PRELIMINARY EVALUATION OF MANSOURIA CANAL SYSTEM
GIZA GOVERNORATE, EGYPT

EWUP Technical Report No. 3

EGYPT WATER USE AND MANAGEMENT PROJECT

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Preface

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By John W. Wolfe, Farouk Shahin, and M. Saif Issa

Egypt Water Use Project*

Irrigation began in Egypt more than 5000 years ago. Through the centuries the "basin system" was developed in the flood plain of the Nile. It was a system to trap water on the land during flood, thus providing one irrigation and one crop each year.

A system of canals and drains gradually developed to provide more control. During the 19th century additional canals and barrages were constructed to provide perennial irrigation for some lands. Since the Valley is narrow, these canals tend to parallel the Nile for hundreds of kilometers. The drains are also generally parallel. Since construction of the High Aswan Dam, all of the land on the valley floor is supposed to have an adequate share of water available to support crops during all the year.

During a recent investigation it was discovered that at least one major canal system is not making equal delivery of water to all the land it serves. The reasons seem to be related to many factors, including the design of the system, and especially to the traditional practices and procedures followed by the irrigation district and by the farmers. This paper briefly describes the favorable climate and the principal water resource, describes in more detail the general mode of operation of Egyptian canal systems, and explains the physical characteristics and the operational procedures, policies, and practices that contribute to unequal water distribution within one particular canal system near Cairo. It also lists a few field trials now contemplated that may reveal some possible solutions to these and related problems.

Climate

Egypt lies in a hydrologically arid zone where the average rainfall ranges between 180 mm on the northern Mediterranean coast and nil in the southern region. The mean monthly temperature ranges from 13.5 °C in January to 26.7 °C in August at the northern coast, and from 16.8 °C to 42 °C in the southern region near Aswan.

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Water Resources

Agriculture in Egypt depends almost entirely on the River Nile, which flows from the equatorial lake plateau in Central Africa and from the Ethiopian Heights in East Africa. The River Nile water is shared among the Nile countries. Its course extends almost 6000 km to reach Egyptian territory and its flow is controlled by a series of dams and barrages.

The Major Irrigation System

A typical irrigation system in Egypt consists of major canals, and main and secondary branch canals. Irrigation water is distributed by the main canals on a rotational basis.

Under the rotational method, the area served by one main canal is divided either into two equal regions and called a double rotational system, or into three regions and called a triple rotational system. In each of these rotations, water is admitted to only one of the regions (during the so-called on-period) and the intakes of all the other regions are closed (so-called off-period). To insure more control of water distribution, a series of regulators are constructed along the main canals.

Different allocations in space and time are applied on this system according to the location, climate and cropping pattern. Examples are:

Two-rotation systems
4 days on and 4 days off
7 days on and 7 days off

Three-rotation systems
4 days on and 8 days off
5 days on and 10 days off
7 days on and 14 days off

The canals are normally designed to maintain a water level that requires the farmer to lift the water up to a maximum of 75 cm. This range allows the farmer to use lifting tools manufactured in the villages. An Archimedes screw is powered by hand, and a water wheel by animal.

Canal cross sections are designed to carry enough water for the crop requirements of the land it serves. The designed canal flow has two limits. The maximum flow occurs in the summer period during maximum evapotranspiration. The minimum flow occurs during the winter when the crops have the lowest water requirement.

The canal is designed to permit the discharge to be controlled by changing the canal water level at its intake.

The job of the irrigation district engineers and their gate operators is to fulfill the water distribution schedules by maintaining the specified water levels in the main irrigation system. With the help of the head regulators in the main canals, each one just below a group of branch intakes, they can close and open sluice gates to control the water levels, both in the main canals and just behind the branch intakes. They must adjust these gates according to the rotation schedules.

Figure (1) is a diagrammatic representation of the designed distribution operation in the main canals where:

When the water is appointed to the first reach; i.e. it is the on-period for the first reach:

The intake (a) is adjusted to have the specified water level in the main canal just downstream from its intake.

The regulator (b) is closed to maintain the required water level at its upstream side.

All the intakes (d) between regulators (a) and (b) are adjusted to pass the quantities of water that keep their downstream levels at those specified.

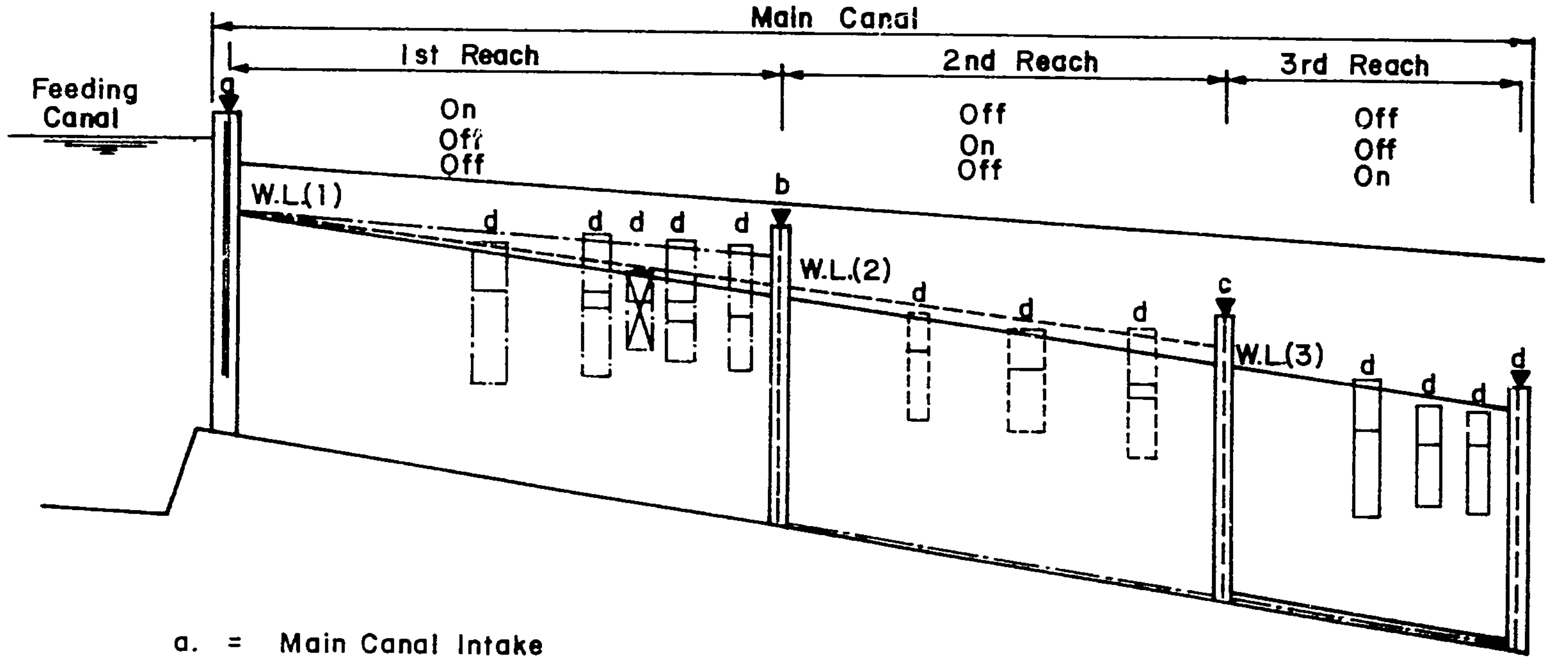
No water is allowed to the second or third reaches.

When water is scheduled for the second reach, the first and third are off and:

The intake (a) is regulated to have the required water level at its downstream side, while the regulator at (b) is fully opened and that at (c) is closed to keep water from flowing to the third reach.

The water at the upstream side of (c) is maintained at a specified level to make adequate head available for the intakes between points (b) and (c).

The intakes between (b) and (c) are regulated to maintain the water levels of the branches downstream from those intakes at the designed levels for the rotation.



a. = Main Canal Intake

b & c = Water Controll Regulators along the Main Canal for Rotation Cperations

d = Branch Canal Intakes

e = Tailend Regulator or Spillway

—·—·— Water Level in the Ist Reach On-period

– – – – Water Levels in the 2nd Reach On-period

——— Water Levels in the 3rd Reach On-period

W.L.(I) is Water Level when the Water is Appointed to the Ist Reach and 2nd and 3rd Reaches are Off

Fig. 1 Operation of a typical main canal on a triple rotation system.

During this period, the water still has adequate head available for the intakes on the first reach, but they must be closed to provide enough water for the second reach.

When the water is appointed to the third reach the first and second reaches are off while:

The intake (a) is regulated the same as before, regulators at (b) and (c) are fully opened and the water level on the upstream side of the tail end of the main canal is maintained as specified.

The intakes (d) of the third reach are regulated to maintain the designed water levels in the branch canals.

During this period, the water is still available at only slightly reduced heads at the intakes in the first and second reaches. They must be officially closed to convey the water to the last reach. Otherwise the last reach will not have its fair share of water.

While the internal distribution within one or more irrigation districts is accomplished only by the maintenance of the adopted water levels in their main and secondary canals, most of the intakes of the major canals and the main distribution sites between Governorates are calibrated, and the water flow through them quantitatively measured.

The Minor Irrigation System

While the major irrigation system is operated and maintained by the government, the minor system, beginning from the canals and extending to individual farms, is in private ownership and is maintained by the farmers themselves.

The canal outlets to the private ditches are normally steel or concrete pipes laid through the canal banks, with their crests 25 cm lower than the designed canal water levels. The hydraulic pressure is thus approximately equal on them. The pipe diameters are chosen to supply adequate water to each private ditch according to its length and the area served by it. Pipe outlets are used in all Governorates except Fayoum where the water is distributed quantitatively by free flow weirs. In Fayoum all the weir crests are installed at the same vertical distance below the designed water levels in the canals and only widths are changed according to the area served.

One private ditch may serve up to 75 farmers, or even more, depending on the size of farms, the size of fields, and the total area served. The area served usually ranges between 20 and 150 feddans (8 to 63 hectares). The farmers are allowed to lift water directly from this ditch to their fields. Fortunately the small fields tend to be long and narrow, with one end touching a ditch. The irrigation scheduling along a ditch is arranged by the farmers. On some ditches, the next turn is given to the one who has been waiting beside his field the longest time. If problems arise between farmers concerning either scheduling irrigation turns or maintainance of ditches, the district irrigation engineer has the legal responsibility to solve them by designing an irrigation scheduling program along the ditch, or by arranging for and supervising a ditch cleaning operation at the farmers expense.

Irrigation Water Rights

Egyptian water legislation is based mainly on Moslem water law. It involves the system of control and administrative mechanisms. The basic Moslem laws provide that water be delivered in the most equitable manner possible. All irrigators receiving water from a particular canal have an equal right to the water according to the size of their holdings. They must not take more than their share or deprive anyone else of his right to a turn. The relationship between man and water results from the infusion of two basic Moslem principles:

Water is common property for use by the entire community.

Water should be shared equally.

From these basic rules, the Egyptian water law has fixed the rights of both the farmers and the government concerning irrigation water management. The following points are included in the law:

The Ministry of Irrigation is responsible for the operation and maintenance of the main and secondary canals and drains, while the private field ditches and distributaries must be operated and maintained cooperatively by the farmers.

The safety of the canals, drains, and their embankments is public responsibility and secured.

A strip of land 20 m on each side of the canals and drains is to be kept free from construction unless the approval of the Ministry of Irrigation is first obtained.

The Ministry of Irrigation has the right to do any kind of work along this right-of-way, even taking the soil that may be required for the maintenance of the irrigation works, but the land owners are adequately compensated.

All land owners whose land is supplied from one private ditch have the right to take their irrigation water equally according to their land holdings. Although farmers are encouraged to schedule irrigation turns on the ditch, the final authority for planning, scheduling, and administering the delivery of water to each feddan is the inspectorate, a subdivision of the district.

The maintenance, cleaning, and weed control in the private ditches are responsibilities of the farmers.

The Ministry of Irrigation can clean those ditches when required, at the expense of the farmer, either by request of the farmers or if recommended by the irrigation officials.

The lands that are irrigated from one private ditch or drain have water rights on its course. This right is secured.

Any construction on the public canals or drains has to be approved by the Ministry of Irrigation.

The Ministry of Irrigation has the right to supply the lands with field drains at the farmers' expense. Those expenses can be either collected directly or by installment within a 20-year period at most.

The Ministry of Irrigation is responsible for quoting unit fixed prices for lifting irrigation water by each type of device. Thus a farmer with a pump cannot overcharge another farmer for his service.

Current Water Resources Policy of Egypt:

Because rainfall is scarce and other water resources are limited, and because of the rapid increase in the population, the water policy is intended to ensure the most efficient use possible of the available water resources and to increase the agricultural base and its production in the following ways:

Increase efficient use of the water resources by controlling and developing the application system, and by limiting its flow to the irrigation requirement of the crop pattern.

Increase the farm crop production through a developed on-farm water management program.

Limit the flow to the removal system by recirculating part of its water to the application system, thus increasing the water use efficiency.

Control the water use, and prevent a high water table due to excessive seepage from the system and excessive irrigation, by generally requiring the lifting of irrigation water at the farm level.

Evaluate the existing ground water aquifers and use ground water as an additional water resource.

Insure better drainage conditions by expanding the area served by field tile drainage.

The Mansouria Irrigation Canal System

The Mansouria Irrigation District is in the Giza governorate extending mostly north from the pyramids. It contains 24,745 feddans (10,400 hectares). Rather long and narrow, it is bounded by the desert on the west and by a deep drain, Ganabiet El-Mohiet, on the east.

This district is served by the Mansouria Canal (a branch of Giza Canal, km 101.00 left hand side). The Mansouria Canal is 37 kilometers long and has about 650,000 m^3 daily discharge. It works only as a carrier in its first reach of 12.460 kilometers. Its inlet is a 2-vent sluice gate, each vent 3.0 m wide. The canal is also supplied by three regulators, first at km 16.274 (2-vent sluice gate, 3.0 m wide each), second at km 28.545 (2 vents, 2 m wide each, controlled by timber blocks) and the last as km 37.00 (one vent, 3.80 m wide, controlled by timber blocks). The Mansouria Canal supplies 24 secondary canals (8 to the left side and 16 to the right side) with an average length of 3.0 kilometers, besides 121 intakes to single farms.

The designed cross section of Mansouria canal is as follows:

Reach	Bed Width	Side Slopes	Bed Slopes	Water Depth
from	m		cm/km	m
0.0 - 16.274	13	3:2	6	1.55
16.274 - 28.545	12	3:2	2	1.55
28.545 - 37.00	9	3:2	8	1.05

In addition to the Mansouria canal, three of its branch canals with the following descriptions were chosen for study.

	Branch Canals		
	Kafret Nassar	Beni Magdoul	El Hammami
Intake location	km 14.500, R.S.	km 21.475, R.S.	km 25.850, R.S.
Area served	476 Fed (200 ha)	860 Fed (361 ha)	780 Fed (328 ha)
Length	1465 m	2910 m	1660 m
Branches (laterals)	1) Galal	1) Beni Magdoul	1) El Shemi
Intake location	km 0.465, R.S.	km 1.850, R.S.	km 0.775, L.S.
Area served	90 Feddans (38 ha)	140 Feddans (59 ha)	400 Feddans (168 ha)
Length	783 m	900 m	1,970 m
	(2 Kafret Nassar		
Intake Location	km 1.340, L.S.		
Area Served	290 Feddan (122 ha)		
Length	1482m		

Note:
R.S. = right side
Fed = feddans
1 feddan = 1.038 ac. = 0.42 ha

Designed hydraulic properties just downstream for the intake are:

	Kafret Nassar	Beni Magdoul	El Hammami
Bed width	0.75 m	3.00 m before lining	2.00 m
Side slopes	1:1	1.25:1 after lining	1:1
Hydraulic gradient	13 cm/km	11 cm/km	13 cm/km

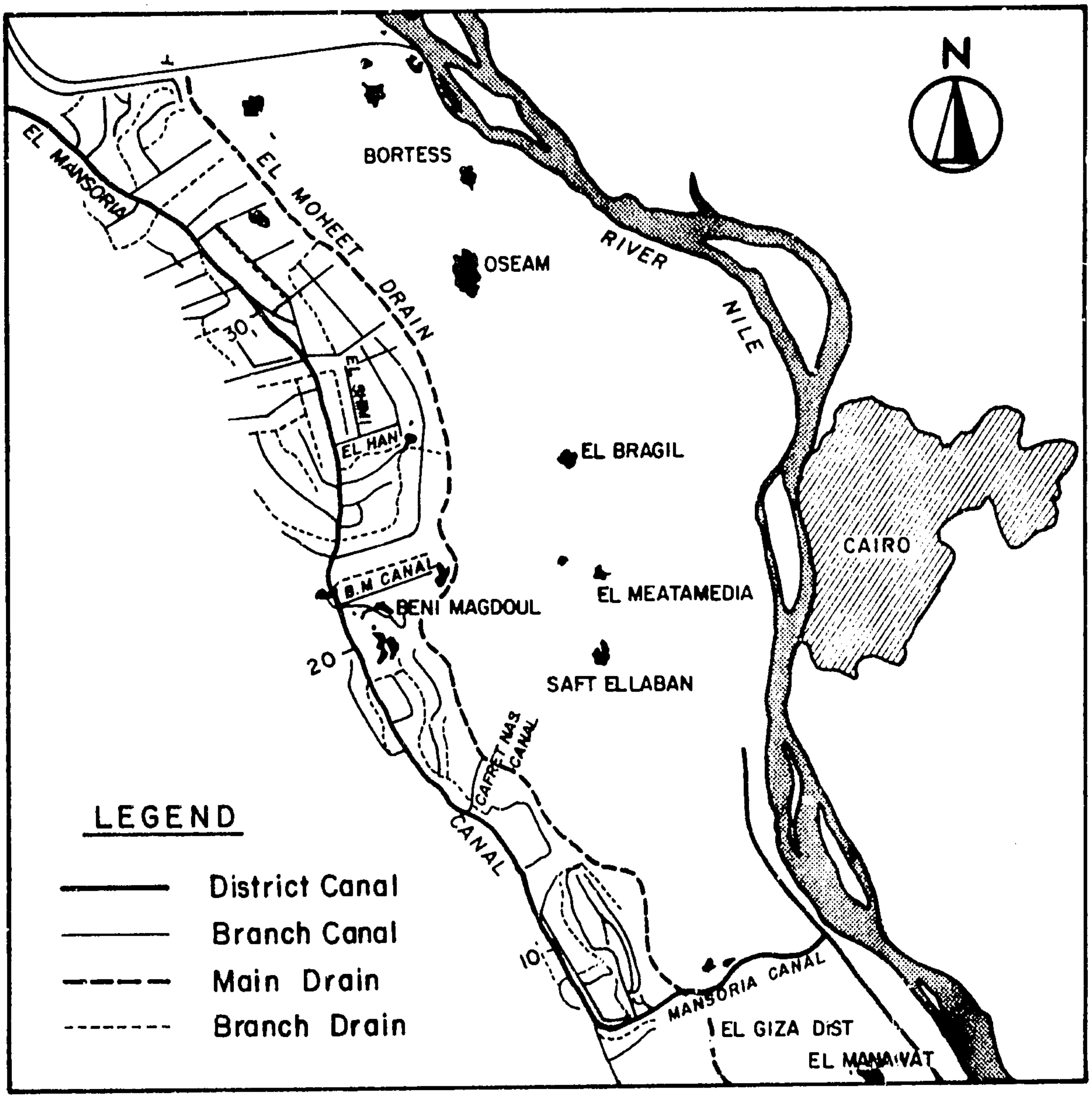


Fig. 2 The area served by the Mansouria Canal and three selected branches.

Irrigation Water Regulation in Mansouria

The Ministry of Irrigation, through the Giza Irrigation district, releases into the Mansouria canal a quantity of water calculated to meet the irrigation requirement of all the land served by this canal. The water is distributed by the triple rotation method where the canal is divided into 3 reaches. The area of the first reach is 6,288 feddans (2640 ha), the second 12,763 feddans (5360 ha), and the third 5,694 feddans (2390 ha). The schedule is 4 days on and 8 days off (Figure 2).

Because the three reaches are unequal in size, and the second reach has an area of more than double that of the others, a part of the water is diverted to the second reach from the on-periods of the first and third reaches. The second reach receives a full flow for four days. During each of the other four-day periods it receives partial flow, but for two of those days in each period the water level remains high, then drops to a lower stage. This procedure helps to equalize the water shares. Figure 3 shows a diagrammatic representation of the applied rotations.

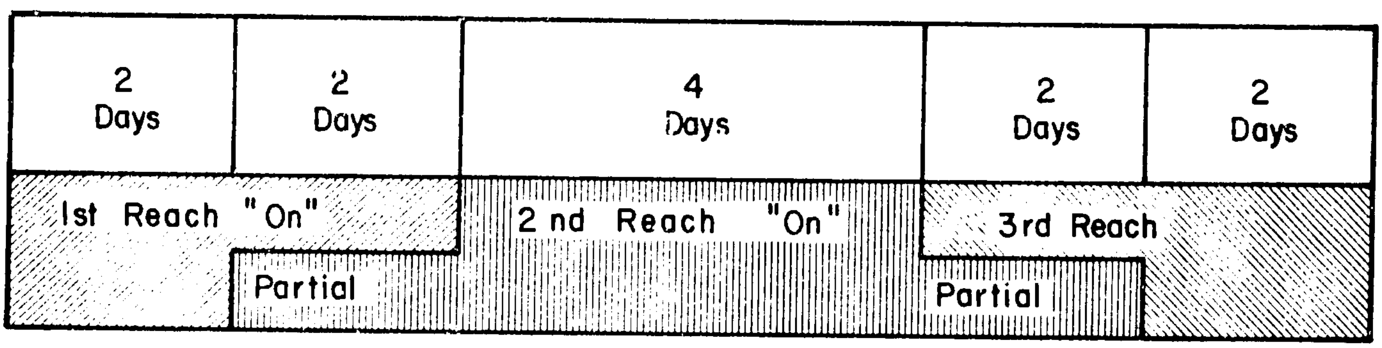


Fig. 3. Irrigation rotation schedule in the Mansouria Canal.

During the on-periods, water is controlled in the main and secondary canals by maintaining the water levels just upstream from the main regulators and just downstream from the branch canal intakes, according to the levels specified in the initial designs.

The Mansouria Canal and its branches are unlined except Beni Magdoul, which received a cast-in-place concrete lining in 1977. Also, this branch canal receives a continuous flow, as part of a comparison study for evaluation of the rotation system.

A study by the Water Distribution and Irrigation System Institute in August and September 1975 on the main Mansouria canal found that while the daily average water share at Mansouria intake was 23.5 m^3/feddan (5.6 mm/day) during a full rotation period, it was 41.7 m^3/feddan (9.9 mm/day) in the first reach, 19 m^3/feddan (4.5 mm/day) in the second, and 27 m^3/feddan (6.4 mm/day) in the third. This water share includes both water use and water losses within each reach.

Objectives of This Study

The data reported in this paper represent only a portion of the effort of the Egypt Water Use Project (EWUP). The long range objective of EWUP is to raise the economic and social standing of the Egyptian farmer by improving water management, agronomic practices, farm management, and social structure. The objectives of this portion were to:

1. Determine the variability of the water shares delivered within the Mansouria District.

2. Determine the conveyance losses in the Mansouria Canal.

Procedure

1. To determine the variability of the water shares, the following discharges were measured:

    a. The inflow to the Mansouria District at the Mansouria Canal intake.

    b. The inflow to the Kafret Nassar Canal.

    c. The inflow to the Beni Magdoul Canal and to its branch.

    d. The inflow to the El Hammami Canal and to each of its branches.

    The inflow to the Beni Magdoul Canal was obtained from a calibrated sluice gate known as a Nyrpic gate. It served as a free-flow orifice with the width adjustable. The inflow to the Beni Magdoul branch was obtained from a 9-inch Parshall flume. All other discharges were obtained from frequent current meter measurements plus at least daily staff gage readings. In addition to a staff gage, the Kafret Nassar intake was fitted with a water stage recorder. The measurement sites were thus calibrated, and this calibration up-dated every two or three months. One staff gage reading was assumed to be representative of a 24-hour period. Thus the relative values of water shares are assumed valid.

The five-month period between March 1, 1978, when the discharge measurement in El Hammami area began, and July 31 was chosen for the comparative water shares calculations.

2. To determine conveyance losses in the Mansouria canal.

   a. Six sites were chosen along the Mansouria Canal for measuring discharge. They are numbered consecutively from one to six. The first four of these are along the first reach, where there are no authorized outlets. They are at km 0.200, 4.700, 8.380, and 11.980, respectively. The others are at km 24.890 and 27.450 respectively. Figure 2 shows the location of km 10, km 20, and km 30.

   b. All measurements were made by current meter. Two sites were measured simultaneously, each measurement being conducted by a trained crew and supervised by an experienced engineer. Farmers were requested not to take water from the reach being measured. Technicians patrolled the canal banks to insure compliance with this request. The conveyance loss in the reach between the two measurement sites was assumed to be the difference between the two discharge measurements.

<u>Results of the Water Shares Study</u>

Comparing the three chosen canals it was found that:

The share of each feddan served by the Mansouria intake was 3281 m^3 in the period with an average of 21.4 m^3/day (5.09 mm/day).

The share of each feddan served from the Kafret Nassar canal that lies on the first reach where water is given under the rotation method was 4700 m^3 in the period with an average of 30.7 m^3/day (7.31 mm/day).

The share of each feddan under Beni Magdoul canal where the water is given continuously without rotation was 3283 m^3 in the period with an average of 21. 4 m^3/day (5.09 mm/day).

The share of each feddan served from the Hammami canal on the second reach, under rotation, was 1370 m^3 in the period with an average of only 9.1 m^3/day (2.17 mm/day).

A similar comparison on a smaller scale was made for the El Hammami canal, using the discharges from both the Shimi and El Hammami branches. The discharge distributed by each of the three reaches of the canal, and for the canal as a whole, were obtained as follows:

The first discharge (Q_1) was measured at the intake of El Hammami and was used to calculate the average share of the canal serving 780 feddans.

The second discharge (Q_2) was measured just downstream from the head works of the Shimi branch and was used to calculate the share for the last reach of El Hammami serving 298 feddans.

The third dischare (Q_3) was measured at the intake of the Shimi branch and was used to calculate its share of water for 400 feddans.

The fourth discharge (Q_4) was the calculated differences (Q_1-Q_2-Q_3) and was used to estimate the shares for the 81 feddans area served by the first reach.

For the measurements collected from March to July it was found that:

The average share of each feddan in the entire Hammami area served by Q_1 was 1370 m^3 in the period, with an average daily rate of 9.1 m^3 (2.17 mm/day).

The average share of each feddan in the last reach served by Q^2 was 1321 m^3 in the period, with an average daily rate of 8.8 m^3 (2.09 mm/day).

The average share of each feddan in Shimi branch served by Q_3 was 1139 m^3 in the period with an average daily rate of 7.5 m^3 (1.79 mm/day).

The average share of each feddan in the first reach of Hammami canal served by Q_4 (where the water is readily available during the "on" periods) was 2642 m^3 in the period with an average daily rate of 17.5 m^3 (4.17 mm/day). This latter figure is twice the quantity available to the two branches.

"A comparison of water delivered to these branch canals during this five month period is shown in figure 4".

Conveyance Losses Measured

In the first reach between sites (1) and (2), there was more gain than loss. There were small losses at the higher discharges. The gain increases with a decrease of canal flow. It appears to begin at zero at a flow of about 6 m^3/s and increases to about 6% at a flow of 3.5 m^3/s. The gain is almost certainly due to seepage from the surrounding water table.

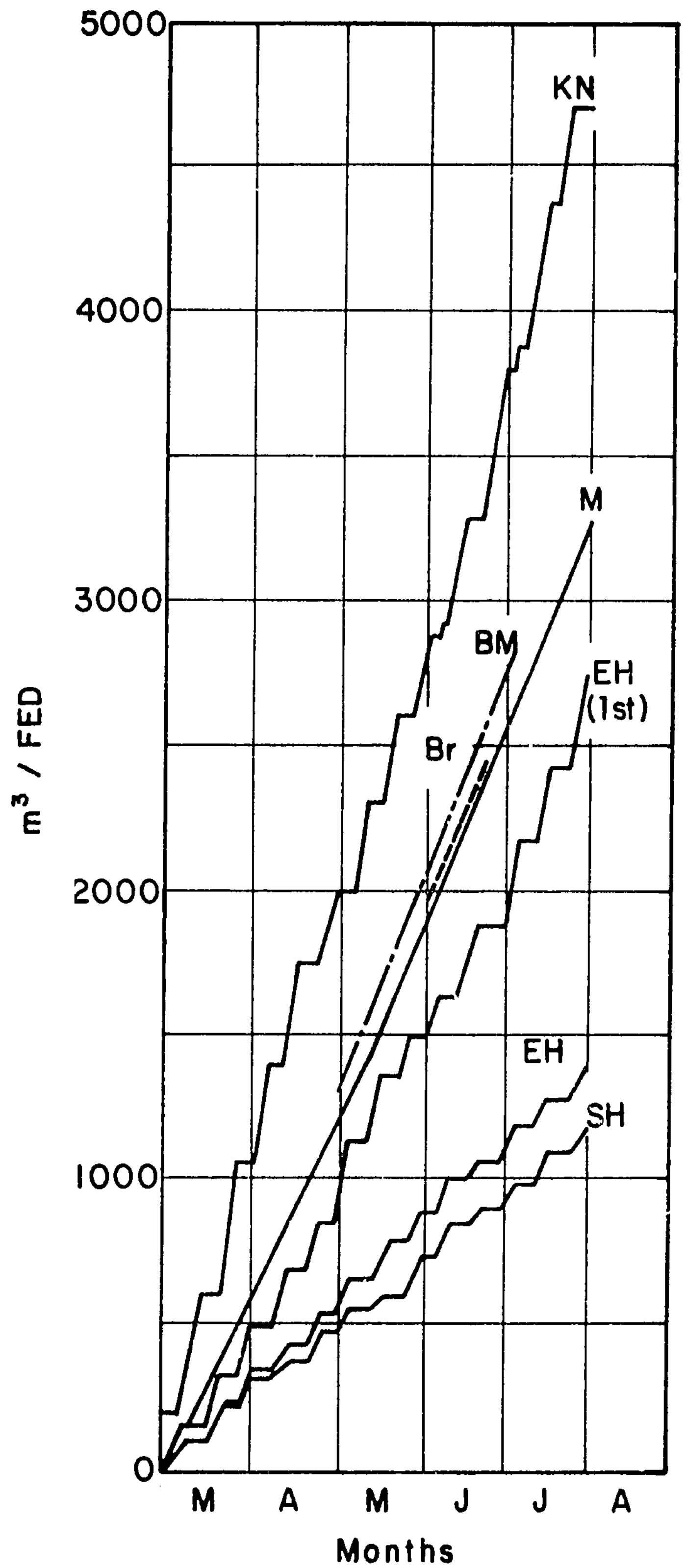


Fig. 4 Accumulated water delivery shares to various branch canals from the Mansouria Canal during a five month period in 1978.

In the rest of the first reach, losses were dominant. Between sites 2 and 4, a total length of 7.28 km, the losses increased with an increase in flow, and ranged between 5% and 13%, with an average of 9.7% of the entering discharge at site 2. This is a loss of 1.3% per km length. These results may be representative of all losses in that first reach.

The second reach, between sites 5 and 6, is near the Hammami area. It may be representative of the middle reach of the canal. The measured discharges show a higher rate of loss than appeared in the first reach. They also show an increase in water loss with an increase in flow. From the limited number of readings (3) it appears that the loss ranges between 7.9% at a flow of about 4.2 m^3/s and 12.9% at 4.41 m^3/s, with an average of about 10.1%. This is a loss of about 3.9% for each km. Table 1 shows the calculated values for this reach.

Table 1. Conveyance losses from the Mansouria Canal between site 5 and site 6

Date of Measurement	Site 5 at km 24.89		Site 6 at km 27.45	Loss in reach		
	Water Level elevation m	Discharge m^3/s	Discharge m^3/s	m^3/s	$m^3/km/s$	%
June 13,1978	17.275	4.212	3.879	0.333	0.129	7.9
June 14,1978	17.28	4.309	3.903	0.406	0.159	9.4
June 25,1978	17.285	4.408	3.839	0.569	0.222	12.9

Discussion of the Problem Identified

Among the three branch canals chosen for study, it appears that progressively less water per unit land area is delivered to those branches which are farther from the Mansouria intake. The figures are 7.31, 5.09, and 2.17 mm/day delivered by the canals located at kilometer 14.5, 21.5, and 25.9, respectively. These values compare with 5.09 mm/day delivered by the entire Mansouria Canal system during the chosen five-month period.

The same kind of relationship appears to exist within the area served by the El Hammami Branch Canal and its Shimi Branch. The figures are 4.17, 2.09, and 1.79 mm/day, respectively, for the first reach before the final branching, for the shorter Hammami Branch, and the longer Shimi Branch. These compare with 2.17 mm/day per day for the entire Hammami area. In addition, it has been observed that farms near the end of a private ditch receive less water than those near the intake, and that some farmers can only find water in the ditch at night.

All of these water delivery measurements include whatever conveyance loss there is within the area served. Estimates of these losses are not yet available. However, because a high water table exists in the region, it is assumed that at least a part of the seepage from the canals is available for consumptive use. Perhaps some idea of the conveyance losses in the branch canals can be obtained from the measurements that were made in the Mansouria Canal. These ranged from a slightly negative loss for one short section to 1.3% per km through most of the clay soil, and reached the very high value of 3.9% per km through sandy soil. If we assume that these percentage losses can be applied to the smaller canal cross sections in the clay soil of Kafret Nassar and in the sandy soil of El Hammami, respectively, the total loss in Kafret Nassar's 3.73 km would be 5%, and in El Hammami's 3.63 km, 14%. If these losses are not all recoverable as consumptive use, they make the disparity among the water shares even greater. All figures are based on one year measurements.

Since both the Beni Magdoul Canal and its branch are lined, it is assumed that their conveyance losses are less. A separate paper is being prepared on the combined effect of the canal lining, the slightly lower designed water level in these canals, the change from rotation to continuous flow (delivery on demand), and the extension of the lining to many of the private ditches served by these canals.

During this test period, engineers for the Egypt Water Use Project were permitted to regulate the inflow to the Beni Magdoul Canal. It was somewhat comforting to learn that the 5.09 mm/day distributed by the Beni Magdoul Canal was identical with the amount delivered by the entire Mansouria system.

It is apparent from the foregoing that the shares of water are not equally distributed, and that some regions receive more than they need and others less than they need for maximum production.

The area served by the Kafret Nassar Canal receives more than three times as much water as that served by El Hammami Canal and more than four times that supplied by the Shimi Branch. Several reasons for these differences have been identified. Some of them relate directly to the practice of using water levels to regulate discharge rather than water measurement, and to the physical characteristics of the system. Among them are:

1. The water level near the intake of any canal is maintained up to the design level most of the time, making water available when it is supposed to be. This becomes less true toward the end of the canal.

2. Intakes to private ditches, especially near the intake of a canal, will discharge more water if the users lift more out onto their lands. This results from the reduced head on the downstream side of the pipe inlet, thus increasing the total head causing flow through the pipe. The same effect is transmitted back to the sluice gate at the intake of the canal, increasing the flow there also.

3. Since the water level in the Mansouria canal remains fairly high at the initial end during all rotations, there is more opportunity for water to be obtained during the off-period of a particular branch canal through a leaky gate, or by direct diversion to a field.

4. Weeds in unlined canals, including submerged weeds are very prolific in this climate. In spite of frequent cleaning, they can increase the required hydraulic gradient in a canal so much that essentially no water reaches the end until they are removed.

5. Silt deposits give nourishment to weeds even in lined canals, greatly restricting flow. In unlined canals the silt builds up with the weed growth in just a few months, even to the point of causing a reverse gradient in the bottom of the canal, especially near the end. Some of this silt is blown into the canals, especially during the windy period in the spring. The weeds tend to trap both the wind-borne and water-borne silts.

6. When a canal passes by or through a village, it may receive enough trash to restrict flow. Sand and gravel used to scour dishes and pans accumulate in the bottom. Garbage, including broken glass, not only restricts flow but makes the hand-cleaning operation more difficult. During 1978, Beni Magdoul Canal had to be drained and cleaned twice, and El Hammami three times. Some of the material discovered in the

cleaning included bricks and concrete blocks that may have been illegally placed to raise the water level behind them, at the expense of users farther down the canal.

7. Illegal pipe intakes to private ditches probably constitute one of the most important factors causing unequal shares. In the first reaches, where a good head of water is available most of the time, an extra pipe through the canal bank will double the flow, thus providing enough water so night irrigation is not required. When there is not night irrigation, the unused portion of the flow may be lost over the canal spillway directly to the drain at night, or perhaps from the end of a private ditch. Farther downstream near the ends of the canal system, illegal intakes can then become almost a necessity to get enough water to supply a sakia (water wheel for lifting water usually driven be animal power) even when irrigating with the water level that reaches a maximum at night. The night water level, even though higher, may still be below the design level for that reach.

The Search for Solutions

The Egypt Water Use Project is now beginning a search for solutions to the problems identified in the Mansouria district. A number of different trials are being considered. Among those which may have a beneficial effect on the problems identified in this paper are:

1. Lining of canals and ditches

   A full-scale trial is already underway in Beni Maydoul under the auspices of the Water Distribution and Irrigation System Institute. It is hoped that the lining will reduce the weed growth and therefore the maintenance required to get adequate water to the end of the branch canals and private ditches. The lining should also reduce the seepage loss, leaving more water for the last users. If the reduced seepage lowers the water table, the resulting increased gradient may cancel some of the expected reduction in seepage.

2. Water measurement

Measuring structures of concrete, masonry, and steel have already been installed at the intake of Beni Magdoul and Kafret Nassar and at the end of spillways. A few have also been installed on selected farm sites. The larger structures contribute to a water budget study that should provide information for better management of the canal system. Various additional techniques for measuring the water delivered to each farm or field may have to be tried before an acceptable one is found.

3. Control of intakes to private ditches

A suitable method will be sought to control the intake to any private ditch to a reasonable amount. Anticipated problems include the cost of any possible modification of the control structures, the cost of water measurement if that becomes necessary, and the cost of enforcement or the alternative cost of obtaining voluntary cooperation.

4. Scheduling irrigation turns along the private ditches

Perhaps trials can be initiated that would encourage the farmers to take turns using the water from their private ditches, thus insuring that those near the end get a fair share. Ideally, each should agree that some of his turns will occur at night.

5. Land leveling and the use of water control devices

Land leveling will make night irrigation easier, thus eliminating part of the reluctance to irrigate at night. At the same time it should reduce the quantity of water needed for each irrigation, leaving more water for those farther downstream. The introduction of water control devices such as spiles, siphon tubes, or gated pipe, should further reduce labor and increase efficiency.

6. Irrigation scheduling on fields

The training of irrigation advisors who would be able to measure or calculate when it is time to irrigate and how much to apply should reduce the number of excessive irrigations.

At the same time these advisors could prevent moisture stress caused by waiting too long before irrigating. If an acceptable program for this kind of service can be found, it should decrease over-irrigation, leaving more water for areas now in short supply. Hopefully it would also increase yield.

7. Auxiliary water supplies

Farmers in the water-short areas have already discovered they can augment their water supplies by pumping from the drains or from wells. Some use these sources exclusively because they are more dependable than the canal water. The drain water has medium-high salinity, and has apparently contributed to an increase in soil salinity. With adequate leaching it could be used for tolerant crops. The well water is somewhat better. EWUP will likely not initiate trials with these water unless other efforts fail.

Summary and Conclusions

The irrigation canal system in Egypt may be unique in the world. It consists of relatively long canals and drains, each paralleling the Nile River down a narrow valley. The water level in the canals is designed to deliver water to the land about 30 to 50 cm below ground surface, thus requiring the farmer to lift it. An Archimedes screw and a well-designed water wheel are the most common lifting tools. Water control to the various branch canals is maintained by setting a specified water level at the canal intakes, rather than by measurement. Delivery is on a rotation basis. A typical private ditch serving several farms takes water from a canal through a pipe buried in the canal bank, the diameter of which is chosen according to the area served by the ditch. A constant head of water is supposed to be available over the pipe inlet. Ingenious farmers have added extra pipes to give them more insurance of receiving the amount of water they would like to have when they want it.

Measurements indicate that the system is not supplying equal amounts of water to all areas served. The most remote areas may receive only one-fourth as much water as those at the beginning of the canal system. Reasons for the differences include the illegal intakes, the rapid accumulation of weeds, silt and debris in the canals, and conveyance losses from the canals. In sandy soils, canal losses may reach nearly 4% per kilometer, plus any discharge over the spillway. A search for solutions to remedy these and other problems in the Mansouria district is now underway by the Egypt Water Use Project.

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