

Introduction of subsurface drainage in Pakistan East Khairpur Tile Drainage: a pilot project

H. Jokhio

East Khairpur Tile Drainage Project, WAPDA, Khairpur, Pakistan

1 Introduction

Irrigated agriculture dominates the economy of Pakistan. It accounts for about one-third of the GNP, employs nearly two-third of the labour force and is practiced on more than 30 million acres. Although it accounts for 90% of the total agricultural production aided in the recent past by (a) introduction of high yielding crop varieties, (b) rise in use of fertilizer, and (c) increase in number of private tubewells, the future growth is threatened by increasing problems of waterlogging and salinization.

A comprehensive programme of Salinity Control and Reclamation Projects (SCARP) has been undertaken in that direction. In the Sind province these projects were identified within the framework of a development plan presented in the Lower Indus Project report in the mid-sixties on the study carried out by the Water and Power Development Authority (WAPDA) with the advice of Hunting Technical Services and Sir M. MacDonald and Partners (England).

The East Khairpur Tile Drainage Project covers an area of about 36000 acres and is one of the interrelated projects envisaged in the plan for the development of land and water resources of the Sind province (Figure 1). Priority is given to the development of fresh groundwater resources followed by tubewell drainage projects in the saline groundwater areas and lastly tile drainage projects in areas where the physical conditions do not allow for tubewells. Selection of priorities is based on economic and social criteria.

An exception to this general order of priorities was given to the East Khairpur Tile Drainage Project which is effectively an integral part of the earlier completed SCARP Khairpur but not suitable for tubewell drainage. East Khairpur had thus been undertaken as a pilot drainage project for introduction of modern techniques which would be required for extensive tile drainage works in an area of about 1.4 million acres with poor discharge from aquifers or other adverse characteristics (bed rock at a shallow depth of 13-14 m below ground level in the case of East Khairpur), which made the area unsuitable for any other type of drainage activity.

The top soil is mainly medium to fine textured with low drainability, becoming coarser textured in the northern part with medium drainability. The depth of occurrence of the sand layer varied from near the surface to depths greater than 12 ft below ground surface. About half of the area has a thickness of the sand layer of less than 6.5 ft. With such a shallow depth of the sandy layers and the watertable generally at a depth varying from 0-5 ft below ground surface the soils were extremely sloughly,

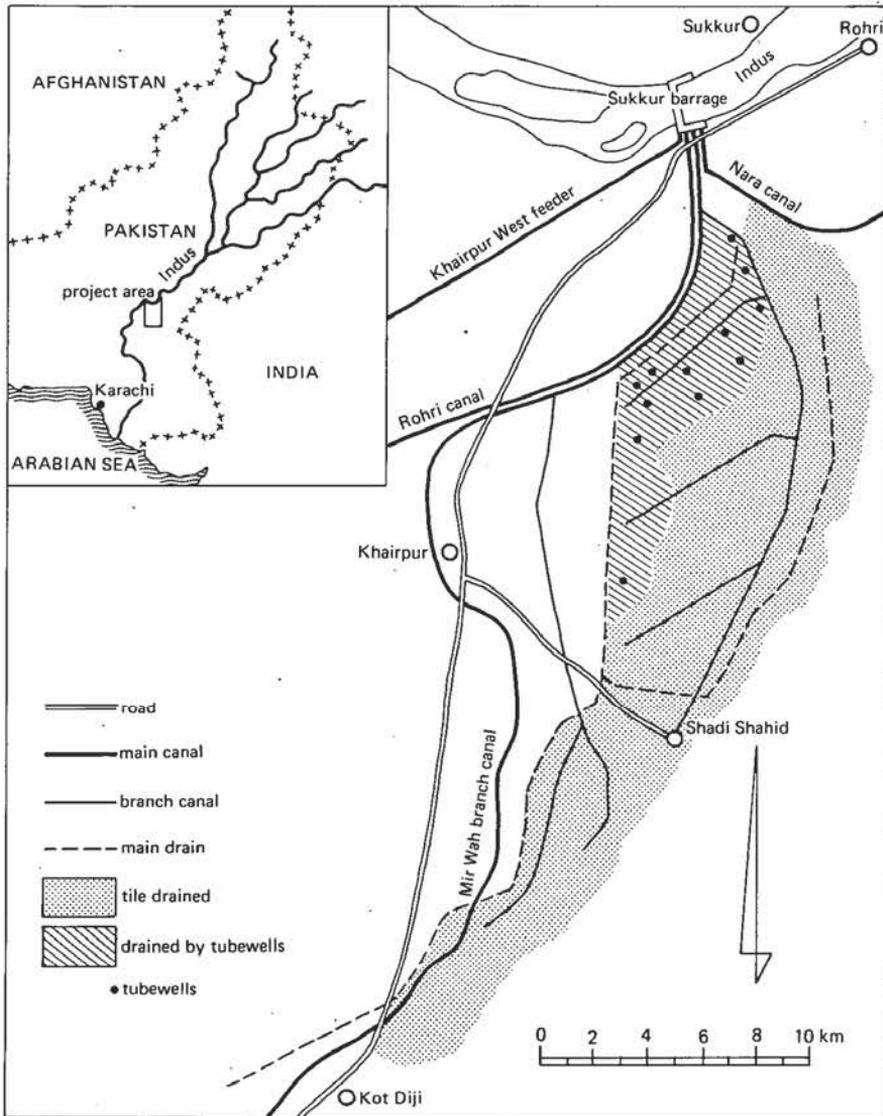


Figure 1 East Khairpur Tile Drainage project in Pakistan

and therefore the suitability of the alternative of deep open drains has been completely ruled out.

The pilot project has three objectives:

- To demonstrate the suitability of tile drains on a representative scale in the field by the construction of a prototype project;
- To confirm the basic principle of tile drain design and construction techniques by monitoring;

- To complete the development of a small area unsuitable for tubewell drainage adjacent to the SCARP Khairpur Tubewell Project.

A World Bank mission appraised the project and ILACO from The Netherlands was appointed as consultant in June 1977 to provide technical assistance for the design, planning and construction works.

2 Project implementation

The project appraised and approved as a multidisciplinary scheme, consisted of the following works:

- The installation of a subsurface tile drainage system and surface disposal drain including buried tiles and collector drains, pump stations and small surface drains;
- The enlargement and remodelling of irrigation canals and structures and the reconstruction of irrigation outlets serving the project area;
- The improvement of existing watercourses;
- The construction of a wider and improved road network and associated structures;
- The reorganization and intensification of agricultural extension services provided by SCARP Khairpur Agricultural Wing under the Sind Irrigation and Power Department;
- The procurement of equipment, materials, vehicles, supplies and spare parts for carrying out the construction work, the operation and maintenance of facilities constructed under the project and the construction of tubewells in the project area and adjacent lands.

The project construction started from early 1977 and the consultant prepared a project plan report in May 1979. Meanwhile the orders for the import of project machinery and equipment were placed, the preliminary work was started such as construction of the residential colony and offices, widening and improvement of roads, enlargement and remodelling of irrigation canals and structures, and intensification of agricultural extension services.

The major project work component was the construction of the subsurface drainage system together with pump stations and the main surface drain for the disposal of the drainage effluent.

A normal composite system with lateral drains joining the collector drain at right angles has been designed. At each junction between lateral and collector drain a man-hole has been provided. For lateral drains corrugated 100 mm P.V.C. pipes were used and for collector drains unreinforced concrete pipes of 1 m length with nominal internal diameters of 9, 12 and 15 inches were laid with a slope of 0.03% and at a depth of 3 to 3.5 m below ground surface. The pipes were made of sulphate resistant cement and manufactured locally. For collector drains concrete pipes were selected for the following reasons:

- The cost estimates presented in the World Bank Appraisal Report were based on the installation of cement concrete collector pipes using a heavy duty machine excavating the trench below the watertable with a protective steel box attached;
- The concrete pipes were cheaper when compared with the cost of rigid P.V.C. pipes.

The drainable surplus has been estimated at 2 mm/day being field irrigation losses. The canal seepage losses vary over the project area from 0.5 to 1.5 mm/day. The drainable surplus therefore ranges from 2.5 to 3.5 mm/day.

The drain spacings and drain depths have been designed keeping into consideration the soil permeability values and the balance between the cost of tile drain construction and the resalinization of the soil profile.

The spacing ranges from 50 to 150 m, the average drain depth is 1.8 m, the slope of the tile lines is 0.1% and the length is maximum 400 m.

The gravel from natural deposits located in the eastern part of the project area at the toe of the hills was screened and used as envelope material. The thickness of the gravel under and above the pipes was taken at about 3 inches.

Various types of equipment and machinery in sufficient quantity were procured for the construction of the project as WAPDA was responsible for the force account construction of the project. This was clearly spelled out in the appraisal report by the World Bank with a view to enable WAPDA in building sufficient expertise which would be quite useful in the construction of similar projects in the Sind province in the future.

Instead of a heavy duty machine for laying of cement concrete collector pipes a horizontal dewatering machine was procured. The reason was that heavy duty machines were still under testing at that time. A new method of horizontal dewatering, developed in Europe for laying of gas pipe lines under waterlogged conditions, was considered as an alternate suitable for laying pipes under project conditions.

The implementation of the project started with the construction of sumps for the pump stations and a drain for disposal of the drainage effluent. After satisfactory commissioning of the equipment and training of local staff as per agreement with the suppliers, the work on the construction of collector and lateral drains started in March 1980.

The project major component of the work involved construction of 37 tile drainage units with 175 km of collector drains, 1000 km of lateral drains and 35 km of disposal drains with a design capacity of 100 m³/sec discharge at the outfall.

The project was approved with a construction schedule of five years to start in January 1977. The construction period for the major component of the works was three years. Since the actual work started in March 1980 (with a delay of about two years) the completion of the project was then envisaged in June 1984 after completion of the watercourses improvement works to be carried out as a follow-up of the construction of the lateral drains. However installation of concrete collector drain pipes in the heavy waterlogged and unstable soil turned out to be more difficult with the system of horizontal dewatering than expected. The progress of work was slow and remained behind schedule. The total progress achieved up to June 1982 was only 25%. By that time only 38 km of the required 176 km collector pipe length had been installed and at that rate an additional nine years were required to complete these drains.

It was therefore decided to use an alternative method for installing collector drains without dewatering and to replace the 12 inch diameter and smaller concrete pipes with recently manufactured large diameter corrugated and perforated plastic pipes. Only the 15 inch diameter concrete pipes would still be used. The plastic pipes would

be laid by a big trencher with gravel envelope, and the idea was that this would dewater the area above the collector drain pipe, facilitating the connection of lateral drains at a later stage thus rendering the provision of a manhole at each junction unnecessary.

The big trencher and big diameter plastic pipes (polyethylene) were imported in 1983-84 for carrying out the balance work on the laying of 12 inch diameter and smaller collector drain plastic pipes. Some delay occurred due to modification of the big trencher to suit local conditions and the work on the installation of the collector drains was finally completed in February 1986. During the construction manholes were provided at all intersection points and ends. The one at the end of the line was for inspection purposes only.

The installation of small diameter lateral drain pipes was carried out through special drainage trenchers equipped with devices to lay pipes at the required depth and grade and to provide the necessary gravel envelope both above and below the pipe in a single operation. The work on the installation of the lateral drains was finally completed in March 1986.

It may be worth mentioning that the work on the installation of collector and lateral drains was carried out by a departmental task-force tight up from March 1980 to March 1986. The total number of these skilled, semi-skilled and un-skilled staff was about 300. It is heartening to say that 63% of the project construction progress was attained in the last 18 months (Figure 2).

The last item of work was the improvement of the existing watercourses as a follow-up of the lateral drains. This work was carried out through petty contractors and was completed in June 1986. The salient features of the project are given in Table 1.

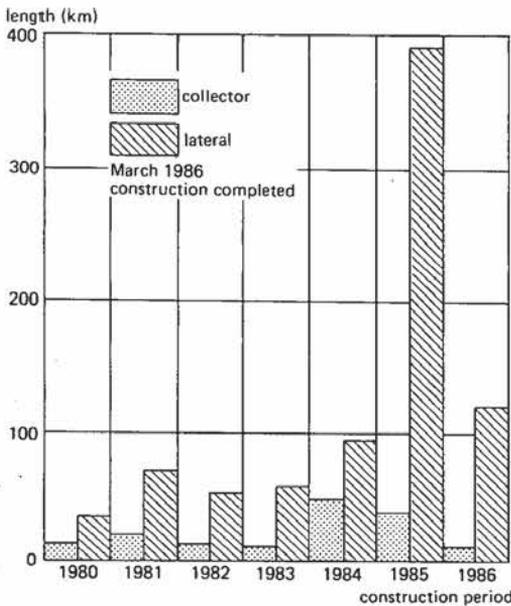


Figure 2 Progress of collector and lateral drain installation

Table I Salient features of the project

General	
Present cropping intensity	119%
Future cropping intensity	145%
Total command area	44000 acres
Drainage	
Total project area	44000 acres
Total area provided with tile drainage	36000 acres
Length of P.V.C. lateral drains	823 km
Length of collector drains	153 km
Length of disposal drains	33 km
Number of pump stations	37
Number of pumps installed in sumps	90
Total power requirement	1.8 million kWh
Irrigation	
Length of canals remodelled in Patni command area	42 km
Length of canals remodelled in Sathio Wah and Mir Wah command areas	7 km
Area to be served by remodelled watercourses	27000 acres
Roads	
Length of constructed bituminuous roads	17 km

3 Project costs

In the absence of a local precedent the World Bank mission appraised the project on price levels prevailing in December 1975 for similar works in Egypt, Europe and North America. The project costs were estimated at about US\$ 28 million. The foreign exchange component was US\$ 14.0 million or 50% of the total costs.

The government of Pakistan approved PC-I of the project in 1976 at a total cost estimate of Rs. 372.2 million with a foreign exchange component of Rs. 178.7 million inclusive interest during construction. Due to delay in the completion of the project the cost estimates were revised at 1983 prices and PC-I was approved in 1985 at a total cost estimate of Rs. 630.03 million with a foreign exchange component of Rs. 199.85 million (Table 2). The project cost estimates were prepared on the unit rates of works established locally with experience gained during the implementation of the project.

The actual cost of the project on the finalization of accounts comes to Rs. 575.000 million with a foreign exchange component of Rs. 189.00 million. The rates per acre have been worked out and are given hereunder:

- Rate of tile drainage including all other development works Rs. 16335/acre
- Rate of tile drainage only Rs. 14549/acre

Table 2 Summary of cost estimates (in million rupees)

Item	Description	Local	Foreign	Total
I	Civil works			
	Drainage system	77.18	45.17	122.35
	Canal remodelling	2.45	9.40	11.85
	Watercourse reconstruction	10.10	3.40	13.50
	Road improvement	4.30	6.21	10.51
		94.03	64.18	158.21
II	Equipment, vehicles and material to be imported			
	Drainage system	14.01	88.36	102.37
	Canal remodelling	0.06	2.11	2.17
	Road improvement	0.06	0.90	0.96
	SCARP Khairpur	0.10	1.90	2.00
		14.23	93.27	107.50
III	Agricultural equipment and vehicles to be imported			
	Agricultural extension equipment	0.41	—	0.41
IV	Consultants and training	10.26	13.16	23.42
V	Engineering and administration			
	Staffing and housing	32.50	2.35	34.86
	Crop compensation	3.49	—	3.49
	Buildings	21.51	—	21.51
		57.50	2.35	59.85
	Basic project costs (Total I to V)	176.43	172.96	349.39
VI	Physical contingencies	12.83	10.84	23.67
VII	Expected price increase	18.15	8.55	26.70
VIII	Aerial photography and erts surveys	3.02	7.5	10.52
IX	Custom duties and taxes	76.68	—	76.68
X	Land acquisition	3.46	—	3.46
	Total I to X	290.57	199.85	490.42
XI	Interest during construction local currency component at 14% per annum	138.70	—	138.70
XII	Service charges on foreign loan at rate of 1%	0.91	—	0.91
	Grand total I to XII	430.18	199.85	630.03

The unit costs are considered on the high side when compared with similar costs in other countries of the world. One reason is that the project has been constructed in an area which is very flat (general slope of about 6 inches/mile) thus provision of pump stations for evacuation of drainage effluent of small units is necessary. This is not required in areas with steeper slopes. The other reason is that the project was implemented by a departmental task-force as a pilot project to train local people in this modern technology. The completion of the project took double the time i.e. about 10 years against 5 years as planned. This delay has added more costs in administration, overhead, interest and consultant charges apart from escalation of all important ingredients for the construction of the project. Had the project been completed in the planned construction schedule, five years ago the cost of tile drainage would have been not more than Rs. 8000/acre (estimated). This cost per acre could be considered as most reasonable for future tile drainage projects in the country.

In fact the lack of speed in the construction of this project was a major constraint. During the implementation of the project the machinery could not be used optimally due to many difficulties encountered. It has been observed that the machinery utilization was nearly 35% of the available machine time.

The World Bank mission in its appraisal report has estimated the annual operation and maintenance costs of tile drainage at Rs. 25/acre. The project estimate of annual operation and maintenance costs on 1986 prices has been worked out at Rs. 30/acre.

4 Conclusion

The project was a major challenge and many difficulties were encountered during construction of the project. Famous experts visiting the project during construction recognized that the project was being constructed under the most difficult conditions in the world.

Although the project was delayed due to reasons given earlier, the impact of the project on the agricultural development has been remarkable. Surveys carried out in late 1985 show a sharp increase in the annual cropping intensity from 90% in 1975 to over 150% in 1985, compared to the 145% anticipated future annual cropping intensity after completion of the project. The increase in the annual cropping intensity was more than planned even during construction which is due to the following reasons:

- Increase in the capacity of the irrigation system;
- Recovery of abandoned areas and bringing them back into cultivation as the installed drainage system allowed for effective leaching of the saline soils;
- Improvement of existing watercourses on the principle of on-farm water management resulting in less seepage losses and more water available for irrigation and reclamation.

It is expected that with the continued efforts to recover land and water, the annual cropping intensity will ultimately reach a figure of 160% in 1990 against 145% anticipated in the development plan.

The yields of cotton and other crops have remained stable during the period 1975 to 1985 but wheat and sorghum have shown a significant increase. This is shown in Table 3.

Table 3 Wheat and sorghum yields in 1975 and 1985 respectively

Crop	Yield in maunds/acre*	
	1975	1985
Sorghum	6.0	14.0
Wheat	15.0	22.0

* 1 maund/acre = 92.5 kg/ha

It has also come to our notice that in some areas the maximum wheat yield has been of the order of 60 maunds/acre.

It can now be said with confidence that this pilot project though delayed due to various bottlenecks, is still feasible and that the technology of horizontal drainage has a great potential.

Most important is the detailed monitoring on a scientific basis which will confirm the parameters used for the design. The discharge from the drainage units has been monitored during construction from January 1984 onwards. The discharge has remained in the order of 30% of the design rate. This may be due to the following reasons:

- Irrigation supplies from the canals are still less than the capacity on which they have been remodelled;
- Actual drainable surplus is less than what has been estimated in the design.

Such parameters can only be confirmed after detailed monitoring has been carried out.