Development of land drainage in Egypt

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1 Introduction

The land area in Egypt for agricultural production consists of 5.5 million feddan (1 feddan = 1.04 acre) of old lands and 0.9 million feddan of reclaimed lands. The agricultural area represents 3.5% of the Egyptian territory (1.0 million km^2 leaving 96.5% as arid desert lands. Egypt has a population of 50 million (estimated in 1986), increasing at an annual rate of 2.6%. The per capita cultivated area which was 0.19 feddan in 1960 is at present about 0.14 feddan. Nearly all Egyptian agriculture is irrigated with Nile water. The water supply from the Nile amounts to 55 500 million m^3 per year. Since the completion of the High Aswan Dam (1967) irrigation is possible throughout the year (perennial). All agricultural lands are double cropped (200% cropping intensity). The cropping pattern is wheat and berseem in winter and cotton and rice as cash crops in summer while maize and sorghum are the major subsistence crops. In addition there are vegetables, orchards, and sugarcane.

Egypt's arable land, although limited in area, is among the best in the world in terms of soil, water and climatic conditions. Egyptian crop yields are already substantially above world averages. However, there is a considerable potential for further increase of yields through improved drainage.

2 Drainage projects in Egypt

2.1 Historical development of land drainage

After the introduction of perennial irrigation and high cropping intensities, the use of water per unit area has increased sharply. Consequently the natural drainage system could not longer cope with the increased percolation losses from irrigation and lot of land became waterlogged and/or salt-affected. To overcome these problems open drains were excavated. In the late 1930's investigations started into covered field drainage that eliminates land losses. In 1956, a programme was launched to provide the whole Nile Valley with tile drains within 30 years. A UNDP/FAO pilot project was implemented in 1961-64 to establish design criteria and to test the feasibility of mechanized tile laying. Based on this study the first Nile Delta drainage project encompassing 950 000 feddan (400 000 ha) was identified and financed by the World Bank. This project was executed during the period 1971-80 being the world's largest drainage scheme. This project was followed by other World Bank supported projects which cover an area of 3.1 million feddan by 1987. The projects have also attracted other

donors including USAID, EEC, CIDA, The Netherlands Government and the World Food Programme. Beside these outside funded projects, the Ministry of Irrigation carries out similar tile drainage projects.

2.2 Present status and areas provided with open and covered drainage

The intensive land drainage programme which was initiated in the 1970's includes:
- The construction of open collector drains;
- The deepening and widening of existing open drains;
- The construction of additional pumping stations;
- The installation of field tile drainage.

By June 1987, an area of about 3.1 million feddan in the Delta and Upper Egypt will be completed with subsurface drainage systems and improved open drainage channels (Figure 1). A summary of the data of the completed drainage works is shown in Table 1.

Table 1 Areas completed with drainage works as of 30.06.1986

Area	Open drains (1000 fed)	Tile drains (1000 fed)
Nile Delta		
- Government of Egypt	1893	619
- WB Nile Delta I	926	950
- WB Nile Delta II	794	392
- Dutch Project	–	44
Subtotal (A)	3613	2005
Upper Egypt		
- Government of Egypt	996	285
- WB Upper Egypt I	303	300
- WB Upper Egypt II	500	335
Subtotal (B)	1799	920
Total (A + B)	5412	2925

In the recently reclaimed lands, the following areas were provided with drainage including covered field drains:

- North Tahrir and Thawra farms	42 000 fed
- Mariut	45 000 fed
- Mechanized farm	10 000 fed
Total	97 000 fed

At present another 48 000 feddan forming the sugar-beet farm are provided with subsurface drains in a three stage project of which the first stage is completed.

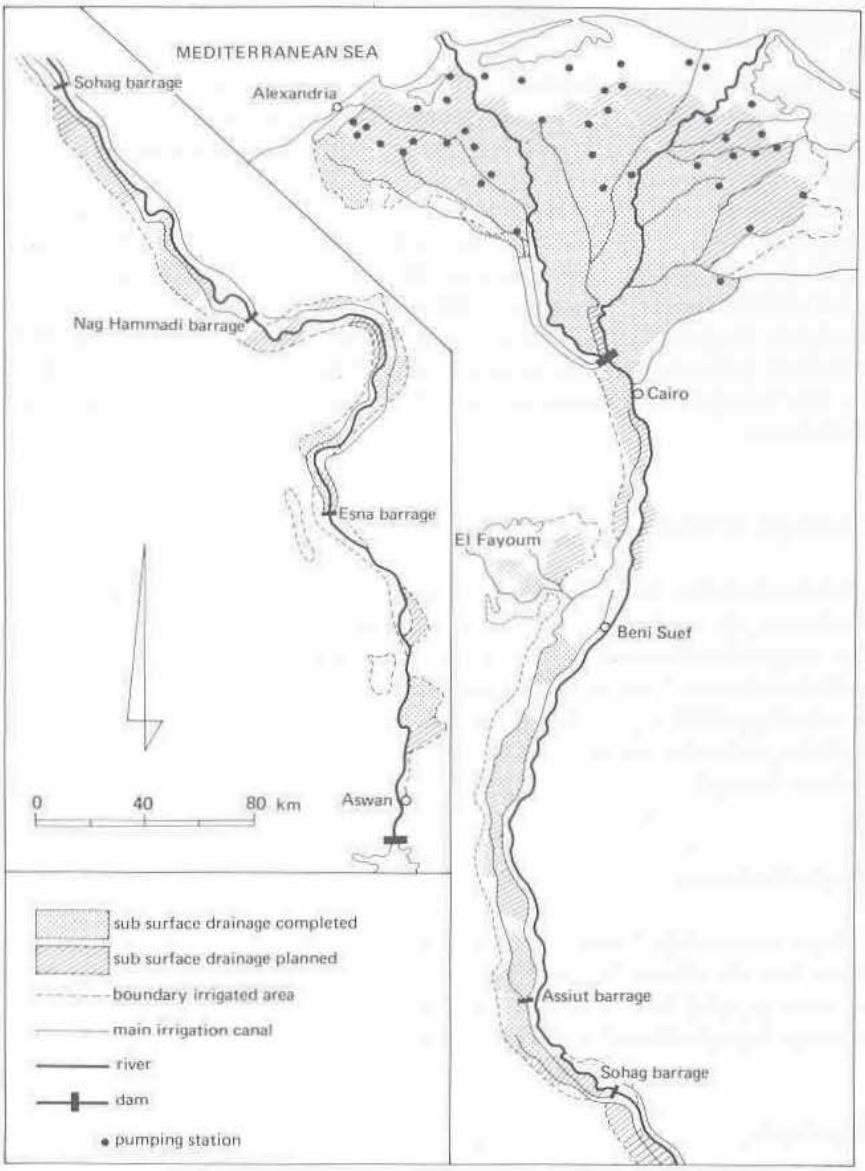

Figure 1 Location of drainage projects in Egypt

2.3 Main areas for future drainage

The future programme for land drainage in Egypt consists of another 1.33 million feddan with open and tile drains to be implemented during the next 10 years. These projects will be implemented either directly by the government own resources or with financial support from international agencies.

The Fifth Drainage Project (1985-89) is mainly financed by the World Bank. The project covers an area of 465 000 feddan in the Delta and Upper Egypt and involves tile drainage construction and modelling of open drains in 280 000 feddan. The Canadian International Development Agency (CIDA) finances an Integrated Soil and Water Improvement Project (ISAWIP) covering an area of 80 000 feddan in the Nile Delta (1987-92) to be provided with tile drainage. The Hamoul Project (65 000 feddan) is financed by the European Economic Community and involves among others tile drainage construction.

3 Drainage criteria

Despite the dynamic nature of the watertable in the irrigated areas of Egypt the criteria adopted describe steady state conditions. The cropping pattern includes crops with different water requirements, rooting depths, and salt and waterlogging tolerances. Agriculture follows a two or three years rotational pattern and thus crops with a clearly different water management regime may follow each other in the same field. The field drainage system lay-out is the composite gridiron type consisting of field drains (laterals) and collectors (mains).

3.1 Watertable depth

A minimum static watertable depth of 1.0 m is required to maintain favourable soil water conditions for the relatively deeply rooting plants (cotton). However, recent monitoring of crop yields in the Nile Delta showed that cotton yields started to decrease at an average watertable depth during the growing season of less than 0.9 m.

3.2 Drain depth

For reason of economy and outlet depth (main open drains) a maximum field drain depth of 1.5 m is possible. As the average field drain length is 200 m and the slope varies between 0.1 and 0.2% the average drain depth varies between 1.30 and 1.40 m.

3.3 Drainage coefficient

a. For drain spacing computation
   A steady drainage rate of 1.0 mm/day is considered a sufficient design criterion for a dewatering zone of 1.0 m below soil surface. This rate is sufficient to control the salinity level of the soil water and to allow the growth of all kinds of crops.
b. For drain pipe capacity
   A peak lateral drain discharge of 4 mm/day is rarely exceeded. Therefore a lateral drain pipe of 50 mm inner diameter is quite sufficient to meet the requirement of evacuating this discharge safely without over-pressure, even for a spacing of 60 m. However, the minimum inside pipe diameter used is 72 mm.
   The design discharge rate for collector capacity in non-rice areas is taken as 2.0 mm/day including a safety factor of 100 per cent for the calculation of the pipe diameters. In rice growing areas a drainage coefficient of 4.0 mm/day is adopted including a 33 per cent factor of safety.
c. Modified drainage system in rice growing areas
   A new lay-out of drainage systems in rice growing areas is introduced to eliminate the problem of unnecessary high drainage rates during the rice season in addition to other operational advantages. The new concept provides each crop unit a separate subcollector with at its outlet a control gate (Figure 2). The gate is closed during the season in which the crop unit is cultivated with rice and is kept open during other crop seasons. In this case the design drainage rate for calculating pipe diameters is kept the same as for non-rice areas (2.0 mm/day).

4 Machines and materials used in drainage construction

4.1 Machinery

The drainage projects in Egypt involve different activities which require a variety of machines and supporting equipment.

Draglines of 1.2 m^3 bucket capacity, and backhoes or hydraulic excavators of 0.75 m^3 bucket capacity are used for digging new main open drains or deepening and widening old existing drains. Lateral drain trenchers (trench box of 1.70 m depth and 0.25 m width) and heavy duty collector drain trenchers (trench box 2.70 m depth and 0.50 m width) are used for installation of covered drains. Supporting equipment is used like low-bed loaders for transport of equipment, wheel loaders, bulldozers, laser units for grade control, agricultural tractors with trailers, trucks for material transport, fuel trailers and mobile workshops.

4.2 Pipes manufacturing

Corrugated PVC pipes with 80 mm outside diameter are produced in 11 extruder units (6 in Upper Egypt and 5 in the Nile Delta). Peak annual production requirements

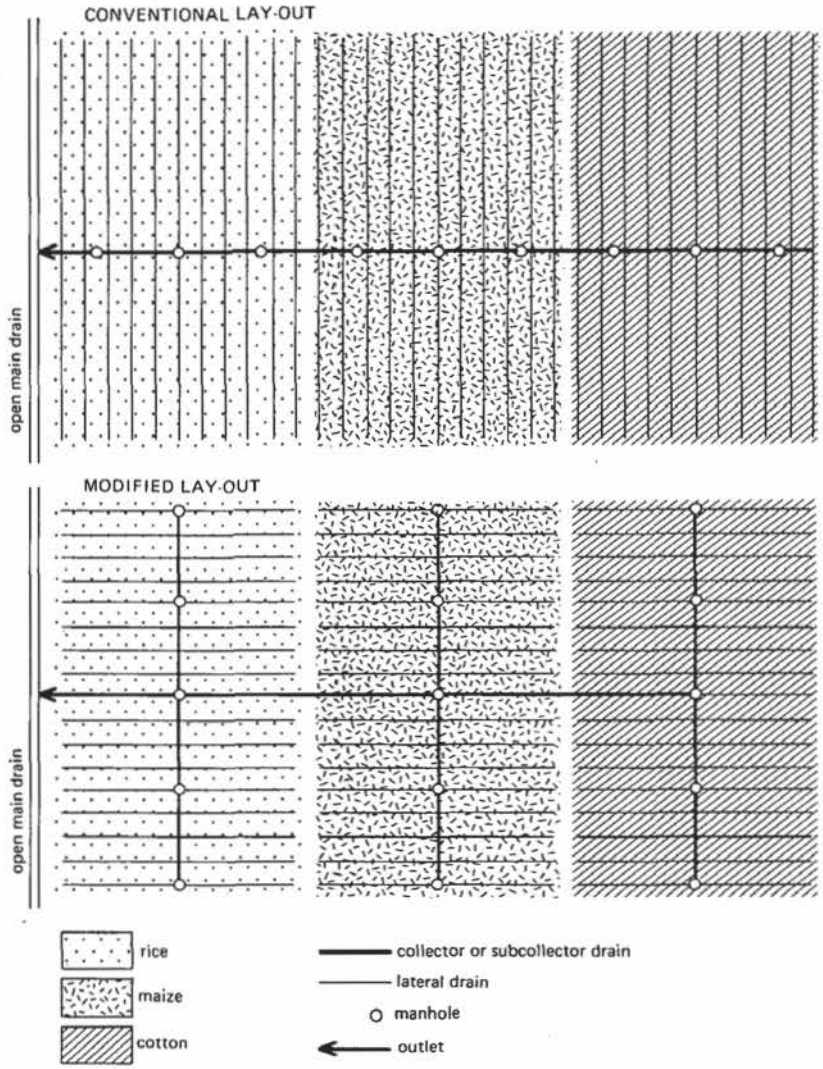

Figure 2 Drainage systems with conventional and modified lay-out in areas with rice in the crop rotation

for the next phase are estimated at 18 400 km. Concrete and reinforced concrete pipes of different diameters for collectors are produced on project sites or at central pipe factories.

4.3 Envelope material

Graded gravel (natural or crushed) is used as envelope material for laterals in unstable

soils. Crushing and sieving equipment is available at the central pipe factories. The criteria currently applied for providing envelope material is the use of 5 cm envelope for drains spaced at 60 m or more and for unstable soils. Recent use of envelope material is more related to the soil physical properties. The clay content of the soil is considered a good stability index of the soil. Soils with a clay content of more than 30 per cent can be considered stable and no gravel envelope should be used.

The use of pre-wrapped synthetic envelope material is still restricted to trials and pilot schemes.

5 Cost development

5.1 Cost of construction

The total cost of drainage projects in Egypt is determined by the cost of the following components:

a. Installation of field drains which is dependent on the drain spacing and the need for envelope material. At present, the average cost of installation of field drains is about LE 170 per feddan (Avarage currency rate end 1986: US$ 1.00 = LE 1,34);
b. Crop compensation for damage resulting from construction activities during installation of the covered drains. The present average rate for compensation is LE 10 per feddan;
c. Deepening and widening of existing main open drains or digging of new ones;
d. Construction of drainage pump stations or increasing the capacity of existing pump stations;
e. Pre-drainage field investigations and design of covered and open drains;
f. Management, administration and supervision of drainage projects;
g. Operation and maintenance of subsurface and open drainage systems;
h. Training and evaluation programmes.

5.2 Cost recovery

The Egyptian law provides for the direct and full recovery of the cost of field drainage during a 20 year period. Provisions are also made for the indirect recovery of maintenance cost through the annual land tax after the completion of drainage works.

6 Project organization and management

6.1 Executive agency

The Egyptian Public Authority for Drainage Projects (EPADP), established in 1973 and belonging to the Ministry of Irrigation, is entrusted with the implementation of

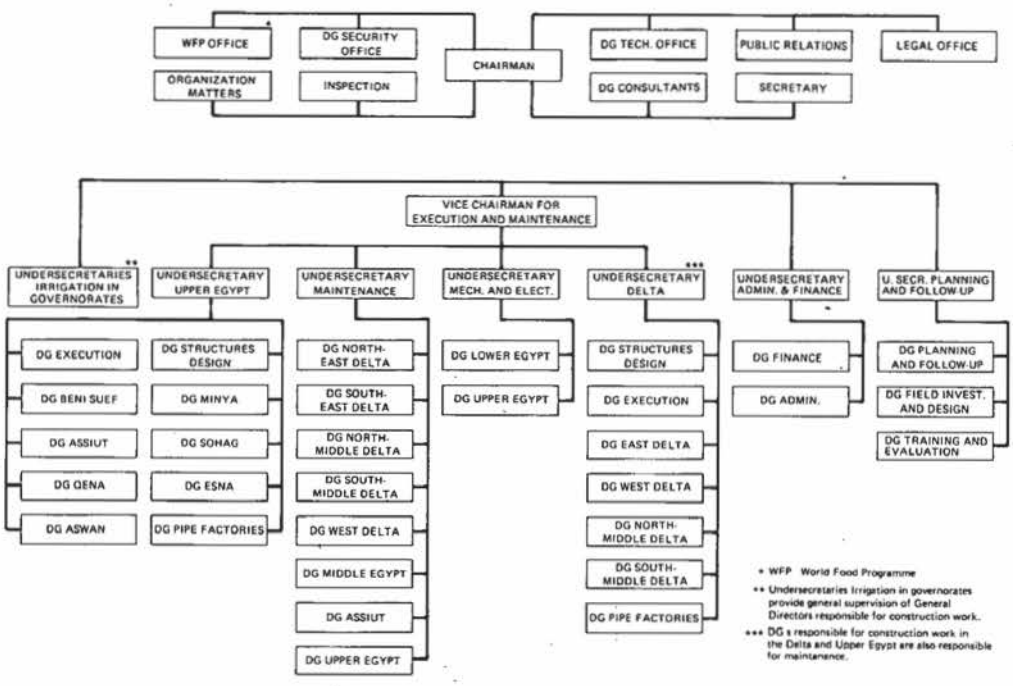

Figure 3 Organization chart of EPADP

the drainage projects. The organization of EPADP is shown in Figure 3. The activities of EPADP involve field investigations, planning, design, procurement of equipment and civil works, budgeting and operation of budget accounts. In the reclaimed areas the Ministry of Irrigation is only responsible for the implementation of the main systems. The secondary and field systems are the responsibility of the Ministry of Land Reclamation.

6.2 Research and consulting institutions

The Drainage Research Institute (DRI) was established in 1977 within the framework of the Water Research Center of the Ministry of Irrigation to conduct applied research, monitoring, testing and evaluation of drainage methodologies and techniques. Its activities are intended to support the implementation programme of EPADP and to solve their technical problems.

The Egyptian-Dutch Advisory Panel on Land Drainage in Egypt was created in 1975 within the framework of the technical cooperation between Egypt and The Netherlands. The panel consists in principal of fourteen members of high managerial level, working in land drainage and related fields. The panel meets twice every year. The main objective of the panel is to assist EPADP, DRI and the Ministry of Irrigation in their effort to combat drainage and salinity problems in Egypt.

6.3 Contractors and subcontractors

Earth work for remodelling of open drains, is carried out by local public sector contractors. Structures to be rebuilt in open drains are awarded to local contractors in the private and public sectors following local procedures for tendering. For the construction of tile drains previously contractors were selected through international competitive bidding. The equipment was imported by EPADP and advanced to the contractors in the form of a mobilization award. Recently EPADP allowed contractors to purchase equipment directly.

7 Operation and maintenance of drainage projects

7.1 Organization

EPADP has established a well structured organization to take the responsibility for the operation and maintenance of all completed drainage works (see Figure 3). The area with completed drainage projects is divided into 8 maintenance directorates, 47 maintenance centers and 214 subcentres. The annual programme for open main drain maintenance is implemented by public sector contractors employed directly by the maintenance directorates. The maintenance programme of covered drains is carried out by the centers and subcenters. Each subcenter is responsible for 5000 feddan and one center maintains tile drains in an area of 40 000 to 50 000 feddan.

7.2 Activities and equipment

Periodic maintenance of open drains is a pre-requisite for satisfactory performance of both the open and tile drainage systems. Weed is the main problem in open drains. Weed control is done manually in 45 per cent of the drains and mechanically in 37 per cent by draglines and excavators. Chemical control of weed is carried out in the rest of the drains. High pressure flushing machines are used for covered drain cleaning. Each flushing machine is operated by an agricultural tractor and supported with a water tank trailer and a booster pump. Bamboo rods are used too for manual cleaning of pipes.

8 Comments and conclusion

The drainage design criteria adopted in Egypt lead to satisfactory results in controlling watertable and salinity levels, and ultimately lead to higher crop yields. However, these criteria need further verification and adaptation for specific geohydrologic and agronomic conditions. At present the criteria are reviewed on the basis of field data from pilot areas and monitoring of existing drainage systems.

The main problem areas which still need further consideration by the implementation and research institutions in Egypt are:

- Quality control of completed construction works such as:
  - Covered drain depth and slope;
  - Gradation of gravel envelope;
  - Uniformity of the gravel envelope layer around the pipe;
  - Installation of covered drains in unstable sandy soils;
  - Joints between laterals and collectors.
- Criteria of using envelope materials in medium to weak soils.
- Use of synthetic envelope material.
- Better organization of construction activities especially the timely supply of materials, spare parts and fuel.

During the last five years considerable improvement in these problem areas were made based on technical studies and field trials and testing of improved methodologies and techniques.