IMPACTS OF THE IRRIGATION IMPROVEMENT PROJECT, EGYPT,
On Drainage Requirements and Water Savings

Report to the Egyptian-Dutch Advisory Panel on Land Drainage and Drainage Related Water Management of a short-term consultancy mission

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Table of contents

1. ABBREVIATIONS USED

IAS	Irrigation Advisory Service, IIS
AAP	Egyptian-Dutch Advisory Panel Project on Water Management and Drainage, NWRC
APRP	Agricultural Policy Reform Program, MPWWR and MALR
DRI	Drainage Research Institute, NWRC
EPADP	Egyptian Public Authority for Drainage Projects, MPWWR
EPIC	Environmental Policy and Institutional Strengthening Indefinite Quantity Contract, APRP
EWUP	Egyptian Water Use Management Project
ICID	International Commission on Irrigation and Drainage
IIS	Irrigation Improvement Sector, MPWWR
IIP	Irrigation Improvement Project, IIS
MALR	Ministry of Agriculture and Land Reclamation
MPWWR	Ministry of Public Works and Water Resources
NWRC	National Water Research Center, MPWWR
RDI	Reform, Design and Implementation Unit, APRD
RIGW	Research Institute for Ground Water, NWRC
USAID	United States Agency for International Development
WDMRI	Water Distribution ad Management Research Institute, NWRC
M&E	Monitoring and Evaluation
O&M	Operation and Maintenance
WUA	Water Users Association

2. SUMMARIES

2.1 Summary of findings

The findings summarized here are limited to land and water aspects of irrigation and drainage. Other irrigation and drainage aspects, like agricultural, economic, and social aspects are not specifically discussed.

1. The Egyptian Irrigation and Improvement Project (IIP) has taken a modest start in the last decade, but is planned to cover over 3 million ha by the tear 2017.

   It is to save about 8 billion m^3 of water annually. The IIP wishes to accomplish the savings by increasing the irrigation efficiency. The savings are to be used for:

   a. reducing the shortages of water felt within the present irrigation systems, especially at the tail ends of the canals
   b. increasing the availability of irrigation water for new developments.

2. The total amount of water available at the Aswan High Dam is approximately 55 billion m^3/year.

   The amount of water available for the purpose of irrigation is roughly 46 billion m^3/year. This includes usable return flows from municipal and industrial water uses.

   The discharge of drained irrigation water to the sea and coastal lakes is some 8 billion m^3/year (see also point 4 below).

   Therefore, the net amount of irrigation water for crop consumptive use is about 38 billion m^3/year

3. The area irrigated at present is about 7.8 million *feddan*. Thus the net amount of irrigation water per *feddan* is some $38 \times 10^3/7.8 = 4900$ m^3/year.

   According to the reports, the area irrigated from Nile waters will increase with some 0.9 million *feddan* in the coming two decades: roughly 0,4 million *feddan* in North Sinai and the northern delta, and 0,5 million *feddan* in south Egypt (Toshka project), where the required water will be abstracted directly from Lake Nasser behind the Aswan High Dam.

   When the total irrigated area thus increases to 8.7 million *feddan* and the allocation for irrigation is not augmented, the net amount of irrigation water may reduce to about 4400 m^3/year, and less when the drainage losses from the additionally irrigated land is discounted.

4. The discharge of drainage water to the sea and coastal lakes through pumping stations is presently about 12 billion m^3/year.

Of this, 2 billion m^3/year is stemming from salt-water intrusion from the sea into the coastal zone through the underground, and another 2 million m^3/year consists of municipal and industrial wastewater.

A relatively small amount (1 billion m^3/year) of drainage water is lost to lake Qarun in Fayoum.

Altogether the discharge of agricultural drainage water to the sea and lakes would be some 12-2-2+1 = 9 billion m^3/year, of which 8 billion m^3/year originates in the delta.

5. Relating the annual discharge of 9 billion m^3 agricultural drainage water to the annual quantity of water available for irrigation (46 m^3/year), the present overall irrigation efficiency can be estimated at about 82%

Compared to irrigation efficiencies world wide, this is a high figure.
The internal irrigation efficiency within in the canal commands is much lower and less than 50%

The high overall efficiency is owing to the recovery of internal surface and subsurface water losses and to the reuse of municipal and industrial wastewater for irrigation.

Local surface water losses are led through drainage systems to the downstream irrigation canals, either by gravity or by pump lifting, so that the losses can be used elsewhere.

Local subsurface water losses are either pumped up through wells or collected by subsurface drainage systems, from where the water is recovered by gravity or through pumping.

6. The salt import from the Aswan high dam is about 14 million ton/year.
Neglecting the drainage of salty intrusion of water from the sea through the underground, the salt export amounts to 27 million ton/year.

A desalinization process is occurring, possibly due to the massive installation of subsurface drainage systems in the Nile delta during the last decades.

Despite the above logic explanation, there still seems to be a need for review of the salt balance data.

7. From salt balance point of view, there is scope to reduce the discharge into the sea and coastal lakes by roughly 5 billion m^3/year and reuse this gain for irrigation.

For safety reasons related to soil salinity control in the northern part of the Delta, the above gain may have to be reduced to about 4 billion m^3/year

8. The most immediate plans to achieve additional reuse of the drainage water in the northern part of the Delta are:

   a. about 2 billion m^3 drainage water that would otherwise be pumped annually from the eastern Delta into the sea and coastal lakes will be diverted to the Salam canal for irrigation in north Sinai, after blending with fresh irrigation water

   b. about 1 billion m^3/year drainage water from the middle Delta will be used after blending with fresh irrigation water for new reclamation areas in its northern part: Kalabsho.

   c. a yet unknown quantity of drainage water, probably not more than 1 billion m^3 that would otherwise be pumped annually from the western delta into the sea and coastal lakes will be used in the Umam Drain project.

   d. another yet unknown quantity of drainage water, probably not more than 1 billion m^3, will be reused for irrigation in the Irrigation Improvement Projects (IIP) through additional pumping stations.

9. Further on in this report it is shown that:

   a. there has been a general perception with agricultural water users and suppliers that the availability of irrigation water falls short of the potential (=optimal) crop water use

   b. in accordance to the shortage of water felt, the traditional *sakia* irrigation systems were subjected to operational restrictions

   c. the massive adoption, in the last two decades, of the privately owned mobile diesel pumps by farmers, partly introduced to circumvent the restrictions imposed on the *sakia* systems and thus to attempt to increase field irrigation applications, is in line with the farmers' perception of water deficit

   d. the adoption of the pumps also increased the competition amongst farmers for water and has led to increased differences of water use between the head-end and tail-end farmers in favor of the first.

10. The above features demonstrate that the irrigated agriculture has been, and still is, coping with a perceived shortage of water. The reasons for this could be that

    (i) either the users' perceptions of irrigation requirements are unrealistically high, or

    (ii) the full crop water requirements are in reality higher than the actual amounts of irrigation water delivered by the suppliers.

    The IIP has been designed primarily on the basis of the first interpretation: realistic irrigation requirements are less\than presently felt.

11. In fully completed IIP areas there is:
    a. improved water control at secondary level, i.e. there are improved branch-canals with new hydraulic structures for downstream water level control and continuous availability of rotational flow of irrigation water
    b. improved water management at tertiary level including new Water User Associations (WUA's) who:
        (i) operate a communal pumping station instead of the presently prevailing individual mobile pumps;
        (ii) avail of high level tertiary canals (*meska*'s) from which the water can be distributed by gravity instead of the previous low level *meska*'s from which the water had to be lifted individually by the farmers

12. In fully completed IIP areas there would be:
    a. a fair distribution of irrigation water amongst the water users and disappearance of the difference in water availability between head-end and tail-end farmers
    b. a shift from the present irrigation rotations at secondary branch-canal) level to rotations at tertiary (WUA, *meska*) level
    c. more efficient irrigation, reduced water losses, and a reduced surface and subsurface drainage
    d. disappearance of the informal reuse of drainage water, i.e. there would be no more pumping of water by individual farmers from the main drains for irrigation use
    e. saving of water for use elsewhere

13. At present, data on actual water saving in fully completed IIP areas are scarce, if not absent.

Hence, the prerogative of IIP (see point 9) cannot yet be confirmed

To obtain confirmation, a program to monitor the water savings needs to be developed.

14. The lifting gates at the heads of the branch-canals, through which the inflow of irrigation into the branch-canals used to be regulated, are thought to be no longer required in fully completed IIP areas, but they would be maintained as "stand by".

However, it has been observed that they are still being operated in fully completed IIP areas.

When the water savings in the fully completed IIP areas would be below expectation (if not negative due to an increased availability and demand), the gates can be used to restrict the inflow into the branch-canals.

If this were to become a regular feature, then the phenomenon of competition for water would manifest itself again, as well as the head-end and tail-end differences of water availability and use.

15. The Irrigation Sector (IS) of MPWWR (Ministry of Public Works and Water Resources) operates the primary (main and feeder canals) irrigation systems up to the level of the control structures (the lifting gates) at the head of the branch-canals.

    The Irrigation Improvement Projects (IIP) would construct the secondary (branch-canal) and lower level irrigation systems.

    There may be unforeseen yet serious effects of the IIP's on the functioning of the primary irrigation systems in terms of changes in water level and/or discharge regime. The hydraulic aspects involved are complicated.

    The necessary coordination between the above irrigation management and execution agencies has recently become subject of meetings. The outcome of a common strategy is awaited.

16. The direct costs (i.e. excluding the Government's overhead costs) of the latest IIP's are estimated at LE 2700 per *feddan* (say 2000 US$ per ha).

    Some 25% of the costs relate to the improvement of the secondary canal system and some 75% to improvements at tertiary level.

    The costs at tertiary level are to be repaid by the farmers free of interest during a period of 20 years after a certain grace period. This amounts to roughly LE 135/*feddan*/year.

    At present the evidence is lacking that the repayment duty can readily be met from the incremental benefit accruing from the IIP to the farmers.

17. In all evaluation reports it was concluded that the actual progress of IIP was slow due to a considerable number of serious constraints, and that a major effort is required to relax the constraints.

2.2 Summary of gaps in knowledge

I. Scarcity of data

The following points indicate scarcity of data:

a. All project assessments and/or evaluation reports conclude that there is a lack of monitoring of IIP effects on agricultural benefits, operational gains for the farmers, and change (increase or decrease) of water use and equity (fairness) of water distribution
b. Most of the data on agricultural benefits and operational gains for the farmers were obtained from only one of the earliest IIP improvements carried out near Minya, in the Nile valley of Middle Egypt. The data were gathered around 1990, and need to be upgraded.
c. The data from Minya indicate that there are certainly positive agricultural benefits and operational gains. However, the evaluation reports state that the information is not sufficient to assess the economic viability. The few available crop production data from the Minya area, and also in the Balaqtar area in the northern part of the Middle

Delta, tend to indicate that increases in crop yield do occur, but they do not reach the target levels.

d. In general, farmers appear highly satisfied with the improvements brought about upon completion of IIP in their area. However, it remains to be verified to what degree the satisfaction results from the preferential water allocation to the completed areas and whether the preferential treatment can be maintained when many more areas are being completed. If there were to arise a reason for diminishing satisfaction upon withholding preferential treatments, the risk exists that farmers in WUA's enter anew into individual competition for water, whereby the goal of equity (fairness) and efficiency of water distribution is jeopardized.

II. Progress uncertainty

There exists some uncertainty about the future progress of IIP in the light of:

a. The present progress
b. The high costs involved
c. The below target yield increase
d. The lack of monitoring data needed to support high-level policy decisions
e. The question of the real improvement of on-farm irrigation efficiencies
f. The discussion about the validity of the present project concepts and whether they need to be adjusted ("modified III")

2.3 Summary of recommendations

I. Quoting from the EPIQ study: "An independent Monitoring and Evaluation Unit within MPWWR is recommended for: (i) designing an implementing comprehensive evaluation programs (ii) analyzing data and information needed to support policy decisions regarding programs like IIP

II. Without more definite information about the actual changes in water use quantities, on-farm irrigation efficiencies, and future expansion of IIP, the consultant finds it difficult to venture any substantial predictions on the IIP impact on quantity and quality of surface and subsurface drainage water and its reuse, drainage requirements, and replenishable sources of groundwater. As the IIP progress has proved to be slow, and as the IIP concepts are still under scrutiny, there is still some time available to await the outcomes of future monitoring and evaluation reports before the above predictions are taken up.

III. To obtain a timely answer to the questions raised in the terms of reference, i.e. the impact of IIP on water savings and the drainage situation, it appears appropriate to start the monitoring activities with a priority component consisting of collecting information on the flow regime of irrigation water at the interface between the main and branch canals, both before and after IIP

Such a program could very well be carried out in collaboration with the Water Distribution and Management Research Institute (WDMRI) of NWRC

As outlined before, the activities that will develop around the mentioned interface will play a crucial role in the near future in the conceptualization of "modified" IIP programs.

The information to be obtained from the priority component will definitely contribute to the filling of the knowledge gaps in the sphere of:

a. (in)equity, i.e. (un)fairness, of water distribution before and after IIP
b. (in)sufficiency of water supplies along the canal systems
c. coordination between main and feeder canal management and construction agencies at the level of branch canal and IIP
d. water savings by IIP, whether positive or negative

From data on the last issue, substantial conclusions can be drawn about the IIP impact on the drainage situation. In addition, the information will be useful to assist MPWWR in their water resources planning activities.

The procedures required to collect the information are relatively simple and much more easy than the procedures required to obtain the same information at farm level. Yet, they will yield basic and essential data, without which any evaluation effort of the impact of IIP on irrigation (in)efficiency and (un)timeliness at tertiary level is bound to be of limited consequence.

In fact, it s surprising that the survey elements described here have so far hardly been taken up in Egypt while many investments were made in the other IIP research and survey issues and in IIP implementation.

2.4 Qualitative Estimates of Impacts of IIP Measures

Data to relate the actual (post IIP) water supply conditions in the field to the desired (post IIP) water supply conditions in the field are lacking. Therefore, the consultant could not evaluate the effects and improvements of the IIP in detail. Nevertheless, he prepared a Table with qualitative indications of the impact.

IIP MEASURES	Water saving	Reduc. drainag. requir.	Drainage water		Ground water	
			better quality	reduced quantity	better quality	higher quantity
Cropping liberalization (market mechanism)	-1	-1	+1	-1	+1	+1
Increasing price of rice (incl. export promotion, excl. modified drainage)	-2	-2	+1	-2	+1	+1
Increasing price of rice (incl. export promotion, incl. modified drainage)	-1	-1	+1	-1	0	0
On farm water management (incl. land levelling)	0	0	0	0	0	0
Water users organisations (at tertiary level)	+1	+1	-1	+1	-1	0
Elevated lined mesqa's (under WUA control)	+1	+1	-1	+1	-1	-1
Central pump lifting (under WUA control	+1	+1	-1	+1	-1	-1
Unrestricted continuous water supply (through d.s. control)	-2	-2	+1	-2	+1	+1
Restricted continuous water supply through branch canal head gates	+1	+1	-1	+1	-1	-1
Water user federations (at sec. level with restricted supply)	+2	+2	-1	+2	-1	-1

Ratings	score
Major positive impact	+2
Minor positive impact	+1
No impact	0
Minor negative impact	-1
Major negative impact	-2

3. GENERAL DATA ON IRRIGATION AND DRAINAGE IN EGYPT

3.1. Water and salt balances

3.1.1. Irrigation

Apart from natural groundwater supplies in oases and the limited rainfall along the Mediterranean coast, agriculture in Egypt is entirely dependent on surface irrigation with waters from the river Nile.

The construction of the High Dam at Aswan in Upper Egypt close to the border with Sudan, completed around 1968, had a great impact on the irrigation and drainage situation in Egypt. On the one hand it increased the availability of irrigation water to some 46 billion m^3 per year. On the other hand, the intensified irrigation has led to a rise of water tables, drainage problems, and an increased salt import into the agricultural lands.

The availability of irrigation water (fig. 1) is determined as follows:

1 - The High Dam releases annually about 55 billion m^3 per year;
2 - Un-beneficial evaporation losses from Egypt’s extensive river and irrigation canal system are about 3 billion m^3 per year;
3 - Industrial water use is around 8 billion m^3 per year, of which some 1 billion m^3 per year evaporates, 1 billion m^3 per year is pumped into the sea, and some 6 billion m^3 per year returns to the surface water and can be re-used for irrigation;
4 - Municipal water use is more or less 5 billion m^3 per year, of which some 2 billion m^3 per year evaporates, and some 2 billion m^3 per year returns to the surface waters and can be re-used for irrigation;
5 - Escape losses from the Edfina barrage at the downstream end of the Rosetta branch of the river Nile into the sea, in relation to shipping requirements and the closure period of the irrigation for maintenance, are presently close to 1 billion m^3 per year;
6 - The availability of irrigation water results from the balance of the above quantities: 46 billion m^3 per year.

The data used are essentially derived from Dr. Bayoumi et al., RDI, 1997, but some rounding off has occurred.

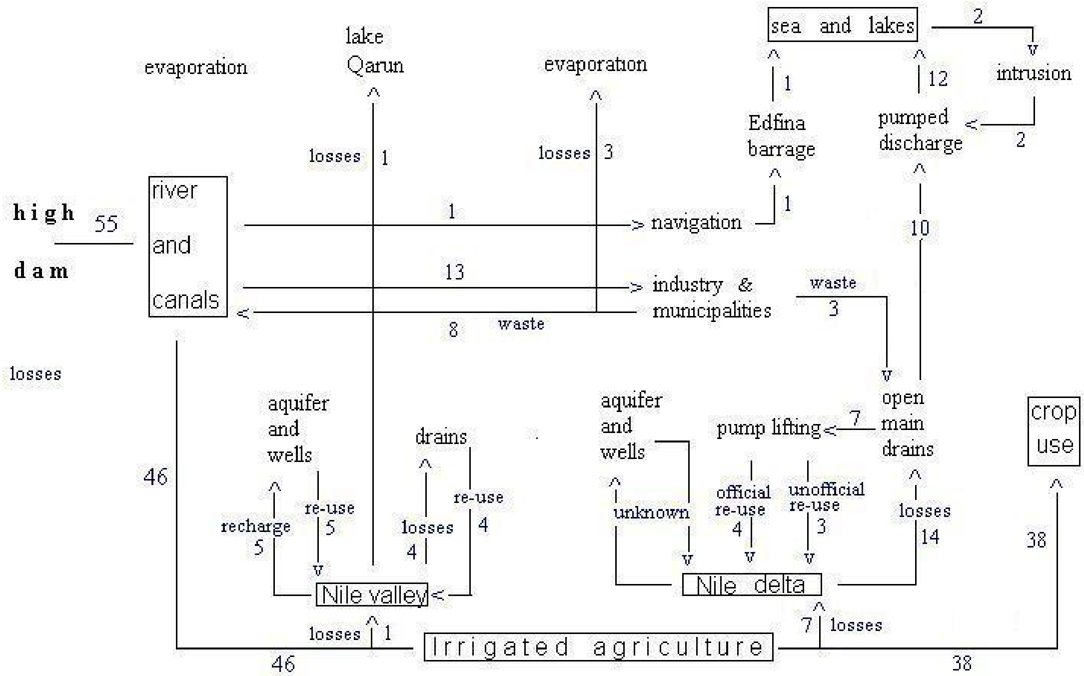


Figure 1. Average annual water balance of the river Nile downstream of the High Dam

In some reports, the availability of irrigation water is estimated to be higher, as the annual use of groundwater pumped by wells from the aquifer in the Nile Delta, and the re-use of drainage water is added. However, both the RIGW and the DRI institutes have confirmed that annual groundwater recharge (replenishment) exclusively stems from the deep percolation of water from the Nile River, the irrigation canal systems, and the irrigation applications on the agricultural lands. Hence, groundwater and drainage water are not an independent source of water and their use is merely a recirculation (recapturing) of a part of the losses of the irrigation water. The re-use of water losses to the groundwater results merely in a decrease of the total losses and an increase of the water use efficiency. Whether the recapturing is done by well or drainage systems makes essentially no difference when it concerns the water balance.

The water streams for different categories of water use cannot be separated as they are intermingled continuously in Egypt’s river and canal systems. The same holds for the re-use as the water losses from the various categories may en up in the same drainage systems. So it may very well happen that one drop of water has passed through a municipal, industrial and agricultural stage.

The intermingling complicates the assessment and allocation of water resources.

3.1.2. Salinity and drainage

The salt concentration of the water in lake Nasser at the High Dam is about 0.25 kg salt/m^3. The salt import into Egypt’s water use systems thus amounts to about 14 million tons per year (55 billion m^3 water/year x 0.25 kg salt/ m^3 water) or roughly 1.6 ton/*feddan*/year over 8.7 million *feddan* of irrigated land, i.e. 4.0 ton/ha/year.

To combat the problems of water logging and salinity, Egypt's drainage systems have been gradually intensified. After partial use of the drainage water for supplementary irrigation downstream, some 12 billion m^3 of drainage water is discharged annually through pumping stations into the sea and coastal lakes. Of this water some 2 billion m^3 is estimated to originate from sea water intrusion through the underground, while an unknown amount, say also 2 billion m^3 stems from municipal and industrial waste water, so that the discharge of drained irrigation water is about 12-2-2=8 billion m^3/year.

In the Fayoum area, about 1 billion m^3 of drainage water is discharged annually into lake Qarun.

Excluding the drained salty water intrusion from the sea through the underground, the salt concentration of water evacuated into the sea and lakes is, on average, 2.7 kg salt/m^3. The salt export from the Delta thus amounts to some 10 x 2.7 = 27 million ton/year.

The above data, derived from DRI yearbook 1995/1996, excluding the salt export from Fayoum, lead to the conclusion that much more sat is exported than imported: on average the agricultural land desalinizes.

3.1.3 Overall irrigation efficiency and re-use

Relating the amount of drainage water from agricultural lands discharged into the sea and lakes (8 billion m^3/year in the Northern Delta and 1 m^3/year Fayoum) to the total amount of water available for irrigation (47 billion m^3/year) one arrives at an overall irrigation efficiency of about 81%

According to international standards he above efficiency is very high. The reason for this is the continuous re-use of the drainage losses of irrigation water.

In the Nile valley, the drainage water (perhaps some 4 billion m^3/year) returns by gravity or by pump lifting to the river and it is re-used downstream. The re-used water is not considered a loss.

The pumping from groundwater through wells is estimated at roughly 5 billion m^3/year. This water is used for irrigation. Thus the deep percolation from the irrigated lands to the underground is recovered, and the percolation is not considered a loss.

Also there is a considerable un-official re-use through private pumps for application directly to the crop land, but the quantity is unknown. Yet, DRI estimates it at about the same quantity as the official re-use, while RDI sets it at 2.8 billion m^3/year. Let us tentatively say that the amount is 3 billion m^3/year.

Of the 8 billion m^3/year drainage water from the irrigated agricultural lands and the 2 billion m^3/year municipal and industrial waste water, together 10 billion m^3/year that is presently discharged into the sea and lakes (excluding the drainage of groundwater intrusion along the sea), some 4 billion m^3/year are planned to be re-used for irrigation in the new lands of the El Salam canal in the Eastern Delta, Kalabsho in the Middle Delta, and Umun Drain Project in the Eastern Delta (DRI yearbook 1995/1996). Further, the IPP envisages an additional re-use by installing extra pumping stations. The quantity of this re-use is unknown, but for the time being it may be set at 1 billion m^3/year. All this would reduce the discharge into the sea and lakes to some 5 billion m^3/year. To that one must add the yet unknown amount of discharge that will come in the future from the new irrigation developments.

Most of the planned additional re-use will be abstracted from the open drains carrying the relatively best quality drainage water. Hence the additional re-use consists of water that is a mixture of agricultural drainage water and municipal/industrial waste water.

The salt export from the Delta will be unaffected by the proposed additional re-use, excepting the re-use in the IIP areas. However, as the present total export of salts from the agricultural lands is greater than the import, the IIP re-use appears harmless from point of view of the overall salt balance.

Still excluding the evacuation of intrusion water, the salt export into the sea and coastal lakes after effectuation of the additional re-use plans will be minimum 5 x 2.7 = 13.5 million ton/year. The export will in reality be somewhat more as the salt concentration of the exported water may slightly increase as a result of the additional re-use in IIP areas. Also, a small part of the additional re-use will again be drained to the sea at a still higher salt concentration and contribute to the export. Further, the export figure still excludes the export from the Sinai area and the export to lake Qarun.

All in all, the conservatively estimated salt export of 13.5 million ton/year almost equals the import, which was calculated before at 14 million ton/year. Hence the overall alt balance will still look healthy.

In the overall salt balance, no provision has been made for the salt balance in the individual command areas of the irrigation canals. In some command areas, the salt balance may become critical after execution of the additional re-use programs. Therefore it can be recommended that evacuation of drainage water to the sea and lakes should not be less than, and the incremental re-use more than 5 billion m^3/year.

3.1.4. Crop water demands

The overall net quantity of irrigation water, equaling inflow (47 billion m^3/year) minus outflow (some 9 billion m^3/year) is roughly 38 billion m^3/year.

The irrigated area presently amounts to some 7.8 million *feddan* (RDI, 1997), consisting of 6.2 million *feddan* “old land” and 1.6 million *feddan* new reclamation areas.

Relating he net quantity of irrigation water to the irrigated area, one arrives at an annual average crop consumptive use of 4900 m^3 per *feddan* or 1200 mm.

Farooq Shahin (1995) estimated the crop water use in he Manaifa canal area, in the Northern Middle Delta (around Kafr El Sheikh), where the water availability is less than average, at 4500 m^3/year per *feddan*.

The Staff Appraisal Report (SAR) sets the irrigation deficit in the Mahmoudia Canal Command at 750 million m^3/year over 0.246 million *feddan*, i.e. 3000 m^3/year per *feddan*), the deficit in the Manaifa Command would be 133 million m^3/year over 0.042 million *feddan*, i.e. 3000 m^3/year per *feddan*, and in the El Wasat Command at 125 million m^3/year over 0.075 million *feddan*, i.e. 1500 m^3/year per *feddan*.

Even though the above deficits seem improbably high, they explain clearly why the areas depend heavily on re-use of drained irrigation water from elsewhere.

During the present mission it could not be ascertained whether the crop water use of about 38 billion m^3/year corresponds to the optimal crop water use, i.e. the use that would yield maximum crop production, or whether it is sub-optimal so that a certain yield depression would occur from water deficit. In the latter case, there would certainly be competition for water.

The crop requiring a particular high irrigation supply is paddy rice. The high requirement is not only due to continuous ponding of water on the fields during the growing season, but also to the regular refreshing of the ponded water by surface drainage and irrigation replenishment as practiced by the farmers. On top, the subsurface drainage systems tend to discharge an excessive amount of water from the rice fields. Seasonal irrigation requirements of rice of over 7000 m^3/year per *feddan* have been reported, which is almost 150% of the average annual availability.

The remedy against excessive subsurface drainage, the “modified/controlled drainage system (fig. 2), has not yet been implemented at a large scale. This is partly due to the difficulty of maintaining crop consolidation in the “sub-collector areas” under the present liberalization trends in Egyptian agriculture.

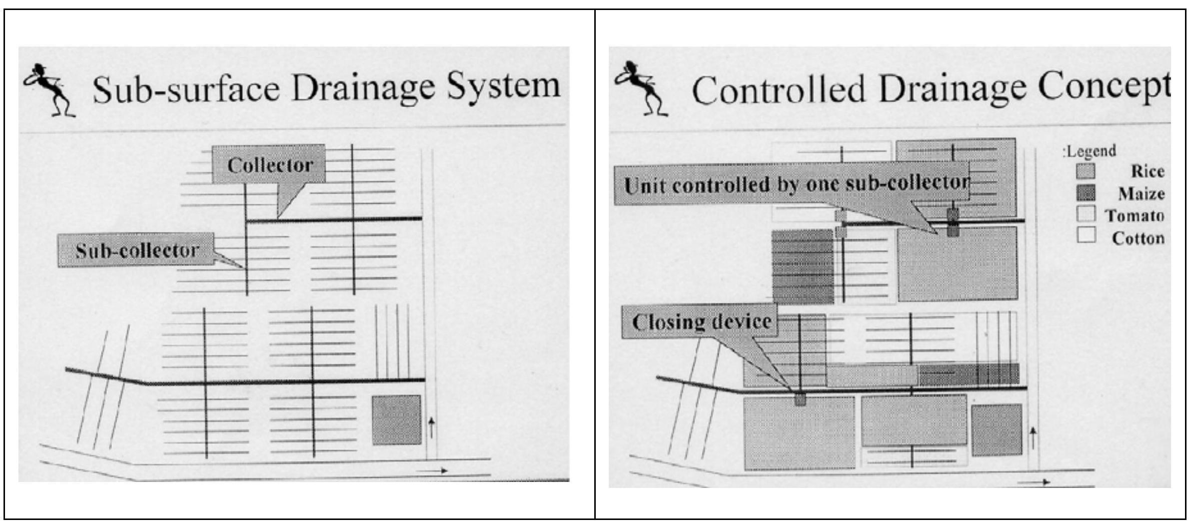


Figure 2. A drainage system with piped collector (left) and the modified (controlled) system for rice cropping (right).

Recently, the area under rice crops has been expanding rapidly, the market process of rice has increased sharply, and export promotion of rice is being undertaken. All this has given rise to an increasing water demand at farm level.

When the potential water savings through IIP need to be assessed, more accurate information on the optimal crop water use, given present copping patterns and estimating future cropping patterns, would be necessary.

3.1.5. Future irrigation water use

The government of Egypt is intending to divert canal water for new irrigation developments: some 3 billion m3/year for the Toshka (South Valley) project in upper Egypt, and about 1 billion m3/year for the Salam canal project in Sinai.

The water diverted to the Salam canal project is to be mixed with drainage water diverted from the North-Eastern delta.

Due to the re-allocation of Nile waters to the new irrigation developments (“ horizontal expansion”), the availability to the presently irrigated lands will be reduced to about 90% of the original supply, and the existing net availability of irrigation water would drop from 4900 to 4400 billion m3/year per *feddan*.

To mitigate the decrease, water savings would have to be realized through improvement of irrigation efficiencies and reduction of irrigation water losses within the presently irrigated lands.

3.2. Distribution of irrigation water

3.2.1 Primary systems

The irrigation water is diverted from the Nile by barrages (fig. 3), and from there through a system of main canals. This is the primary irrigation system, and it works continuously except during the 3 weeks closure period needed for canal maintenance. With the water supply through the main canals it is in principle possible to irrigate the total command area with 2 crops per year.

The quantity of flow (discharge) in the main irrigation canal systems is essentially regulated by head-control structures, generally equipped with lifting gates. Between the main regulators one finds cross-regulators at the boundaries between the irrigation directories.

The target discharge in the main canals is determined by the irrigation sector of MPWWR on the basis of estimated cropping patterns and corresponding expected consumptive of the crops per irrigation directorate.

The Central Directorate of Water Distribution allocates the water to the Irrigation directories, and the latter distributes it to the Irrigation Districts. The district areas are on the average 50.000 *feddan*.

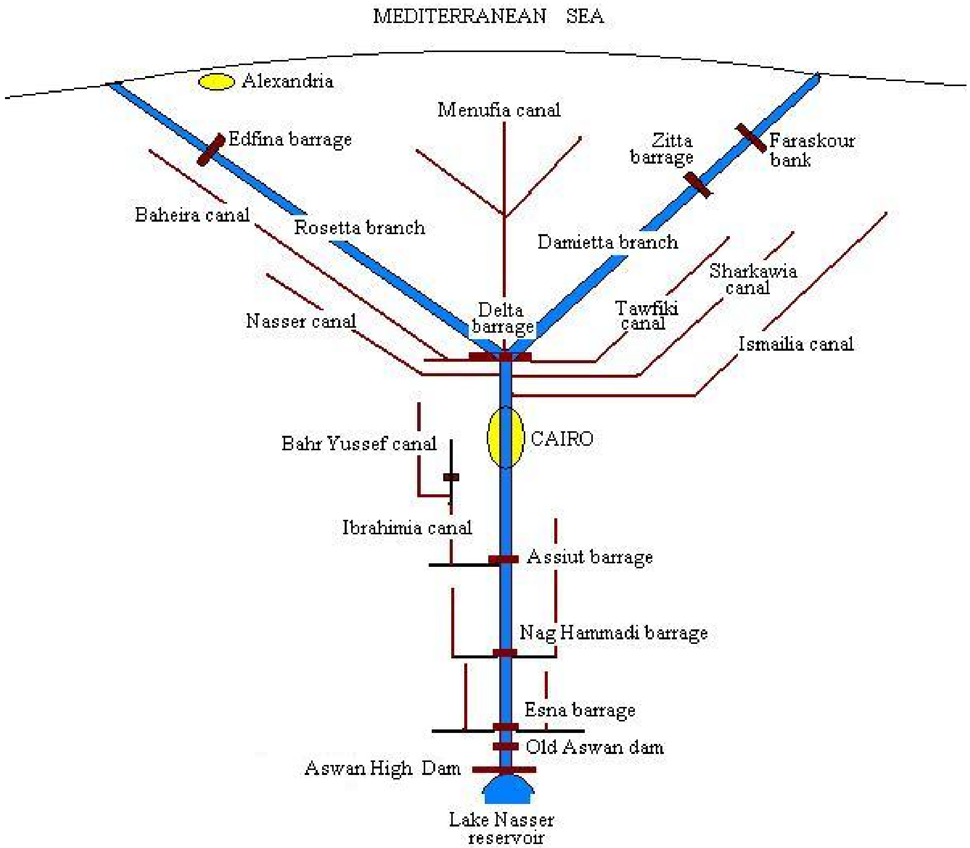


Figure 3. Sketch of the primary irrigation systems.

The method to achieve the target discharge is based on rating curves of the structures (i.e. the known relation between discharge and upstream water level at the gate) or on rating curves of the downstream channel (i.e. the known relation between discharge and the water level in the downstream channel. Periodic current metering checks the latter curves.

3.2.2. Secondary systems

From the main system, the irrigation water is admitted to the secondary systems, consisting of branch canals (or distributaries or delivery canals) by means of lifting gates operated under supervision of district engineers. The gates are opened so as to maintain the target downstream water levels. Here, however, the discharges are not routinely controlled.

Often the final ramifications of the main canal system from which the branch canals derive their water are called feeder canals.

The off-take point of the branch canals from the feeder canals is the last instance where the discharge can be regulated. It is the meeting point of water users and water suppliers.

Of old, the branch canals are set to work under rotations according to “on” and “off’ periods. The rotational periods are typically 1:2 (e.g. 5 days on and 10 days off) or 1:1 (e.g. 4 days on and 4 days off). The 1:2 rotation prevails in the winter season whereas the 1:1

rotation prevails in summer, especially in view of the demands for rice crops. However, other rotation sequences are also used.

The area served by branch canals is variable in the order of 1000 to 10.000 *feddan*.

3.2.3. Tertiary systems

The water in the branch canals is distributed over the tertiary canals (meska's). In the last two decades, the method of off-take from the branch canals underwent drastic changes, and IIP is now aiming, again, at innovations. Below, an overview will be given of the tertiary systems in the past and at present.

Tertiary systems in the past

In the past, the water levels in the *meska*'s were 0.5 m or more below the soil surface. From here the irrigators lift the water into the quarternary canals (*marwa*'s), and from there it is spread over the cropland. However, water can also be lifted directly from the branch canals.

The area served by a *meska* is variable and usually in the range of 50 to 100 *feddan*. A *marwa* serves an area of 10 to 20 *feddan*.

The lifting of water from the *meska* into the *marwa* was carried out mainly by animal driven wheels (*sakia*'s), which were licensed by the irrigation districts. The *sakia* was a fixed installation whose sump was connected to a can or *meska* by an intake pipe of a specified diameter. The farmer's capacity to abstract water from this delivery system was thus restricted in terms of number and location of lifting points and of the discharge. In particular the need to share the use with several other famers in the same *sakia* "ring", and the limited discharge of the *sakia* combined with the restriction of the rotation system, meant that farmers were considerably retrained in terms of when, how long, and with how much water they could irrigate.

The output (discharge) of a *sakia* is directly related to the water level in the sakia sump and thus in the parent *meska* or canal. This limited the ability to draw down the water level in the meska and canal since, when the water level becomes low, the output of the *sakia* would be considerably reduced. In effect, the particular characteristics of the *sakia* introduced a degree of self-compensation in the operation of the system, which helped to assure a modest withdrawal of water.

Some further restrictions were also applied at the *meska* off-take from the branch canal. The off-take takes the form of a pipe whose diameter was originally related to the area served on the basis of a defined hydraulic head loss at the design discharge.

Tertiary systems at present

Over the last 20 or 30 years *sakia*'s have been progressively replaced by mobile diesel driven pumps. Unlike the *sakia*, which was almost always collectively owned by the member of the *sakia* ring, most motor pumps are privately owned by individual farmers, but a significant number of farmers do not own pumps but rent them form others. In some cases engine-driven *sakia*'s were installed.

Many of the pumps have a discharge capacity of around 60 l/s whereas the sakia's could lift only around 15 l/s.

The widespread introduction of the motor pumps has largely removed the various constraints imposed by the *sakia*-based system. The larger discharge provided by the pumps means that farmers can complete their irrigation in a shorter time.

In some cases two or more pumps may operate simultaneously at a former sakia site. In addition, many farmers whose fields are adjacent to canals or meska's have established additional lifting points. Even where lifting takes place at former sakia-sites the pump suction is often placed directly in the canal or *meska* rather than in the old *sakia* sump, because the *sakia* inlet pipe would not be big enough to supply the pump discharge. Also, the original *meska* off-takes were sometimes replaced by pipes with a larger diameter. Many of these changes are, strictly speaking illegal.

In summary, the tertiary system has gradually evolved from one which operated at a rigid set of controls down to the head of the *marwa*, to one in which there is little operational control within the branch canal and many farmers now enjoy a considerable degree of autonomy and flexibility, though still subject to the constraints of the canal rotation system.

However, this un-planned evolution, combined with changes in the cropping patterns, such as the increased rice areas, has led to problems of water distribution. In particular, there is an increased inequity of water availability between head and tail areas along the branch canals. The ability of head farmers to abstract water preferentially at the start of the rotational "on" periods means that, at times of peak demand, tail farmers receive initially little or no water, restricting their irrigation in time, if not in quantity. As an insurance against the uncertainty of the rotation system, head farmers may also carry out a top-up irrigation at the end of the "on" period, again reducing the availability of water at the tail end.

The reduction of equity in the water distribution over the *meska*'s along a branch canal owing to the introduction of the pump sets, forced the farmers who initially did not wish to acquire a pump set to join the ranks of pump owners. Hence, the replacement of the *sakia*'s by mobile pumps was not always done voluntarily but rather out of a competitive necessity, which increased the speed of the partly auto-propelled evolution.

The quite sudden wave of pump applications at a time that relatively cheap pumps appeared on the market, suggests that the farmers must have been perceiving a certain shortage of water, and it would seem highly relevant to investigate if the perception is based on realistic experience that the actual crop consumptive use of water under the prevailing water distribution system is less than the optimal consumptive use at which the maximum crop production is obtained. In other words, the standard supply of water might not have been sufficient to secure the highest possible crop yields.

3.3. Efficiency and equity of water distribution

The variations in the distribution of the irrigation water of the Mansuriya canal (near Gizeh, Cairo) over the branch canals in terms of m^3/*feddan* is illustrated in Table 1, derived from EWUP, 1984.

Table 1. Water distribution over branch canals in the period of March to August (summer)

Name of canal	water supply m^3/fed
Kafret Nasser (KN)	4600
Beni Magdul Branch	4000
El Mansuriya	3500
El Hammami upstream (EH-1)	2700
El Hammami downstream (EH-2)	1400
Shimi Branch (ShBr)	1200

The 5-monthly (summer) supply of more than 4500 m^3/*feddan* to the KN canal is high, certainly compared to the average availability of 4900 m^3/*feddan* in 12 months as calculated in chap. 2.1. The summer supplies of less than 1500 m^3/*feddan* to the EH(2) and ShBr canals are low.

Presumably the variation is mainly attributable to the operational difference at the control gates. It appears that the target discharges in the main and feeder canals are not strictly translated into corresponding target discharges in the branch canals.

Hence the district engineers, and possibly the gatekeepers of the branch canal (who have the day-to-day control) appear to be able to exercise some flexibility and discretion in the water table control. The gate openings, and sometimes the rotation schedules, are adjustable to some extent with the aim to minimize complaints from the farmers. Possibly the growing of rice with its higher water requirement may have been of influence.

Although no extensive information like in table 1 is available for the whole of Egypt, the original restrictions imposed on the *sakia* system and the massive adoption of the mobile pumps suggest that there is a definite scarcity of irrigation water. The scarcity may be due to one or more of the following factors:

1 - the crop water requirements are higher than perceived by the supplier;
2 - the cropping pattern may include more high water demanding crops than foreseen by the supplier;
3 - the irrigation requirements perceived by the farmers are higher than the crop water requirements;
4 - the field irrigation efficiency is lower than estimated by the supplier;
5 - the timing of the supplies and the farmers’ irrigation needs deviate to a certain extent from each other, which mat result in spillage of canal water into the drains.

4. CONCEPTS AND RATIONALE OF IIP

4.1 General

The IIP aims at saving Irrigation water by introducing:

1. A replacement of the rotational irrigation system in the secondary (branch) canals by a continuous flow system using downstream water level control structures
2. A replacement of the low level *meska*'s (tertiary canal delivering the water to the farms) with individual water lifting devices by elevated *meska*'s and/ or pipelines with single point lifting through pumping stations at the *meska* head, installed, operated and maintained by Water User Associations (WUA's) at tertiary level
3. On farm irrigation improvement with guidance of IAS

The concept of continuous flow is further discussed in section 4.2

The IIP measures are thought to lead to a reduced inequity in water distribution, a better timeliness of irrigation, saving in pumping costs per *feddan*, higher irrigation efficiencies, and increased crop yields.

The costs of improvement are now estimated at about LE 2700 per *feddan* (say 2000 US$ per ha), of which one third serves the hydraulic improvements to the delivery system (i.e. the secondary irrigation system with branch canals) and two thirds for both the establishment of pumping stations and *meska* improvements (i.e. the tertiary irrigation system).

To repay the costs of improvements to the tertiary irrigation system, farmers would have to make annual payments of about LE 70 per *feddan* per year over 20 years. It remains to be seen what fraction this is of the annual benefit from the project.

Other costs involved\are related to the operation of the Irrigation Advisory Service (IAS), which is to initiate the IIP activities and support the formation of the WUA's.

The International Irrigation Management Institute (IIMI, 1995) designed 3 scenarios for possible IIP results:

1. Positive saving of water per unit of land area and maintaining or increasing crop production per unit of land area
2. Positive saving of water per unit of land area at the expense of a decreased crop production per unit of land area while the total crop production increases owing to irrigation expansion made possible by the water saving
3. Negative saving of water per unit of land area (i.e. higher consumption of water to offset the present scarcity felt) while increasing the crop production per unit of land

In some IIP areas new pumping stations are foreseen to augment the supplies of the irrigation canals by water from open drains.

With regard to the water savings, the Sanyu report (1998) states as follows:

1. In the Kahwagy area of about 12000 *feddan*, *meska* improvement had progressed to 20%. There are no data available on the discharge of the Kahwagy canal before and after IIP. It is therefore difficult to estimate the effect of water saving by the IIP

2. In a part of the Bahr Tera area covering 56930 *feddan*, there are 29 delivery (i.e. branch) canals with on average almost 2000 *feddan* per canal

   From the observation on spillage of water from the tails of the delivery canals it is concluded that there is no noticeable waste spillage

   In total there a 187 *meska*'s, on average just over 30 *meska*'s per delivery canal, with on average about 300 *feddan* per *meska*. Though four *meska*'s were observed to have frequent waste spilling at the tail ends, as a whole it can be concluded that waste spilling from *meska* tails are very small.

The conclusions of the Sanyu consultants seem to be in contrast to the findings of the Drainage Research Institute (DRI) that the source of the drainage water stems for almost 40% from canal and *meska* spillage (Yehia Abdel Aziz, 1995). However, an explanation may be that the findings of Sanyu relate to the northern part of the Nile Delta, while the DRI figure relates to the whole of the Delta. In the northern part, the availability of irrigation water is probably less than in the remaining parts, so that the water is more carefully used. At the same time, any spillage in the northern part, i.e. the lower part of the Delta, is difficult to recover, while in the remaining higher parts the spillage can be reused for irrigation in the lower parts.

According to Yehia Abdel Aziz (1995), DRI reported that about 15% of the delivery of irrigation water supplied to the Nile Delta below the Delta Barrage (Qanater) is lost as spillage from the tail ends of the irrigation canals and *meska*'s.

Estimating the flow at Qanater roughly at 35 billion m^3/year (DRI yearbook 1995/1996), the above 25% delivery losses would mean that almost 9 billion m^3/year would be spilled from the canals into the drains. Again, taking this at 40% of the source of the drainage water, the total amount of drainage water becomes some 22 billion m^3/year, which seems to be an excessively high quantity.

From the above, an impression is gained that the spillage losses are generally overestimated. Consequently, the water savings from the IIP might well be less\than expected.

4.2 Continuous flow

The UNDP sponsored study of MacDonald & Partners (1988) called attention to the fact that the continuous water flow to the branch canals would be used for field irrigation mainly in daytime. At night, , when the field irrigation stops, the branch canals store water and the water levels rise while downstream control gates gradually cutoff the incoming flow from the feeder canals. Thus, further storage and rise of water levels is bound to occur in the feeder and main canals.

Hence, the IIP concept of continuous flow cannot be interpreted literally, because that daily fluctuating use of the irrigation water by the farmers and the resulting opening and closing of the downstream control gates induces a non-continuous flow.

Rather, the IIP concept is to be interpreted in terms of continuous availability of a limited flow of irrigation water, the limitation being imposed by the capacity of the canal systems and the operation mode of the control structures.

Whether the “continuous but limited availability” corresponds to the concept of “on demand” irrigation, as is sometimes said, depends on the degree of restriction of the flow admitted from the feeder canals into the branch canals. Further, the “on demand” irrigation concept needs to be distinguished in “on WUA demand” and “on farmer demand” irrigation. The “on famer demand” irrigation is, under IIP, quite restricted as the farmers will have to adhere to the “within WUA rotations”.

It is not likely that the IIP concept will lead to full “on demand” irrigation, either at farm or at WUA level.

4.3 Overnight storage

In the traditional (“without IIP”) situation, the main and feeder canals function seasonally under practically constant water levels, while apportioning constant flow, day and night, to the branch canals, albeit in “on” and “off” turns. During the “on” periods, the branch canals receive a more constant flow than in the “with IIP” situation even though, in the latter case, the “off” periods have vanished. The discontinuity in the “with IIP” situation will arise from the further reduction of the night irrigation so that the downstream control structures will reduce or cutoff the flow by the end of each day.

In fact, in the “with IIP” situation, the “on-off” rhythm of the “without IIP” rotation system will be replaced by a daily “high-low” rhythm.

He differences between the intensities of day and night field irrigation in the “without” case is buffered by the relatively higher storage capacity of the branch canals and the low level *meska*’s combined, compared with the storage capacity in the “with” case, where the low level *meska*’s are eliminated.

In contrast to the “without” case, the “with IIP” case and its nightly reduction of the water flows in the branch canals will make itself felt in a fluctuation of the water levels in the main and feeder canals.

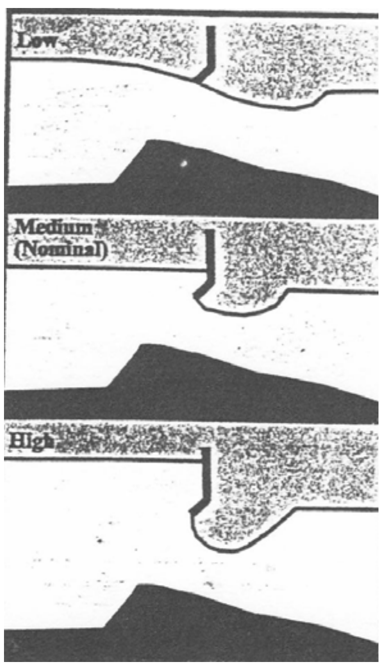
Owing to the vastness and inertia of Egypt’s main canal systems and the long delays in response to changes in gate settings, it is hardly possible to cut back the nightly discharge rhythm in the main and feeder canals so that the fluctuations of the water levels in the main and feeder canals, induced by the IIP, cannot be mitigated. This may have serious consequences.

The change in functioning of the main canal systems in the “with IIP” situation was reported by MacDonald (1988), and the IIMI study (1995) reiterated the issue. The matter is presently under review. Any future changes in the water distribution policies resulting from the review may affect the IIP concepts and lead to alternative approaches.

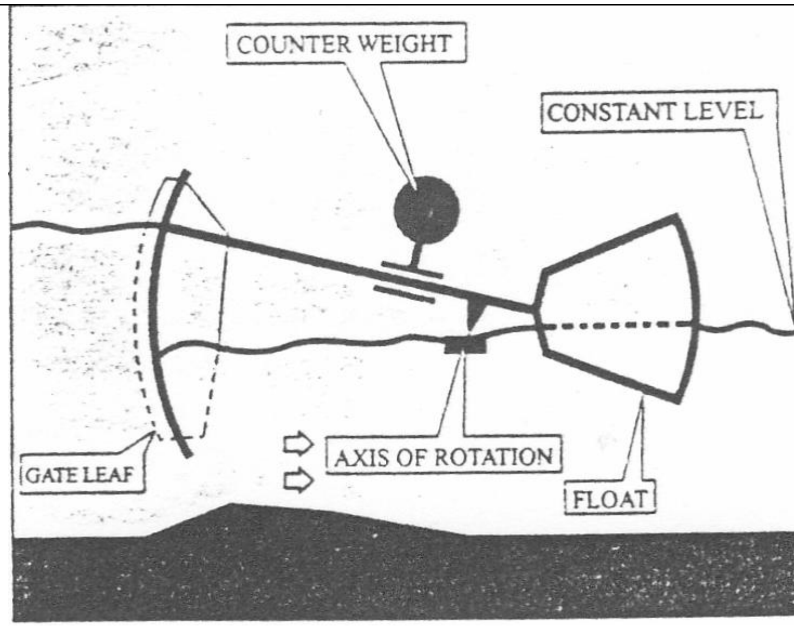
Figure 5 presents a sketch of the hydraulic control structures envisaged by the Central Directorate for Irrigation Improvement, including the use of downstream control gates and baffled distributers, i.e. discharge regulators that are able to pass a near constant flow at varying upstream water levels as long as the variations remain within a certain range.

To keep the variation in upstream levels within the safe range, it has been considered to add another downstream control structure upstream of the baffled gate.

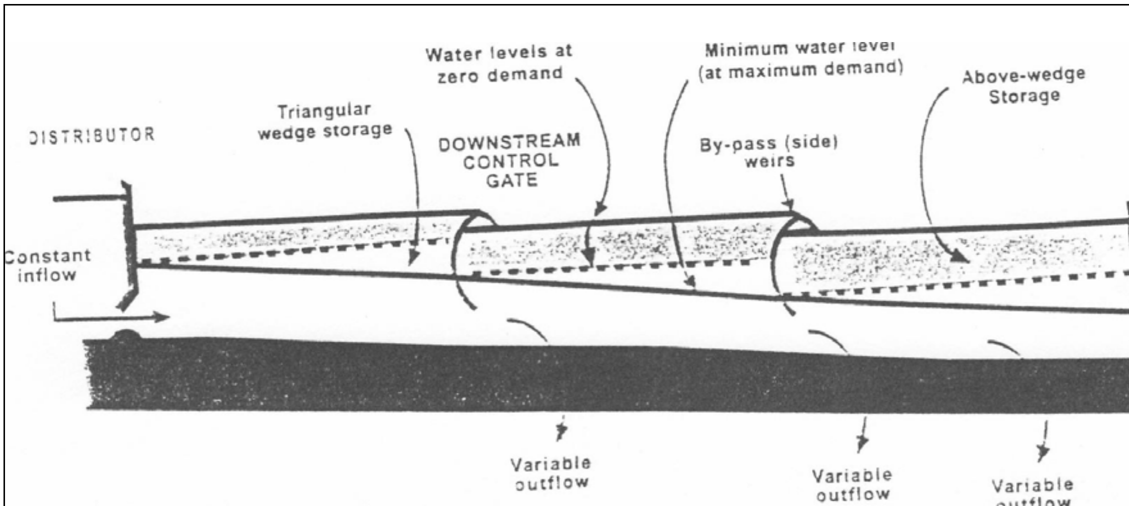
The distributors are an addition to the earlier designs in which only downstream flow control structures were foreseen. In the “with distributor” case, the downstream control structures would have to be designed so that the maximum upstream level at full closure is not so high as to impede the flow from the distributor. Hence, in contrast to the original design "without distributor", the entry of water from the feeder canals would continue during the night and the fluctuation of the water level in the main canal system would be avoided. The continuous entry would require adjustments in the branch canal designs to accommodate the resulting storage of water.



Baffled distributors, constant flow for varying upstream water levels



Downstream control gate, the downstream water level is maintained constant
At high downstream water extraction, the gate opens wider and reverse.



Storage in branch canals equipped with baffled distributor, downstream control gate and side weirs

Figure 5. Hydraulic structures used for regulating the flow and levels of water in the branch canals

The overnight storage in branch canals in the “with distributor” case may consist of three components: triangular wedge storage, above wedge storage, and below wedge storage.

The triangular wedge storage is usually not sufficient to accommodate all the water that continues to flow at night in the “with distributor” case. Therefore, the possibility of a greater “above wedge storage” is given by permitting the flow to bypass the downstream control structures via side weirs.

The above wedge storage requires a deeper excavation of the branch canals and the establishment of a lower normal water level than without above wedge storage.

As an alternative, the idea of “below wedge storage” is now taken into study. The alternative concept implies that, during daytime, the draw down of the water level in the branch canals must be more than in the previous case. The greater draw down provides additional storage during the night. As the WUA’s are not supposed to pump more water than usual from the branch canals, the greater draw down must be effectuated by a restriction of the continuous inflow from the feeder canals to the branches trough the distributors. This further limits the availability of water to the farmers, and may be a means to “save” water for the expansion of the irrigated land elsewhere.

The above adjustments through the introduction of distributors are complicated. On top of that, it is unlikely that the existing, traditional, hydraulic control structures with lifting gates in the feeder canals, at the head of the branch canals, will cease to be operated, and in any case they will be maintained as “standby”.

Resuming, it may be said that the adjustments “with distributor” in the “with IIP” case are, at least partly, re-introducing the principles of controlled flow into the branch canals that existed “before IIP”. It can be concluded that the final answer to the above issues rests on the degree of coordination between the agencies concerned.

4.4 Schools of thought

A characterization of the different “schools of thought” of irrigation improvement in Egypt is given in the table on the next page. The table shows three focuses, their origin, key perceptions, approach and proposed actions/prescriptions. Of course, all the existing views cannot be exactly captured in three groups, but it is believed that the descriptions given in the table represent the existing tendencies in project concepts to a reasonable extent.

Characterisation of different views of irrigation improvement

Focus	Tertiary/on–farm system	Farmers' abstraction arrangements	Delivery system
Origins	EWUP – RIIP	Traditional top–down view (not well documented)	UNDP
Key perceptions of existing situation	– unreliable and inequitable water supplies – inefficient on–farm irrigation practices – poor land levelling – high water losses at field level (low application efficiency) – inefficient lifting with multiple lifting points – lack of cooperation between farmers – inequity of distribution along mesqas – water losses from mesqas – obstruction of mesqas/inadequate maintenance	– lack of discipline and control over farmers astractions associated with changeover from sakias to pumps – excessive number of lifting points – illegal direct pumping from canals – illegal suction arrangements (bypassing sakia sumps) – illegal meska intakes (enlarged pipes) – wastage of water by farmers – water losses from mesqas and canal tails – inadequate maintenance of meskas	– poor operational flexibility due to rigidity/uncertainty of rotation system – lack of explicit discharge measurement – inequitable distribution between branch canals – system not adapted to changeover from sakias to pumps – inequity of water availability (quantity and timing) between head and tail of branch canals – leakage and escape losses concentrated at certain places and certain times
Approach	– participatory rural appraisal / interdisciplinary – site–specific solutions – on–farm water management	– standardised, universal improvement package – application of the law	– main system water management – generalised solutions at delivery level
Prescriptions	– continuous flow at secondary level to : . increase flexibility of irrigation scheduling . reduce incentive for over–watering – water measurement to regulate supplies according to crop needs – single–point lifting with greater stream size to : . increase field application efficiency . reduce irrigation time . reduce pumping costs – improved meskas to : . increase meska "conveyance" efficiency . reduce maintenance costs – improved irrigation techniques, water scheduling etc – land levelling – tertiary level WUAs to operate and maintain improved meskas and provide focus for irrigation extension and other farmer–related activities	– single point lifting to restore order and to control abstractions by farmers – improved meskas (pipeline or raised) to eliminate losses at meska level – new parallel meskas to replace direct irrigation from canals	– continuous flow at secondary level to : . increase reliability and flexibility of irrigation . reduce incentive for over–watering by head farmers . enhance night storage capacity . eliminate conveyance capacity constraints – regulation/measurement of discharges at head of branch canals to ensure equitable distribution – formalisation of night storage in delivery system with new regulating structures – targeted loss control measures on low–level system (may include "alternative" meskas in certain cases) – need for institutional improvements related to branch canal operation

5. IIP PROGRESS

The Egypt Water Use and Management Project (EWUP, 1977 – 1984) was one of the first attempts to achieve irrigation improvement. Three pilot areas were taken up, one each in Upper, Middle and Lower Egypt with USAID support.

In 1984, a follow-up was given with the Regional Irrigation Improvement Project ((RIIP) in the Minya Governorate in the Nile valley to improve 34000 *feddan* by 1987.

At the same time Egypt launched an UNDP supported feasibility study to assess the possibilities for irrigation improvement in eight command areas (see map on the next page):

Command	Area (*feddan*)	Directorate
Balaqtar	11000	Damanhour
Bahr el Saidi	30000	Tanta
Qahwagi	12000	Tanta
Saidiya	70000	Minya
Qiman el Arus	6000	Beni Suef
Iqal Shamiya	17000	Assiut
Khor Sahel	8000	Sohag
Abbadi Radissia	13000	Esna

In quick succession, in 1989, the Irrigation Improvement Project (IIP) took off in eleven canal commands with the aim to improve almost 400000 *feddan*, of which about 100000 were completed to different degrees by 1996 with a total budget of 70 million US$. The project was supported by USAID. The commands added to the previously mentioned commands were:

Command	Area (*feddan*)	Directorate
Bahig	30000	Damanhour
Bahr el Gharak	47000	Fayoum
Serri	109000	Zagazig

Next, in 1996, Egypt started the World Bank/KfW IIP project to tackle about 250000 *feddan* in the northern part of the Nile Delta: the Mahmoudia command in Beheira Governorate (131000 *feddan*) and the Wasat and Manaifa commands in Kafr el Sheikh (with respectively 75000 and 42000 *feddan*).

Map showing approximate locations of IIP projects

The African Development Bank, through the FAO investment Centre, is studying the co-financing of irrigation improvement of about 125000 *feddan* in the eastern Delta along the Bohia canal.

The Egyptian Government is planning to continue the improvement works to reach a target of more than 3 million *feddan* by the year 2017.

The present policy emphasizes improvements at both secondary and tertiary levels of the irrigation systems. This contrasts with the recommendations of the UNDP sponsored feasibility studies, which emphasized secondary level improvements alone. These would cost only one quarter of the cost of comprehensive secondary and tertiary improvement and would remove the major part of the inequities in water distribution and would realise the major part of the envisaged incremental crop production.

The EPIQ report (1998) reiterates the importance of secondary level improvements by introducing the idea of "modified IIP", in which branch canal water user organizations are set up prior to *meska* WUA's.

In view of:

1. the inequity in water distribution over the secondary branch canals as reported by EWUP (see table on p. 19) and others
2. the MacDonald and EPIQ recommendations regarding "modified IIP's"
3. the ambitious overall irrigation development plans

it seems necessary that a monitoring and stock taking study on the functioning of Egypt's secondary canal is soon undertaken.

Such a monitoring study is easier to perform than the more elaborate monitoring studies at *meska* level that have hitherto been proposed but not yet implemented.

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(listed in reverse chronology)

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7. PERSONS INTERVIEWED

This list of persons interviewed is arranged alphabetically by last name.

Dr. Hasan Amer, Advisor, Drainage Research Institute (DRI)

Dr. Nahed El Araby, Groundwater Research Institute (RIGW)

Eng. Ramsis Bakhoum, Chairman, Irrigation Improvement Sector (IIS)

Eng. Essam Barakat, General Director, Irrigation Advisory Service (IAS)

Dr. Bayoumi, Reform, Design and Implementation Unit, Agricultural Policy Reform Program, Ministry of Public Works and Water Resources and Ministry of Agriculture and Land Reclamation

Dr. Magdy Salah el Deen, Asst. Director, Central Office of the Advisory Panel Project on Water Management and Drainage (APP)

Dr. Eng. Mohamed el Din, IIP consultant, Hydraulics Specialist, Associate Professor, Ain Shams University, Faculty of Engineering, Irrigation and Hydraulics Department

Mr. Shinawi Abdel Elati, Consultant, Agricultural Economist, Irrigation Improvement Project (IIP)

Eng. Mohamed Fathi, Chairman, Egyptian Public Authority for Drainage Projects (EPADP)

Dr. Shaden Abdel Gawad, Director, Drainage Research Institute (DRI)

Dr. Samia El Guindy, Director, Central Office of the Advisory Panel Project on Water Management and Drainage (APP)

Mr. David Higgins, Consultant, Construction Engineer, Irrigation Improvement Project (IIP)

Dr. Mohamad Abdel Khalek, Deputy Director, Drainage Research Institute (DRI)

Mr. Ayman Khoudir, Program Officer, Water Sector, Royal Netherlands Embassy (RNE)

Mr. High Morrison, Consultant, Team Leader, Irrigation Improvement Project (IIP)

Dr. Lotfi Youssef Nasr, Economist, Water Management Research Institute (WMRI)

Ms. Anouk te Nijenhuis, Associate Expert, Central Office of the Advisory Panel Project on Water Management and Drainage (APP)

Mr. Tony Peacock, Consultant, FAO Investment Centre, on mission for the African Development Bank in relation to Irrigation Improvement

Eng. Farouk Shahin, Consultant, Asst. Team Leader, Irrigation Improvement Project (IIP)

Eng. Hasan Shouman, Consultant, Farmers Organization Specialist, Irrigation Improvement Project (IIP)

Prof. Dr. Mohamad Abu Soliman, Team Leader, Egyptian On-Farm Water and Soil Management Project (OWSOM), Kafr El Sheikh Governorate

Mr. Caspar Veeningen, Consultant, Team Leader, National Water Resources Planning Project (NWRP)

Mr. Rob van der Weert, Consultant, Hydrologist, National Water Resources Planning Project (NWRP)

Dr. Nahla Zaki, Director, Water Distribution Department, Water Management Research Institute (WMRI)

Dr. Mohamad Zanati, Team Leader, Canadian On-Farm Water and Soil Management Project (OWSOM), Kafr El Sheikh Governorate

8. ANNEXES

8.1 Terms of reference

TOR for a short consultancy on the impact of Irrigation Improvement on Drainage Requirements and Water Savings

Background information on APP

The advisory Panel Project (APP) is a project funded by the Government of Egypt and the Government of The Netherlands. The objective of the project is to assist the MPWWR, in an advisory capacity, in carrying out its responsibilities with regard to managing the quantity and quality of Egypt's fresh water resources more efficiently and effectively.

The project follows two paths to reach this objective:

1. By discussing policy issues, strategies and researches once a year with a group of high level experts from Egypt and The Netherlands (The Panel). The issues for discussion will be derived from:
   - suggestions or requests from the MPWWR (Sectors, Departments, HE the Minister, Institutes) and other Ministries
   - suggestions from the Panel members
   - information from other foreign funded projects after communication has been realized
   - suggestions from the Egyptian-Dutch projects
   - information on water management developments in Egypt and other countries
2. By enhancing communication and coordination at a professional level between the Egyptian-Dutch projects in the MPWWR in order to:
   - lessen friction between projects
   - learn from each other's experiences and knowledge
   - solve general constraints from technical or institutional nature together
   - strengthen the cohesion between the projects by identifying new projects
   - filing the gaps with short consultancy studies
   - define the issues to be discussed in the Panel

The APP is an advisory body only and its recommendations are directed to the MPWWR, including the agencies for implementation (like EPADP) or research and technology (like Institutes of NWRC).

Problem definition

The APP is considering the impact of the Irrigation Improvement Program (IIP) on water management in Egypt. Therefore, APP organized two working group meetings in February and April 1998 in which the interaction between IIP and land drainage requirements and other water management options was discussed.

The working group meetings presented four working papers on IIP impact on:
- Water availability
- Drainage requirements
- Drainage reuse and the environment
- Groundwater availability and reuse

The working papers have been integrated and summarized by a local consultant in one document, which was discussed during the Panel meeting in May 1998.

During the meeting and follow-up discussions in September 1998, the Panel members concluded that the impact of IIP on drainage, groundwater and water savings needs further elaboration. Since the manpower in the Irrigation Improvement Sector (IIS) is limited and a new vision is valued, the input of a Dutch expert is required to conduct further elaboration. This consultant should have a broad experience in irrigation, drainage and groundwater management.

Objective of the consultancy

The objective of the consultancy is to analyze the existing information on the impact of IIP on drainage requirements and drainage water reuse, groundwater and water savings and t define the gaps in information together with the organizations involved. Based on this analysis a (preliminary) conclusion about the impact of IIP on drainage, groundwater and water savings should be presented. Furthermore, a plan of approach should be formulated to fill in the blanks in information necessary to come t a definite conclusion and recommendations.

Activities of the consultant

The following activities will be carried out by the consultant during 3 weeks:
- Collecting all relevant information
- Reviewing literature on the impact of IIP
- Meeting staff involved in IIP
- Visiting IIP and non-IIP areas
- Conducting meetings with organizations responsible for research and management aspects affected by IIP (groundwater, drainage)
- Evaluating the information collected to identify the impact of IIP
- Reporting the preliminary conclusions on the impact of IIP on:
    - Water savings
    - Drainage requirements
    - Drainage water quality and quantity
    - Groundwater quality and quantity

- Formulation a plan of approach to collect missing information for definite assessment of IIP impact on water savings, drainage requirement drainage water quality and groundwater
- Writing a final report to APP that contains the final conclusions of the consultant concerning the impact of IIP on drainage, groundwater and water savings as well as concerning the missing information

Conditions

The consultancy will be carried out during a period of three weeks by the Dutch consultant and the local consultant Eng. Farouk Shahin. A condition for a successful mission is that the Irrigation Improvement Sector assigns on of its staff members to support the consultant continuously. APP Central Office will make appointments with officials of other organizations (like EPADP, Research Institute for Groundwater, Drainage Research Institute) within the MPWWR based on requests from the consultant and his counterpart of the IIS.

8.2 Itinerary

(To be digitized)

8.3 Acknowledgements

(To be digitized)