FARMERS PARTICIPATION IN THE OPERATION OF MODIFIED DRAINAGE SYSTEM

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Abstract

Egypt is implementing a large scale programme of land drainage. About 150,000 feddans\textsuperscript{1} are provided with subsurface drainage systems yearly. Among the drained areas there are areas planted with rice and provided with a subsurface drainage system. The presence of rice as wet-foot crop in the crop rotation requires that the farmer closes the subsurface drain during the summer season. This creates a problem of groundwater table rise in the neighboring areas cultivated with maize and cotton (dry-foot crops) if served by the same collector. The modified drainage system was proposed for rice areas to prevent this problem by consolidating rice areas on selected (sub)collectors. Pilot area research and monitoring activities revealed that there is considerable water saving when the modified system principles are applied.

Before 1992 farmers were required to apply consolidated cropping, meaning summer crops are concentrated in blocks of 24 – 48 fed, which made the modified system principle possible. Since then cropping was liberalized and the farmers are free to plant any crop. This created difficulties in operating and managing the modified drainage system, unless farmers can be made to appreciate the importance of collective efforts to operate the system according the modified drainage system principle.

A study was conducted in the Balaktar area, Behaira Governorate, to involve farmers in operating the drainage system during the rice season according the modified drainage system principle. Along five collectors farmers were organized on voluntary basis to consolidate the rice areas and the collectors were provided with closing devices. Observations were also made along two other collectors where farmers did not consolidate rice areas. Results after the first season are reported. Future work in organizing Collector User Groups is indicated.

Introduction

Egypt has a total area of one million km\textsuperscript{2}, of which about 3% (6.5 million fed, 2.69 Mha) is agricultural productive. The climate is warm and arid with a short and mild winter. The soils

\textsuperscript{1} 1 feddan = 4200 m\textsuperscript{2}, fed = feddan.
in the Nile Delta are fine textured, medium heavy to heavy clays, becoming heavier towards the sea. The River Nile is the main source of irrigation water for the agricultural lands. Since the completion of the Aswan High Dam in 1970 and the introduction of a perennial water supply to all the irrigated areas, the cropping intensities and water use in each irrigation unit increased sharply and all agricultural lands are now double cropped with crop intensities of up to 200%. The natural drainage system could no longer cope with the increased percolation from irrigation water and much of the land became waterlogged and/or salinized. To overcome these problems the Government of Egypt has initiated an intensive land drainage programme which includes, among others, the installation of subsurface drainage systems.

Figure 1. Layout of conventional and modified drainage systems (Cavelaars et al., 1994).
A: Conventional layout, not adapted to the cropping units
B: Modified layout, adapted to the cropping units
The subsurface drainage systems installed in Egypt are generally of the composite type, which means that they consist of lateral and collector drains (Figure 1A). The laterals are on average 200 m long. The collectors, which transport the water to open drains, vary in their length from a few hundred meters to more than two kilometers depending on the topography and the layout of the main irrigation and drainage systems.

The problem of implementing a drainage system in rice areas was realized soon after the start of the World Bank supported large scale drainage programme in the Nile Delta in 1970 (Abdel Dayem, 1995). The problem occurred as a result of the mixed cropping pattern in the Nile Delta where rice is cultivated with cotton and maize in the area served by the same collector drain. The water requirements of rice and other crops are distinctly different. Rice is a wet-foot crop requiring continuous standing water in the field, while the other crops need good control of the groundwater table below the root zone.

As the implementation of the conventional drainage system causes rapid drainage of the rice fields to an extent that the standing water cannot be compensated by fresh irrigation water, the farmers plugged the drain pipes using plant leaves and mud. The problems which were created are:

1. drainage water is backing-up in the subsurface drainage system and causing a poor growing environment for the other crops sharing the same collector drain with rice;
2. the dirt used for plugging the pipes often slipped into the pipes causing serious maintenance problems.

Several studies to develop more appropriate drainage techniques for rice growing areas were started. The major objective was to minimize the drainage flow from the rice field (controlled drainage) and at the same time to allow free drainage flow from the other crop fields (conventional drainage). A modified drainage system layout was developed (Figure 1B). An investigation programme was conducted from 1977 until 1979, while, during the period 1980-1988, the concept of the modified drainage system was developed and tested both in experimental fields and in pilot areas. A total of 5400 ha was constructed according to the modified drainage system principle. By the mid 90’s there were two developments in Egypt which affected the implementation of the modified drainage systems:

1. The abandonment of mandatory crop consolidation in 1992, leaving the farmers free to choose the crops they like. Hence, the block system of land use could not be imposed any more;
2. The government plans to involve farmers in the on-farm water management and make them more responsible for operation and maintenance of the irrigation and drainage systems.

The aspect of free non-consolidated cropping patterns decreases the chances for implementing modified drainage systems. However at the same time, the move to stimulate farmer’s participation in on-farm water management may help to introduce these systems. The Egyptian Public Authority for Drainage Projects (EPADP) is moving towards farmer’s participation in the operation and maintenance of the (sub-)surface drains. This is one of the requirements for successfully operating the modified system. DRI therefore, followed up on a suggestion of the Advisory Panel on Land Drainage, to investigate the possibility of applying the modified drainage system design and principle of operation under the new conditions.

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2 These 5400 ha were constructed as “Modified Drainage System”, however, EPADP has since then constructed many hectares with the collector-subcollector idea, but did not install gates to control drainage.
The main objectives of this paper are:

- To present results of the water management studies of rice fields in areas provided with sub-surface drainage systems since 1977-1979;
- To present results of applying the concept of modified and conventional drainage systems in rice field since 1980-1988;
- To present the experiences with farmer’s participation in voluntary crop consolidation and application of controlled drainage during the 1996 rice season;
- To present future plans for the introduction of voluntary crop consolidation by farmers and to recommend on modifications in traditional drainage system design which will give farmers more flexibility in operating the subsurface drainage system.

**Previous work**

In arid climates such as Egypt, the high groundwater table causes salinization of the root zone. Without adequate drainage facilities, the accumulated salts cannot be leached from the root zone. To overcome these problems, a widespread system of open main drains and pumping stations was constructed. The installation of subsurface drainage systems began on a large scale in the 70’s as the existing drainage system could no longer handle the rising groundwater table. About 1.76 million ha of agricultural lands have been provided with subsurface drains. The installation of subsurface drainage systems is primarily meant to improve the growing conditions of dry foot crops such as cotton, maize, berseem, wheat, etc. In Egypt, rice is grown along with dry foot crops. Rice cultivation is concentrated in the Nile Delta, with the main rice belt in the northern part.

In rice areas provided with subsurface drainage some farmers were obliged to close the drain outlets using straw and need to keep standing surface water in the field as long as possible. These methods of field water management from the farmers point of view caused many problems on system maintenance. Therefore DRI and EPADP started to study and implement modified drainage systems in rice areas.

Drainage of rice should be based on the following principles (Abdel Dayem and Ritzema, 1987):

- To operate the covered drains in the rice fields independently from the rest of the drainage system. This can be achieved by using a subcollector drain for each crop area;
- To reduce the outflow from a field cultivated with rice a closing device should be installed in the downstream part of the (sub)collector. If other crops than rice are cultivated the closing device should be left open, enabling unrestricted outflow conditions;
- The design criteria for pipe drain capacity of a modified layout can be the same as those applied for non-rice areas. In the conventional design, a drainage duty of 4 mm/day is applied for the calculation of drain capacities for areas with rice in the crop rotation versus 2 mm/day for non-rice areas. With the modified layout this increase in capacity is not necessary. Even on occasions when rapid drainage is required, e.g. for renewal of the standing water in a field or at the end of the rice season, which can be achieved by accepting temporary over pressure for short periods.

The studies executed by DRI included those described in the next two sections.
Water management observations

From 1977-1979 DRI carried out a field study on the water management in rice fields during three successive summer seasons (1977, 1978 and 1979) in the North West of the Delta near Damanhour (Figure 2). It was found that although yields remained the same or slightly increased with subsurface drainage, there was a continuous loss of irrigation water standing in the rice fields through percolation to the subsurface drains. The amount of water removed by drains from the rice fields was estimated at 5-10 mm/day. In order to compensate these continuous subsurface drainage discharge, an increase in irrigation water is required. In areas with a shortage of irrigation water supply, specially during and for some time after the nursery bed stage, the lack of water may cause an adverse effect on the crop. A temporary closure of the drainage system was therefore recommended.

Figure 2. Location of experimental fields, monitoring and pilot areas of DRI

Testing of modified drainage system

The modified layout of the drainage system was introduced in 1980 at the Mahmoudiya-I drainage project in the Bahr Saf area in the Eastern Nile Delta (Amer and De Ridder, 1989). It consists of covered main collector drains with subcollector branches. Each subcollector serves an area coinciding with a “one crop block” of the crop consolidation system (Figure 1B). The junction of the subcollector to the main collector consists of a manhole with a suitable device for regulating the subcollector outflow. In this way, there will not be a need
for unauthorized blocking of the system and regulation will be carried out without any conflict for the drainage requirements of the various crops.

The most important feature of the design criteria for a modified drainage system in areas with rice in the crop rotation, is the design drainage rate which is the same as for non-rice crops. This implies a reduction in the pipe size as compared to the current design norms and consequently a saving in construction costs. In addition the introduction of the modified system indirectly helps in saving precious fresh irrigation water.

After comparing the results of the study it was concluded that the results obtained in the experimental fields (King Osman, Sakha, Zankalon) in 1984 are in agreement with those of the detailed studies carried out in farmers fields in respectively Mahmoudiya, Mashtul (1986) and Nashart Rods (1986). The conclusions are summarized as follows (DRI staff 1988).

The introduction of a modified drainage layout in the rice growing areas in the Nile Delta will:

- Save between one and three billions cubic meter of irrigation water which would otherwise be lost through the subsurface drainage system in a total area of 1 million feddans in the Nile Delta (being the difference in drainage rate between the conventional and modified system 1-3 mm/day over a growing season of 100 days);
- Save the drainage system from unauthorized and improper interference of farmers to stop irrigation water losses from rice fields through the subsurface drainage system;
- Save other crops than rice from the damaging effects of the improperly blocked conventional collector drains.

These benefits are obtained without causing any negative effects on either the soil salinity levels in the blocked subcollectors of the modified system or on the yield of cotton, maize or rice.

Since the detailed research by DRI, seemingly little was done about the modified drainage system. However, EPAPD experienced problems with the O&M of long collectors in, amongst others, rice areas. When farmers blocked long collectors large areas were affected. Hence EPAPD adjusted their designs to short collectors, or long ones, but with subcollectors. If farmers then would block the collector only a small part would be affected. EPAPD did not install gates at the end of the subcollectors but left the decision on how to close/block to the farmers. EPAPD did not call the system 'Modified Drainage', but in fact they are. The main objections to the gates were the costs and the more difficult maintenance and operation of systems with gates. Therefore since 1988 very little has been done with the modified drainage system principle.

Reasons to look more into the application of the modified drainage system are:

1. the increased interest in creating more water for new irrigation areas and the increased awareness of the limited supplies of the Nile River;
2. the world wide attention given to controlled drainage, not only from water savings point of view, but also to control the environmental impact of drainage systems;
3. the attention to involving farmers in O&M of irrigation and drainage systems in Egypt, which is actively taken up by EPAPD for management of its drainage systems.

The objective this time is to first interest the farmers in the idea and then see if further changes are necessary in the collector-subcollector design as presently used by EPAPD. At the same time the legal option to formalize the organisation of farmers needs to be looked
Legal aspects of water user associations (WUA) in Egypt

It is commonly accepted that for water user associations to be able to operate effectively they need to have a legal basis which allows them to levy fees and execute penalties. Following is a brief description of the laws that affect the operation of water user associations in Egypt. Most of these pertain to irrigation improvement and none of them thus far mentions drainage.

To date many attempts have been undertaken in Egypt through numerous projects to increase the benefits and minimize the losses of water resources. The concept that maximum benefits from technical solutions can only be attained through full collaboration with the intended beneficiaries is still rather new in Egypt.

Major efforts aiming at greater farmer involvement are undertaken in the Irrigation Improvement Project (IIP) and the Fayoum Water Management Project (FWMP staff, 1995).

The IIP concentrated at mesqa (tertiary canal) level: technical improvements accompanied by organizational development. It is the latter which has proved to be the most difficult. Mesqas are considered private property and therefore Water Users Associations to be established at this level and notably to acquire a legal status, would not have been in accordance with the law on Irrigation and Drainage (Law 12/1984). Modifications to the Law were prepared and proposed to Parliament. The ensuing Law 213/1994, stipulating modifications to Law 12/1984, makes a distinction between old and new lands. In new lands it is now possible to establish Water Users Associations, albeit at the mesqa level only. In old lands, Water Users Associations, according to Bylaws to this Law as issued recently by the Minister of Public Works and Water Resources Resolution (FWMP 1995), have to be established in those areas where the irrigation system is improved. For the remaining areas of old lands, Law 12/1984 remains basically as it was, implying that the creation of Water Users Associations, let alone granting them a legal personality, is not permitted. Although above Bylaws have primarily been geared to the requirements of the second phase of the IIP, the interpretation of what is an improved irrigation system, appears to leave some leeway for further experiments in the old lands as well.

Apart from Law 12/1984 and Law 213/1994 the following laws could also pertain to the organization of Water User Associations:

- Law No.43/1979 and its modifications concern the organization of the Local Administration. According to this Law the management of irrigation is a national, and not a local, service. It is a task carried out by and under supervision of the central government. The only local participation is realized through the people’s council at the Governorate’s level. Still, this council can only exercise its authority within the general policy and rules set by the Ministry of Public Works and Water Resources;

- Law No.32/1964. This law concerns private and non-government organizations. Membership of such an organization is voluntary and decisions are applicable to members only. A regional union of associations at Governorate level may be formed. The decisions of the associations and unions with respect to water management can only be consultative, not binding to local and central authorities.
From the foregoing it may be clear that there is little at present that would legalize the organization of farmers in Collector User Groups (CU Groups). Nevertheless, the organization of CU Groups seems legal under Law 32/1964. DRI therefore decided to organize on voluntary basis a number of farmers in CU Groups with the aim to investigate the potential for voluntary crop consolidation along selected collectors or subcollectors. Because of the implied legal connotation of the word 'Association', the word 'Group' is used to avoid implying more than is intended.

**Controlled drainage with collector user groups**

DRI approached the farmers in the area of interest indirectly: they first identified which organization had the trust of the farmers. It was decided that the "Cooperatives" of the Ministry of Agriculture were the best focal point for DRI's intentions. The Cooperatives provide farmers on a day to day basis with advice, provide fertilizer, seeds and assists with resolving any problem that might occur in the field. Over time they have built up a good reputation amongst the farmers. The staff of EPADP's Maintenance Centres in the area (which are responsible for the O&M of the drainage system) were also involved right from the start, but as their interactions with the farmers are less intensive, they were not selected as the main go-between DRI and the farmers. DRI then arranged a meeting at EPADP's Damanhour office with EPADP, the Cooperative, the EPADP Maintenance Centre staff, and EPADP's Regional Headquarters staff, and introduced the plans as well as arranged which areas to perform the tests. The Cooperatives then talked with the farmers and introduced DRI staff. Video tapes were made of these meetings. During subsequent meetings with the farmers (always under guidance of the Cooperative and at the Cooperatives quarters in the area or in the field) a memorandum of understanding was drafted which primarily assured cooperation between farmers and DRI to install the necessary equipment for the experiment. For each of the subcollectors selected the farmers elected a leader of the CU Group with concurrence of the Cooperative. All parties involved, the leader of the farmers and the representatives of the Cooperative, DRI and EPAPD's Maintenance Centre signed the MOU. The leaders became the direct contact point for the DRI staff in the field, and assisted with installing the gates, arranged field observers, performed measurements, etc.

![Figure 3. Location of collectors selected for the study](image-url)
Finally seven collectors were selected, five subcollectors along which farmers agreed to consolidate rice, and two conventional collectors in areas close to the subcollectors where rice consolidation was not practiced. Table 1 gives some of the characteristics of each of the (sub)collector areas. The study was conducted at Balaktar area (Figure 3) which is situated in the Western Delta, 20 km east of Damanhour in Beharia Governorate (Figure 2).

Table 1. Characteristics of collectors with collector user groups

<table>
<thead>
<tr>
<th>Collector number</th>
<th>type</th>
<th>area feddan</th>
<th>number of rice fields out of total fields</th>
<th>number of farmers</th>
<th>farmers with schooling %</th>
<th>farmers with no schooling %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agreed to rice crop consolidation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>subcollector</td>
<td>12.33</td>
<td>9/9</td>
<td>9</td>
<td>44</td>
<td>56</td>
</tr>
<tr>
<td>11</td>
<td>subcollector</td>
<td>20</td>
<td>24/24</td>
<td>22</td>
<td>17</td>
<td>83</td>
</tr>
<tr>
<td>12</td>
<td>subcollector</td>
<td>27</td>
<td>30/30</td>
<td>26</td>
<td>19</td>
<td>81</td>
</tr>
<tr>
<td>29</td>
<td>subcollector</td>
<td>29.5</td>
<td>25/25</td>
<td>30</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>31</td>
<td>subcollector</td>
<td>22.3</td>
<td>26/26</td>
<td>26</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>No rice crop consolidation</td>
<td>Ext.1</td>
<td>collector</td>
<td>5.5</td>
<td>1/2</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>collector</td>
<td>9.25</td>
<td>1/6</td>
<td>7</td>
<td>14</td>
<td>86</td>
</tr>
</tbody>
</table>

Special closing gates designed by DRI (DRI, 1987) were supplied to the five subcollector CU Groups and DRI assisted with the installation of the gates. Operation and maintenance of the gates were fully the responsibility of the CU Groups. The gates were left open till rice plants were transplanted from the nursery beds to the main fields; then they were closed.

In order to monitor what was going on in the fields the following observations were made:
- the groundwater table depth under the rice fields;
- the groundwater level in the rice fields from installed staff gauges to check the amount of water applied;
- the discharge of a number of diesel pumps were determined;
- the rice yield of 1994 was determined through interviews with farmers;
- the 1996 rice yield was determined from crop sampling;
- the costs of fuel and rental of irrigation pumps were determined;
- soil samples were taken before and after the season to determine soil salinity levels;
- periodic meetings were held with the farmers to solve any problem during the study period.

Results first season (1996)

The Collector User Groups (CUG) which are formed for the first time for field drainage do not have a formal structure, but are a voluntary group of farmers. After one month since the starting of the study, the farmers of modified collectors noticed that the closing of the collectors prevent drainage and reduced the frequency of irrigation applications to the rice fields. Consequently, this helps in saving money for the farmers. For the modified drainage system, the response of accepting the idea of farmer participation in CUG are quicker in the collectors with a higher percentage of educated farmers. Table 1 shows the modified collectors under study and the educational level of the farmers. It is observed that collector
no. 1 has the highest percentage of educated farmers followed by collectors no. 12 and 11 respectively. The results obtained from these collectors showed that these collectors do not need more time to accept the CUG. During the study period religious people in mosques and churches were informed about the study by DRI engineers and consequently they invited the farmers to participate in this study. Many farmers have accepted the idea and meet with DRI staff to apply the study for the next year. Figure 4 presents the yields of 1994 and 1996, without and with modified drainage, respectively.

![Yield of Rice in 1994 and 1996](image)

**Figure 4. Yields of rice with and without modified system management application.**

**Saving irrigation water and operational costs**

Figure 5 shows the total irrigation water amounts during the rice season for the modified and the conventional collectors. It is observed that the amount of irrigation water used for modified system are less than the amounts used for conventional system. The average amount of irrigation water used for the modified system is 4298 m³/fed and 7545 m³/fed for conventional collectors. This means that the modified drainage system saves about 43 % of the irrigation water comparing with the conventional one.

![Total Seasonal Amount of Irrigation Water Applied](image)

**Figure 5. Irrigation water applied with and without modified system principle.**
Figure 6. Comparison of some of the costs of irrigation water.

Figure 6 shows the costs of fuel for pumps owned by farmers and the cost of renting irrigation pumps including fuel. Although these two amounts cannot be compared with each other in a strict sense, they reflect the actual expenditures of the farmers during the season. Further details will be worked out at a later stage.

The total costs of renting the pump was 113 LE/fed/season\(^3\) for farmers using controlled drainage and 197 LE/fed/season for the conventional drainage.

The costs of fuel for privately owned pumps ranged between 30-37.5 LE/fed/season with an average of 33.75 LE/fed/season for rice cultivation with controlled drainage and ranged between 56-62.5 LE/fed./season (average 59.25 LE/fed/season) for rice cultivation with the conventional drainage system.

The difference in expenditure to obtain irrigation water to achieve a satisfactory rice crop was approx. 43\% lower than with controlled drainage.

Table 2. 1994 and 1996 yields and water use in 1996.

<table>
<thead>
<tr>
<th>Collector number</th>
<th>average 1994 rice yield by farmers recall in kg/fed</th>
<th>avg.1996 rice yield kg/fed (**)</th>
<th>avg. total m(^3)/fed/season irrigated in 1996</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agreed to rice crop consolidation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2640</td>
<td>2611 (6)</td>
<td>4104</td>
</tr>
<tr>
<td>11</td>
<td>2630</td>
<td>2441 (5)</td>
<td>3617</td>
</tr>
<tr>
<td>12</td>
<td>2710</td>
<td>2756 (5)</td>
<td>4103</td>
</tr>
<tr>
<td>29</td>
<td>2100</td>
<td>2544 (5)</td>
<td>4424</td>
</tr>
<tr>
<td>31</td>
<td>2600</td>
<td>2731 (3)</td>
<td>4762</td>
</tr>
<tr>
<td>No rice crop consolidation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ext.1</td>
<td>-</td>
<td>2016 (1)</td>
<td>7140</td>
</tr>
<tr>
<td>3</td>
<td>-</td>
<td>2348 (1)</td>
<td>7956</td>
</tr>
</tbody>
</table>

** in brackets is number of fields from which samples were taken.

\(^3\) 1 LE (= 1 Egyptian pound) is equal to US$ 0.30 (July 1996)
Conclusions and recommendations

The results of the first season of using controlled drainage with the modified drainage system principle (collector-subcollector design) are very positive. Farmers were organized on voluntary basis in groups along small subcollectors to consolidate crop cultivation to rice only in the catchment of the subcollector. Farmers clearly observed the savings in expenditures to the reduced amount of irrigation water applied. No significant major difference was observed in yield in areas with and without controlled drainage, nor were other detrimental effects observed. This confirms the findings of work done during the period 1980-1988.

A major achievement was the methodology followed in establishing the Collector User Groups. An existing organisation that had the trust of the farmers already, essentially organized the CU Groups.

Farmers of adjacent areas have expressed interest in performing similar experiments in their areas. As rice is grown in a two year crop rotation, new areas for the experiment will be selected for the 1997 rice season. During 1998 we hope to return to the same collectors to see if the farmers are willing to consolidate again.

References


Discussion

Asked about observations on other fields, the author replied that on other fields no effects were observed. Most farmers had a rice-cotton-maize cropping pattern. A question about discussion with the farmers was answered by the author explaining, that the impact on water saving and on neighbouring fields and the slight yield increase of cotton and maize was communicated to the farmers through video presentations. The report of the study was also presented to the farmers. A participant was interested in the timings of the different crops rice, cotton and wheat. The author explained that a group of farmers volunteered in the crop rotation. In Egypt the planting dates of various crops coincide, so that this was no problem. The farmers agreed to close subcollectors during rice cultivation.