Economic and Technical Aspects of Egypt's High Aswan Dam
by
Ahmad Abu-Shumays
Economical and Technical Aspects of Egypt's

HIGH ASWAN DAM

Ahmad Abu-Shumays
Ec 125

California Institute of Technology
Pasadena, California
March 1962
FOREWORD

This paper contains a general survey of the economic and technical aspects of Egypt's High Aswan Dam project of the Nile River. The main purpose is to assess, as comprehensively as possible, the value of the project from the viewpoint of economic development of Egypt. A brief survey of the related features of Egypt's economy is first presented. This is followed by a description of the engineering and technical features of the project. Some figures of overall cost of the project and ancillary works are also included with an estimate of benefits and financial returns.
Before dwelling on the subject of Egypt's High Aswan Dam, a brief consideration of some related aspects of Egypt's economy is included here as a background material:

I. Egypt's economy has been and will continue to be predominantly agrarian. Recent discoveries of industrial minerals (iron ore, manganese and petroleum) and plans for the development of hydro-electric power give promise of sizable industrial growth, but there is little doubt that Egypt will always be an agricultural economy. The role of agriculture in the country's economy may be seen from the following figures:

(a) Agricultural products make up to 90% of the country's total exports; furthermore, one product, namely cotton, constitutes the main bulk as is shown in the following table:

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Exports (Millions of Egyptian pounds; L.E./$1 = $2.87)</th>
<th>Exports of Raw Cotton</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1938</td>
<td>28.6</td>
<td>21.2</td>
<td>74.1</td>
</tr>
<tr>
<td>1952</td>
<td>142.6</td>
<td>126.4</td>
<td>88.5</td>
</tr>
<tr>
<td>1957</td>
<td>170.3</td>
<td>124.2</td>
<td>72.9</td>
</tr>
</tbody>
</table>

(b) The contribution of agriculture to the total Net National Income is more than a third:

<table>
<thead>
<tr>
<th>Year</th>
<th>Net National Income (millions of Egyptian pounds)</th>
<th>Income from Agriculture</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950</td>
<td>800.6</td>
<td>353.0</td>
<td>44.0</td>
</tr>
<tr>
<td>1953</td>
<td>788.0</td>
<td>272.8</td>
<td>34.6</td>
</tr>
<tr>
<td>1956</td>
<td>918.2</td>
<td>299.0</td>
<td>32.6</td>
</tr>
</tbody>
</table>

(c) The rural population constitutes about 70% of the total population of Egypt:

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Population</th>
<th>% Rural</th>
<th>% Urban</th>
</tr>
</thead>
<tbody>
<tr>
<td>1947</td>
<td>19.1 million</td>
<td>70.0</td>
<td>30.0</td>
</tr>
<tr>
<td>1957</td>
<td>24.0</td>
<td>67.1</td>
<td>32.9</td>
</tr>
</tbody>
</table>

II. Egypt is practically a rainless country. The northern part, that is the Mediterranean coast, receives 8 inches of rainfall per year (entirely in the winter season). The average rainfall in the country as a whole is less than 1 inch per year (see maps on the next two pages). Irrigation is therefore completely dependent on the Nile, the only waterway in the country. The productive land of Egypt is concentrated in the Nile valley and the delta. This productive land amounts to about 13,500 square miles or 3.5% of the total 386,000 square miles of Egypt.

III. The rate of population increase in Egypt is one of the fastest in the world; during the period from 1937 to 1947 the population was increasing at the annual rate of 20 persons per 1,000. The health programs which were expanded during the last decade will certainly increase the rate of population growth and result in higher man-land ratio. Cultivated area per inhabitant is now one of the lowest in the world: 0.1 hectare per person. The scarcity of cultivable land is partly offset by the high gross returns per unit of land which exceeds by far those of modern agriculture in other parts of Africa and are among the highest in the world.* Such results are due primarily to the basic fertility of the soil of the Nile valley and delta and its responsiveness to intensive cultivation and commercial fertilizers. Fertilizer
Economic survey of Africa since 1950

AVERAGE ANNUAL RAINFALL

AFRICA

MAP NO. 626 REP. UNITED NATIONS NOVEMBER 1959

Figure 1
Chapter 1. Structural aspects

MAP NO. 826 X REP. UNITED NATIONS
NOVEMBER 1959

Figure 2

Moisture Regions

Moist Climates

<table>
<thead>
<tr>
<th>Moisture Index</th>
<th>Perhumid</th>
<th>Humid</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>C2</td>
<td>C1</td>
</tr>
<tr>
<td>-20</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>-40</td>
<td>E</td>
<td></td>
</tr>
</tbody>
</table>

Dry Climates

<table>
<thead>
<tr>
<th>Moisture Index</th>
<th>Semiarid</th>
<th>Arid</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-40</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

By Douglas E. Carter
After the 1948 system of C.W. Thornthwaite

1954 Preliminary - Subject to Revision

UNITED NATIONS
NOVEMBER 1959
consumption per unit land in Egypt is one of the highest in the world.* Per-
ennial irrigation, practiced on a large scale in Egypt, makes possible the
growing of three crops each year and thus results in considerable gain in
gross revenue.

With the above facts in mind, let us now examine the High Aswan
Dam project and its projected influence on the economy of the country.

* U. N., ECONOMIC SURVEY OF AFRICA, N. Y., 1959, Chapter 1.
THE HIGH ASWAN DAM (SADD EL-AALI)

The need for the project:

Water, rather than land, is the limiting factor of agricultural production in Egypt. The flow of the Nile is fickle and unsteady. During a high flood, the flow of the Nile which escapes to waste into the sea may be so abundant as to expose the country to destructive inundations with loss of life and property. The discharge at Aswan may be as large as 450,000 cubic feet per second. In a low year, the river flow may fall short of cultivation requirements. In order to avoid these extreme fluctuations and in order to obtain maximum benefits from the available water supply, it was found necessary to devise measures to regulate the river's flow. The now existing Aswan Dam is not adequate enough to control the Nile's flow. In some low years the Aswan reservoir cannot be filled with the result that the irrigation requirements cannot be guaranteed and any further expansion and development of irrigation programs would run the risk of disaster in low years. Hence emerged the idea of constructing a HIGH DAM at Aswan, 4 miles upstream of the existing dam, for the storage of all surplus water for use in expansion of cultivated land and for stabilization of the river's flow. Moreover, the generation of enormous electric power will be of great significance in furthering the economic development of the country.

The project is therefore a PRODUCTIVE and PROTECTIVE work.

The objectives are to control the water resources of the Nile, to expand cultivation and to produce cheap hydro-electric power necessary for industrialization and development.
THE PROJECT

The High Dam project calls for the construction of one of the highest dams in the world. The High Dam will be a rockfill dam 365 ft. in height from the river bed to the roadway that will cross the top of the dam. The water to be impounded behind the dam will create the second largest man-made lake in the world. The lake will extend 315 miles upstream with an average width of 6.5 miles and a total gross capacity of more than 104 million acre-ft. (about 3-1/2 times the capacity of the Hoover Dam and a little less than that of the new Kariba Dam in Rhodesia).

After the construction of the dam, the guaranteed net annual draft from the reservoir is estimated to be 60 million acre-ft., about 40% in excess of the present irrigation requirements of Egypt and the Republic of Sudan.

The design of the High Dam faces many difficulties. It has to be constructed in the lake of the now existing dam where the depth of water exceeds 115 ft. The selection of the rockfill type of construction rather than an earth or concrete dam was dictated by the natural features of the site and the availability of suitable rock in the vicinity.

The Nile river at the site of the High Dam is about 1900 ft. wide. The crest of the dam will be about 2-1/2 miles. The dam will be 3300 ft. at the base and 100 ft. at crest level. The dam will consist of three main structures shown in the diagram of the dam's cross section. These are: the upstream cofferdam, the downstream cofferdam, and the main dam.

The upstream cofferdam will serve the purpose of diverting the Nile water during the construction of the main dam. The upstream dam will be
CROSS SECTION OF THE DAM shows how cofferdams up and downstream will be incorporated in final structure. A considerable part of both cofferdams will have to be built under water.
made of rockfill and will be progressively sluiced with sand to fill the voids. The trapezoidal-shaped rockfill of this upstream cofferdam will have a base width of about 80 ft. It will be 150 ft. high and will extend for 1600 ft. across the river.

The downstream cofferdam, 125 ft. high, will be similar but smaller than the upstream cofferdam. Together with the upstream dam it will allow for the construction of the main dam in still water. The construction of the main dam will follow the completion of the cofferdams which constitute an integral part of the whole structure. The dam will be protected against seepage by two lines of defense: a horizontal impervious blanket in the upstream part and a vertical grout curtain descending the pervious bed of the river to a depth of about 700 ft. until it strikes the natural rock (see cross section of the dam).

In the early stages of the project, it was proposed to pass the water from the reservoir to the downstream of the dam through seven diversion tunnels. Further studies proved that it will be preferable to dig an open canal instead of these tunnels. The idea of the open canal has been adopted as a substitute to the tunnels because it will reduce the fall in the water level at the upstream cofferdam thus solving the problem of gates. The diversion canal is shown in the general layout of the project shown on the next page.

The canal will be cut through the solid granite rock on the east bank of the Nile. Six tunnels, shown in the general layout, will be provided to control the flow. The tunnels will have iron gates. The total canal length including the control tunnels will be about 6,000 ft. and its bed width about 200 ft. At the downstream end of the control tunnels the power plant will be
constructed. It will be one of the biggest hydro-electric power plants in the world. It is designed for an ultimate capacity of 2,100,000 kilowatts and will generate about 10 billion kilowatt-hours per year.

It is evident from the above considerations that the High Dam is one of the largest and most ambitious engineering projects ever proposed. Following is an estimate of the total expenditure for the construction of the dam and auxiliary works:

**PUBLIC INVESTMENT:**

1. Cost of construction of the dam including cost of civil works for the power station and indemnities for Nubia and Wadi Halfa 350.0
2. Cost of twelve turbine units and a transmission line to Cairo with its branches 258.0
3. Cost of irrigation and drainage projects necessary for the conversion of basins and the reclamation of one million acres 245.0
4. Cost of constructing roads and other public utilities in the reclaimed area 57.0

**TOTAL PUBLIC INVESTMENT** 910.0

**PRIVATE INVESTMENT:**

5. Cost of preparing lands for perennial irrigation 21.0
6. Cost of reclaiming one million acres 210.0
7. Houses for the new reclaimed areas 60.0

**TOTAL PRIVATE INVESTMENT** 291.0

**TOTAL COST OF THE PROJECT:** $1,201,000,000

(The total cost does not include interest of capital during the period of construction of the project.)

Of the above total cost of $1,201 million, the project called for an expenditure of about $500 million in Egyptian currency by the government of Egypt; $300 million by private investors and $400 million in foreign currency.

* Data included here are taken from the U.A.R., 1961 Year Book. The conversion factor L.E+1 = $2.87 is used.
In December 1955, the United States, the United Kingdom and the International Bank for Reconstruction and Development offered to make available $270 million of the total foreign currency needs. ($56 million from the U.S., $14 million from the U.K., and a ten year loan of $200 million from the Bank.) On July 19, 1956, the United States withdrew its offer. The United Kingdom and the Bank immediately followed suit.

In an investigation by the Public Affairs Institute following the withdrawal of the U.S. offer to help financing the High Dam project, the following conclusions are drawn:

(1) "Of questionable economic soundness, the project has strong political overtones." The U.S. offered its financial aid primarily for the purpose of inducing Egypt to curtail her dealings with the communist countries.

(2) The High Dam would not increase the standard of living in Egypt. Population increase would outstrip any benefits the project might produce "in terms of individual economic well-being."

(3) "The waters of the Nile can probably be harnessed less expensively and more effectively."

These conclusions, according to the report of the Public Affairs Institute, challenge the validity of the High Aswan project and point out "the necessity for a new look at the development problems of East Africa and the Middle East."


1955). The project, according to these documents, is economically and technically feasible. However, the Bank's documents emphasize the fact that the construction of the project would impose upon Egypt a period of rigid austerity. The project, when completed, will not increase the living standards but it will "at least prevent a disastrous deterioration...and give the country a breathing spell which will provide an opportunity for broadening the industrial base of the country."

The withdrawal of the Western offer to finance the Dam project was the precipitating factor for the Egyptian nationalization of the Suez Canal and the subsequent strengthening of economic relations with the Eastern countries. An agreement was reached in December 1958 with the Soviet Union for a loan of 400 million Rubles (about $100 million) to meet the foreign exchange requirements of the first stage, that is, construction of the cofferdams, the diversion canal, and the six tunnels. This loan will cover all expenses connected with technical assistance and delivery from the Soviet Union of all equipment and materials. The loan bears an interest of 2.5% and is repayable in 12 years as from 1964. On the 8th of January 1960 it was officially announced that the Soviet Union would participate in the financing and execution of the second stage of the project on the same basis. An agreement was reached in August 1960 for a loan of 900 million Rubles ($225 million) to meet the foreign exchange requirement of the second stage. This includes the construction of the project to its final stage, together with the power station and transmission networks to Cairo. This arrangement will enable the merging of the two stages with the result that expenditure will be cut down and the time required for completion shortened.
BENEFITS OF THE PROJECT

According to reports published by the U.A.R. Ministry of the High Dam, the project will bring substantial gains to the national economy of the country. The following are some of the special benefits and advantages which the enterprise will guarantee to Egypt:

1. Expansion of cultivation by about 1.8 million acres including the conversion of nearly 700,000 acres in the south of Egypt to the perennial irrigation system. The increase in cultivable area will be about 30% of its present size.

2. Guarantee of water requirements even in years of low supply. This will increase the yield of the existing and the newly irrigated areas.

3. Improving drainage conditions in cultivated lands thus increasing their output.

4. The cultivation of 700,000 acres of rice every year.

5. Complete protection against high floods, thus eliminating damage caused to many cultivation.

6. Improving navigation conditions in the Nile.

7. Increasing the power capacity of the existing Aswan Dam.

8. Producing hydro-electric power potential of about 10 billion kilowatt hours per year. This is about five times the energy now being consumed from the hydro-electric power of the existing dam.

9. Improving the balance of Egypt's international payment as the project will result in saving in annual imports and in an increase in export earnings.

10. Employment of hundreds of thousands of Egyptians in the reclamation of land and in the new industries.

Expressing these advantages in figures, the estimate of the High Dam Ministry of Egypt is as follows:

<table>
<thead>
<tr>
<th>A. INCREASE IN NATIONAL INCOME</th>
<th>$ millions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Increase in national income from expansion of cultivated land by about one million acres and conversion of basins in the south of Egypt to perennial irrigation</td>
<td>190.0</td>
</tr>
<tr>
<td>2. Guarantee of water requirements, improving drainage conditions and the cultivation of 700,000 acres of rice every year</td>
<td>160.0</td>
</tr>
<tr>
<td>3. Protection against high floods, prevention of seepage to lands alongside the river embankments, and protection of islands and river banks from inundation</td>
<td>30.0</td>
</tr>
<tr>
<td>4. Improving navigation conditions due to full control of the Nile's flow downstream of the dam</td>
<td>15.0</td>
</tr>
<tr>
<td>5. Production of hydro-electric power and improving the existing plant</td>
<td>290.0</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>685.0</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B. INCREASE IN GOVERNMENT INCOME</th>
<th>$ millions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Increase from taxation on new cultivated areas and from extra taxation on existing areas due to the improvement of their output</td>
<td>25.0</td>
</tr>
<tr>
<td>2. Increase of Government income as a result of improving navigation conditions and from saving expenditure on flood protection measures</td>
<td>7.0</td>
</tr>
<tr>
<td>3. Increase of Government income from the hydro-electric power plant at the High Dam</td>
<td>30.0</td>
</tr>
<tr>
<td><strong>TOTAL INCREASE IN GOVERNMENT INCOME</strong>: 62.0</td>
<td></td>
</tr>
</tbody>
</table>

The annual increase in Government income is about 7% of the total $910 million public investment which the project calls for. In other words, the cost of the project to the Government will be covered in a period of about 15 years. Considering the total increase in national income as a result of the project ($747 million), it is revealed that the project will cover its whole cost in about two years.

BIBLIOGRAPHY


M. L. Cooke, Nasser's High Aswan Dam, Panacea or Politics, Public Affairs Institute, Washington 3, D. C.


N. V. Sovani, Economics of a Multipurpose River Dam, Asia Publishing House, Bombay, 1960.


U.A.R., 1961 Year Book, Information Department, Cairo (in Arabic).
