to account for schistosomiasis, which is a major endemic disease in Egypt. The extension of irrigation and the change from basin irrigation to perennial in Upper Egypt is bound to increase the occurrence of the aquatic snail vectors of schistosomiasis.

8. Agricultural Impacts

The main impacts of the Aswan High Dam on agriculture in Egypt are :-

a) Land reclamation: Apart from the change over from basin to perennial irrigation in Upper Egypt, which results in vertical increase in land productivity, more land is reclaimed making use of the increase in available water for irrigation. This expansion of land, and the tendency to over-irrigate, require a corresponding expansion in the construction of drains.

b) With the disappearance of the annual floods in the Nile Valley, the ground water level has become rather stablised, though somewhat higher. The salinity in the irrigation canals is increasing, and some of the reclaimed lands are facing difficulties.

The Data Bank and Modeling

All the data made available from present studies on the above mentioned impacts, specially those concerned with water quality, are selected and stored in a computer for future analysis and retrieval.

Information will be made available concerning all aspects of water quality.

Problems of water quality are quite complex, where several variables and parameters are involved. For complete investigation of these problems ecosystem modeling will be constructed to help in the decision making actions.

Some of the impacts of the Aswan High Dam have negative effects, but these are over-weighed, by far, when compared with the benefits so far accrued:

1. The protection of the country from high and low floods,

2. Securing enough water needed for agricultural expansion and for industrialization,

3. Increasing the electric power, and making it available for domestic and industrial purposes. The Aswan High Dam has more than coubled the electric power,

4. Creating a huge wealth of fish in Lake Nasser, which more than compensates the losses of sardine along the coast,

5. Improving navigation conditions, and

6. Creating great possibilities for more tourism in Aswan area.