A STUDY OF DEEP TUBEWELL IRRIGATION WITH BURIED PIPE DISTRIBUTION SYSTEM

Submitted

by

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In partial fulfillment of the requirements for the Degree of
Master of Engineering (Water Resources)

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CERTIFICATE

This is to certify that this work has been done by me and neither this report nor any part thereof has been submitted elsewhere for the award of any degree or diploma.

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We hereby recommend that the project report presented

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A STUDY OF DEEP TUBEWELL IRRIGATION WITH BURIED PIPE DISTRIBUTION SYSTEM be accepted as fulfilling this part of the requirement for the Degree of Master of Engineering (Water Resources).

Chairman of the Committee (Dr. M. Mirjahan)

Member (Dr. A. Hannan)

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ABSTRACT

Three buried pipe irrigation water distribution systems of Tangail Agricultural Development Project were selected to study their performance in respect of water losses, variation of water availability at various locations of canal system and economic feasibility. It was found that the average water losses in buried pipe ranged from 0.45 to 1.70 l/s/100 m. However, the water loss in earthen channel was found to vary from 4.4 to 7.7 l/s/100 m. Water distribution (water delivered per unit area) was found nearly uniform in two scheme areas but non-uniform in one scheme area. The economic feasibility of the buried pipe irrigation system was assessed using Benefit Cost Ratio. It was found that all the schemes were economically attractive.

ACKNOWLEDGEMENT

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I deem it a great privilege to have Dr. M. A. Hannan and Dr. A. Nishat as the members of the Board of Examiners.

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Md. Shirazul Islam

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INTRODUCTION

1.1 BACKGROUND

The performance of an irrigation mode is generally controlled by engineering, agronomic, organizational and management aspects. The principal modes of development in the water sector for agriculture are :

- flood control and gravity drainage
- irrigation
- flood control, drainage and irrigation and
- additional modes

The major components of these modes are shown below :

Principal Modes of Development

Mode	Major Components
1. FCD (Flood Control and Gravity Drainage)	
a) Gravity Drainage	Embankment, regulator/sluices
b) Submersible Embankment	Embankment, regulator,overflow-spillway
2. Irrigation	
a) Major Irrigation Modes	
(i) Primary pump (pp)/ Gravity Distr.(Single Lift)	Primary pumps, built-up canal distribution system, ancillary structures
(ii) PP/LLP Distr. (Double Lift)	Primary pumps, ancillary structures, LLPs, earthen canals/ditches.
(iii) Floating pump (FP)/ LLP Distr.(Double lift)	Pontoon-mounted floating pumps, ancillary structures, LLPs, earthen canals/ditches.
(iv) Barrage/Gravity Distribution	Barrage, canal distribution system

b) Minor Irrigation Modes	
(i) Traditional (Non-Mechanized)	Dhoon, swing basket, dugwell, bucket
(ii) Mechanized Suction Lift MOSTI	Manually operated tubewell (Treadle, Rower, No. 6)
STW, Diesel	STW, small scale earth distr. system
DSSTW, Diesel	Deepset STW, earthen distr. system.
(iii) Mechanized Forced Lift MSTW, Diesel	STW with submersible turbine pump
DTW, Diesel	DTW, small scale earthen distr. system
LLP, Diesel	LLP, small scale earthen distr. system
3. FCDI (Flood Control, Drainage and Irrigation)	
a) Primary pump/Gravity Distr.	Embankment, regulator, reversible pump, canal distribution system
b) Primary pump/LLP Distr.	Embankment, regulator, reversible pump, LLPs, earthen canals/ditches
4. Additional Modes	
a) Water Conservation	Control structures
b) Command Area Development	Canal lining, buried pipe distr. system
c) Conjunctive Irrigation Development	Conjunctive operation of surface and groundwater irrigation system

Source : Technical Report No. 12, Modes of Development : Engineering, and Cost Analysis, 1985.

The water conveyance and distribution systems are of utmost importance in the irrigation projects. These systems are mostly of earthen open channels for minor irrigation schemes in Bangladesh and suffer from a number of problems like-low conveyance and distribution efficiency, less irrigated area and high maintenance cost.

Field channels in surface water distribution system, originating from tubewells or even from most canal outlets, run in a random manner with little consideration of topographical features of the area. Seepage, leakage and evaporation losses are high in such systems. Besides, about 2-4 percent of the cultivable area is taken up by the open channel distribution system (Michael, 1987).

Possible economic solutions to some of these problems for the areas with plain topography and having heavy to medium textured soil, include construction of improved (compacted) earthen channels with necessary water control structures and strengthening operation and maintenance capabilities to improve performance of the system. However, for uneven topography and light textured soils, buried pipe distribution may be the best solution to these problems provided the users can afford it.

Since the pipe lines are placed underground, they do not interfere with farming operations, and when properly installed they are very durable and maintenance cost is low. The pipes are operated under pressure, therefore, they can be laid uphill or downhill, thus permitting the delivery of irrigation water to areas not accessible when open channels are used. With an underground pipeline system, wells need not be located at the high point of the farm but may be at a location that provides the best water supply. No right-of-way is required by a buried pipe distribution system. This is not only an economic advantage but also a practical benefit when a large number of field plots belonging to different individuals are not crossed to distribute water from a deep tubewell. It is also not necessary to follow plot boundaries, thus reducing the lengths of channel.

Considering the benefits discussed above, some initiatives were taken by different agencies to install buried pipe irrigation systems in Bangladesh. So far about 80 buried pipe distribution systems have been installed all over the country.

But systematic study on the performance of these systems is lacking. Therefore, the present study has been undertaken to evaluate the performance of three buried pipe water distribution systems of Tangail Agricultural Development Project (TADP) at Shakipur Upazila under Tangail District.

1.2 OBJECTIVES

The objectives of the proposed study were :

1) To determine the water losses in buried pipe irrigation distribution systems of the selected deep tubewells.
2) To monitor the water distribution in the selected scheme area.
3) To study the economy of the buried pipe distribution systems.

CHAPTER II

DISTRIBUTION SYSTEM FOR MINOR IRRIGATION

2.1 Buried Pipe Irrigation Distribution System

An underground pipeline water distribution system consists of buried pipes and some allied structures for the efficient functioning of the system. The use of this system is usually limited to areas irrigated by wells using pumps. With pumps, the necessary pressure head to operate the underground distribution system can be obtained with very little extra power. Some important components of a typical buried pipe system are described below:

2.2.I Pipes:

Usually the following types of pipes are used in a buried pipe water distribution system.

-Non-reinforced Cement Concrete (CC) pipe

-Reinforced Cement Concrete (RCC) pipe

-Plastic pipe (PVC/uPVC)

-Asbestos Cement (AC) pipe

Non-reinforced concrete pipes are commonly used when the pipe is not subjected to high pressures. Normally, they are suitable for operating heads (pressures) not exceeding 6 metres (0.6 kg/cm^2). Non-reinforced concrete pipes are cheaper than reinforced pipes and could be used with advantage in small to medium size farms (Michael, 1986).

Reinforced cement concrete pipes can withstand higher pressure than that of cement concrete pipes. These pipes are usually available in sizes 15 cm to 45 cm and their lengths vary from 2.0 m to 2.5 m. These pipes are generally made by spun process.

Two types of asbestos cement pipes are used for irrigation pipe lines. One type is a pressure pipe and the other type is a non-pressure pipe. The former is joined by any one of the following three ways:

-with asbestos cement couples,

-with a cast iron detachable joint,

-with a loose concrete collar.

The asbestos cement non-pressure pipes are made with a socket and spigot. The joint is made with a jute rope dipped in cement slurry caulked into the space between socket and spigot. The space is then caulked with cement mortar and the joint is pointed. Some types of joints usually used in pipe jointing are described below:

2.1.1.1 Bell Joints :

Pipes with bell ends are laid with their sockets (bell ends) facing upstream. The ends of the pipe are cleaned and wetted with a brush. Jute or hemp rope dipped in a cement paste is wrapped round the plane end of each pipe. The rope is just thick enough to be inserted into the socket of the pipe already in position. Before the pipe is inserted in the socket, mortar made of one part cement and two parts sand is applied to a thickness of about one centimeter over the spigot end of the pipe and also inside the socket. The pipe is placed well into the socket and care is taken that the packing is not pressed through the pipe. The hemp is then rammed tightly with a steel tool and the remaining space in the socket is filled with mortar and finished with a bead on the outside.

2.1.1.2 Tongue and Groove Joints :

Pipes with tongue and groove joints are laid with the groove ends facing upstream. The tongue and spigot end of the first section of pipe is cleaned and wetted with a brush. Sufficient mortar to form the lower section of the outside band or collar is placed in a depression at the lower side of the pipe joint. The groove end of the next section is wetted and filled with mortar. This section is then tipped over carefully so as not to dislodge the mortar and is pushed into place to make a snug, tight joint (Fig 1). Excess mortar will be squeezed out of the joint on both the sides.

2.1.1.3 Collar Joints :

Reinforced concrete pipes, usually 2.5 m to 3.0 m in lengths, are lowered into the trench for buried pipe and a collar is slipped to its end before the adjacent pipe is laid down. The gap between the ends of the adjacent pipes is about one centimeter for fixing a rope dipped in bitumen in the recession of the pipe ends. Squeezing of individual pipes in the line is done when at least four or five pipes have been laid. Of these pipes, the leading one is forced by a heavy duty screw jack towards the tail end to such an extent that there exists no gap between the facing ends and the rope threads are forced out to

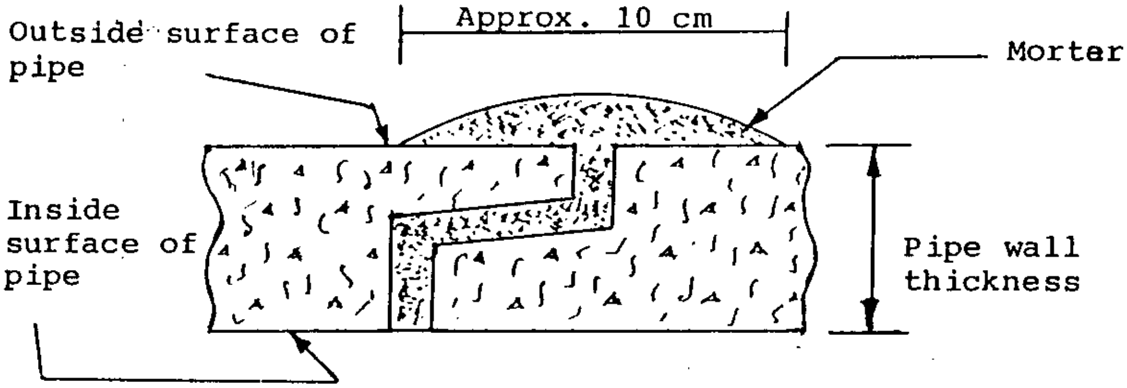

Fig. 1 Tongue and groove joint

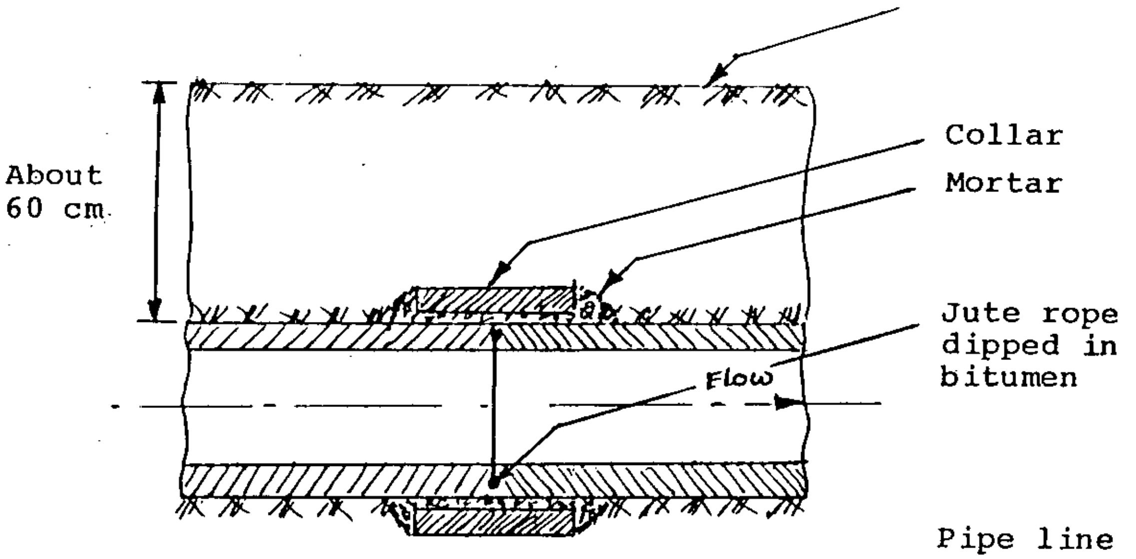

Fig. 2 Collar joint

the periphery. Then, the collars are slipped over the squeezed joints so that half of the collar width covers each side of the joint. In order to maintain a uniform clearance between the pipe joint and the collar, wooden battens of uniform thickness are plugged in on both sides of the collar. The gap between the pipe and the collar is then filled with a dry mixture of cement and sand (1:1). Once the gap is sealed, the collar is lined with 1.0 cm to 1.5 cm thick plaster (1:2 ratio) and bevelled off an angle of 45 degree with the outside edge of the collar. The finishing of the joints should be at least five sections behind the laying operation. In Fig 2 is shown a collar joint for reinforced concrete pipe.

2.1.2 Pump Stand :

A vertical pipe extending above the ground and connected to the underground pipe line system is known as a stand (Fig 3). These are located at the inlet of an underground pipe line system having diameters at least 60 cm. A stand permits dissipation of the high velocity stream and release of entrapped air before the water enters the pipe line. Any air entrained by the high-velocity stream coming from the pump will have an opportunity to escape at the pump stand. Entry of air into the pipeline can cause air pockets which restrict the flow of water, surging flow condition and development of excessive pressures. Pump stand must extend upward to a point where water will overflow, except when unusual pressures occur. The elevation of water surface in the stand must be sufficient to permit the discharge of water through

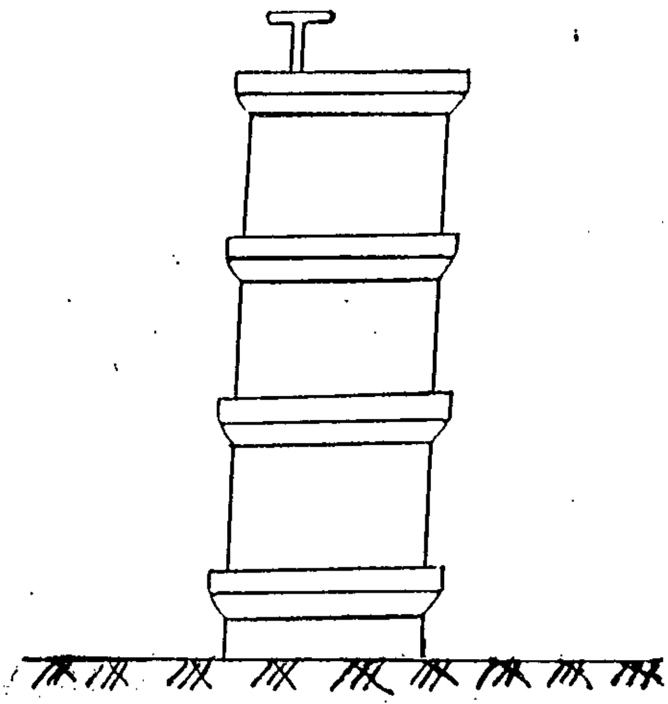

Fig.3 A Pump Stand

the outlets at any point on the farm. This should also include the pressure head required to overcome friction in the pipe and valves.

2.1.3 Air Vent:

Air vents are vertical pipe structures to release air entrapped in the pipeline and to prevent vacuum (Fig 4). Entrapped air must be removed to permit an even flow and avoid the danger of water hammer. They are installed near the pump stand, at all high points in the line, at sharp turns, at points where there is a downward deflection of more than 10 degrees, directly downstream from any structure that may entrap air, and at the end of the pipe line. They are also required immediately upstream from gates where closure of the gates would make such points the downstream ends of a lateral or line. Vents are generally installed at points about 150 m apart on straight pipe lines with uniform slope. The first airvent is located near the pump stand at a point where the design velocity exceeds 30 cm per second. The vents should be high enough to provide a free board of at least 60 cm above the maximum height at which the water will rise during normal operation.

2.1.4 Outlet :

The most common outlet consists of a concrete riser pipe to bring the water from the buried pipe line to the ground surface and an attached valve to control delivery of water to the fields at any desired location (Fig 5). These should be easy to open and close, be of proper size to provide the flow required, and be so

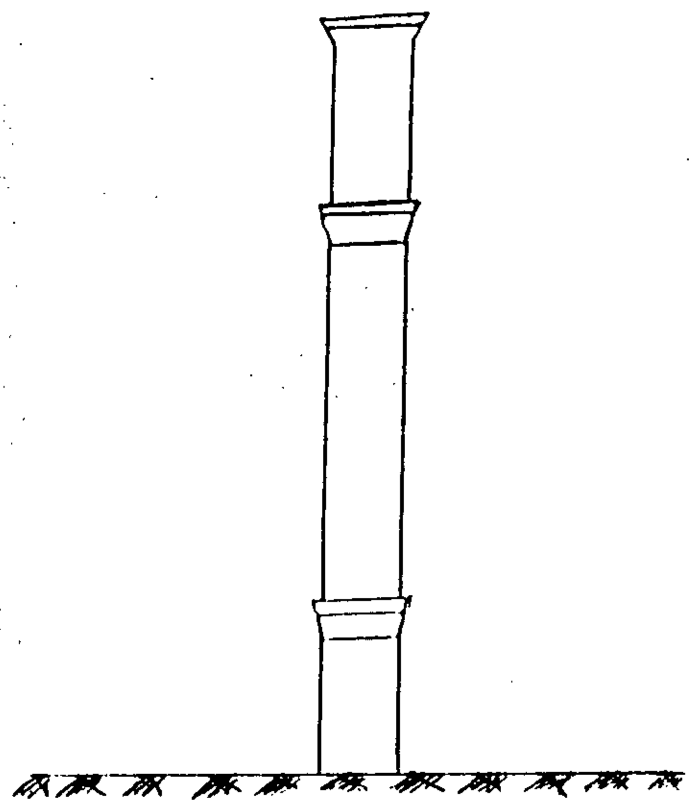

Fig.4 An Airvent

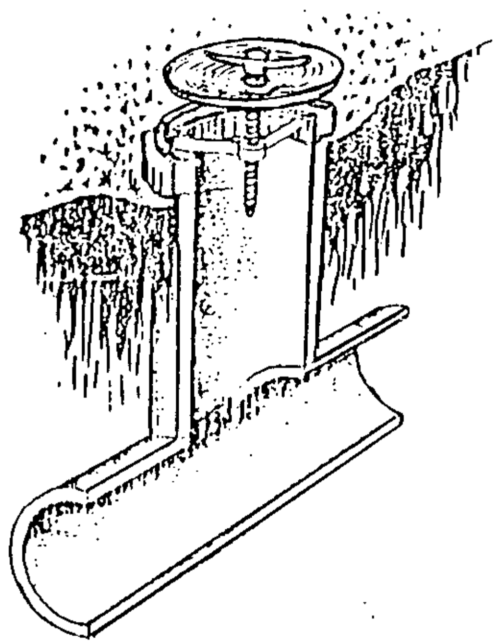

Fig.5 An Outlet Valve Mounted On Concrete Pipe

constructed that the water released will not cause soil erosion. The diameter of the riser pipe is usually the same as the main pipe. This will permit the entire flow of the pipeline to be released through the valve. However, in large size pipelines, when a number of outlets are to discharge water simultaneously, the size of the riser pipe is smaller than the main pipe.

The outlet may open directly into a border strip or check basin or at point to deliver water directly to several furrows. It may also discharge into open channels or portable surface pipes. The outlet valve should be constructed so that the top of the riser or valve is at, or slightly below the ground surface.

Beside these structures, some designers use check structures on the buried pipe distribution lines. A check is described below:

2.1.5 Check-Structure :

Checks are usually 'H' shaped concrete pipes constructed beyond the pump stand (Fig 6). A check structure connects the pump stand and the main line to prevent backwater hammering from the main line into the pump stand.

2.2 Buried Pipe Systems in Bangladesh

Buried pipe distribution systems in tubewell irrigation have been introduced in Bangladesh for over a decade. The first one was introduced in 1982 by the Rural Development Academy (RDA), Bogra, under the technical assistance of the Food and Agriculture Organization (FAO) of the United Nations. The project was implemented in Narhatta under Kahalu Upazila. Asbestos cement

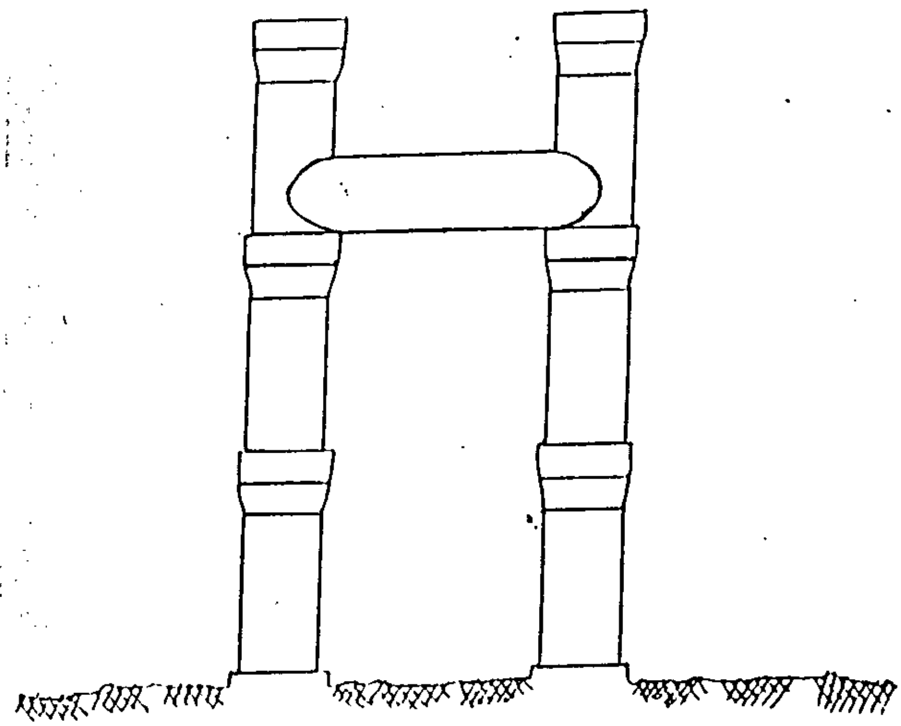

Fig.6 A Check Structure

pipes were used in the system having two loops to irrigate 67 hectares of land. The total pipe length of the system was around 3000 m (Matin, 1988). RDA implemented another buried pipe system of PVC pipes having diameter of 15.24 cm and a length of 1000 m to irrigate 60 hectares of land in the same upazila. In 1984, RDA also installed a third buried pipe system at Rajapur under the technical and financial support from the Food and Agriculture Organization (FAO). Low cost concrete pipes were used for a total pipe length of 990 m to irrigate an area of 12.0 hectares.

A buried pipe water distribution system was installed at the central farm of Bangladesh Agricultural Research Institute (BARI), Joydebpur, in 1982 to irrigate around 100 hectares of land (Michael, 1987). Three deep tubewells were interconnected by 20.32 cm diameter PVC pipe lines. In 1985, a concrete buried pipe system was built for the Development Service Centre, an eight hectare agricultural facility at Savar, run by a foreign mission group (Gisselquist, 1989).

Barind Integrated Agricultural Development (BIAD) Project started constructing buried pipe systems in 1987-88 in Rajshahi district. A total of 13 schemes have so far been completed but 11 of these have been non-operational due to various problems and 2 are working.

Mott. MacDonald International (MMI) under IDA-DTW II Project have constructed 16 partial and 5 full buried pipe distribution systems for farmers' co-operatives (KSS) in different parts of Dhaka, Mymensingh and Manikgonj districts.

In pursuance of an agreement between Bangladesh and the Government of the Federal Republic of Germany concerning technical and economic co-operation, an agriculturally based area development project namely, Tangail Agricultural Development Project (TADP), was taken up in 1982. In the two years' orientation phase (1982-1984), various studies were carried out and fields of potential project interventions were identified. A number of pilot schemes were taken up for experimentation during this phase. Based on this extensive practical field experience and through investigations, a Plan of Operation (POP) for the subsequent implementation phase of TADP was drafted and later on became the approved legal basis for the joint promotion of the project. The implementation phase scheduled to start from July 1984 was actually started from April, 1985 with the goals to increase food production with emphasis on irrigated crops and to reduce under-employment in rural areas by public works for the improvement of rural infrastructure.

Under this project, irrigation equipments and lined irrigation channels were installed, rural roads were improved and high yielding varieties of wheat, banana, and other crops were demonstrated in Tangail district.

In January, 1986 the project was jointly evaluated by a team of independent Bangladesh and German consultants followed by a replanning workshop to delineate the project objectives in the light of the findings and to suggest further course of action. After the evaluation, some changes were recommended in project design including a focus on Command Area Development (CAD), in which, area irrigated per unit of flow rate were to be increased through better management of irrigation water, improving services of Krishak Shamabay Samiti (KSS) and strengthening extension works.

Thus, from early 1986, the project adopted a co-ordinated programme for Command Area Development with components to strengthen farmers' organizations for more efficient and equitable use of pumps, to improve water distribution from pumps to fields and to increase yield and income per irrigated hectare. For management of irrigation water, TADP considered the following two things equally important :

- Water Users Organization (WUO) and
- Water Conveyance Structures.

Therefore, TADP put emphasis on the improvement of these two things to achieve their goals. Thus, they decided to install buried pipe irrigation distribution systems to irrigate 40 hectares by a deep tubewell (56 l/s capacity) and 14 hectares by a shallow Tubewell (14 l/s capacity). They set a target of converting earthen channels into buried pipe systems for deep tubewell within 1987 (Rahman, 1987). At present 47 buried pipe systems are working under Tangail Agricultural Development Project.

No systematic study has so far been made to evaluate the existing buried pipe systems in Bangladesh. However, some initiatives have already been taken in this regards recently. The following paragraphs give a brief account on some assessments made by different evaluators.

Ahammed (1984) reported that new buried pipe systems gave high conveyance and distribution efficiencies besides yielding other economic and non-economic advantages. However, a conversion from earthen channel to buried pipe requires a large additional investment.

Bangladesh Agricultural Research Institute in collaboration with Loughborough University, UK, and MacDonald International, Bangladesh have taken up a study to evaluate the water loss and head losses in the pipe systems in Dhaka, Mymensingh, Tangail and Manikgonj districts including detailed monitoring of irrigation and agronomic practices.

2.3 Buried Pipe Systems in Other Countries

The buried pipe distribution systems are being used in the United States for many years. According to Worstell (1979), the potential benefits from a buried gravity irrigation system include eliminating or greatly reducing energy requirements (as compared with sprinkler system), labour savings (as compared with present gravity system), increased water application efficiency, erosion control, increased crop production under saline conditions and much convenence.

According to Jenkins (1984), buried pipe irrigation distribution system made of asbestos cement pipes become very much costly and farmers find it difficult to pay the construction cost of the system. Merriam (1985) conducted a study on a 145 ha buried pipe distribution system in Srilanka with the lines taking off from the level top canal and supplying water on demand to individual 1.o ha farm. He found that : i) installation costs were about US Dollars 810.0 per hectare (1982) which was US Dollars 475.0 higher than the conventional unlined tertiary canal system, ii) farmers' crop production increased and conflicts over water was reduced, iii) un-reinforced tongue and groove mortar-jointed pipe proved much more satisfactory than collar-jointed pipe which had leakage problems and iv) various operation problems were experienced such as erratic supplies from the canal system which prevented the farmers obtaining water on demand, wastage of water by some farmers, difficulties, sometimes, experienced by upstream farmers in withdrawing water when outlets were open downstream and leakage around control gates and valves.

Yadav (1985) carried out a cost comparison of lined canals and underground pipe-lines in Nigeria and concluded that under-ground pipelines would be cheaper to construct if the canal would require embankments higher than 1.2 m. James (1988) mentions that buried pipe distribution systems have been used in the USA since the mid 19th century and are now common in use there. Design materials are available for engineers and farmers (Soil Conservation Service, 1967 and University of California, 1977) and specialist manufacturers have become established which produce the necessary valves, hydrants and meters.

According to Moigne and others (1989), in France, attention has been paid in the 1980s to modernizing traditional surface gravity irrigation schemes without converting them to sprinkler or drip irrigation and this has included use of 150 to 300 mm diameter

PVC pipes. The low heads available have proved an important constraint and miscellaneous inexpensive valves have been developed which may be of interest for use elsewhere.

Michael (1978) mentions that India has been using low pressure buried pipes on a significant scale for more than 20 years. Hannan and Haque (1984) reported that world Bank funded a series of major projects on buried pipes eg. the Uttar Pradesh Public Tubewell Project, the Bihar Public Tubewell Project, the West Bengal Minor Irrigation Project etc. In Uttar Pradesh only there are 6000 cc and 560 plastic pipe systems installed by 1984. In Gujrat Pradesh farmers themselves have installed pipe systems on private tubewells. World Bank has also funded buried pipe systems in Sri-Lanka through the Concrete Pipeline Pilot Project" Mahaweli Project". Buried pipe systems have been in use in Thailand, too, on the Sukhothai Groundwater Development Project.

CHAPTER III

METHODOLOGY

3.1 The Study Site

The study site is located in Shakipur Upazila under Tangail district and is about 14 km north to the Upazila headquarter (Fig 7).

The selected site falls under the Madhupur Tract, the land distribution of which is as follows :

High land	56 %
Medium high land	18 %
Medium low land	7 %
Low land	9 %
Homestead and water bodies	10 %

The top soil texture is loam, loam to clay or silty to silty clay loam and the sub-soil-texture is clay or silty clay loam.

The average annual rainfall in this area as recorded at the nearest meteorological station, Mirjapur, is 1892 mm. The highest mean monthly temperature is 34 degree centigrade in April and the lowest is 12 degree centigrade in January. The percentage of Relative Humidity ranged between 49 and 88. The mean monthly evaporation rate varies from 60 mm to 133 mm over the year. From the relationship between the rainfall and evaporation, it was found that, the period from November to April is the moisture deficit period (Manalo, undated).

Before the installation of deep tubewell the major cropping patterns were :

For high land

B. Aus-Mashkalai/Mustard/Fallow-Fallow

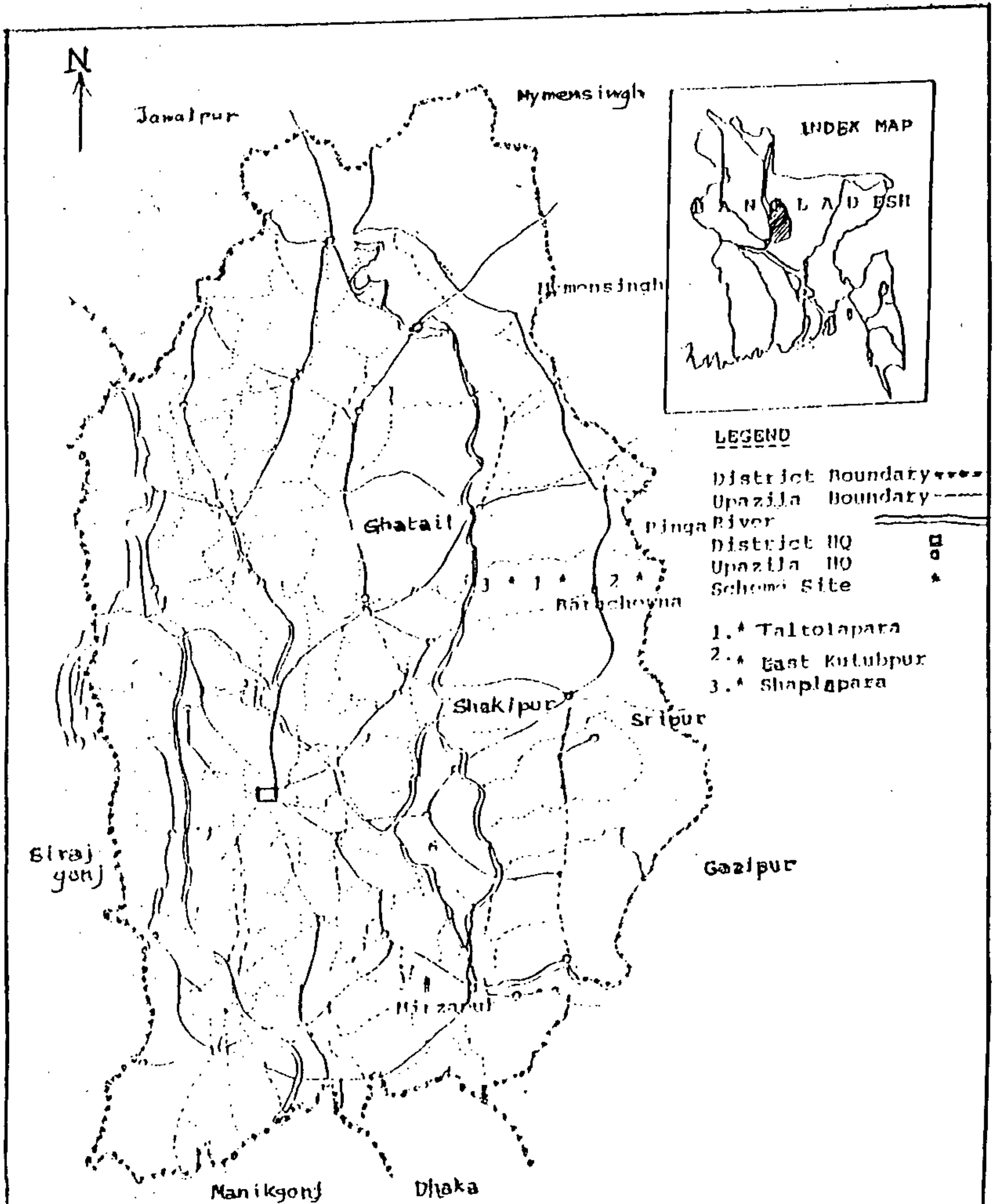

Fig. 7 Location map

For medium high land

B. Aus/T.Aus/Fallow-T.Aman - Fallow

After the installation of deep tubewell the cropping patterns have been changed. The present practices are :

For high land

B. Aus/T.Aus/Jute-T.Aman-Boro/Soybean

For medium high land

B. Aus/T.Aus/Fallow -T.Aman-Boro/Wheat/Fallow

Boro, Wheat, T. Aus and T. Aman cover about 20,34, 22 and 46 present of the total cultivated land, respectively.

The average family size in the study area is 6.4 which is a little bigger than the district average of 5.9. All farm category family labour is 64 percent of family size out of which 55 percent is male and 45 percent is female. Average farm size of landless, marginal, small, medium and large farmers is 0.089, 0.343, 0.723 1.519 and 3.975 ha respectively (Hossain et al 1990).

The most prevalent tenancy system is 1:1 sharing between the land owner and the crop sharer. Recently, Gramin Bank has introduced a new tenancy system in which the Bank supplies the irrigation water only and in return, it collects 25 percent of grain yield from the farmers and rest of the grain is shared equally by the land owner and the cultivator.

3.2 The Study Schemes

Three deep tubewell schemes with buried pipe systems under Tangail Agricultural Development Project were selected for this study. All the schemes are located in Shakipur Upazila. Detailed information on tubewells and pumps of these schemes is presented in Table 1.

Table 1 Information on deep tubewells of the selected schemes.

Item	Scheme		
	Taltolapara	Shaplapara	East Kutubpur
Tubewell			
Date of installation	28-04-1986	10-08-1986	13-03-1986
Total depth (m)	64.94	84.15	77.13
Pump setting depth (m)	22.26	21.34	22.87
Length of strainer (m)	29.39	30.49	30.49
Diameter of strainer (cm)	15.24	15.24	15.24
Pump Type	KSB B12 B/2	KSB B12 B/2	KSB B12 B/2
Number of stages	2	2	2
Design discharge (l/s)	56.60	56.60	56.60
Design RPM	1500	1500	1500
Prime mover Type	Horizontal Deutz-diesel F 2L- 912	Horizontal . Deutz-diesel F 3L- 912	Horizontal Deutz-diesel F 2L -912
Design RPM	2250	2250	2250
Design HP	27	32	27

All the selected schemes are operated under the farmers' co-operatives. The members pay half yearly bank instalment of Tk. 20,520.00 for a deep tubewell. A total of 13 installments are to be paid usually in a period of six years and a half. The amount of instalment is shared by the registered farmers on the basis of their irrigated lands irrespective of location. Pump driver's salary, repairing charge and oil costs are also collected from the farmers before the start of the season but the fuel is purchased by individual farmer.

Initially, these schemes had earthen channel distribution systems which were subsequently converted to buried pipe distribution systems. Some information on the selected buried pipe systems is presented in Table 2a

Some of the outlets are provided with earthen channels, usually 30-300 m long. These channels are designed to carry the entire pipe ;flow. Layouts showing pipes, outlets and airvents are shown in Figures 8a, 8b and 8c for Taltolapara, Shaplapara, and East Kutubpur, respectively.

Table 2a Information on buried pipe systems.

Item	Schemes		
	Taltolapara	Shaplapara	East Kutubpur
Date of Installation	Nov. 1988	Nov. 1988	Nov. 1987
Buried Pipe Length (m)			
45.72 cm dia	18.28	-	-
30.48 cm dia	236.67	-	782.57

Continued to page 27

27.94 cm dia	172.39	297.27	–
25.40 cm dia	1314.34	820.25	985.02
22.86 cm dia	417.22	626.73	–
20.32 cm dia	31.06	114.95	–
Total	2189.96	1859.20	1767.59
Height of Header Tank(m)	4.15	3.56	3.37
Diameter of Pump stand (m)	0.91	0.92	0.92
Number of check structure	–	–	2
Number of outlet	21	21	20
Number of airvent	20	21	19

3.3 Measurement of Water Losses in the Distribution System

Water losses in the buried pipes as well as the earthen channels originated from the outlets of the selected systems were measured during the Rabi season (October to March), 1989-90.

3.3.1 Buried Pipes

Water losses in the buried pipes were determined by both inflow-outflow and ponding methods.

3.3.1.1 Inflow-outflow Method

Engine rpm versus pump discharge curves for the selected deep tubewells were first developed by measuring the discharge at different engine rpm. The discharge of the tubewell was measured by noting the time to fill the pump stand of known volume (Appendix A). The developed curves are shown in Appendix B.

The pump was run at a certain rpm and the discharge at an

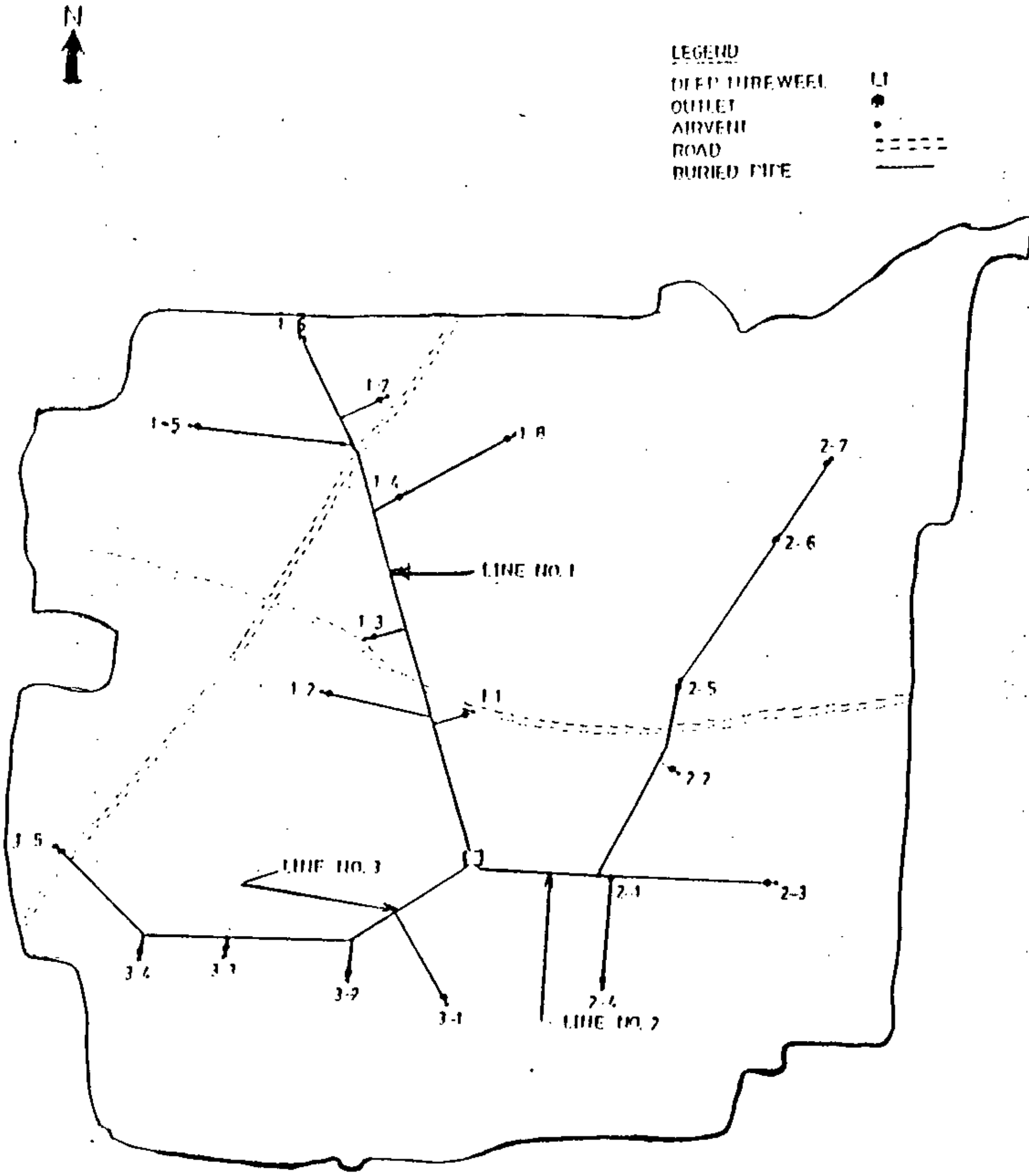

Fig 8a Buried Pipe Layout at Taltolapara

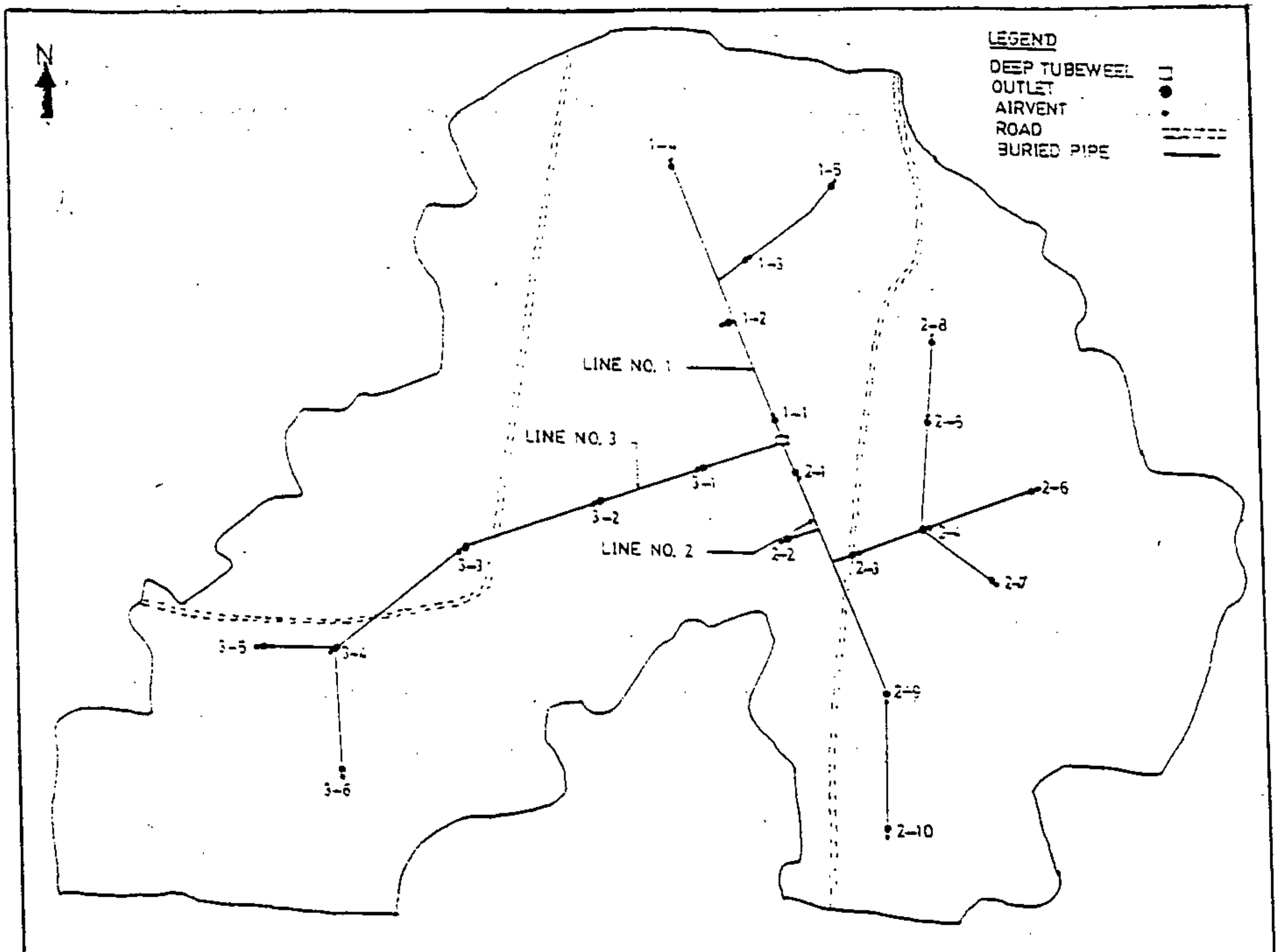

Fig. 8b Buried Pipe Layout at Shaplapara

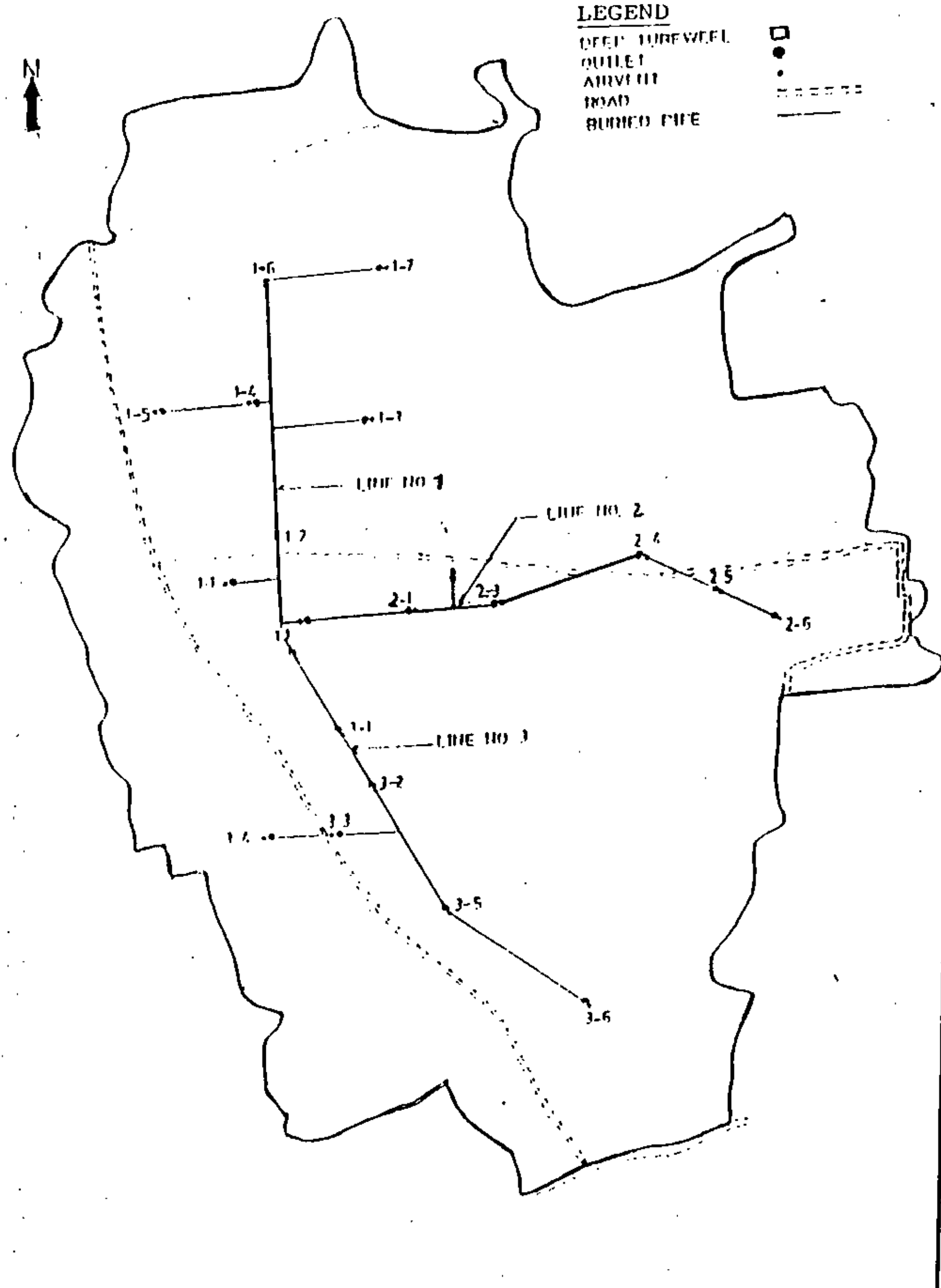

Fig. 8c Buried Pipe Layout at East Kutubpur

outlet near the end of main line was measured by a standard Cutthroat Flume (Skogerboe, 1973) of size 91.44 cm x 20.32 cm. The flume was set at a suitable position nearest to the outlet. The flume reading was taken when the flow became steady. The discharge of the pump at this specific rpm or the inflow was found out from the rpm-discharge curve. With the known length of the line under test, the inflow and the outflow, the loss of water per 100 m was calculated.

3.3.1.2 Ponding Method

The ponding test was carried out for 2 out of 3 main lines of Taltolapara and Shaplapara schemes. A flap valve was fitted at the end of pump discharge pipe. At first the pump stand was checked for any seepage losses which was found to be negligible for all the selected schemes. To run the test, the outlet valves on the line under test were closed. The pump stand and the line were filled by pumping water until overflow occurred through the airvents, when the pump was stopped and the flap valve closed automatically by water pressure. After sometime when the water level in pump stand stabilized, the drop of water level in the tank with time were recorded. Then the cumulative volume loss was calculated using the following equation :

$$V_c = 1000 \ L\pi (D^2 + n \ d^2)/4 \ \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where,

V_c = cumulative volume loss in the pump stand and the airvents, litre

D = internal diameter of the pump stand, m

d = internal diameter of an airvent, m

L = cumulative drop of water level in the pump stand, m

n = no. of airvents on the line under test.

The ponding test could not be performed for East Kutubpur scheme because the valves on the lines could not withstand the pressure.

3.3.2 Earthen Channels

It was mentioned earlier that the water was distributed from the outlets of the buried pipe system to the fields by earthen channels. Water losses in these channels were measured by inflow-outflow method. Two earthen channels from each of the schemes were selected to measure the water losses.

Two Cutthroat Flumes were set in a channel - Flume 1 near the outlet of buried pipe and Flume 2 a distance apart. The Flume readings were taken simultaneously when steady flow occurred in the channel. The distance between the two Flumes were measured. Then from the known Flume discharges and the distance between them, loss of water per 100 m was calculated using the following relationship:

$$CL = [(Q_1 - Q_2)/L] \times 100 \quad \text{.....................(2)}$$

Where,

CL = water loss in the channel, l/s/100 m

Q_1 = discharge in Flume 1, l/s

Q_2 = discharge in Flume 2, l/s

L = distance between the flumes, m

3.4 Water Distributions in the Scheme Areas

The uniformity of water distribution within the scheme area was determined by measuring the water delivered per unit of area at the head, middle and tail of the system. Six sample outlets representing the head, middle and tail of each system were selected for the purpose. A Cutthroat Flume was installed at each of these outlets and the total volume of water delivered from each outlet during the Rabi season of 1989-90 was measured. The total depth of water delivered from each outlet was then determined from the volume of water delivered and the area irrigated under the outlet.

3.5 Benefit-Cost Ratio

Benefit cost ratio is widely used to justify the economic feasibility of an irrigation project or scheme. In this study, the ratio was calculated from the selected schemes by dividing the incremental benefit of buried pipe system over that of earthen channel system by their incremental cost, i.e,

$$B/C = \text{Incremental Benefit} / \text{Incremental cost} \quad \ldots\ldots(3)$$

3.5.1 Cost

The annual cost of the buried pipe system includes the fixed cost and annual operation and maintenance cost. The fixed cost was obtained from the depreciation and the interest on investment for deep tubewell, buried pipe and earthen channel systems. The depreciation was calculated using the following equation (Michael,1981):

$$D = (P - S) / L \quad \ldots\ldots(4)$$

Where,
- D = depreciation, Tk/year
- P = initial cost of the system, Tk.
- S = salvage value, Tk.
- L = life of the system, year.

The initial costs of the deep tubewell, buried pipe and earthen channels were obtained from the secondary sources like

Tangail Agricultural Development Project and Bangladesh Rural Development Board and are shown in Table 2b.

Table 2b Initial cost of deep tubewell, buried pipe and earthen channel.

Name of the scheme	Initial cost ('000 Tk)*		
	Deep Tubewell	Buried Pipe	Earthen Channel
Taltolapara	731.25	304.64	39.42
Shaplapara	731.25	230.72	33.47
East Kutubpur	731.25	277.90	31.82

* Including 12.5 percent engineering cost.

The salvage value was considered nil for buried pipe and earthen channel systems and 10 percent of deep tubewell cost (Singh,1977). The life of a deep tubewell was considered 12 years with buried pipe system and 15 years with earthen channel system and those of buried pipe and earthen channel systems were taken as 30 years and 50 years respectively (Ahammed, 1984 and Gisselquist,1989). The interest on investment was calculated by the following equation (Singh, 1977):

$$I = \{ (P + S) / 2 \} \times i \quad \ldots\ldots (5)$$

Where,
- I = interest on investment, Tk/year
- i = bank interest rate, 16 percent a year
- P = initial cost of the system, Tk.
- S = salvage value, Tk.

The data on annual operation and maintenance costs of the systems were collected from the scheme managers. The crop production costs like land preparation cost, seed, manure and fertilizer costs, insecticide and pesticide cost, intercultural operation and harvesting costs were collected from the farmers, scheme managers and the local markets. The annual repair cost of earthen channel was considered to be Tk. 4 per metre length of the channel (Gisselquist, 1989). All cost items are shown in Appendix D. The incremental system cost of buried pipe was obtained as the difference between the system costs of buried pipes and earthen channels.

3.5.2 Benefit

The benefit of the buried pipes was calculated from the additional area that could be irrigated by using the water saved and the net return per hectare. This additional area was determined as follows :

It is known that, not all water which leaks from a channel is wasted. Some plots adjacent to frequently used sections of feeder channel are never irrigated directly, but receive sufficient water from leakage through holes and cracks and seepage. About 50 to 70 percent of the visible water losses is wasted (Rashid et al.,1991). Therefore, it was assumed that 40 percent of the visible loss was utilized in the adjacent plots to the feeder channel (Table 1 of Appendix C). However, for the buried pipes, all the visible losses were considered wasted as the pipes were laid at a depth of around 3.0 m from the soil surface.

The amount of water saved in buried pipe over earthen channel was found by considering the net water losses in both the buried pipes and earthen channels. First, the percentage of water utilized in both the systems was calculated separately by considering 100 m, 300 m, and 500 m long sections of pipes and channel (Tables 1 and 3 of Appendix C). Then the percent water utilized in earthen channel was subtracted from that in buried pipe to obtained percent water saved in buried pipe system (Table 4 of Appendix C).

The net return per hectare was obtained as the difference of the gross return and the production cost. Table 2c shows the calculation of net return.

Since, the calculated additional area would produce some returns (Appendix E) against some production costs (Appendix D) under non-irrigated condition, the net benefit from additional area irrigated was calculated by subtracting the net benefit of non-irrigated condition from that of buried pipe irrigation. It should be mentioned here that the yields of crop (Appendix F) for non-irrigated condition were obtained from Bangladesh Bureau of Statistics, 1983 for the location.

Table 2c Acreage, yield, production cost and net return of crops grown in Rabi and Kharif seasons of 1989-90.

Season/ Crop	Area (ha)	Yield (t/ha)	Unit Price ('000 Tk)	Gross Return ('000 Tk)	Production Cost ('000 Tk)	Net Return ('000 Tk)
Taltolapara						
<u>Rabi Season</u>						
Wheat	6.74	1.71	6.00	69.15	33.69	35.46
Boro	4.12	3.40	6.50	91.05	30.02	61.03
Watermelon	1.96	35.58	4.00	278.95	15.58	263.37
Chilli	1.36	4.37	10.00	59.43	16.37	43.06
Soybean	1.04	8.30	10.00	86.32	9.78	76.54
Banana	1.05	49.72	5.00	261.03	22.59	238.44
Others	2.61	-	-	48.23	27.05	21.18
Total	18.88	-	-	894.16	155.08	739.08
Return or Cost per ha.				47.36	8.21	39.15
Kharif Season						
T.Aman	18.90	3.51	7.00	416.75	137.23	279.52
T.Aus	16.10	2.05	6.50	214.53	107.38	107.15
Jute	0.80	1.68	6.00	8.06	8.56	-0.50
Others	1.70	-	-	29.22	11.95	17.27
Total	37.50	-	-	668.56	265.12	403.44
Return or cost per ha.		-	-	17.83	7.07	10.76
Shaplapara						
<u>Rabi Season</u>						
Wheat	5.53	1.78	6.00	59.06	27.63	31.43
Boro	4.11	3.40	6.50	90.83	29.93	60.90
Watermelon	3.72	31.50	4.00	468.72	29.48	439.24
Chilli	1.04	4.41	10.00	45.86	14.89	30.97
Soybean	1.55	7.56	10.00	117.18	14.73	102.45
Banana	1.71	48.12	5.00	411.42	37.76	373.66
Others	3.00	-	-	62.82	32.13	30.69
Total	20.66	-	-	1255.89	186.55	1069.34
Return or Cost per ha.				60.79	9.03	51.76
<u>Kharif Season</u>						
T.Aman	21.94	2.99	7.00	459.20	159.38	299.82
B.Aus	8.20	1.34	6.50	71.42	50.21	21.21
T.Aus	5.80	1.65	6.50	62.21	38.68	23.53
Banana	1.13	20.72	5.00	117.07	27.67	89.40
Jute	1.00	1.25	6.00	7.50	11.45	-3.95
Others	3.28	-	-	60.95	24.83	36.12
Total	41.42	-	-	778.35	312.22	466.13
Return or cost per ha.		-	-	18.79	7.54	11.25

East Kutubpur						
Rabi Season						
Wheat	3.66	1.86	6.00	40.85	17.99	22.86
Boro	0.17	3.59	6.50	3.97	1.22	2.75
Watermelon	0.90	36.38	4.00	130.97	12.30	118.67
Chilli	0.86	4.37	10.00	37.58	10.09	27.49
Soybean	0.90	8.12	10.00	73.08	8.55	64.53
Banana	0.87	40.86	5.00	177.74	19.13	158.61
Others	1.89	-	-	96.26	19.97	76.29
Total	9.25	-	-	560.45	89.25	471.20
Return or Cost per ha.				60.59	9.65	50.94
Kharif Season						
T.Aman	13.50	3.12	7.00	294.84	98.05	196.79
B.Aus	9.17	1.29	6.50	76.89	56.54	20.35
T.Aus	6.70	1.77	6.50	77.08	46.01	31.07
Mashkalai	3.42	1.20	25.00	102.60	16.95	85.65
Jute	3.23	1.56	6.00	30.23	34.27	-4.04
Others	1.26	-	-	20.70	8.52	12.18
Total	37.28	-	-	602.34	260.34	342.00
Return or cost per ha.	-		-	16.16	6.98	9.17

However, the cost parameters and their amounts for non-irrigated condition were obtained through farmers' interview and the prices of items were obtained from the market.

Thus, knowing the incremental benefit and the incremental cost, the system benefit cost ratio of buried pipe irrigation distribution system was obtained from equation (3).

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Water Distribution Losses

The water losses in the selected buried pipe systems as measured by inflow-outflow method are shown in Table 3. It is seen that the highest loss of 1.70 l/s/100 m occurred in East Kutubpur scheme and the lowest (0.45 l/s/100 m) in Shaplapara scheme.

Table 3. Water losses in buried pipes measured by inflow-outflow method.

Name of the scheme	Pipe line no.	Length of line (m)	Pump discharge (l/s)	Outlet discharge (l/s)	Water loss (l/s/100 m)
Taltolapara	1	919.00	52.6	44.73	0.86
	3	527.47	52.6	48.10	0.85
Shaplapara	1	396.99	37.01	34.67	0.59
	2	838.68	37.01	34.39	0.31
East Kutubpur	1	668.55	40.07	29.97	1.51
	2	583.15	40.07	29.05	1.89

The loss measured by ponding method was found 0.59 l/s/100 m in Taltolapara and 0.14 l/s/100 m in Shaplapara schemes (Table 4).

The water losses from the buried pipes were different for different schemes. This was due the fact that, the hand made cement concrete pipes were used in East Kutubpur Scheme and the spun pipes together with some hand made pipes were used in Taltolapara and Shaplapara schemes. The spun pipes being better in quality prevented higher losses in pipes at Taltolapara and Shaplapara schemes. Besides, the East Kutubpur scheme was one of the oldest buried pipe scheme of Tangail Agricultural Development Project and therefore, relatively unimproved technology was used which resulted in higher water losses. Moreover, the poor outlet and valve condition, and inferior pipe joints were responsible for such higher losses in East Kutubpur scheme.

Table 4. Water loss in buried pipes measured by ponding method

Name of scheme	Pipe line no.	Length of the line (m)	Water level in the pump stand (m)		Total volume lost (l)	Time period (min)	Water loss (l/s/100 m)
			at the beginning	at the end			
Taltolapara	1	919.00	1.74	0.05	1360.0	4.0	0.62
			1.72	0.01	1340.0	3.5	0.69
	3	527.47	1.97	0.03	1460.0	9.0	0.50
			2.03	0.04	1500.0	9.0	0.53
Shaplapara	1	396.99	2.14	0.08	1522.0	30.0	0.21
			2.13	0.14	1470.0	30.0	0.21
	2	838.68	1.78	0.01	1200.0	38.0	0.06
			1.76	0.01	1185.0	38.0	0.06

From both the tables above, it is seen that the losses measured by inflow-outflow method was higher than that measured by ponding method for the individual scheme. This was due to the fact that, in ponding method, the water level in the pump stand during data collection was much below the normal operating level. On the other hand, in inflow-outflow method, the water level in the pump stand was maintained at normal working level.

Table 5 shows the water losses in earthen channels for the three schemes. The loss was found highest (7.72 l/s/100 m) in Taltolapara scheme and the lowest (4.38 l/s/100 m) in Shaplapara scheme. This was due to higher leakage of water through the cracks and rat holes in the earthen channels in Taltolapara. Also the water logging in some sections of the channels enhanced higher water losses.

Table 5. Water loss in earthen channel measured by inflow-outflow method.

Name of the scheme	Channel originated from outlet	Length of the channel section(m)	Inflow (l/s)	Outflow (l/s)	Water loss (l/s/100m)
Taltolapara	1 - 6	150	40.66	28.72	7.96
	3 - 5	100	44.84	37.36	7.48
Shaplapara	1 - 3	120	32.60	27.42	4.32
	2 - 10	80	31.80	28.25	4.44
East Kutubpur	1 - 6	100	27.45	23.00	4.45
	2 - 6	120	27.15	21.68	4.56

Table 6 shows that for all the selected schemes, the loss (4.38 l/s/100 m to 7.72 l/s/100 m) was higher in earthen channels than that (0.45 l/s/100 m to 1.70 l/s/100 m) in buried pipes.

Table 6. Average water losses (l/s/100m) in buried pipes and earthen channels

Name of schemes	Conveyance system	Method of measurement	
		inflow - outflow	ponding
Taltolapara	Earthen Channel	7.72	-
	Buried Pipe	0.86	0.59
Shaplapara	Earthen Channel	4.38	-
	Buried Pipe	0.45	0.14
East Kutubpur	Earthen Channel	4.50	-
	Buried Pipe	1.70	-

4.2 Water Distributions in the Selected Scheme Areas

Table 7 shows the depth of water distribution to different outlet areas of the selected schemes for the Rabi season of 1989-90.

Table 7. Water distribution in the selected buried pipe schemes areas.

Name of the scheme	Outlet no.	Location of outlet	Area irrigated by the outlet	Volume of water delivered	Depth of water applied
Taltolapara	1 - 1	Head	0.52	0.18	0.35
	1 - 4	Middle	0.96	0.31	0.32
	1 - 5	Tail	1.09	0.37	0.34
	3 - 1	Head	0.70	0.23	0.33

Continued to page 42

	3 - 3	Middle	0.96	0.33	0.34
	3 - 5	Tail	0.46	0.16	0.35
Shaplapara	1 - 1	Head	1.71	0.58	0.34
	1 - 3	Middle	1.29	0.43	0.33
	1 - 5	Tail	0.91	0.28	0.31
	2 - 1	Head	0.37	0.13	0.35
	3 - 9	Middle	0.79	0.27	0.34
	2 -10	Tail	1.45	0.48	0.33
East Kutubpur	1 - 1	Head	0.48	0.07	0.15
	1 - 3	Middle	0.90	0.13	0.14
	1 - 6	Tail	1.13	0.16	0.14
	2 - 2	Head	0.48	0.06	0.13
	2 - 4	Middle	0.33	0.04	0.12
	2 - 6	Tail	0.54	0.06	0.11

It was found that the distribution was nearly uniform in Taltolapara and Shaplapara schemes but non-uniform in East Kutubpur scheme areas. But the distribution of water in East Kutubpur scheme area was found to vary considerably from the head end to the tail end of the pipe lines. This might be due to considerable water losses in the pipe line. Faulty outlets also created problems in the distribution system.

4.3 Benefit-Cost Ratio

Table 8 shows the benefit-cost ratio of the individual scheme. All the three schemes are found economically attractive as the B/C value is greater than 1.0 for each scheme. Among the schemes, Shaplapara has the highest B/C value (7.35) and East Kutubpur the lowest (1.09).

Table 8 Benefit cost ratios of the selected schemes.

Name of the scheme	Annual cost of buried pipe system ('000 Tk.)	Annual cost of earthen channel system ('000 Tk.)	Incremental cost of buried pipe system ('000 Tk.)	Incremental system benefit ('000 Tk.)	Benefit-Cost Ratio (B/C)
Taltolapara	220.77	182.97	37.80	225.19	5.96
Shaplapara	189.34	158.77	30.57	224.76	7.35
East Kutubpur	200.18	144.28	55.90	60.96	1.09

The loss of water in the pipe lines at Shaplapara was the lowest that encouraged the tail end farmers to irrigate the crops adequately thereby increasing the command area. But the situation was reverse at East Kutubpur. Frequent breakdown of engine at this site made the farmers uncertain to rely on timely water supply. Besides, the farmers of East Kutubpur were economically very poor and their social conflicts were much higher than that of other two schemes. All these constraints eventually reduced the command area of East Kutubpur Scheme to only 9.25 hectare in the Rabi season of 1989-90. Hence the gross return of the scheme was the minimum, and as a result, there was a wide variation in the B/C values among the selected schemes.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

From this study the following conclusions can be made :

1. The water loss in buried pipe system is only 10 to 38 percent of that in earthen channel system when measured by inflow-outflow method and about 3 to 8 percent when measured by ponding method.
2. The water distribution is nearly uniform in Taltolapara and Shaplapara scheme areas but non-uniform in East Kutubpur scheme area.
3. All the buried pipe schemes are found economically attractive.

5.2 Recommendations

1. The study should be repeated with other buried pipe schemes at different locations to evaluate their performances.
2. Quality materials should be used in proper proportions for the construction of concrete pipes. Extra care should be taken to install the pipes and to make their joints for leakproofness. Also the outlet valves should be of standard quality.
3. A comparative economic analysis should be done with buried pipe, earthen channel and lined channel systems.

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APPENDISES

APPENDIX A

Discharge Measurement of Deep Tubewell

Scheme : Taltolapara

Engine RPM : 1600

Water ht.in PS* (m)	Volume of water (l)	Time (sec)			Discharge (l/s)			Average discharge (l/s)
		I	II	III	I	II	III	
2.15	1397.50	39	40	40	35.83	34.94	34.94	35.23
2.65	1722.50	49	50	50	35.15	34.45	34.45	34.68
3.13	2047.50	60	59	60	34.18	34.70	34.21	34.31
3.65	2372.50	70	70	70	33.89	33.89	33.89	33.89

Average = 34.53 l/s

Engine RPM : 1720

Water ht.in PS (m)	Volume of water (l)	Time (sec)			Discharge (l/s)			Average discharge (l/s)
		I	II	III	I	II	III	
2.15	1397.50	30	30	30	46.58	46.58	46.58	46.58
2.65	1722.50	38	37	38	45.33	46.55	45.33	45.74
3.15	2047.50	45	46	44	45.50	44.51	46.53	45.51
3.65	2372.50	54	53	54	43.94	44.76	43.94	44.21

Average= 45.51 l/s

Engine RPM : 1900

Water ht.in PS (m)	Volume of water (l)	Time (sec)			Discharge (l/s)			Average discharge (l/s)
		I	II	III	I	II	III	
2.15	1397.50	27	27	27	51.76	51.76	51.76	51.76
2.65	1722.50	35	34	34	49.21	50.66	50.66	50.17
3.15	2047.50	40	39	39	51.15	52.50	52.50	52.06
3.65	2372.50	46	46	47	51.57	51.57	50.47	51.20

*** PS = Pump Stand**

Average= 51.29 l/s

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Engine RPM : 2000

Water ht.in PS (m)	Volume of water (l)	Time (sec)			Discharge (l/s)			Average discharge (l/s)
		I	II	III	I	II	III	
2.15	1397.50	27	27	26	51.75	51.75	53.75	52.42
2.65	1722.50	33	34	32	52.19	50.66	53.83	52.22
3.15	2047.50	39	38	38	52.50	53.88	53.88	53.42
3.65	2372.50	45	46	44	52.72	51.57	53.92	52.72

Average= 52.67 l/s

Scheme : Shaplapara

Engine RPM : 1640

Water ht.in PS (m)	Volume of water (l)	Time (sec)			Discharge (l/s)			Average discharge (l/s)
		I	II	III	I	II	III	
1.56	1029.60	43	43	42	23.94	23.94	24.51	24.13
2.06	1359.60	57	56	57	23.85	24.28	23.85	23.99
2.56	1689.60	70	71	70	24.14	23.80	24.14	24.03
3.06	2019.60	84	83	83	24.04	24.33	24.33	24.23

Average = 24.10 l/s

Engine RPM : 1830

Water ht.in PS (m)	Volume of water (l)	Time (sec)			Discharge (l/s)			Average discharge (l/s)
		I	II	III	I	II	III	
1.56	1029.60	28	27	28	36.77	38.13	36.77	37.22
2.06	1359.60	35	36	37	38.85	37.77	36.74	37.78
2.56	1689.60	45	45	46	37.54	37.54	36.73	37.27
3.06	2019.60	56	57	57	35.06	35.43	35.43	35.64

Average = 36.98 l/s

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Engine RPM : 1890

Water ht.in PS (m)	Volume of water (l)	Time (sec)			Discharge (l/s)			Average discharge (l/s)
		I	II	III	I	II	III	
1.56	1029.60	27	26	26	38.13	39.60	39.60	39.10
2.06	1354.60	32	33	31	42.48	41.20	43.85	42.51
2.56	1689.60	40	41	41	42.24	41.20	41.20	41.55
3.06	2019.60	52	53	53	38.84	38.10	38.10	38.35

Average = 40.38 l/s

Engine RPM : 2020

Water ht.in PS (m)	Volume of water (l)	Time (sec)			Discharge (l/s)			Average discharge (l/s)
		I	II	III	I	II	III	
1.56	1029.60	23	22	22	44.76	46.80	46.80	46.12
2.06	1359.60	29	30	30	46.88	45.32	45.32	45.84
2.56	1689.60	36	36	37	46.93	46.93	45.66	46.51
3.06	2019.60	44	44	43	45.90	45.90	46.97	46.26

Average = 46.18 l/s

Scheme : East Kutubpur

Engine RPM : 1510

Water ht.in PS (m)	Volume of water (l)	Time (sec)			Discharge (l/s)			Average discharge (l/s)
		I	II	III	I	II2	III	
0.14	89.60	3.58	3.60	3.56	25.03	24.89	25.17	25.03
0.64	409.60	16.38	16.40	16.35	25.00	24.28	25.05	25.01
1.14	729.60	29.20	29.17	29.22	24.98	25.01	24.97	24.97
1.64	1049.60	41.98	41.90	41.96	25.00	25.05	25.01	25.02

Average = 25.00 l/s

Continued to page 51

Engine RPM : 1550

Water ht.in PS (m)	Volume of water (l)	Time (sec)			Discharge (l/s)			Average discharge (l/s)
		I	II	III	I	112	III	
0.14	89.60	2.97	2.94	2.94	30.17	30.50	30.50	30.39
0.64	409.60	13.74	13.73	13.77	29.81	29.83	29.74	29.80
1.14	729.60	24.32	24.20	24.20	30.00	30.15	30.15	30.10
1.64	1049.60	35.10	35.28	35.57	29.90	29.75	29.51	29.72

Average = 30.00 l/s

Egine RPM : 1625

Water ht.in PS (m)	Volume of water (l)	Time (sec)			Discharge (l/s)			Average discharge (l/s)
		I	II	III	I	II	III	
0.14	89.60	2.55	2.52	2.52	35.14	35.56	35.56	35.42
0.64	409.60	11.70	11.76	11.65	35.00	34.83	35.16	35.00
1.14	729.60	20.72	20.75	20.70	35.21	35.16	35.25	35.21
1.14	1049.60	29.82	29.85	29.80	35.20	35.16	35.22	35.19

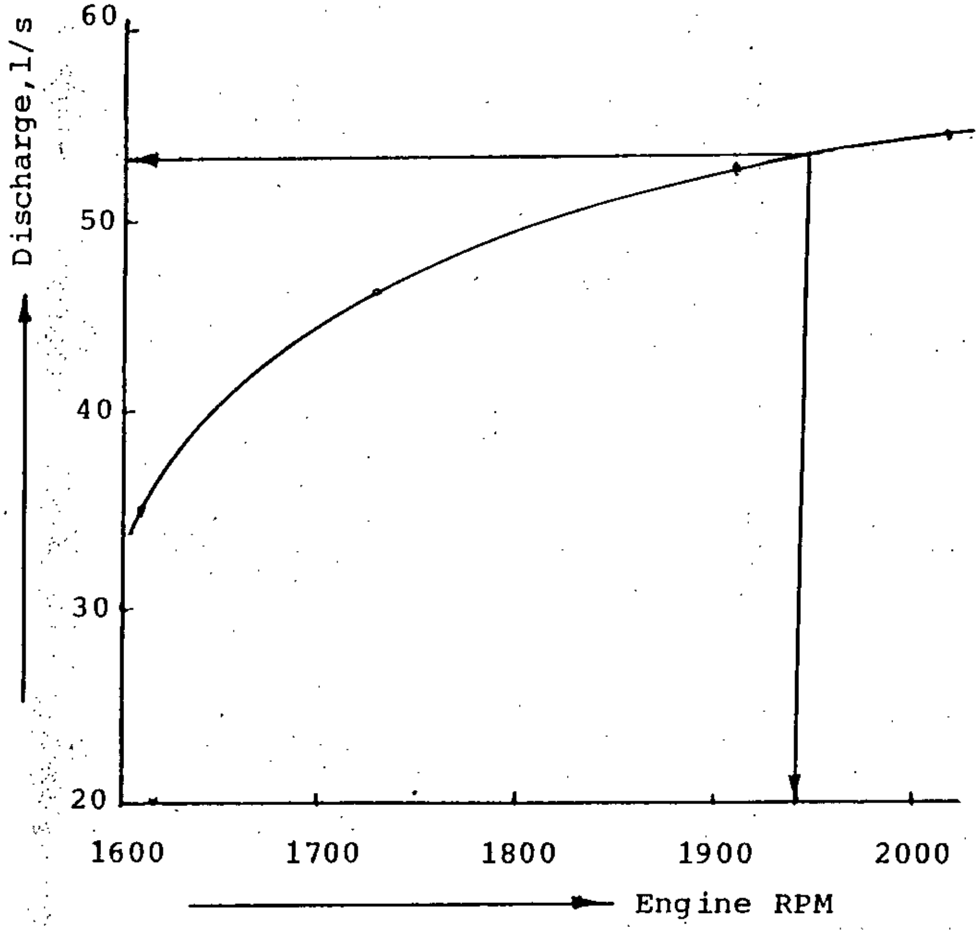
Average = 35.21 l/s

Engine RPM : 1700

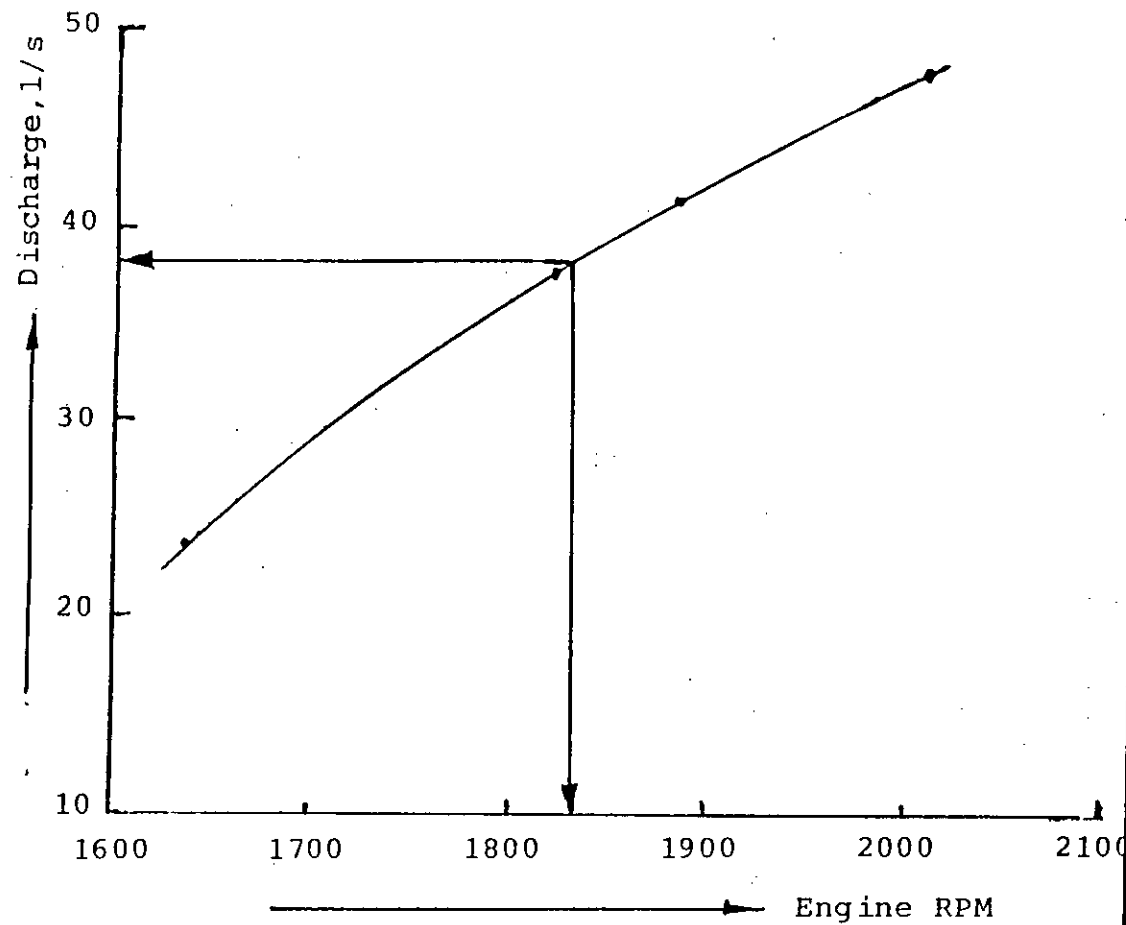
Water ht.in PS (m)	Volume of water (l)	Time (sec)			Discharge (l/s)			Average discharge (l/s)
		I	II	III	I	II	III	
0.14	89.60	2.24	2.22	2.25	40.0	40.36	39.82	40.06
0.64	409.60	10.20	10.21	10.19	40.16	40.12	40.20	40.16
1.14	729.60	18.20	18.24	18.18	40.09	40.00	40.13	40.07
1.64	1049.60	26.25	26.27	26.24	39.98	39.95	40.00	39.98

Average = 40.07 l/s

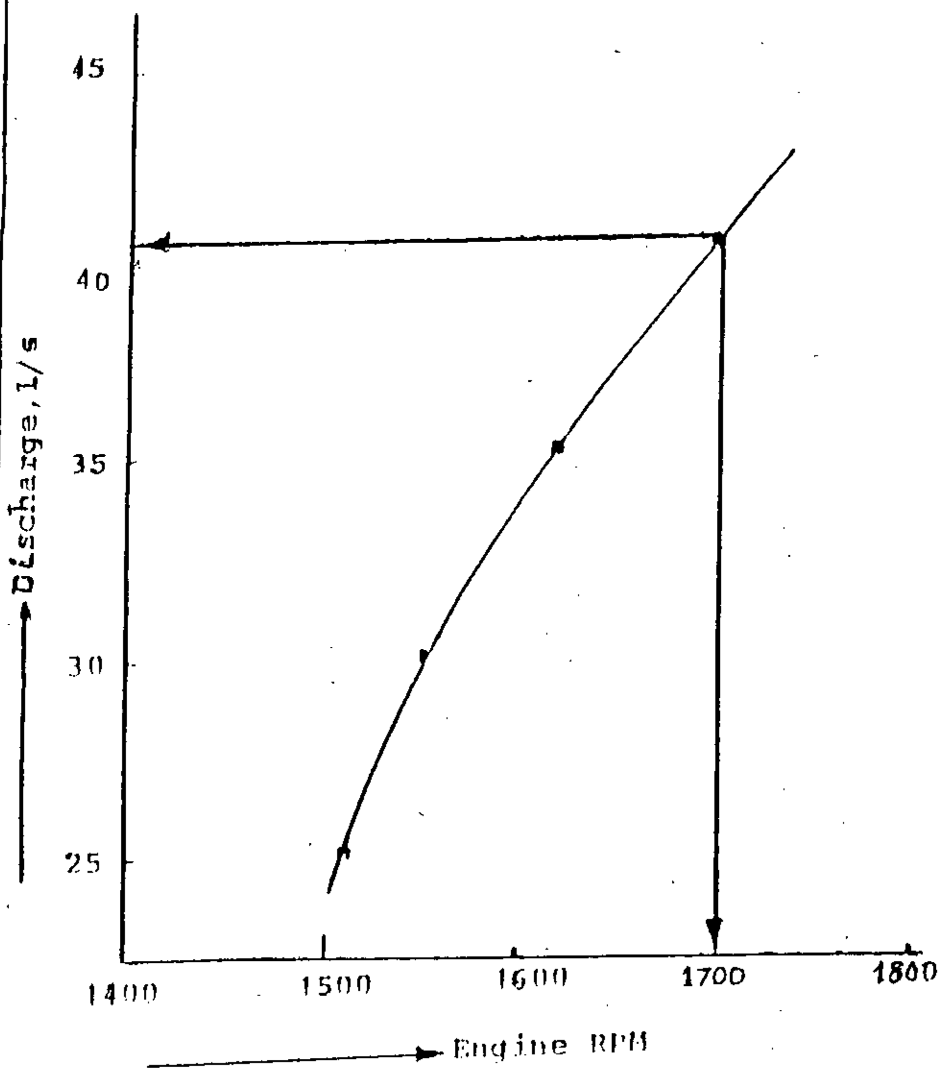
APPENDIX B



Discharge Vs Engine RPM at Taltolapara



Discharge Vs Engine RPM at Shaplapara



Discharge Vs Engine RPM at East Kutubpur

APPENDIX C

Water Loss, Water Saved and Benefit from Saved Water

Table 1 Net Water Loss from Earthen Channel

Name of scheme	Line no.	Observed water loss (l/s/100m)	Water utilized by the adjacent field (l/s/100m)	Net water loss from earthen channel (l/s/100m)	Average net water loss (l/s/100m)
Taltola-para	1	7.96	3.18	4.78	
	3	7.48	2.99	4.49	4.64
Shapla-para	1	4.32	1.73	2.59	
	2	4.44	1.78	2.66	2.63
East-Kutubpur	1	4.45	1.78	2.67	
	2	4.56	1.82	2.74	2.71

Table 2 Percentage of Water Utilized in Buried Pipe System

Name of the scheme	Line no.	Section length (m)	Pump discharge (l/s)	Rate of net water loss (l/s/100m)	Total loss (l/s)	Percentage of water utilized (%)	Average utilization (%)
Taltolapara	1	100	52.6	0.86	0.86	98.37	
	3	100	52.6	0.85	0.85	98.38	98.38
2	1	300	52.6	0.86	2.58	95.10	
	3	300	52.6	0.85	2.55	95.15	95.13
	1	500	52.6	0.86	4.30	91.83	
	3	500	52.6	0.85	4.25	91.92	91.88
							Average: 95.13%
Shaplapara	1	100	37.01	0.59	0.59	98.41	
	2	100	37.01	0.31	0.31	99.16	98.79
	1	300	37.01	0.59	1.77	95.22	
	2	300	37.01	0.31	0.93	97.49	96.36
	1	500	37.01	0.59	2.95	92.03	
	2	500	37.01	0.31	1.55	95.81	93.92
							Average: 96.36%
East-Kutubpur	1	100	40.07	1.51	1.51	96.23	
	2	100	40.07	1.89	1.89	95.28	95.76
	1	300	40.07	1.51	4.53	88.69	
	2	300	40.07	1.89	5.67	85.85	87.27
	1	500	40.07	1.51	7.55	81.16	
	2	500	40.07	1.89	9.45	76.42	78.79

Average : 87.27%

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Table 3 Percentage of Water Utilized in Earthen Channel System

Name of the scheme	Line no.	Section length (m)	Pump discharge (l/s)	Rate of net water loss (l/s/100m)	Total loss (l/s)	Percentage of water utilized (%)	Average utilization (%)
Taltolapara	1	100	52.6	4.78	4.78	90.91	
	3	100	52.6	4.49	4.49	91.46	91.19
	1	300	52.6	4.78	14.34	72.74	
	3	300	52.6	4.49	13.47	74.39	73.57
	1	500	52.6	4.78	23.90	54.56	
	3	500	52.6	4.49	22.45	57.32	55.94
						Average:	73.57%
Shaplapara	1	100	37.01	2.59	2.59	93.00	
	2	100	37.01	2.49	2.49	93.27	93.14
	1	300	37.01	2.59	7.77	79.01	
	2	300	37.01	2.49	7.47	79.82	79.42
	1	500	37.01	2.59	12.95	65.01	
	2	500	37.01	2.49	12.45	66.36	65.73
						Average	:79.43%
East-Kutubpur	1	100	40.07	2.67	2.67	93.34	
	2	100	40.07	2.74	2.74	93.16	93.25
	1	300	40.07	2.67	8.01	80.01	
	2	300	40.07	2.74	8.22	79.49	79.75
	1	500	40.07	2.67	13.35	66.68	
	2	500	40.07	2.74	13.90	65.81	66.24
						Average :	79.75%

Table 4 Percentage of Water Saved in Buried Pipe System over Earthen Channel

Name of the scheme	Percentage of Water Utilized in		Percentage of water saved in buried pipes
	Buried Pipes	Earthen Channel	
Taltolapara	95.13	73.57	21.56
Shaplapara	96.36	79.43	16.93
East Kutubpur	87.27	79.75	7.52

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Table 5 Additional Area Irrigated by Buried Pipe System with Saved Water.

Name of the scheme	Actual Water Utilized (%)	Area Irrigated(ha) in Rabi	Area Irrigated(ha) in Kharif(I & II)	Percentage of water saved in buried pipe	Additional Area Irrigated(ha) Rabi	Additional Area Irrigated(ha) Kharif (I & II)
Taltola-para	95.13	18.88	37.50	21.56	4.28	8.50
Shapla-para	96.36	20.66	41.42	16.93	3.63	7.28
East-Kutubpur	87.27	9.25	37.28	7.52	0.80	3.21

Table 6 Incremental Benefit from Additional Area Irrigated by Buried Pipe Systems.

Name of the scheme	Additional Area Irrigated (ha) by Buried Pipes		Net Return per ha ('000Tk) for irrigated condition		Net Return per ha ('000Tk) for non-irrigated condition		Total Incremental Benefit ('000Tk)
	Rabi	Kharif(I&II)	Rabi	Kharif(I&II)	Rabi	Kharif(I&II)	
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h) = [b(d-f) + c(e-g)]
Taltola-para	4.28	8.50	39.15	10.76	5.78	1.07	259.19
Shapla-para	3.63	7.28	51.76	11.25	7.57	2.41	269.79
East-Kutubpur	0.80	3.21	50.94	9.17	6.56	1.24	70.19

APPENDIX D

Cost Involvement in Buried Pipe & Earthen Channel Systems and Non-irrigated Condition.

i) Buried Pipe System Cost

Cost Parameter	Taltolapara ('000 Tk)	Shaplapara ('000 Tk)	East Kutubpur (' 000 Tk)
Fixed Cost			
Deep Tubewell			
i) Depreciation	54.83	54.83	54.83
ii) Interest on Investment	64.34	64.34	64.34
Buried Pipe			
i) Depreciation	10.15	7.69	9.26
ii) Interest on Investment	24.37	18.46	22.23
Total Fixed Cost per year	153.69	145.32	150.66
Variable Cost			
i) Fuel & Oil Cost	57.48	35.02	22.43
ii) R & M Cost of the System	5.02	4.26	23.73
iii) Operator's Wage	4.58	4.74	3.36
Total variable cost per year	67.08	44.02	49.52
Total system cost per year	220.77	189.34	200.18

i) Earthen Channel System Cost

Cost Parameter	Taltolapara ('000 Tk)	Shaplapara ('000 Tk)	East Kutubpur ('000 Tk)
Fixed Cost			
Deep Tubewell			
i) Depreciation	43.88	43.88	43.88
ii) Interest on Investment	64.34	64.34	64.34

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Earthen Channel			
i) Depreciation	0.79	0.67	0.64
ii) Interest on Investment	3.15	2.68	2.55
Total Fixed Cost per year	112.16	111.57	111.42
Variable Cost			
i) Fuel & Oil Cost	57.48	35.02	22.43
ii) R & M Cost of the System	8.75	7.44	7.07
iii) Operator's Wage	4.58	4.74	3.36
Total variable cost per year	70.81	47.20	32.86
Total system cost per year	182.97	158.77	144.28

Crop Production Cost for Buried Pipe System during 1989-90 Rabi Season.

Scheme : Taltolapara

Crop	Area irrigated (ha)	Land preparation cost ('000 Tk)	Price of seed ('000 Tk)	Labour cost ('000 Tk)	Manure & fertilizer cost('000 Tk)	Insecticide cost ('000 Tk)	Total cost* ('000 Tk.)
1.Boro	4.12	6.78	1.03	16.87	4.44	0.90	30.02
2.Wheat	6.74	11.10	5.93	11.56	4.55	0.55	33.69
3.Water-melon	1.96	4.03	6.37	3.43	1.32	0.43	15.58
4.Chilli	1.36	4.48	0.61	10.00	1.12	0.16	16.37
5.Banana	1.05	1.30	5.56	4.93	9.80	1.00	22.59
6.Soybean	1.04	1.28	0.60	7.00	0.85	0.05	9.78
7.Others	2.61	5.21	6.56	10.34	4.48	0.46	27.05
Total Cost/ha.	18.88	34.18	26.66	64.13	26.56	3.55	155.08 8.21

* Full cost basis

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Scheme : Shaplapara

Crop	Area irrigated (ha)	Land preparation cost ('000 Tk)	Price of seed ('000 Tk)	Labour cost ('000 Tk)	Manure & fertilizer cost('000 Tk)	Insecticide cost ('000 Tk)	Total cost* ('000 Tk.)
1.Wheat	5.53	9.10	4.87	9.48	3.73	0.45	27.63
2.Boro	4.11	6.77	1.02	16.80	4.44	0.90	29.93
3.Water-melon	3.72	7.65	12.00	6.51	2.50	0.82	29.48
4.Banana	1.71	2.11	9.51	8.44	15.99	1.71	37.76
5.Soybean	1.55	1.91	0.89	10.58	1.27	0.08	14.73
6.Chilli	1.04	3.42	0.47	10.01	0.86	0.13	14.89
7.Others	3.00	5.97	6.69	13.50	5.56	0.41	32.13
Total Cost/ha.	20.66	36.93	35.45	75.32	34.35	4.50	186.55 9.03

* Full cost basis

Scheme : East Kutubpur

Crop	Area irrigated (ha)	Land preparation cost ('000 Tk)	Price of seed ('000 Tk)	Labour cost ('000 Tk)	Manure & fertilizer cost('000 Tk)	Insecticide cost ('000 Tk)	Total cost* ('000 Tk.)
1.Wheat	3.66	6.02	3.22	6.28	2.47	-	17.99
2.Water-melon	0.90	1.85	2.92	1.58	5.95	-	12.30
3.Soybean	0.90	1.11	0.51	6.14	0.74	0.05	8.55
42.Banana	0.87	1.07	4.84	4.29	8.10	0.83	19.13
5.Chilli	0.86	2.83	0.38	6.09	0.70	0.09	10.09
6.Boro	0.17	0.27	0.04	0.70	0.18	0.03	1.22
7.Others	1.89	3.52	4.59	7.25	4.28	0.33	19.97
Total Cost/ha.	9.25	16.67	16.50	32.33	22.42	1.30	89.25 9.65

* Full cost basis

Crop Production Cost for Buried Pipe System during 1989-90 Kharif (I & II) Season

Scheme : Taltolapara

Crop	Area irrigated (ha)	Land preparation cost ('000 Tk)	Price of seed ('000 Tk)	Labour cost ('000 Tk)	Manure & fertilizer cost('000 Tk)	Insecticide cost ('000 Tk)	Total cost* ('000 Tk.)
1.T.Aus	16.10	26.50	4.02	65.92	10.30	0.64	107.38
2.T.Aman	18.90	34.20	4.70	78.00	17.48	2.83	137.23

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3.Jute	0.80	1.31	0.19	4.98	1.68	0.40	8.56
4.Others	1.70	2.94	0.47	6.88	1.45	0.21	11.95
Total Cost/ha.	37.50	64.95	9.40	155.78	30.91	4.08	265.12 7.07

* Full cost basis.

Scheme : Shaplapara.

Crop	Area irrigated (ha)	Land preparation cost ('000 Tk)	Price of seed ('000 Tk)	Labour cost ('000 Tk)	Manure & fertilizer cost('000 Tk)	Insecticide cost ('000 Tk)	Total cost* ('000 Tk.)
1.T.Aman	21.94	39.71	5.48	90.61	20.29	3.29	159.38
2.B.Aus	8.20	13.49	2.05	28.70	4.74	1.23	50.21
3.T.Aus	5.80	9.54	1.45	23.75	3.71	0.23	38.68
4.Banana	1.13	4.81	5.99	5.31	10.56	1.00	27.67
5.Jute	1.07	1.76	0.26	6.66	2.24	0.53	11.45
6.Others	3.28	5.96	1.43	13.33	3.57	0.54	24.83
Total Cost/ha.	41.42	75.27	16.66	168.36	45.11	6.82	312.22 7.54

* Full cost basis

Scheme : East Kutubpur

Crop	Area irrigated (ha)	Land preparation cost ('000 Tk)	Price of seed ('000 Tk)	Labour cost ('000 Tk)	Manure & fertilizer cost('000 Tk)	Insecticide cost ('000 Tk)	Total cost* ('000 Tk.)
1.T.Aman	13.50	24.43	3.37	35.75	12.48	2.02	98.05
2.B.Aus	9.17	15.09	2.29	32.09	5.30	1.77	56.54
3.T.Aus 2	6.70	11.02	1.67	27.43	4.89	1.00	46.01
4.Maskali	3.42	5.62	3.47	7.18	0.68	-	16.95
5.Jute	3.23	5.31	0.77	20.12	6.78	1.29	34.27
6.Others	1.26	2.08	0.39	4.87	0.98	0.20	8.52
Total Cost/ha.	37.28	63.55	11.96	147.44	31.11	6.28	260.34 6.98

* Full cost basis

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Crop Production Cost for Non-Irrigated Condition in Rabi Season.

Scheme : Taltolapara

Crop	Area irrigated (ha)	Land prepa-ration cost ('000 Tk)	Price of seed ('000 Tk)	Labour cost ('000 Tk)	Manure & fertilizer cost('000 Tk)	Insecticide cost ('000 Tk)	Total* cost ('000 Tk)
1. Boro	4.12	6.78	1.03	12.65	3.33	0.90	24.69
2. Wheat	6.74	11.10	5.93	8.67	3.41	0.55	29.66
3. Water-melon	1.96	4.03	6.37	2.50	0.99	0.43	14.32
4. Chilli	1.36	4.48	0.61	7.50	0.84	0.16	13.59
5. Banana	1.05	1.30	5.56	3.70	7.35	1.00	18.91
6. Soybean	1.04	1.28	0.60	5.25	0.64	0.05	7.82
7. Others	2.61	5.21	6.56	7.82	3.36	0.46	23.41
Total	18.88	34.18	26.66	48.09	19.92	3.55	132.40
Cost/ha	-	-	-	-	-	-	7.01

* Full cost basis

Scheme : Shaplapara

Crop	Area irrigated (ha)	Land prepa-ration cost ('000 Tk)	Price of seed ('000 Tk)	Labour cost ('000 Tk)	Manure & fertilizer cost('000 Tk)	Insecticide cost ('000 Tk)	Total* cost ('000 Tk)
1. Boro	4.11	6.77	1.02	12.60	3.32	0.90	24.61
2. Wheat	5.53	9.10	4.87	7.10	2.80	0.45	24.32
3. Water-melon	3.72	7.65	12.00	4.88	1.88	0.82	27.23
4. Chilli	1.04	3.42	0.47	7.50	0.64	0.13	12.16
5. Banana	1.71	2.11	9.51	6.34	12.00	1.71	31.67
6. Soybean	1.55	1.91	0.89	7.94	0.95	0.08	11.77
7. Others	3.00	5.97	6.69	10.14	4.18	0.41	27.39
Total	20.66	36.93	35.45	56.50	25.77	4.50	159.15
Cost/ha	-	-	-	-	-	-	7.70

* Full cost basis

Scheme : East Kutubpur

Crop	Area irrigated (ha)	Land prepa-ration cost ('000 Tk)	Price of seed ('000 Tk)	Labour cost ('000 Tk)	Manure & fertilizer cost('000 Tk)	Insecticide cost ('000 Tk)	Total* cost ('000 Tk)
1. Boro	0.17	0.27	0.04	0.53	0.14	0.03	1.01
2. Wheat	3.66	6.02	3.22	4.71	1.85	-	15.80
3. Water-melon	0.90	1.85	2.92	1.17	1.46	-	7.40
4. Chilli	0.86	2.83	0.38	4.57	0.53	0.09	8.40
5. Banana	0.87	1.07	4.84	3.22	6.08	0.83	16.04
6. Soybean	0.90	1.11	0.51	4.61	0.56	0.05	6.84
7. Others	1.89	3.52	4.59	4.27	1.76	0.33	14.47
Total	9.25	16.67	16.50	23.08	12.38	1.33	69.96
Cost/ha	-	-	-	-	-	-	7.56

* Full cost basis

Continued to page 63

Crop Production Cost for Non-Irrigated Condition in Kharif (I & II) Season.

Scheme : Taltolapara

Crop	Area irrigated (ha)	Land preparation cost ('000 Tk)	Price of seed ('000 Tk)	Labour cost ('000 Tk)	Manure & fertilizer cost('000 Tk)	Insecticide cost ('000 Tk)	Total* cost ('000 Tk)
1. T. Aus	16.10	26.50	4.02	49.44	7.73	0.64	88.33
2. T. Aman	18.90	34.20	4.70	58.50	13.11	2.82	113.34
3. Jute	0.80	1.31	0.19	3.74	1.26	0.40	6.90
4. Others	1.70	2.94	0.47	5.16	1.08	0.21	9.86
Total	37.50	64.95	9.38	116.84	23.18	4.08	218.45
Cost/ha	-	-	-	-	-	-	5.83

* Full cost basis

Scheme : Shaplapara

Crop	Area irrigated (ha)	Land preparation cost ('000 Tk)	Price of seed ('000 Tk)	Labour cost ('000 Tk)	Manure & fertilizer cost('000 Tk)	Insecticide cost ('000 Tk)	Total* cost ('000 Tk)
1. T. Aman	21.94	39.71	5.48	67.96	15.22	3.29	131.66
2. B. Aus	8.20	13.49	2.05	21.52	3.55	1.23	41.85
3. T. Aus	5.80	9.54	1.45	27.81	2.78	0.23	31.81
4. Banana	1.13	4.81	5.99	3.98	7.92	1.00	23.70
6. Jute	1.07	1.76	0.26	5.00	1.68	0.53	9.23
7. Others	3.28	5.96	1.43	10.00	2.68	0.54	20.60
Total	41.42	75.27	16.66	126.27	33.83	6.82	258.85
Cost/ha	-	-	-	-	-	-	6.25

* Full cost basis

Scheme : East Kutubpur

Crop	Area irrigated (ha)	Land preparation cost ('000 Tk)	Price of seed ('000 Tk)	Labour cost ('000 Tk)	Manure & fertilizer cost('000 Tk)	Insecticide cost ('000 Tk)	Total* cost ('000 Tk)
1. T. Aman	13.50	24.43	3.37	41.81	9.36	2.02	80.99
2. B. Aus	9.17	15.09	2.29	24.06	3.98	1.77	47.19
3. T. Aus	6.70	11.02	1.67	20.57	3.67	1.00	37.93
4. Maskali	3.42	5.62	3.47	5.39	0.51	-	14.99
5. Jute	3.23	5.31	0.77	15.10	5.08	1.29	27.55
6. Others	1.26	2.08	0.39	3.65	0.73	0.20	7.05
Total	37.28	63.55	11.96	110.58	23.33	6.28	215.70
Cost/ha	-	-	-	-	-	-	5.79

* Full cost basis

APPENDIX E

Benefits from Buried Pipe Systems and Non-irrigated Condition

Cropwise Return from Buried Pipe System for 1989-90 Rabi Season

Scheme : Taltolapara

Crop	Area irrigated (ha)	Average yield (t/ha)	Unit price ('000 Tk/t)	Total return ('000 Tk)
1. Wheat	6.74	1.71	6.00	69.15
2. Boro	4.12	3.40	6.50	91.05
3. Water-melon	1.96	35.58	4.00	278.95
4. Chilli	1.36	4.37	10.00	59.43
5. Soybean	1.04	8.30	10.00	86.32
6. Banana	1.05	49.72	5.00	261.03
7. Others	2.61	-	-	48.23
Total	18.88			894.16
Return/ha.				47.36

Scheme : Shaplapara

Crop	Area irrigated (ha)	Average yield (t/ha)	Unit price ('000 Tk/t)	Total return ('000 Tk)
1. Wheat	5.53	1.78	6.00	59.06
2. Boro	4.11	3.40	6.50	90.83
3. Water-melon	3.72	31.50	4.00	468.72
4. Banana	1.71	48.12	5.00	411.42
5. Soybean	1.55	7.56	10.00	117.18
6. Chilli	1.04	4.41	10.00	45.86
7. Others	3.00	-	-	62.82
Total	20.66	-	-	1255.89
Return/ha.				60.79

Scheme : East Kutubpur

Crop	Area irrigated (ha)	Average yield (t/ha)	Unit price ('000 Tk/t)	Total return ('000 Tk)
1. Wheat	3.66	1.86	6.00	40.85
2. Soybean	0.90	8.12	10.00	73.08
3. Water-melon	0.90	36.38	4.00	130.97
4. Banana	0.87	40.86	5.00	177.74
5. Chilli	0.86	4.37	10.00	37.58
6. Boro	0.17	3.59	6.50	3.97
7. Others	1.89	-	-	96.26
Total	9.25	-	-	560.45
Return/ha.				60.59

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Cropwise Return for 1989-90 Kharif (I & II) Season

Scheme : Taltolapara

Crop	Area irrigated (ha)	Average yield (t/ha)	Unit price ('000 Tk/t)	Total return ('000 Tk)
1. T.Aman	18.90	3.15	7.00	416.75
2. T.Aus	16.10	2.05	6.50	214.53
3. Jute	0.80	1.68	6.00	8.06
4. Others	1.70	-	-	29.22
Total	37.50	-	-	668.56
Return/ha.				17.85

Scheme : Shaplapara

1. T.Aman	21.94	2.99	7.00	459.20
2. B. Aus	8.20	1.34	6.50	71.42
3. T.Aus	5.80	1.65	6.50	62.21
4. Banana	1.13	20.72	5.00	117.07
5. Jute	1.00	1.25	6.00	7.50
6. Others	3.28	-	-	60.95
Total	41.42	-	-	778.35
Return/ha.				18.79

Scheme : East Kutubpur

1. T.Aman	13.50	3.12	7.00	294.84
2. B.Aus	9.17	1.29	6.50	76.89
3. T.Aus	6.70	1.77	6.50	77.08
4. Maskali	3.42	1.20	25.00	102.60
5. Jute	3.23	1.56	6.00	30.23
6. Others	1.26	-	-	20.70
Total	37.28	-	-	581.64
Return/ha.				15.60

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Cropwise Return for Non-Irrigated Condition in Rabi Season

Scheme : Taltolapara

Crop	Area irrigated (ha)	Average yield (t/ha)	Unit price ('000 Tk)	Total return ('000 Tk)
1. Wheat	6.74	1.29	6.00	52.17
2. Boro	4.12	1.63	6.50	43.65
3. Water-melon	1.96	5.80	4.00	45.47
4. Chilli	1.36	0.50	10.00	6.80
5. Soybean	1.04	0.28	10.00	2.91
6. Banana	1.05	12.93	5.00	67.88
7. Others	2.61	-	-	22.60
Total	18.88	-	-	241.48
Return/ha	-	-	-	12.79

Scheme : Shaplapara

Crop	Area irrigated (ha)	Average yield (t/ha)	Unit price ('000 Tk)	Total return ('000 Tk)
1. Wheat	5.53	1.29	6.00	42.80
2. Boro	4.11	1.63	6.50	43.55
3. Water-melon	3.72	5.80	4.00	86.30
4. Chilli	1.04	0.50	10.00	5.20
5. Soybean	1.55	0.28	10.00	4.34
6. Banana	1.71	12.93	5.00	110.55
7. Others	3.00	-	-	22.80
Total	20.66	-	-	315.54
Return/ha	-	-	-	15.27

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Scheme : East Kutubpur

Crop	Area irrigated (ha)	Average yield (t/ha)	Unit price ('000 Tk)	Total return ('000 Tk)
1. Wheat	3.66	1.29	6.00	28.33
2. Boro	0.17	1.63	6.50	1.80
3. Water-melon	0.90	5.80	4.00	20.88
4. Chilli	0.86	0.50	10.00	4.30
5. Soybean	0.90	0.28	10.00	2.52
6. Banana	0.87	12.93	5.00	56.25
7. Others	1.89	-	-	16.50
Total	9.25	-	-	130.58
Return/ha	-	-	-	14.12

Cropwise Return for Non-Irrigated Condition in Kharif(I&II) Season

Scheme : Taltolapara

Crop	Area irrigated (ha)	Average yield (t/ha)	Unit price ('000 Tk)	Total return ('000 Tk)
1. T. Aman	18.90	1.26	7.00	166.70
2. T. Aus	16.10	0.70	6.50	73.26
3. Jute	0.80	1.05	6.00	5.04
4. Others	1.70	-	-	13.75
Total	37.50	-	-	258.75
Return/ha	-	-	-	6.90

Scheme : Shaplapara

Crop	Area irrigated (ha)	Average yield (t/ha)	Unit price ('000 Tk)	Total return ('000 Tk)
1. T. Aman	21.94	1.26	7.00	193.51
2. T. Aus	5.80	0.70	6.50	26.39
3. Jute	1.00	1.05	6.00	6.30
4. B. Aus	8.20	0.62	6.50	33.05
5. Banana	1.13	12.93	5.00	73.05
6. Others	3.28	-	-	26.33
Total	41.42	-	-	358.83
Return/ha	-	-	-	8.66

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Scheme : East Kutubpur

Crop	Area irrigated (ha)	Average yield (t/ha)	Unit price ('000 Tk)	Total return ('000 Tk)
1. T. Aman	13.50	1.26	7.00	119.07
2. T. Aus	6.70	0.70	6.50	30.49
3. Jute	3.23	1.05	6.00	20.34
4. B. Aus	9.17	0.62	6.50	36.96
5. Maskali	3.42	0.53	25.00	45.31
6. Others	1.26	-	-	10.08
Total	37.28	-	-	262.25
Return/ha	-	-	-	7.03

APPENDIX F

Cropwise Yield and Return of Different Crops in Non-Irrigated Conditions

Crop	Yield* (t/ha)	Unit Price** (Tk.)	Total Return ('000 Tk/ha)
Boro	1.63	6.50	10.60
Aus	0.70	6.50	4.55
Aman	1.26	7.00	8.82
Wheat	1.29	6.00	7.74
Jute	1.05	6.00	6.30
Potato	4.54	3.50	15.90
Watermelon	5.80	4.00	23.20
Soybean	0.28	10.00	2.80
Mashkalai	0.53	15.00	7.95
Chilli	0.50	10.00	5.00
Onion	1.35	8.50	11.48
Banana	12.93	5.00	64.65

* Source : Bangladesh Bureau of Statics, 1983.

** Present Market Price