WATER PRICING IN DIFFERENT MINOR IRRIGATION SYSTEMS

Md. Ruhul Amin

January, 2007

Institute of Water and Flood Management (IWFM)

Bangladesh University of Engineering and Technology (BUET)

WATER PRICING IN DIFFERENT MINOR IRRIGATION SYSTEMS

M.Sc. Thesis

by

Md. Ruhul Amin

Submitted to the Institute of Water and Flood Management (IWFM)
in partial fulfillment of the requirements for the degree of Master of Science
in Water Resources Development.

January, 2007

Institute of Water and Flood Management (IWFM)
Bangladesh University of Engineering and Technology (BUET)

To
My Mother

Certificate of Research

This is to certify that the research work described in this thesis, except where specific references to other investigators are made, is the result of the investigation of the candidate. This thesis or any part of it has not been submitted elsewhere for the award of any degree or diploma.

Signature of the Student

(Md. Ruhul Amin)

Signature of the Supervisor

(Professor Abul Fazal M Saleh)

Bangladesh University of Engineering and Technology

Institute of Water and Flood Management

Recommendation of the Board Examiners

We hereby recommend that the thesis titled "Water Pricing in Different Minor Irrigation Systems", submitted by Md. Ruhul Amin, Roll No.: MP 0328027, has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Master of Science in Water Resources Development on January 21, 2007.

BOARD OF EXAMINERS

Chairman of the Committee (Supervisor) — Dr. Abul Fazal M Saleh, Professor, IWFM, BUET

Member — Dr. M. Shahjahan Mondal, Assistant professor, IWFM, BUET

Member (Ex-Officio) — Dr. Md. Rezaur Rahman, Professor & Director, IWFM, BUET

Member (External) — Dr. K.M. Nabiul Islam, Senior Research Fellow, Bangladesh Institute of Development Studies (BIDS)

Acknowledgement

The author wishes to express his most sincere gratitude and profound thanks to Dr. Abul Fazal M. Saleh, Professor, Institute of Water and Flood Management (IWFM), Bangladesh University of Engineering and Technology (BUET), for kindly supervising this research. This research is really a product of Professor Saleh's invaluable guidance, encouragement and keen interest. The author is indebted to him for the enormous amount of time, effort and support he has given throughout the process of the study. The author considers himself proud to have worked with professor Saleh that greatly helped the author to improve his research capability and writing skills.

The author would like to express his gratitude and thanks to Dr. Md. Rezaur Rahman, Professor and Director, Institute of Water and Flood Management (IWFM), Bangladesh University of Engineering and Technology (BUET), for kindly reviewing the draft final copy of this thesis and making his valuable comments and useful suggestions that helped a lot to upgrade the work.

The author would like to thank Dr. K.M. Nabiul Islam, Senior Research Fellow, Bangladesh Institute of Development Studies (BIDS), Agargaon, Dhaka and Dr. M. Shahjahan Mondal, Assistant Professor, IWFM, BUET, for kindly reviewing the draft final copy of the thesis and providing valuable comments.

Sincere thanks are due to Professor Shefali Nazneen, Vice Principal, Eden Girls' College, Dhaka, for her continuous support, encouragement and blessings throughout the process of the study. Thanks are due to Professor M. Mokhlesur Rahman Shaikh, Head of the Department, Dept. of Geography & Environment, Dhaka College, Dhaka and all the colleagues of the author, Dept of Geography & Environment, Dhaka College, Dhaka, for their supports, helps and encouragement throughout the study.

The author gratefully acknowledges the support and cooperation provided by the interviewed pump owners and farmers of the study areas who have voluntarily participated in the questionnaire survey. Thanks are due to thana level office personnel of the study areas including BMDA officials who have provided different data and information regarding the study.

And, the author must expresses his indebtedness and deep sense of gratitude to his family members, relatives, friends and all the individuals for their encouragement, moral supports and blessings during the study.

Table of Contents

List of Tables

List of Figures

Abstract

This study was designed and carried out in order to reveal the variation of pricing of irrigation water in different areas of the country. Five thanas from different three districts were taken as study areas where all the different modes (STW, DTW & LLP), energy sources (electricity and diesel) and methods (cash payment, crop share and time basis) are practiced by the farmers.

Both primary and secondary data have been used in this study. Fifty three pump owners from five different Thanas and belonging to 53 minor irrigation equipment (STW, DTW, & LLP) groups were randomly selected and surveyed by a structured questionnaire. Pump owners, farmers and related office personnel were also interviewed during data collection.

A number of technical and socio-economic causes were found that lead to the variation in water pricing in different study areas. Energy sources, number of irrigation, type of modes and source of water (groundwater or surface water) were identified as technical causes and prevailing methods, easiness of rent collection, liquidity status of farmers and competition among the pump owners were identified as socio-economic causes behind the variation.

Area based cash payment system is widely used for irrigation water pricing in Phulpur and Haluaghat Thana of Mymensingh District. It has been found that within the same method, pricing varies over different modes, energy sources and number of irrigation. Because of higher command area and relatively less O & M cost, DTW owners per hectare average profit is usually higher than those of the STW and LLP. So, in area based pricing, DTW becomes cheaper to the farmers.

Output based crop share payment system is commonly used in Kumarkhali and Sadar Thana of Kushtia District. In this method, in case of electricity run operation, where fuel cost is completely borne by pump owners, farmers pay one fourth of the total crop from the land for both STW and DTW modes. In case of diesel powered operation, farmers pay fuel cost and 370kg of dry paddy as establishment cost against per hectare irrigation.

Time basis semi-volumetric pricing method is practiced in Poba Thana of Rajshahi District under Barind Multipurpose Development Authority (BMDA). In this area only electricity run DTWs are used in irrigation and farmers pay for per hour of irrigation. In Poba Thana, DTWs of 56 lps capacities are widely used and farmers pay Tk.85/- per hour of irrigation.

Comparative analysis shows that electricity run operation in both STW and DTW under area based pricing (Tk.6000/ha and Tk.5500/ha) is the most favorable pricing method for the farmers. On the other hand, electricity run both STW and DTW under output based crop share pricing (Tk.9000/ha) is the most profitable method for the pump owners. In case of electricity run operation under area based pricing, fuel cost is relatively less and borne by pump owners, moreover, a major part of the labor cost is also borne by pump owners. So, electricity run area based pricing becomes most suitable to the farmers.

Abbreviations:

AEZs	Agro-Eological Zones
AWBs	Area Water Boards
BADC	Bangladesh Agriculture Development Corporation
BBS	Bangladesh Bureau of Statistics
BMDA	Barind Multipurpose Development Authority
DTW	Deep Tube Well
GWP	Global Water Partnership
HP	Horse Power
IIMI	International Irrigation Management Institute
LLP	Low Lift Pump
NWP	National Water Plan
NWMP	National Water Management Plan
NWMPP	National Water Management Plan Project
OECD	Organization for Economic Co-operation and Development
O & M	Operation and Maintenance
STW	Shallow Tube Well

Chapter-1

Introduction

1.1 General

In Bangladesh, agricultural productivity holds the key to the country's overall economic growth and welfare to its people. The economy largely depends on the agricultural development, which is possible only by producing more crops. Irrigation is the lifeline of agriculture as it ensures more crop production in agriculture sector. Irrigation is the leading input for increasing yield and production of foodgrains and other crops. In Bangladesh, the history of the development of irrigation system is not very old. Only few decades ago, different types of irrigation means were developed to supply water for irrigation. Presently, a good number of irrigation methods and technologies have been adopted in the country to cope with the necessity of irrigation in both dry season and for supplementary irrigation. It is noted that, big irrigation projects (large-scale projects) did not play a positive role in the national irrigation sector. But minor irrigation (small- scale projects) program is remarked as very successful and it covers more than 90% of the total irrigation (BADC, 2005). Considering the vital role in agriculture, the National Agriculture Policy and the National Water Plan have given special emphasis on the development of minor irrigation.

Deep tubewells (DTW), Shallow tubewells (STW) and Low Lift Pumps (LLP) are the major modes used in minor irrigation. DTW and STW use groundwater covering about 75% of total area and LLP uses surface water. In the year 2005 there were 1128991 nos. STWs, 27117 nos. of DTWs and 99255 nos. of LLPs in operation during Rabi season in the country and irrigated area covered 3,159,899 hectares (68% of total), 6,54,189 hectares (14% of total) and 8,38,377 hectares (18% of total), respectively (BADC, 2005).

A review of literatures revealed that pricing of irrigation water varies over different modes of irrigation and methods of pricing. There are two major pricing methods commonly used in irrigation: volumetric and non-volumetric methods. Volumetric methods charge for water per unit volume supplied at the measuring point. This requires information on the volume used by each individual farmer and a central water authority or Water Users' Organization to set the price, monitor the use and collect the fees.

There are several non-volumetric methods used in irrigation; these are- output pricing, input pricing and area pricing. Output pricing methods charge a water fee for each unit of output produced by the user. Under input pricing a farmer pays for irrigation water indirectly through higher prices for inputs purchased from the government or water agency. Under area based pricing, farmers pay a fixed price per unit of irrigated area (Johansson, 2000). Area based fixed cost pricing is the most widely used price structure, which is adequate where the sole objective is cost recovery. In some cases this may vary according to crop type, with higher charges for more water demanding crops.

Volumetric water pricing or tradable water allocations are suitable to use where the objective is to reduce water demand in the agriculture sector. This requires information on the volume of water used by each or some other way to infer a measurement of water consumption. Volumetric water allocations, rather than water price, are used to ensure that other sectors' needs are met.

When water flow is reasonably constant, implicit volumetric pricing is possible by charging for time of delivery. This time basis semi-volumetric pricing method requires much less information and in this method implementation cost is relatively low compared to volumetric pricing.

Non-volumetric water pricing can be used where the objective is cost recovery. It is much simpler to administer than volumetric pricing as there is no requirement for extensive measurement infrastructure and continuous field recording.

In Bangladesh, for minor irrigation systems, the common methods of pricing are cash payment and crop share payment. Cash payment system is based upon area and time basis and crop share payment systems are on output basis. The sole objective of such pricing systems are cost recovery. Cost recovery is recovery of annual O&M costs or O&M plus elements of capital investments and depreciation. Cost recovery concerns full supply costs only, where the cost includes the cost associated with the supply of water without consideration of externalities (externalities are the indirect consequences or side effects of supplying water to a particular user or sector). It includes the operation and maintenance of irrigation infrastructure and capital investment.

In minor irrigation schemes, to provide incentives for careful water use, it is necessary to establish a charging system that causes water users to think carefully about the decision to apply water to their crops and to weigh marginal water use against its marginal cost.

1.2 Background of the study

Water is one of the most beneficial natural resources in an agrarian country like Bangladesh. In National Water Plan (NWP) and in National Water Management Plan (NWMP), water has been considered as an economic commodity (NWMP, 2001). In order to ensure a sustainable water development, special emphasis has been given on appropriate use, distribution and preservation of this commodity.

Amongst all the water-sectors, agriculture is the most crucial as the sector consumes huge quantity of water compared to other sectors. Water scarcity will continue to increase, leading to more competition for water between agricultural, municipal and industrial sectors. The agriculture sector is seen as wasteful in its use of water in both minor and large irrigation schemes. For example, on large irrigation schemes with open channel conveyance, as much as 70% of water diverted from a source fails to arrive at the crop (BADC, 2005). Misuse of large quantity of irrigation water and lower irrigation efficiency are the major causes behind the wastes. Some of the major objectives of irrigation water charging are: to cover the costs of providing the service, to allocate water to the highest priority uses, to improve accountability of the water provider to users, to provide an incentive for the efficient use of scarce water resources and to ensure equity of access to water or the benefits of its use.

Water policies and strategies now often require the implementation of some form of water charging. In many cases, attempts at reforming water pricing stem from financial crisis, low recovery of costs, deteriorating infrastructure, and increasing water demand (Johansson, 2000).

It has already been mentioned that pricing of water in minor irrigation systems varies over different modes and methods of irrigation. Considering the economic importance of agricultural water use, currently different countries are reviewing their water policies to establish a rational pricing in irrigated agriculture. The fundamental role of prices is to help allocate scarce resources among competing uses and users. One way to achieve an efficient allocation of water is to price its consumption correctly.

As minor irrigation in Bangladesh is now totally in the private sector, it has been observed that there is no attempt to use water pricing to achieve the balance between supply and demand of competing sectors. Also observed that no research has been carried out on the causes of variation of irrigation water pricing over different modes and methods in Bangladesh. In this study an attempt has been made to identify the causes (technical and socio- economic) behind the variation of irrigation water prices over different modes (STW, DTW & LLP), energy sources (electricity & diesel) and methods (cash payment, crop share and time basis payment) of minor irrigation.

1.3 Objectives of the study

The aim of the study is to reveal the variation of irrigation water pricing in different minor irrigation systems. The specific objectives are as follows:

- To examine the variation of prices of irrigation water over different technologies (STW, DTW and LLP);
- To study the causes (technical and socio-economic) behind the variations of irrigation water pricing over same technology; and
- To assess the profit margin of selling irrigation water by the pump owners.

Chapter- 2
Literature Review

In order to ascertain a rationale of the study, a number of literatures were reviewed. A brief discussion of reviewed literature is outlined as follows.

2.1 Irrigation water pricing and policy

Fujimoto and Tomosho (2003) in their article on water pricing to the Asian humid tropics, revealed that the OECD has introduced a water pricing mechanism and listed eight categories gleaned from experience in OECD countries. In almost all irrigation projects in Japan, area charge has been applied, and collected fees have recovered entire operation and maintenance costs. Although effective volumetric charge is employed in several regions in Japan, most farmers pay area based annual charges at several times of the year via Land Improvement Districts. In the Asian humid tropics, it is important to facilitate the establishment of sound management organizations of irrigation water before introducing a strict water pricing mechanism to levy the charge.

Cornish and Perry (2003) from their case studies on selected schemes in South Asian countries examined that in India, water charges in the major irrigating states are levied on a crop-hectare basis, that is, rates vary across crops, and are charged according to the area irrigated. There is no explicit volumetric charge, but the crop is used as a proxy for volume consumed. For example, the rate for irrigation of rice field in Bihar is Rs 175/ha (equivalent to US$ 3.90/ha). With estimated consumptive use from irrigation of 250mm, or 2500 cubic meter/ha, the effective price per cubic meter is US$ 0.0016, or 0.16 cents.

In Sindh Province, Pakistan, the water pricing strategy under the new Area Water Boards (AWBs) still follows, by and large, the pattern set in the first half of the twentieth century with the price being determined politically by the Provincial Government. Farmers pay the water tax (abiana), together with other taxes – land revenue, local funds and ushr – as a single bill.

Abiana is assessed on the basis of the area under cultivation with different rates applying for different crops. The prices range between US$ 2-8/ha, which are low in comparison with other large-scale systems in South Asia. Different rates apply for gravity systems and lift channels, the latter subject to double rates.

Bosworth (2002) and Cornish and Perry (2003) showed that many countries are currently reviewing their policies towards water pricing in irrigated agriculture. Failure to establish charging systems that are acceptable to governments, irrigation agencies and farmers has led to a vicious circle of physical deterioration, declining performance and unwillingness to pay in many irrigation projects.

Bosworth (2002) in their lessons from the literature showed a comparative feature of water pricing among different countries. In the countries, where irrigated area is used as the charging basis, there is a very great range in the prices. US$ 40-50/ha/year is closer to an 'average' price in more developed countries but in India many states charge not more than US$ 10/ha/year and in Pakistan, the Revenue Department receives approximately US$ 0.33/ha only, whereas in Bangladesh, average water charge is US$ 150/ha/season.

Perry (2001) emphasized that "An orderly system of distributing water must be in place through some existing and respected regulatory framework for allocating water among farmers. If this is not the case or if regulations are not observed, then there is no immediate scope for improving water distribution through pricing, and attention should first be given to clarifying and enforcing water rights and the rules of water distribution". In the developing world, property rights in water are insecure and ineffective and tail-end farmers often have insufficient water, whilst farmers at the head take too much.

Ahmad (2000) mentioned that the policy of setting a low price for water does not create the proper incentives to use water efficiently or to reuse wastewater. It also sends wrong signals to the producer and consumers about the true scarcity value of resources which often leads to over-production over-consumption of commodities which are resource depleting and environmental polluting. Pricing water consumption 'correctly' is one means of achieving allocation efficiency, the author noted.

GWP (2000) set out the general principles for the cost of water. They presented a full analysis of the different cost elements that may be factored into a calculation of the cost of supplying water. GWP distinguished three types of costs: Full Supply Costs, Full Economic Costs and Full Costs. The full supply cost includes the cost associated with the supply of water without consideration of externalities. Full Economic costs include the full supply costs plus opportunity costs and economic externalities. Opportunity costs acknowledge that by using the water, another user is deprived of it. If the other use has a higher socio-economic value, then there are some costs to society due to 'misallocation' of resources or inefficient use. Full Costs include full economic costs plus economic and environmental externalities. Externalities arise when costs or benefits associated with extraction and use of the resource are imposed on third parties.

Renzetti and Dupont (1999) evaluated a two-part water use charge. The first is annual permit fee; the second is a volumetric charge based on consumption. The use of a permit fee will enhance efficiency, improve water quality, increase government revenue, and improve the government's knowledge base regarding water use. Algeria has recently adopted a two-part tariff similar to this in order to reflect the full cost of service.

Dandaragoda (1998) and Small and Carruthers (1991) examined volumetric pricing method of irrigation water. They showed that water meters make volumetric pricing straightforward, involving routine maintenance and periodic meter readings. When water flow is reasonably constant, implicit volumetric pricing is possible by charging for time of delivery. This requires much less information and can be found in small irrigation projects with few users per day.

Saleth (1997) illustrated that water pricing could be used to achieve water use efficiency in India, a country where water resources are becoming increasingly limited. States and provinces of the country set water rates, but these are not standardized and do not reflect the scarcity value of water. Most states charge for canal water. Area based water rates often vary by crop and season, by category of project, irrigation type and category of user. In most states, fee recovery does not cover O&M costs and in certain states (e.g. Bihar and Rajasthan) the collected fees do not even cover the cost of collection.

Tsur & Diner (1995 and 1997) found that effects of implementation costs on the performance of different pricing methods are significant in the sense that small changes in costs can change the order of optimality of those methods. It is therefore possible that a simple and inefficient pricing method such as per area pricing, which is relatively inexpensive to implement, yields a higher social welfare than that obtained with the potentially efficient volumetric pricing method. They also mentioned that water pricing mechanism in general is not very effective in redistributing income, but it may be in a government's national interest to increase water available for certain sectors or citizens.

Bos & Walters (1990) showed that area based pricing is the most common method of irrigation water pricing. In their survey of farmers on 12.2 million ha globally, they found that in more than 60% of the cases water is charged on a per unit area basis. Under this pricing mechanism users are charged for water used per irrigated area.

Rhodes & Sampath (1988) showed that effects on income distribution of water pricing have merit of its own when justified on ethical grounds. Moreover such considerations often appeal to efficiency criteria since they tend to reduce implementation costs.

Seckler, Sampath & Raheja (1988) distinguished efficiency and equity into two distinct problems when evaluating an irrigation pricing system. These are a managerial problem and a policy problem. They note that the performance of a system should be judged according to the managerial problem.

Gardner (1983) in his study introduced the political economics in pricing of irrigation water. The author discussed how in the irrigation economy of California, water is a constraining input and is often priced below the value of its use. This study uses the difference between optimal prices and actual prices as evidence of rent seeking and describes how this rent eventually dissipate with further rent- seeking behavior.

Seagraves and Easter (1983) examined the pricing of scarce water and showed that there are many ways that pricing mechanisms can be used to address scarce water supplies. During seasonal shortages, higher marginal cost prices should be used to ration all of the water and to recover fixed costs during peak demand.

2.2 Irrigation water pricing in Bangladesh

Review of literature on water pricing in Bangladesh showed that most of the past studies were on pricing policy. Only few studies have been carried out on the actual pricing and variations in pricing.

BADC (2005) examined that among South and South-east Asian countries, irrigation cost in Bangladesh is the highest. BADC indicates that the cost of production of paddy (per hectare) is much higher in Bangladesh than India, Thailand and Vietnam. Misuse of large quantity of irrigation water, agro-ecological condition, lower irrigation efficiency and uneven distribution of natural water supply throughout the year were indicated as the main reasons for higher production cost of paddy in their report.

NWMP (2001) mentioned that changes are required in the system of prices and other economic incentives affecting water demand and supply in Bangladesh. Volumetric water pricing or tradable water allocations may be used where the objective is to reduce water demand in the agricultural sector.

NWMP (2000a and 2000b) showed that in Bangladesh, irrigation charging basis varies in two ways; fixed rate per cropping season and per hour of pumping. Fixed rate per cropping season also varies over major surface water schemes and minor irrigation programs. For major surface water schemes per hectare irrigation water price is US$ 0.43-3.01, where as in minor irrigation, average water price is US$148.77-191.29 per hectare. In Barind Multipurpose Development Authority (BMDA), where only electricity run DTWs are used, water price is US$ 1.59 per pumping hour.

NWMP (2000c) in their report on " The Economics of Minor Irrigation" an analysis has been made of the economic and financial costs and returns from minor irrigation. Rural electrification and increased electricity supply reliability are key requirements to enable the minor irrigation sector to cope with the likely future effects of increased seasonal watertable decline resulting from the expansion of tubewell irrigation. Boro irrigation becomes financially marginal when the average static water level falls to 8-9m. Once the depth is reached, irrigation of Boro crop becomes unattractive unless electricity is made available on a sufficiently reliable basis to enable farmers to adopt electric pumping with confidence. Even with full economic pricing of electricity, suction mode Boro irrigation with water level of as low as 11m is then still viable, they demonstrated.

Mondal (2000) in his study on "Performance Evaluation of Some Selected Deep and Shallow Tubewells in Irrigation Development", mentioned that average irrigation water charge in the study area (Rajbari & Pangsha Thana), is much higher compared to other irrigation projects. The charge should be decreased to distribute benefit of irrigation equally between scheme farmers and pump owners.

Saleh & Mondal (2000) showed that in medium scale irrigation projects, for pumped irrigation, irrigation fee (Tk. 4330/ha) is more than double of where irrigation is supplied by gravity (Tk. 2139/ha).

IIMI (1996) in a survey found that in owners practicing crop share payment (one fourth to one third of the crop at the end of the season) system, the water charges were 62 percent higher than those under a cash payment system. IIMI also found that the STW water charges increased by about 41% and LLP water charges by 47% over the last ten years, irrespective of system of payment for water.

Chapter-3
Research Methods

3.1 Introduction

From the review of literature and also from reconnaissance field visits, it was ascertained that in Bangladesh, two major methods of irrigation water pricing are practiced in the minor irrigation. These are semi-volumetric pricing and non-volumetric pricing. The water pricing also depends upon the source of energy used in minor irrigation.

3.2 The Study Area

The study has been carried out in five Thanas where all the different modes (STW, DTW & LLP), energy sources (electricity and diesel) and methods (non-volumetric; cash payment and crop share and semi-volumetric; time basis) are practiced by the farmers. The non-volumetric methods are area based cash payment and output based crop share payment and the semi-volumetric method is time basis payment. Phulpur and Haluaghat Thana of Mymensingh District where area based cash payment system, Kumarkhali and Sadar Thana of Kushtia District where output based crop share payment system, and Poba Thana of Rajshahi District under Barind Multipurpose Development Authority (BMDA) where time basis payment system are dominantly practiced were taken as the study area. Field survey was conducted during 2004-05 and 2005-06 irrigation seasons. Figure 3.1 shows the locations of the study areas.

Although for a more thorough and representative analysis of the different pricing methods, it was necessary to carry out the study in different Agro-Ecological Zones (AEZs) of the country (with different soil and agro-hydrological characteristics), time and money constraints did not permit such a holistic analysis.

3.3 Research Method

This study has been conducted on the basis of mainly primary data. Primary data have been collected through pump owners and farmer's survey to examine the variations of irrigation water pricing and to ascertain the causes behind the variation of pricing in five Thanas. Few secondary data and information related to minor irrigation census, irrigation water pricing mechanism and hydro-geology of study area have been collected from different published and unpublished reports and articles of Bangladesh Agriculture Development Corporation (BADC), National Water Plan (NWP), Bangladesh Bureau of Statistics (BBS) and Barind Multipurpose Development Authority (BMDA).

3.3.1 Primary Data

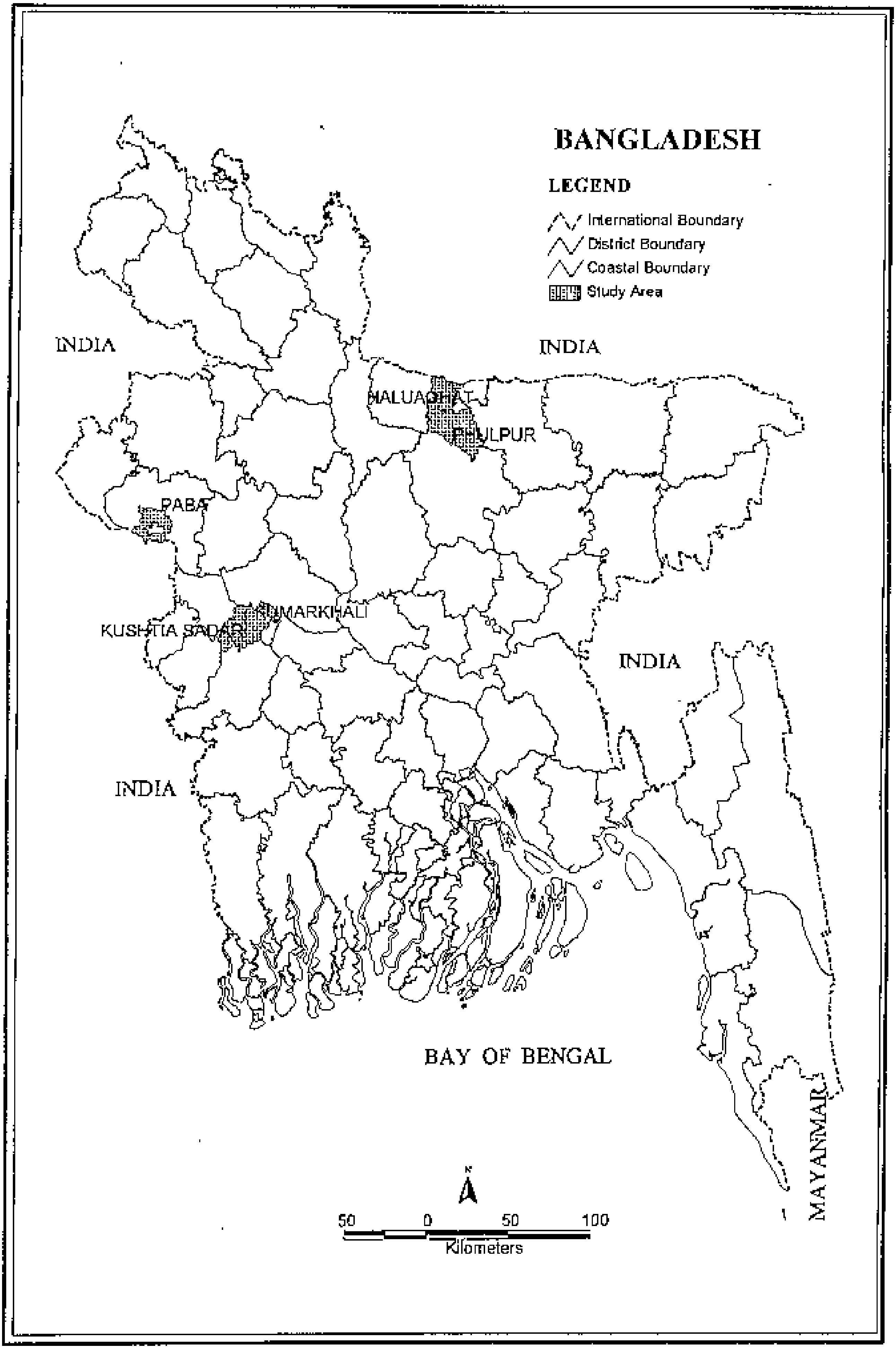
Primary data have been collected through extensive field visits over five distinct study areas. Five field visits within each five Thanas have been carried out to collect data regarding the issues of irrigation modes, energy sources and pricing methods. Fifty three pump owners from five different thanas and belonging to 53 minor irrigation equipment (STW, DTW, & LLP) groups were randomly selected and surveyed by a structured questionnaire. Stakeholder farmers and related office personnel were also interviewed during the field survey. Along with questionnaire, individual and group discussion methods were adopted in data collection. Data and information on features of water pricing, technical & socio-economic causes behind the variation of pricing and profitability of the pump owners and farmers were collected during the survey.

3.2.2 Secondary Data

Different secondary data have been collected from various relevant sources. These are outlined as follows:

- Time based pricing mechanism data in Poba Thana of Rajshahi district have been taken from BMDA report.
- Data related to country's irrigation water pricing methods have been taken from BADC and NWP report.
- Location data and map of the study area have been taken from Thana/ Upazila statistics.
- Statistics of minor irrigation of the Thana have been taken from BADC and BBS reports.

Figure 3.1: Location of the Study Area.



Chapter-4

Pricing Status of Irrigation Water in Study Areas

4.0 Introduction

It has already been mentioned that to identify the variation of irrigation water pricing, a survey was conducted over five thanas where all the different modes (STW, DTW & LLP), energy sources (electricity and diesel), and methods (cash payment, crop share and time basis payment) are practiced by the farmers. Table 4.1 shows the sample distribution of water pricing methods in the five thanas. In Phulpur and Haluaghat Thana, area based cash payment system is dominantly practiced. In Kushtia Sadar and Kumarkhali Thana, output based crop share payment system and in Poba Thana of Rajshahi district under BMDA, time basis payment system is dominantly practiced. It was found from the field survey that both volumetric and input pricing are not practiced in any of the Thanas. Among 53 samples, 28 samples are of area basis, 17 are of output basis and 8 are of time basis. The sample distribution of the different modes are 30 STWs, 18 DTWs and 5 LLPs. The present pricing practices are discussed in details in the following sections.

4.1 Area Based Pricing

As can be seen from Table 4.1, the area based cash payment system is predominantly practiced in Phulpur and Haluaghat Thanas of Mymensingh district. From the survey, it has been revealed that price of irrigation water varies not only over different modes but also on the sources of energy used within the modes. From the discussion with the pump owners and farmers it has been noted that the water price is paid by mostly two or three installments during the season but in all the cases, full payment is made before the harvest. Pump owners claimed that the collection rate of water price is 98-100%. Table 4.2 shows the variation of prices among different modes and power sources. From the discussion with the pump owners and farmers, following reasons were found behind the price variations.

Table 4.1: Water pricing methods over different modes among 53 samples.

Thanas	Modes	Area based	Output based	Time based	Total Samples
Phulpur	STW	10	-	-	10
	DTW	04	-	-	03
	LLP	02	-	-	02
Haluaghat	STW	06	-	-	06
	DTW	03	-	-	02
	LLP	03	-	-	03
Kumarkhali	STW	-	04	-	04
	DTW	-	02	-	02
Kushtia Sadar	STW	-	08	-	10
	DTW	-	03	-	03
Poba	DTW	-	-	08	08
Total		**28**	**17**	**08**	**53**

Table 4.2: Variation of prices in area based pricing over different modes and power sources

Mode	Energy Source	Pricing/ha (Tk)
STW	Electricity	6000
	Diesel	3000+fuel
DTW	Electricity	5500
	Diesel	2500+fuel
LLP	Electricity	-
	Diesel	3000+fuel

4.1.1 Variation among different modes in area based pricing

4.1.1.1 Electricity powered STW and DTW

In case of STW, the pump owners claimed that because of lower command area (effect of scale) and per hectare higher electricity bill, their per hectare average profit is less, compared to DTW. Hence, in case of STW, pump owners ask relatively higher rent of water than that of the DTW. Moreover, STWs are rapidly increasing in number so, DTW owners face a competition with newly installed STW pump units that results in reduction of DTW's command area. So, in order to retain their members, the DTW owners charge a comparatively lower rate. In general, with smaller command areas and fewer members, the STWs are better managed than the DTWs. The average command areas of different modes using different energy sources are given in Table 4.3.

4.1.1.2 Diesel powered STW and DTW

Per hectare water price of diesel powered STW is higher than that of the DTW and the reasons have been mentioned in the preceding article. Moreover, the STW owners also claimed that the per hectare average O & M cost of STW is also relatively higher than that of the DTW.

4.1.1.3 Diesel powered LLP Vs DTW:

In case of LLP, as surface water is used, per hectare fuel consumption is generally less than that of DTW due to lower lift. But, because of lower command area (Table 4.3) and per hectare higher O & M cost, LLP's per hectare irrigation water price is higher than that of the DTW.

Table 4.3 Average command areas of different modes in area based pricing

Mode	Energy	No. of Wells	Command area(ha)
STW	Electricity	05	05
	Diesel	11	04
DTW	Electricity	05	30
	Diesel	02	25
LLP	Diesel	05	04

4.1.2 Variation between energy sources

In case of electricity powered modes, operation (electricity bill), maintenance and water distribution costs are paid by pump owners. But in diesel powered modes, operation (diesel cost) cost is provided by farmers. Farmers pay an establishment cost to the pump owners which includes maintenance, distribution, depreciation costs and also profits for using the machine. As operation with electricity is cheaper than diesel, water price in electricity powered modes is less, compared to diesel powered modes. Hence, farmers using electricity get benefits of reduced water price compared to diesel powered modes. The operation and establishment costs of different modes using different energy sources are shown in Table 4.4.

4.1.2.1 Variation within energy source

Variation of pricing within the same energy source depends on the number of irrigations per week. In case of two irrigations per week, per hectare water price is higher than that of one irrigation per week for both the energy sources (electricity and diesel). The price variations are shown in Table 4.4.

4.1.3 Comparative analysis of area based pricing

Because of comparatively higher command area, per hectare average less fuel consumption and relatively less O & M cost, DTW owner's profit is usually higher than those of the STW and LLP. Moreover, number of STWs are rapidly increasing so, DTW owners face a competition with newly installed pump units that results in reduction of irrigation coverage. So, DTW owners ask a relatively lower price of water to keep the farmers within their command areas.

From Table 4.4 below it can be seen that in case of electricity powered operation, fuel cost is remarkably lower than that of diesel powered operation. Fuel cost is the lowest in case of one irrigation per week under electricity powered DTW operation and highest in case of two irrigation per week under diesel powered STW operation. As a result, in case of two irrigations per week under diesel powered STW operation, total irrigation price is the highest. From the table it can also be seen that both fuel cost and establishment cost are higher in STWs compared to DTWs. So from farmers' perspective, water pricing of electricity based DTWs is the cheapest among all the modes. The diesel based modes are in general more expensive than electricity based modes.

Table 4.4: Average fuel and establishment costs and total irrigation price over different modes and energy sources in area based pricing

Modes	Energy	Fuel cost/ha (Tk)		Establishment cost/ha (Tk)		Total irrigation cost/ha (Tk)	
		A	B	A	B	A	B
STW	Electricity	1700	-	4200	-	5900	-
	Diesel	4500	3000	3000	2500	7500	5500
DTW	Electricity	1500	-	4000	-	5500	-
	Diesel	4000	2700	2500	2500	6500	5200
LLP	Electricity	-	-	-	-	-	-
	Diesel	3700	2500	3000	2500	6700	5000

A= 2 irrigations/week, B= 1 irrigation/week

4.1.4 Pump owners' profit in area based pricing

It has already been mentioned in article 4.1.2 that for electricity based modes all costs (fuel and establishment) are borne by pump owners but for diesel based modes farmers pay for fuel. The establishment cost mainly includes maintenance, water distribution, depreciation costs and pump owners' profit. The depreciation costs have been calculated with average economic lives of 10, 30 and 10 years for STW, DTW and LLP respectively. Sample calculations of depreciation costs for different modes are given in Appendix . Operation and maintenance cost varies over different modes and power sources. All electricity based machines have lesser break downs and are easier and cheaper to maintain. Labor cost varies in two ways. First, because of comparatively higher irrigation coverage, DTW's average labor cost per hectare becomes less than that of STW. And second, in case of diesel run modes, in order to save fuel cost, farmers also attend the field during conveyance of water in order to check the water loss which slightly reduces pump owners labor costs. Table 4.5 shows pump owners average O & M cost over different modes and energy sources.

Based on Table 4.4 and 4.5, the pump owner's profit margin is shown in Table 4.6 and figure 4.1. It is evident from the table and from the figure that electricity run DTWs are the most profitable for the pump owners.

Table 4.5: Pump owner's average O & M cost over different modes and power sources in area based pricing

Modes	Energy	Fuel cost/ha(Tk)		Labor cost/ha(Tk)		Maintenance cost /ha(Tk)		Total O & M cost/ha(Tk)	
		A	B	A	B	A	B	A	B
STW	Electricity	1700	-	1250	-	300	-	3250	-
	Diesel	0	0	800	700	800	600	1600	1300
DTW	Electricity	1500	-	800	-	300	-	2600	-
	Diesel	0	0	600	500	650	570	1250	1070
LLP	Diesel	0	0	800	650	800	600	1600	1250

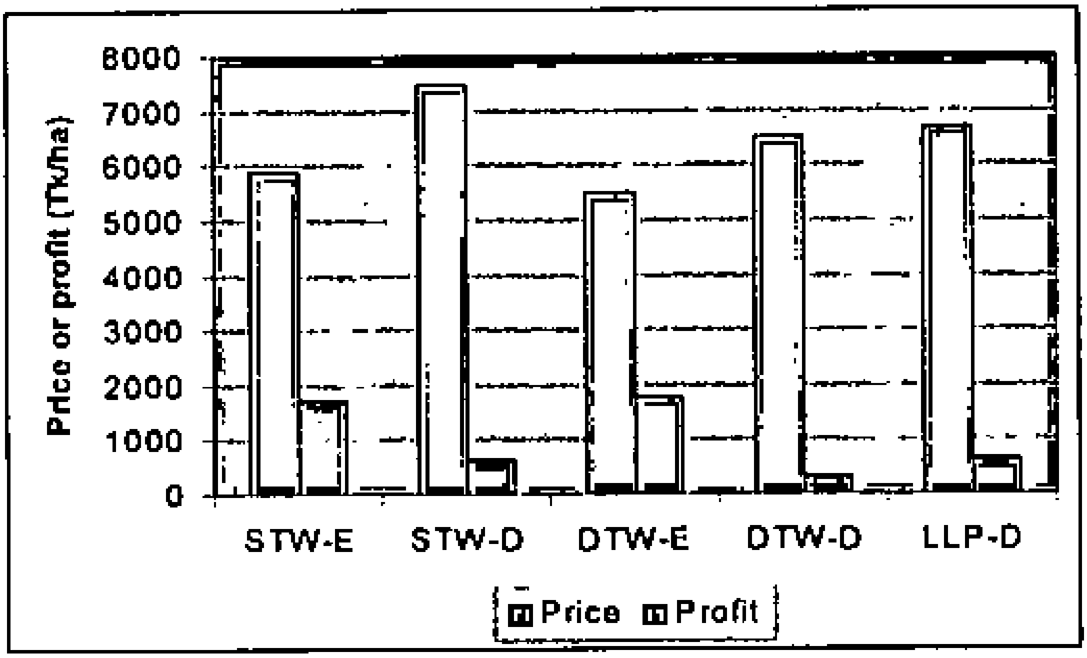
A= 2 irrigations/week, B= 1 irrigation/week

Table 4.6: Pump owners profit margin over different modes and power sources in area based pricing

Mode	Energy	Average O & M cost/ha(TK)		Depreciation cost/ha(TK)	Water price/ha(TK)		Profit margin /ha(TK)	
		A	B		A	B	A	B
STW	Electricity	3250	-	1000	6000	-	1750	-
	Diesel	1600	1300	750	3000*	3000*	650	950
DTW	Electricity	2600	-	1140	5500	5000	1760	-
	Diesel	1250	1070	920	2500*	2500*	330	510
LLP	Diesel	1600	1250	750	3000*	3000*	650	800

A= 2 irrigations/week, B= 1 irrigation/week * Excluding fuel cost

Figure 4.1: Area based water prices and operators' profit margin over different modes (E-electricity; D- diesel)



4.1.5 Change in water price over time in area based pricing

From the discussion with the pump owners and farmers it has been revealed that price of irrigation water has increased gradually during last 15 years. For diesel run modes, as the fuel cost is borne by the farmers, there has been only a slight increase in establishment cost but the price of diesel has increased significantly. Increase in price of spare parts, lubricants, electricity bill and electricity connection fee has contributed to the increase of the price of irrigation water. Table 4.7 shows the changing rate of irrigation water prices over different years.

Table 4.7: Changing rate of irrigation water prices over different years in Phulpur & Haluaghat

Year	STW (Tk/ha)		DTW (Tk/ha)		LLP (Tk/ha)	
	Electricity	Diesel	Electricity	Diesel	Electricity	Diesel
Before1995	-	Tk2500 +fuel	Tk3950	Tk2000+ fuel	-	Tk2500+fuel
1995-2000	Tk5500	Tk2500 +fuel	Tk5000	Tk2500+ fuel	-	Tk2500+fuel
2000-05	Tk6000	Tk3000 +fuel	Tk5500	Tk2500+ fuel	-	Tk3000+fuel

4.2 Output Based Pricing

In Kushtia Sadar and in Kumarkhali, output based crop share payment system is dominantly practiced. From the survey, it has been revealed that price of irrigation water varies depending upon the energy sources of modes in Kushtia. Table 4.8 shows that in case of electricity run modes (both STW & DTW), farmers pay one fourth of their total crop which is equivalent to Tk.9000/ha (30 mound rice/ha @ Tk.300/mound; 1 mound is about 37 kg). In case of diesel run modes (both STW & DTW), farmers themselves pay for fuel and pay 370 kg of dry rice (Tk.3000/ha) for getting access to irrigation. No LLP was found for Boro rice irrigation in this region.

Table 4.8: Variation of water prices in output based pricing over different modes and energy sources

Mode	Energy Source	Pricing/ha
STW	Electricity	¼ of total crop
	Diesel	370 kg of dry rice +fuel
DTW	Electricity	¼ of total crop
	Diesel	370 kg of dry rice +fuel

4.2.1 Reasons behind the adoption of output based pricing

From the discussion with the pump owners, it has been revealed that the output based pricing system has been adopted because of its profitability and certainty of collection. At the end of the season while harvesting, pump owners can easily collect their share of one- fourth of the crop as price of irrigation water.

From the discussion with the pump owners and farmers, it has been noticed that output based payment system has been accepted by the farmers because of their liquidity problem. From the farmers' point of view, production of Boro rice is often falls on risks due to natural hazards (like over rainfall, storms, etc.). Considering the risk factor of production, farmers' feel safe by paying through crops from the field; whatever is the production, farmers pay one-fourth of their crop. If production is hampered, the result affects both farmers and pump owners.

Cultivation of Boro rice is considered as expensive by the farmers. Input costs (i.e. water, fertilizer, seeds, labor, pesticides etc.) are so high that during the Boro season farmers face cash shortage. Farmers want to avoid cash payment of irrigation cost during the season and feel comfortable in paying this cost after the harvest. As in this method the payment in rice is made at the time of harvest so, the farmer's cash expenditure during the Boro season is reduced.

4.2.2 Variation between power sources in output based pricing

In electricity run operation, the price (which includes fuel and establishment costs) of irrigation water is one-fourth of the harvested crop (Tk.9000/ha) for both the modes. But in case of diesel run irrigation, for both the modes, the establishment cost is 370kg of dry paddy/ha (Tk.3000). The establishment cost is paid for getting access to irrigation and includes the maintenance, distribution and depreciation costs and pump owners' profits

4.2.3 Variation among different modes in output based pricing

As it is evident from Table 4.8, no difference was observed in output based pricing of DTW and STW although the command areas of STWs are comparatively lower than those of DTWs (Table 4.9). With decreasing command area due to increasing number of STWs, the pump owners have not increased the share of output in order to remain competetive.

Table 4.9: Average command areas of different modes in output based pricing

Mode	Energy	No. of Wells	Command area (ha)
STW	Electricity	07	05
	Diesel	05	04
DTW	Electricity	03	30
	Diesel	02	25

4.2.4 Comparative analysis of output based pricing

As in output based pricing, the farmers pay a fixed share of their harvest, there is not much difference in irrigation water price between modes or energy sources with similar harvests. The fuel and establishment costs and irrigation price for different modes are shown in Table 4.10. From the table it can be seen that in case of electricity powered operation, fuel cost is remarkably lower than diesel powered operation. Fuel cost is the lowest in case of two irrigations per week under electricity powered DTW operation and highest in case of three irrigations per week under diesel powered STW operation. But total irrigation price is almost the same in both electricity and diesel powered operation as farmers pay one fourth of the total crop from the irrigated area.

It is evident from the table that in output based pricing the water price depends on the farmer's harvest and is independent of mode and energy source. Soil texture affects the water pricing in diesel powered modes as coarse textured soils require more frequent irrigation and increases the irrigation price (Table 4.10).

Table 4.10: Average fuel and establishment costs over different modes and energy sources in output based pricing

Mode	Energy	Fuel cost/ha (Tk)		Establishment cost/ha (Tk)		Total irrigation price/ha (Tk)	
		A	B	A	B	A	B
STW	Electricity	2100	1600	6900	7400	9000	9000
	Diesel	6000	4500	3000	3000	9000	7500
DTW	Electricity	1600	1300	7400	6700	9000	9000
	Diesel	5000	3700	3000	3000	8000	6700

A= 3 irrigation/week, B= 2 irrigation/week

4.2.5 Pump owners' profit in output based pricing

It is mentioned earlier that establishment cost mainly includes maintenance, water distribution, depreciation costs and pump owner's profit. Similar to area based pricing, here also operation and maintenance cost varies over different modes and power sources. As electricity based machines have lesser breakdowns and are easier and cheaper to maintain, hence, O & M cost in electricity based modes is less than that of diesel run modes. Because of comparatively higher irrigation coverage, DTW's per hectare average labor cost becomes less than that of STW. In case of diesel run modes, in order to save fuel cost, farmers also attend the field during conveyance of water in order to check the water loss which slightly reduces pump owners labor costs. Table 4.11 shows pump owners' average O & M cost over different modes and energy sources.

Based on Table 4.10 and 4.11, the pump owner's profit is shown in Table 4.12 and Figure 4.2. It can be seen from the table and figure that electricity run DTWs are the most profitable for the pump owners.

Table 4.11: Pump owners' average O & M cost over different modes and power sources in output based pricing

Mode	Energy	Fuel cost/ha (Tk)		Labor cost/ha (Tk)		Maintenance cost /ha (Tk)		Total O & M cost/ha (Tk)	
		A	B	A	B	A	B	A	B
STW	Electricity	2100	1600	1350	1100	320	300	3770	3000
	Diesel	0	0	800	700	1000	750	1800	1450
DTW	Electricity	1600	1300	850	750	300	250	2750	2300
	Diesel	0	0	650	550	850	600	1500	1150

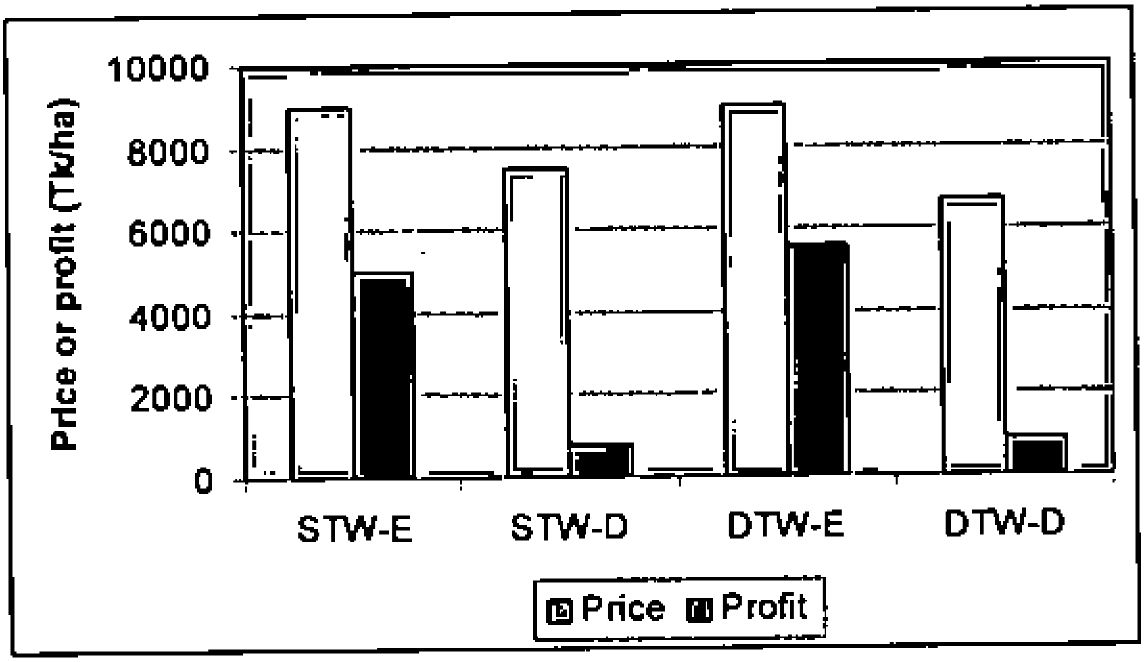
A= 3 irrigations/week, B= 2 irrigations/week

Table 4.12: Pump owners profit over different modes and power sources in output based pricing

Mode	Energy	Average O & M cost/ha (Tk)		Depreciation cost/ha (Tk)	Water price/ha (Tk)		Profit margin /ha (Tk)	
		A	B		A	B	A	B
STW	Electricity	3770	3000	1000	9000	9000	4230	5000
	Diesel	1800	1450	750	3000*	3000*	450	800
DTW	Electricity	2750	2300	1140	9000	9000	5110	5560
	Diesel	1500	1150	920	3000*	3000*	580	930

A= 3 irrigations/week, B=2 irrigations/week. * Excluding fuel cost

Figure 4.2: Output based water prices and operators' profits over different modes (E-electricity, D-diesel)



4.2.6 Change in water pricing over time in output based pricing

From the discussion with the pump owners and farmers it has been revealed that price of irrigation water has changed gradually within last 15 years, only for modes run by diesel For electricity run modes there is no change in pump owner's share of output as the rate of increase of output (rice) was generally higher than that of the input (electricity). Increase in number of diesel run STWs and competition among the pump owners have contributed to the decrease in the pump owners' share of the output and the price of irrigation water. Table 4.13 shows the changing rate of irrigation water prices in output based pricing over different years.

Table 4.13: Changing rate of output based irrigation water prices over different years

Year	STW(ha)		DTW (ha)	
	Electricity	Diesel	Electricity	Diesel
Before1995	¼ of total crop	430 kg (dry rice)+fuel	¼ of total crop	430 kg (dry rice)+fuel
1995-2000	¼ of total crop	395 kg (dry rice)+fuel	¼ of total crop	395 kg (dry rice)+fuel
2000-05	¼ of total crop	370 kg (dry rice)+fuel	¼ of total crop	370 kg (dry rice)+fuel

4.3 Time Based Pricing

Time based irrigation water pricing is practiced in Rajshahi division under Barind Multipurpose Development Authority (BMDA). In this region, due to lower groundwater table and unavailability of surface water, few STWs and LLPs are used for irrigation. Because of higher suction limit, DTWs are used for Boro rice irrigation in this region. Twenty five Thanas of different districts under Rajshahi division are extensively irrigated by DTW through BMDA. Among the 25 thanas, Poba Thana was taken as study area, where time based irrigation water pricing is dominantly practiced. No diesel run mode is used in BMDA irrigation scheme and all the DTWs of BMDA are run by electricity.

4.3.1 Variation in pricing

4.3.1.1 Variation over different capacities of DTWs

Table 4.14 shows that pricing of per hour irrigation varies over capacity of DTWs. In this regard per hour discharge capacity (liters per sec; lps) determines the pricing of irrigation water. Hence, per hour water price in a 56 lps DTW is the highest and lowest in a 14 lps DTW. In Poba Thana, as DTWs of 56 lps capacity are widely used, the water pricing issues discussed here are limited to 56 lps DTWs.

Table 4.14: Variation of water prices in BMDA over different capacities of DTWs.

Mode	Capacity (in lps)	Pricing/hour (Tk)
DTW	42-56	Tk. 85
	21-28	Tk. 75
	14-21	Tk. 70
	14-<	Tk. 65

4.3.1.2 Variation due to number of irrigations

In BMDA irrigation schemes, fuel cost and operation & maintenance (O & M) cost are borne by BMDA. The farmers pay the labor cost for canal maintenance and water distribution. Total irrigation price per season varies within the same mode depending upon labor cost and on number of irrigations given during the season. From the discussion with the BMDA personnel and the farmers it has been revealed that soil type and the distance between cropland and location of pump cause variation in number of irrigations and pumping hours. Table 4.15 shows the variation of total irrigation price due to variations in labor cost and number of irrigations.

Table 4.15: Variation of total irrigation price over labor cost and number of irrigations in BMDA

Number of Irrigation/season	Total irrigation hour/season/ha	Irrigation water cost (Tk)/ Season/ha *	Labor cost (Tk.)/ha	Total irrigation cost (Tk)/ha
28 irrigation	75 hr	Tk.6400	Tk.700	Tk.7100
32 irrigation	85 hr	Tk.7200	Tk.800	Tk.8000
36 irrigation	95 hr	Tk.8100	Tk.1000	Tk.9100

*Irrigation water cost includes fuel cost and O & M costs.

4.3.2 BMDA's profit

In BMDA irrigated area, fuel and maintenance cost are paid by BMDA and labor cost is fully paid by farmers. In case of 32 irrigations per ha/season, 85 hours irrigation is needed during the whole season. DTWs of different capacities consume different units of electricity per hour. From an unpublished register book of BMDA, power consumption (unit/hour) over different types of DTWs were found. Table 4.16 shows per hour electricity consumption over different types of DTWs. It can be seen from the table that DTWs of 56 lps capacities with 21m head (which are common in the area) consume 17 units of electricity/hour. Considering the price of electricity as Tk.2.50/unit, BMDA pays Tk.3610/ha/season as fuel cost whereas farmers pay Tk..7200/ha against 85 hours of irrigation (from Table 4.15). From the discussion with the

BMDA officials, it has been found that the maintenance cost of DTW excluding farmers' borne labor cost (Tk.800/ha/season) is Tk. 400/ha/season. Table 4.17 below shows average O & M cost and profit from the pumps and Figure 4.3 shows the water price and pump owners' profit in BMDA irrigated areas.

Table 4.16: Per hour electricity consumption over different types of DTWs in BMDA

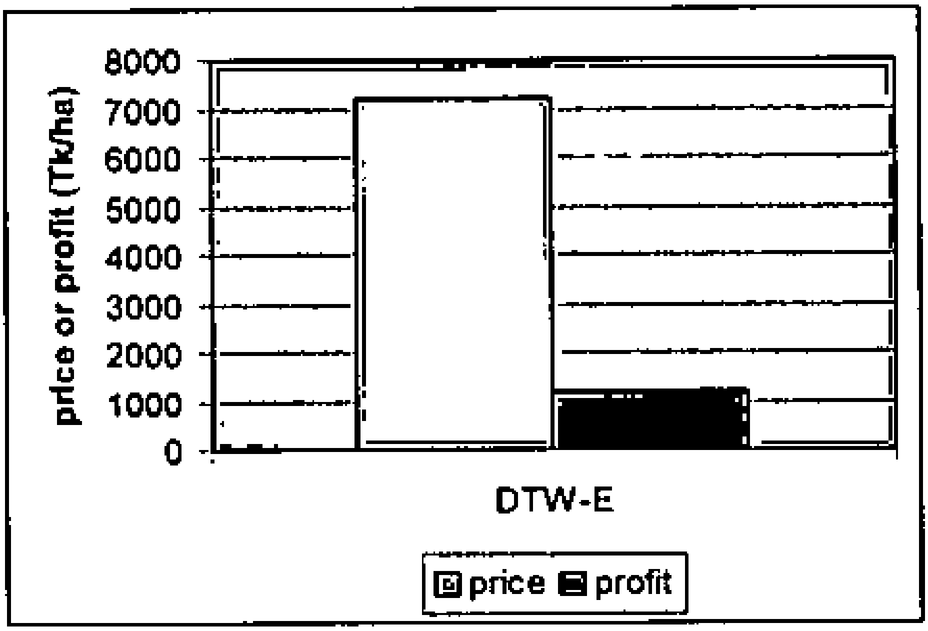
Type of DTW	Power consumption (unit)/hour
24 m head (56 lps)	18 unit
21 m head (56 lps)	17 unit
30 m head (28 lps)	14.5 unit

Table 4.17: BMDA's average fuel and O & M cost and profit

Mode	Fuel cost/ ha (Tk)	Maintenance cost/ha (Tk)*	Total O & M cost/ha (Tk)	Depreciation cost/ha (Tk.)	Water price/ha(Tk)	Profit margin /ha (Tk)
DTW	3610	400	4010	2000	7200	1190

* excluding labor cost

Figure 4.3: Time based water price and BMDA's profit for DTWs (E-electricity)



4.3.3 Change in water pricing over time in BMDA

From the discussion with the BMDA officials and farmers it has been revealed that per unit price of electricity determines the per hour water cost. During 2001/02 to 2005/06 period per unit electricity price has been changed thrice and the irrigation water cost has also been increased accordingly. But, in order to promote irrigation and enhance the command area, BMDA has reduced per hour water cost by giving a discount of TK.5/hour during 2005/06 irrigation season. Table 4.18 shows the changing trend of irrigation water price over the years.

Table 4.18: Changing trend of irrigation water price over the years in BMDA

Years	Water cost/ hour (Tk	Average water cost/season/ha (Tk.)*
2001-02	Tk.75	Tk.6400
2002-03	Tk.75	Tk.6400
2003-04	Tk.80	Tk.6800
2004-05	Tk.90	Tk.7650
2005-06	Tk.85	Tk.7200

* for 32 irrigations/season

4.3.4 Changing trend of average command area in BMDA

The average command area of DTWs in Poba Thana, BMDA, has declined gradually in recent years. From the discussion with the pump owners and the farmers, the causes found behind the declining trend were as follows:

- Due to high cost of irrigation water and other inputs irrigation is now considered less profitable to the farmers.
- As Poba Thana is adjacent to Rajshahi city, urbanization is decreasing the land available for agriculture. Table 4.19 shows the changing trend of average command area of DTWs in Poba Thana, BMDA.

Table 4.19: Changing trend of average command area per mode over the years in BMDA

Years	Average Command area/DTW (ha)
2002-03	20
2003-04	17
2004-05	16
2005-06	12

4.4 Comparative Analysis of Different Pricing Methods

In order to find out which pricing method is favorable to the farmers and which one to the pump owners, a comparative analysis of the different pricing methods was made. In case of electricity run operation under area based pricing, fuel cost is relatively less and borne by pump owners. Moreover, a major part of the labor cost is also borne by pump owners. So, electricity run operation in both STW and DTW under area based pricing (Tk.6000/ha and Tk.5500/ha respectively) is the most suitable pricing method for the farmers. Table 4.20 shows the comparative pricing methods for different modes. Due to higher command area, less fuel consumption per hectare and less O & M cost per hectare, electricity run DTWs under area based pricing is the most favorable to the farmers.

On the other hand, electricity run both STW and DTW under output based crop share pricing where one-fourth of the total land crop is paid as water price (Tk.9000/ha) is the most profitable method for the pump owners. Table 4.21 and Figure 4.4 show pump owners comparative profitability over different pricing methods for different modes.

Analysis of pump owners' return on investment shows that the return is much high in case of electricity run operation of both STW and DTW (122% & 161% respectively) under output based pricing. The return is low in case of diesel run STW and DTW (26% & 15%

respectively) under area based pricing. Table 4.22 and figure 4.6 show pump owners' per year return on investment in percentage basis.

Table 4.20: Comparative prices in different pricing methods for different modes.

Mode	Energy source	Water price/ha* (Tk.)		
		Area based	Output based	Time based
STW	Electricity	6000	9000	-
	Diesel	7500	7500	-
DTW	Electricity	5500	9000	8000
	Diesel	6500	6700	-

*On the basis of 2 irrigations/week

Table 4.21: Pump owners' profitability over different pricing methods and modes

Mode	Energy source	Profit/ha (Tk.)*		
		Area based	Output based	Time based
STW	Electricity	1700	4950	-
	Diesel	625	775	-
DTW	Electricity	1760	5560	1190
	Diesel	330	930	-

*On the basis of 2 irrigations/week

Table 4.22 Pump owners' per year return on investment (%)

Mode	Energy source	Per year investment/ha (Tk)*			Return/ha (%)		
		Area	Output	Time	Area	Output	Time
STW	Electricity	4250	4000		41	125	
	Diesel	2350	2200		27	36	
DTW	Electricity	3740	3440	6010	47	161	20
	Diesel	2170	2070		15	45	
LLP	Diesel	2350	-	-	27	-	

* Investment includes O&M costs and depreciation costs.

Figure 4.4: Irrigation water prices in different methods and modes (E-electricity; D-diesel)

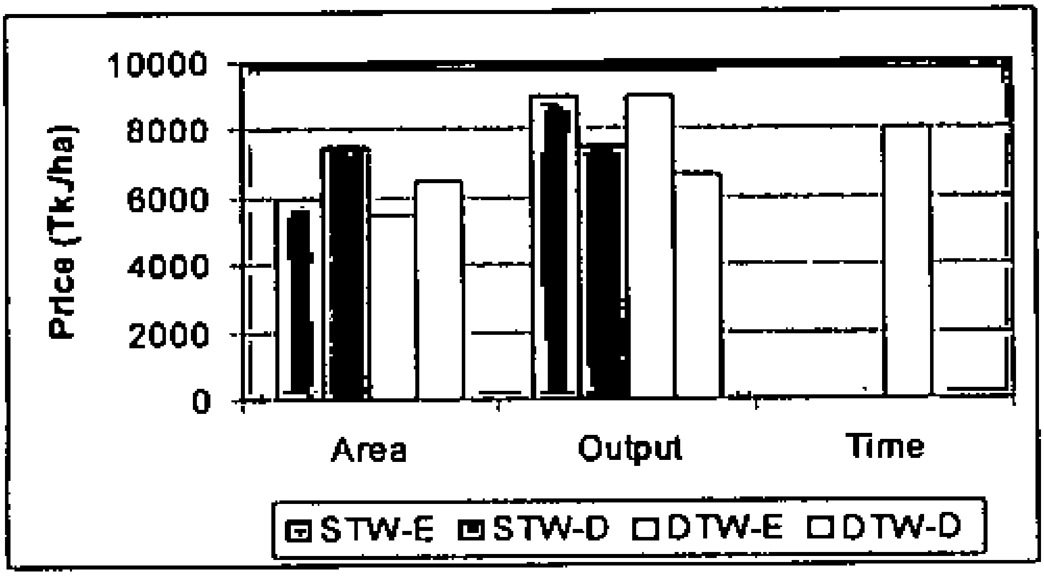


Figure 4.5: Comparative operators' profits over different pricing methods and modes (E-electricity; D-diesel)

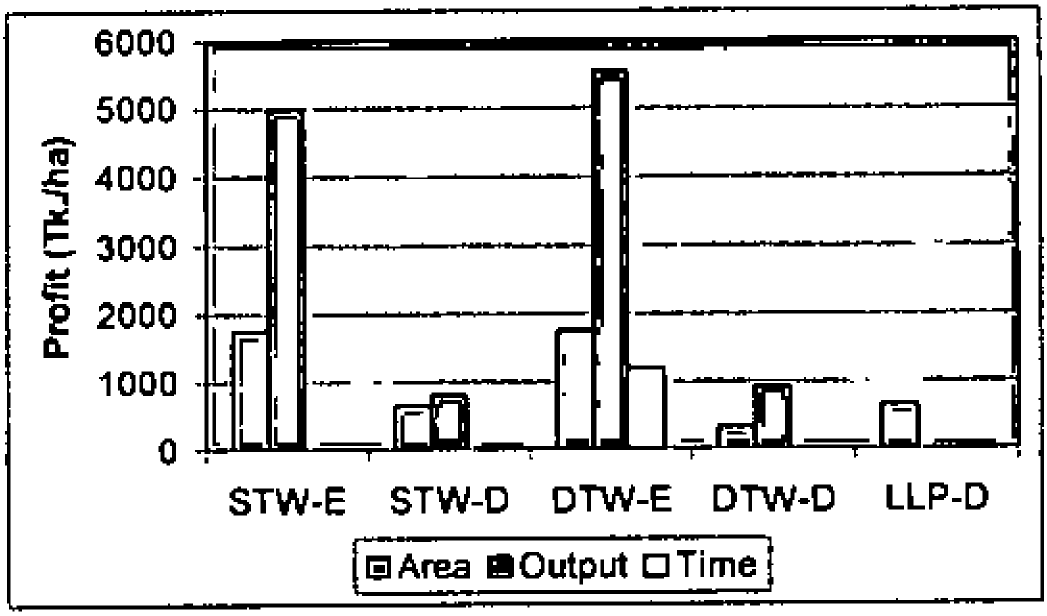
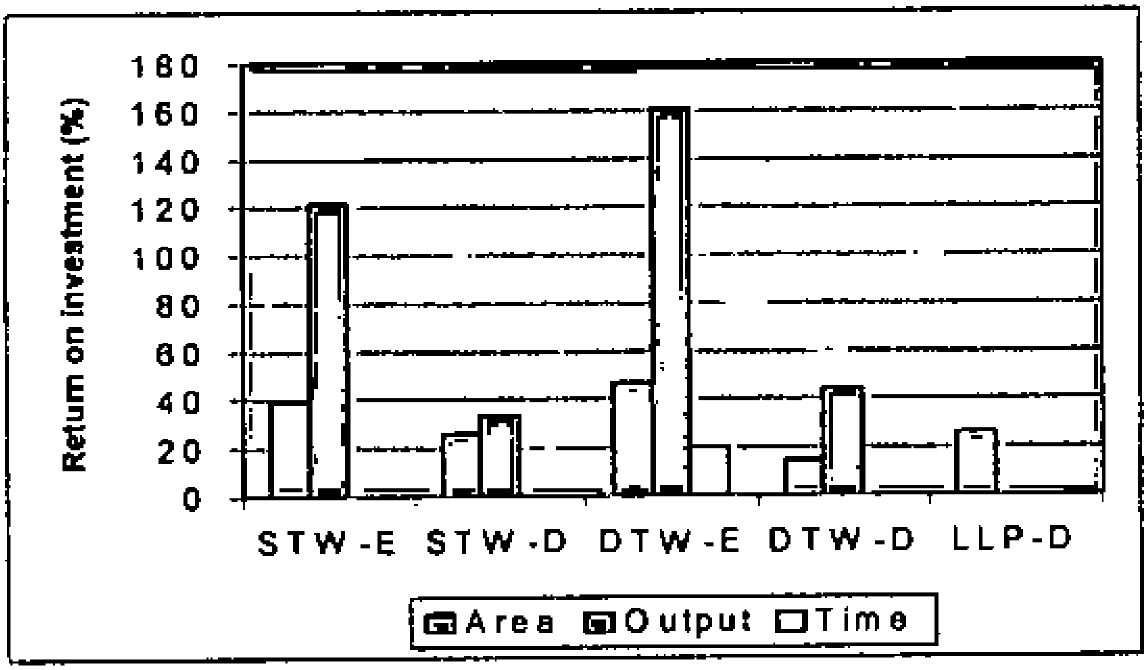


Figure 4.6: Pump owners' per year return on investment (%) (E-electricity; D-diesel)



Chapter-5

Conclusion and recommendations

5.1 Conclusion

In Bangladesh, minor irrigation system is considered crucially important in national economy as the system covers 90% of the total irrigation coverage and plays a vital role in agricultural production. Pricing of irrigation water varies widely over different modes and methods of minor irrigation in the country. STW, DTW and LLP are the major modes, electricity and diesel are the energy sources and semi-volumetric (time basis payment) and non-volumetric (cash payment and crop share) are the pricing methods used in minor irrigation of the country. In this study an attempt has been made to identify the causes (technical and socio- economic) behind the variation of irrigation water pricing over different modes (STW, DTW & LLP), energy sources (electricity & diesel) and methods (cash payment, crop share and time basis payment) of minor irrigation. For the study, five Thanas (Phulpur and Haluaghat Thana of Mymensingh District, Kumarkhali and Sadar Thana of Kushtia District and Poba Thana of BMDA under Rajshahi District) were selected as study areas where all the different modes, energy sources and pricing methods are practiced.

From the study, it has been revealed that price of irrigation water varies widely over different areas of the country. A number of technical and socio-economic causes were found that lead to the variation in water pricing in different study areas. Energy sources, number of irrigation, type of modes and source of water (groundwater or surface water) were identified as technical causes and prevailing method, easiness of rent collection, liquidity status of farmers and competition among the pump owners were identified as socio-economic causes behind the variation.

Area based cash payment system is widely used for irrigation water pricing in Phulpur and Haluaghat Thana of Mymensingh District. In the study it has been found that within the same method, pricing varies over different modes, energy sources and number of irrigations. In both the Thanas, where per week 2 irrigations are needed, average price of irrigation water in diesel powered STWs and DTWs are TK. 7500/ha and Tk.6500/ha respectively. In electricity powered operation, irrigation price in STW is Tk.6000/ha and in DTW, the price is Tk.5500/ha in both the Thanas. Number of STWs are rapidly increasing so, DTW owners face a competition with newly installed pump units that results in reduction of irrigation coverage. So, DTW owners ask a relatively lower rent of water to keep the farmers within their command area. Because of higher command area and relatively less O & M cost, DTW owners total profit is usually higher than those of the STW and LLP. So DTW becomes cheaper to the farmers. LLP uses surface water so, due to lower lift, per hectare fuel consumption in LLP is less than STW. From the discussion with the pump owners and farmers it has been revealed that price of irrigation water has changed gradually within last 15 years, specially for modes run by electricity. Increase in price of spare parts, lubricants, electricity bill and electricity connection fees have contributed to the increase of the price of irrigation water.

Output based crop share payment system is the most common water pricing method used in Kumarkhali and Sadar Thana of Kustia District. In this method, in case of electricity run operation, farmers pay one fourth of the total crop from the land for both the modes -STW and DTW. In case of diesel powered operation, farmers pay fuel cost and 370kg of dry paddy as establishment cost against per hectare irrigation. Crop share based payment system has been adopted because of the liquidity problem of the farmers and easiness of collection. At the end of the season while harvesting, pump owners easily can collect one- fourth of the land crop. Farmers accepted the method because of liquidity problem; whatever the production, farmers pay one-fourth of their land crop. From the discussion with the pump owners and farmers it has been found that the rapid increase in number of diesel run STWs and competition among the pump owners have contributed to the gradual decrease of the price of irrigation water by diesel run STWs.

Time basis semi-volumetric pricing method is practiced in Poba Thana of Rajshahi District under Barind Multipurpose Development Authority (BMDA). In this area only electricity run DTWs are used in irrigation and farmers pay per hour irrigation basis. In Poba Thana, DTWs of 56 lps capacities are widely used and farmers pay Tk.85/- per hour of irrigation. In this method pricing varies over consumed time of irrigation. Increase in maintenance and per unit electricity cost have contributed to increase in per hour water cost in BMDA within last few years.

In case of electricity run operation under output based pricing, water cost was found to be almost double than that of area based pricing. In case of diesel run modes under both area based and output based pricing and in semi-volumetric time basis pricing where electricity run DTWs are used, the water cost were found to be almost the same. From the analysis it has been noticed that in all the cases (area based or output based, DTW or STW) electricity run operation are more profitable to the pump owners. Electricity run operation under output based pricing is the most profitable to the pump owners, on the other hand, electricity run operation under area based pricing is the most favorable to the farmers.

Comparative analysis of different pricing methods show that electricity run operation in both STW and DTW under area based pricing (Tk.6000/ha and Tk.5500/ha) is the most favorable pricing method for the farmers. On the other hand, electricity run both STW and DTW under output based crop share pricing (Tk.9000/ha) is the most profitable method for the pump owners. From the analysis of pump owners' return on investment, it has been noticed that that the return is highest in electricity run STW and DTW operation (122% and 161% respectively) under output based pricing. In case of electricity run operation under area based pricing, fuel cost is relatively less and borne by pump owners, moreover, a major part of the labor cost is also borne by pump owners so, electricity run area based pricing becomes most favorable for the farmers. Due to higher command area, per hectare less fuel consumption and per hectare less O & M cost, electricity run DTWs are more suitable to the farmers compared to STWs.

5.2 Recommendations

Based on the findings of the study, the following recommendations have been made:

i) As operators of both STWs and DTWs using electricity are making much profit, regulatory measures may be imposed on water pricing of electricity based irrigation, so as to distribute the benefit of electricity equally between farmers and pump owners.

ii) As domestic market price of agricultural produces and other inputs (seeds, fertilizer, labor, pesticides etc.) are same around the country, hence, a homogeneous price structure may be allowed in irrigation water pricing to reduce the variations over the same modes and power sources.

iii) As electricity run operation is seen profitable to the pump owners and also favorable to the farmers so, electricity coverage should be increased in rural areas to inspire electricity based irrigation in agriculture sector.

iv) Although volumetric water pricing (time based pricing) is expected to improve the water use efficiency compared to non-volumetric pricing, this aspect was not studied due to lack of facilities for field measurements of flow. Further study is needed on comparative water savings in different pricing methods.

References

Ahmed M. (2000) "Water Pricing and Markets in the Near East: Policy Issues and Options," Water Policy 2 (3), Elsevier Science Ltd, P: 229-242

Bandaragoda D. J. (1998) "Design and Practice of Water Allocation Rules," Lessons From Warabandi in Pakistan's Punjab, IWMI, Research Report No. 17, IWMI, Sri Lanka.

BADC (2005) "Minor Irrigation Survey Report 2004-05", Ministry of Agriculture, Government of the Peoples Republic of Bangladesh, 2005

Bosworth B. (2002) "Water charging in Irrigated Agriculture", Lessons from the Literature, OD 145 HR Wallingford.

Bos M.G. and Walters W. (1990) "Water Charges and Irrigation Efficiencies," Irrigation and Drainage Systems, Vol-4, P: 267-278.

Cornish G.A. and Perry C.J.(2003) "Water charging in Irrigated Agriculture", Lessons from the field, OD 150 HR Wallingford.

Fujimoto N. and Tomosho T. (2003) "A viewpoint to apply water pricing to the Asian humid tropics", Lessons from the field, OD 150 HR Wallingford.

Gardner B.D. (1983) "Water Pricing and Rent Seeking in California Agriculture", in T. Anderson (ed.) Water Rights, PIPPR, San Francisco.

GWP (2000) "Integrated Water Resources Management," TAC Background Papers No. 4, Technical Advisory Committee (TAC), Global Water Partnership, Stockholm, Sweden.

IIMI (1996) " Study on Privatization of Minor Irrigation in Bangladesh", International Irrigation Management Institute and Bangladesh Agricultural University.

Johansson R.C. (2000) "Pricing Irrigation Water: A Literature Survey," World Bank, Washington, D.C

Mondal M.S. (2000) "Performance Evaluation of Some Selected Deep and Shallow Tubewells in Irrigation Development", unpublished M.Sc thesis, Department of Water Resources Engineering, Bangladesh University of Engineering and Technology (BUET), Dhaka.

NWMP (2000a) "Draft Development Strategy", Volume-7, Annex-1, Regulatory and Economic Instruments, Water Resources Planning Organization, Ministry of Water Resources, Government of the Peoples Republic of Bangladesh with Halcrow and Mott MacDonald (consultants).

NWMP (2000b) "Draft Development Strategy", Volume-5, Annex-D, Legacies and Lessons, Water Resources Planning Organization, Ministry of Water Resources, Government of the Peoples Republic of Bangladesh with Halcrow and Mott MacDonald (consultants).

NWMP (2000c) "The Economics of Minor Irrigation", Draft Development Strategy, Annex J Appendix 7, Ministry of Water Resources, Government of the Peoples Republic of Bangladesh, Dhaka.

NWMP (2001) "Supporting Information", Halcrow and WARPO, Ministry of Water Resources, Government of the Peoples Republic of Bangladesh, Dhaka.

Perry C.J. (2001) "Potential Role of Water Pricing in Irrigation: the example of India", Proceedings of conference on sustainable water management, New Delhi, India.

Renzetti S. and Dupont D. (1999) "An Assessment of the Impact of Charging for Provincial Water Use Permits", Paper presentation, 6th Conference of the International Water and Resource Economics Consortium, Hawaii.

Rhodes G.F. and Sampath R.K. (1988) "Efficiency, Equity and Cost Recovery Implications of Water Pricing and Allocation Schemes in Developing Countries," Canadian Journal of Agricultural Economics, Vol.-36, P: 103-117

Saleh A.F.M. and Mondal M.S.(2000) "Performance Evaluation of Rubber Dam Project in Irrigation Development", Institute of Flood Control and Drainage Research, BUET, Dhaka.

Saleth M.R. (1997) "India," Water Pricing Experiences: An International Perspective, World Bank Technical Paper # 386, Washington, D C.

Seagraves J.A. and Easter K.W. (1988) "Pricing Irrigation Water in Developing Countries", Water Resources Bulletin, 4.

Seckler D., Sampath R.K. and Raheja S.K. (1988) "An Index for Measuring the Performance of Irrigation Management Systems with an Application," Water Resources Bulletin, Vol-24, P: 855-860

Small L. E. and Carruthers I. (1991) "Farmer-financed irrigation: the economics of reform", Published in association with the International Irrigation Management Institute, Cambridge University Press, Cambridge.

Tsur Y. and Diner A. (1995) "Efficiency and Equity Considerations in Pricing and Allocating Irrigation Water," World Bank Policy Research Paper # 1460, Washington, D.C.

Tsur Y. and Diner A. (1997) "On the Relative Efficiency of Alternative Methods for Pricing Irrigation Water and their Implementation," World Bank Economic Review, Vol-11, P: 243-262

Appendix A: Calculation of depreciation costs for STW (Diesel)

Installation cost : Tk. 20,000/-

Average economic life : 10 years

Present resale value (after expiry) : Tk. 3,000/-

Total depreciation (10 years) : Tk. 20,000- Tk. 3,000 = Tk. 17,000

Annualized cost: $A/P = i\,(1+i)^n / (1+i)^n - 1$

where, A= Annualized cost

P= Installation cost – Resale value

i = Interest rate (12%)

n = Average economic life

So, $A = 17{,}000 * .12\,(1.12)^{10} / (1.12)^{10} - 1$

$= 17{,}000 * .37 / 2.11$

$= 3002$

Average command area of diesel powered STW : 4 hectare

Per hectare depreciation cost : Tk. 3002/4 = Tk. 750/-

Appendix B: Calculation of depreciation costs for STW (electricity)

Installation cost (including electricity connection fee) : Tk 30,000/-

Average economic life : 10 years

Present resale value (after expiry) : Tk. 1,000/-

Total depreciation (10 years) : Tk. 30,000- Tk. 1,000 = Tk. 29,000

Annualized cost: $A/P = i\,(1+i)^n / (1+i)^n - 1$

where, A= Annualized cost

P= Installation cost – Resale value

i = Interest rate (12%)

n = Average economic life

So, $A = 29{,}000 * .12\,(1.12)^{10} / (1.12)^{10} - 1$

$= 29{,}000 * .37 / 2.11$

$= 5085$

Average command area of electricity powered STW : 5 hectare

Per hectare depreciation cost : Tk. 5085/5 = Tk. 1017/-

Appendix C: Calculation of depreciation costs for DTW (diesel)

Installation cost : Tk. 200,000/-

Average economic life : 30 years

Present resale value (after expiry) : Tk. 15000/-

Total depreciation (30 years) . Tk 200,000- Tk. 15,000 = Tk. 185,000/-

Annualized cost: $A/P= i\,(1+i)^n / (1+i)^n - 1$

where, A= Annualized cost

P= Installation cost – Resale value

i = Interest rate (12%)

n = Average economic life

So, $A = 185{,}000 * .12\,(1.12)^{30} / (1.12)^{30} - 1$

$= 185{,}000 * 3.60 / 28.96$

$= 22366/-$

Average command area of diesel powered DTW : 25 hectare

Per hectare depreciation cost : Tk. 22966/25 = Tk. 920/-

Appendix D: Calculation of depreciation costs for DTW (electricity)

Installation cost (including electricity connection fee): Tk. 280,000/-

Average economic life : 30 years

Present resale value (after expiry) : Tk. 5,000/-

Total depreciation (30 years) : Tk 280,000- Tk. 5,000 = Tk. 275,000/-

Annualized cost: $A/P= i\,(1+i)^n / (1+i)^n - 1$

where, A= Annualized cost

P= Installation cost – Resale value

i = Interest rate (12%)

n = Average economic life

So, $A = 275{,}000 * .12\,(1.12)^{30} / (1.12)^{30} - 1$

$= 275{,}000 * 3.60 / 28.96$

$= 34185$/-

Average command area of electricity powered DTW : 30 hectare

Per hectare depreciation cost : Tk. 34185/ 30= Tk. 1140/-

Average command area of electricity powered DTW in BMDA : 17 hectare

So, per hectare depreciation cost of DTW in BMDA . Tk. 34185/ 17= Tk. 2000/-

Appendix E: Calculation of depreciation costs for LLP (diesel)

Installation cost . Tk. 20,000/-

Average economic life : 10 years

Present resale value (after expiry) : Tk. 3,000/-

Total depreciation (10 years) : Tk. 20,000- Tk. 3,000 = Tk. 17,000

Annualized cost: $A/P = i\,(1+i)^n / (1+i)^n - 1$

where, A= Annualized cost

P= Installation cost – Resale value

i = Interest rate (12%)

n = Average economic life

So, $A = 17{,}000 * .12\,(1.12)^{10} / (1.12)^{10} - 1$

$= 17{,}000 * .37 / 2.11$

$= 3002$

Average command area of diesel powered LLP · 4 hectare

Per hectare depreciation cost : Tk. 3002/4 = Tk. 750/-

Appendix F: Installation costs of different type of STWs over different years

Year of installation	HPs	Country (made in)	Power	Boring dia (inch)	delivery dia (inch)	Length of pipe & filter (in feet)	Cost (in Tk)
1983	8	Japan	Diesel	5	4	85	36,000
1986	10	Japan	Diesel	6	5	180	40,000
1995	8 5	Japan	Diesel	5	4	140	30,000
1997	12	China	Diesel	5	4	150	28,000
1998	8	China	Electricity	5	4	150	35,000
2000	7	China	Diesel	5	4	150	16,000
2004	7	China	Electricity	4	3	85	30,000

Appendix G: Installation costs of different types of DTWs over different years

Year of installation	HPs	Country (made in)	Power	Boring dia (inch)	Delivery dia (inch)	Length of pipe&filter (in feet)	Cost (in Tk)
1975	26 4	England	diesel	20	8	420	50,000
1982	25	Japan	diesel	18	8	200	65,000
1985	27	Germany	electricity	-	8	180	145,000
1988	26	Germany	diesel	20	8	180	185,000
1991	30	England	electricity	20	8	275	240,000
1994	25	-	electricity	18	8	332	292,000

Appendix H: Installation costs of different types of LLPs over different years

Year of installation	HPs	Country (made in)	Dia of delivery pipe(inches)	Cost (in Tk)
1990	12	Japan	5	38,000
1991	8 5	China	4	24,000
1996	7	China	4	15,000
2000	12	China	5	21,000