EVALUATION OF PREPAID AND PRIVATE IRRIGATION PROGRAM FOR *BORO* RICE CULTIVATION AT THAKURGAON DISTRICT

A THESIS

BY

MST. MUKTA PARVIN
Examination Roll No: 1605562
Session: 2016-2017
Thesis Semester: July-December, 2017

MASTERS OF SCIENCE (MS)

IN

IRRIGATION AND WATER MANAGEMENT

DEPARTMENT OF AGRICULTURAI AND INDUSTRIAL ENGINEERING
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December, 2018

Dedicated to

My Beloved Parents

and

Honorable Teachers

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The Author

EVALUATION OF PREPAID AND PRIVATE IRRIGATION PROGRAM FOR *BORO* RICE CULTIVATION AT THAKURGAON DISTRICT

ABSTRACT

Rice (*Oryza sativa* L.) is the most important food grain in Bangladesh. It is extensively cultivated throughout the year and it is also staple food crop in Bangladesh. This experiment was carried out to compare the irrigation cost between prepaid and private irrigation program in the agricultural field at Khochabari union, Thakurgaon sadar, Thakurgaon at farmer's field during *boro* season. Three different treatment namely prepaid irrigation program (DTW) (T_1), Traditional irrigation program (DTW) (T_2), Shallow system (T_3) were used for this experiment. Rice variety BRRI dhan28 was used to conduct the experiment. The results revealed that the irrigation cost for prepaid irrigation program (DTW), Traditional irrigation program (DTW), Shallow system were 4200, 6200 and 15000 Tk/ha, respectively. Prepaid irrigation system saved 32% irrigation cost compared to the traditional irrigation cost. Total production cost were 62,845, 64,845 and 73,645 Tk/ha for Prepaid system, Traditional system and Shallow system respectively. Average irrigation required for prepaid system, traditional system and Shallow system were 2283.4, 3294.7 and 3723.1 L/Kg, respectively. Due to the propar management the gross return for the Prepaid irrigation system, traditional irrigation system and Shallow system were 93,848, 93,848and 90,250 respectively. The benefit cost ratio for the prepaid irrigation system, Traditional irrigation system and Shallow system were 1.49, 1.45, 1.23, respectively.

The prepaid irrigation system is a time consuming method for the farmers and the farmers can easily take the irrigation water from the Deep Tube Well. This system also a digital innovation for irrigation.

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LIST OF ABBREVIATIONS

T	:	Treatment
kg	:	Kilogram
LCC	:	Large Capacity Card
MVU	:	Mobile Vending Unit
VS	:	Vending Unit
SMS	:	System Master Station
t	:	Ton
ha	:	Hectare
L	:	Liter
BCR	:	Benefit Cost Ratio
DTW	:	Deep Tube Well
BMDA	:	Barind Multipurpose Development Authority
TSP	:	Triple Super Phosphate
MOP	:	Murate of Potash
DAT	:	Date After Transplanting
Tk	:	Taka

CHAPTER 1

INTRODUCTION

CHAPTER 1

INTRODUCTION

1.1 Background

About 80% percent people depend on agriculture and agricultural works in Bangladesh. Among the total employment on agriculture, 42 percent generates from own farm, 35 percent from other farm and the remaining 23 percent from other agricultural services (Habibul, 2005). So, the development in agriculture and agricultural production technology in Bangladesh is very essential for growing more food for her rapidly growing population. The proper amount of water and its application is a key factor for crop production. Kaldellis and Kondili (2007) found that increased water demand due to economic growth, irrigation needs, declining precipitation levels and over-abstraction of groundwater are all factors that create fresh water shortage problems in the Aegean Archipelago islands . Bangladesh is one of the world's most fragile countries in terms of water security. Aside from its extremely high population density, high levels of poverty and vulnerability to climate change, other factors that contribute to the country's fragility include the increasing salinity of river water and the high natural level of arsenic in groundwater. Couple all this with the predicted increase in water demand, up to 440 percent by 2050, and it swiftly becomes evident that dramatic change is needed in Bangladeshi water management. Methods of irrigation in the 20th century included traditional flooding, government-controlled canals (particularly widespread), low lift pumps, and shallow and deep tube wells. As the Bangladeshi population rapidly increased, investments were made in surface water irrigation projects, such as the Muhuri Irrigation Project. Currently, farmers must pay pump-owners for access to water, but the absorbent nature of the earthen canals that feed pumps severely distorts the real price of water.

1.2 Scope of irrigation

The prepaid irrigation program is one of the new technologies for operating the irrigation equipments which reduce the irrigation costs. On the other hand the traditional or private irrigation program is very old program to operate irrigation equipment which helps to exploit the poor or general farmers by charging higher irrigation charge.

Food is the main source of energy for the human beings. Every human being needs adequate foods for continuing its life. For this, in every country there have some systems or rules to grow more foods or collect more foods to support the peoples and human beings of that state.

The world population is increasing day by day and it will increase within the next 30 years by around 3 billion (Brown, 1995). Bangladesh is one of the developing countries and the 8th most populous countries of the world, with a population of approximately 133 million in a land area of 55,598 square miles. At the current population growth rate, in 2025 the population will be over 180 million and in 2050 the population will be over 208 million in Bangladesh (www.usaid.gov/bd/pop.html). More food will require feed those peoples. So, to make availability of foods every country works to produce more foods by using their own lands through modern scientific methods of cultivation for crop production which will reduce the shortage of required foods.

The grain foods directly produce from the plants or crops. Crops need adequate water in its growing life. It cannot take solid nutrients. Water plays a vital role to dilute the solid/hard nutrients and makes solution of nutrients which is then prepared for plant/crops to take easily. If water cannot be given at proper time to the crops, the yield reduces or some times the whole crops damage and the farmers or the state fall down in the food crisis and economic hazards.

Though the irrigation to crop is essential but the efficiently use of water is the acute problem till now, especially in the developing countries. Most of the farmers generally waste more water during Irrigation to crops. Proper water management does not follow by the farmers for their lack of knowledge about crop production. They apply irrigation water before or after the proper required time of crops life. Again they would like to apply more water to crops which creates problems in crops. So, yield of crops reduces and qualities of produced crops become lower. Thus, production cost of crops increases and net income of crop production decreases. That is the benefit –cost ratio become very lower. To give easement to the farmers for crop production the irrigation and agricultural specialists developed the schedule of irrigation that is the time when to irrigate and how much water to be applied to the specified crops lands.

The irrigation schedule for a crop is the empirical prescription to grow crops with proper yield and quality. The use of irrigation schedule is very simple. If the farmers use the irrigation schedule and apply water to crops they can save the irrigation water, reduce irrigation cost and get higher yield. Ultimately, they will be financially benefited.

1.3 Marketing of irrigation

There are many types of new technologies and approaches are working simultaneously in the field for increasing the yield of crops and to maximize the profit of farmers. But due to lack of knowledge of farmers they are unable to decide which one is better than to others. So, they would like to use that technology which is familiar to them. They do not think about the cost saving technologies. By this type of thinking they always miss the opportunity to achieve more profit for crop production. There are four methods of irrigation named- surface, subsurface, sprinkler and drip irrigation methods. Farmers of Bangladesh generally practice the surface irrigation method mainly by using ground water to produce crop. Precisely, the surface wild flooding irrigation method is used by the farmers of Bangladesh. The most of the farmers are poor. Only a few farmers have the ability to purchase the irrigation equipments. Some of the solvent farmers have the private irrigation equipments. The private irrigation equipments are deep tubewell and shallow tubewells. So, the poor farmers take irrigation water from the pump of the private owner. The owners of irrigation pump give irrigation water from their pumps by contract irrigation charge basis at any crop season. The private owner of irrigation pump charges high prices of irrigation water to the poor farmers. Some of the owners take irrigation charge by one-fifth to one-fourth of the produced crops, which is very high irrigation charge. For this case the cost of crop production increases and the profit of poor farmer’s crops decrease.

The government of Bangladesh established several government organizations like- Bangladesh Agricultural Development Corporation (BADC), Bangladesh Water Development Board (BWDB) and Barind Multipurpose Development Authority

(BMDA) to deliver irrigation water to the farmers land by cheap rate of costing. Another organization Local Government Engineering Department (LGED) of Bangladesh works for the development of rural areas. That organization also works with the irrigation for crop production.

Till to day most of the organization except the Barind Multipurpose Development Authority deliver irrigation water to farmers land by seasonal contract irrigation charge basis. BWDB uses surface water for irrigation. All these organizations are unable to collect the irrigation charge from farmers though it is very cheap. In the contract basis of irrigation there is no measuring tool for irrigation water. So, the farmers receive and use more water for crop production. They misuse the irrigation water. For using more irrigation water the yield of crops reduces and cost of production increases thereby profit of crops decreases. The storage of water decreases and starts ecological imbalance. Moreover, at every irrigation scheme a lot amount of irrigation charge keeps as arrear, which is never possible to realize from the farmers. This ultimately affects the National Gross Domestic Product and eco-system.

Considering all the factors Barind Multipurpose Development Authority has been developed a new eco-friendly, more profitable, easy to operate and sophisticated irrigation program in Bangladesh, which is known as the prepaid irrigation program. In this program of irrigation farmers receive irrigation water by prepaid basis. Nobody can get water without prior paying of the irrigation charges or water prices.

Now, the prepaid irrigation program is very popular in the field level. Because, in this irrigation program there is no chance of outstanding the irrigation charge, farmers can receive irrigation water in a cheap rate, no fear of creating water lords, the irrigation equipments keep in a stand by condition whole the year and farmers have the opportunity to irrigate their land as required at any time. Some of the peoples get scope to work in the crop land for earning. The program is also balance the eco-system. The prepaid irrigation program is very popular to the farmers for its various types of merits. But there is no comparative study of prepaid and private/traditional irrigation programs for finding out the economic aspect values of the two programs.

1.4 Justification

Most of the farmers of Bangladesh use traditional method for irrigation purpose. Prepaid irrigational system not only easy method for irrigation but also profitable method. BMDA developed prepaid meter for the farmers so that the farmers can give water in their field at low cost. It is necessary to know what kind of irrigation program is suitable for farmers, There is a need to evaluate the prepaid private irrigation program. The findings of this study will be very helpful for all types of farmers and experts in this field. Therefore, the present study was undertaken with the following objectives.

Objectives of the study

i. To determine the amount of irrigation water required for yield 1 kg of *boro* rice at farmers field.

ii. To determine the average yields per hectare of rice in the prepaid and private irrigation program.

iii. To determine the benefit cost ratio on the basis of irrigation water in the prepaid and private irrigation programs.

CHAPTER 2

REVIEW OF LITERATURE

CHAPTER 2

REVIEW OF LITERATURE

The prepaid business and other works have started from the long before. But in the irrigation sector it is very new. Especially, for operating the irrigation deep tube wells or irrigation pumps, prepaid program may not be found out in the development or developing countries except Bangladesh. Some of the partially similar research works have been found and gists of the findings have been discussed. Few of them are listed below.

2.1 The Purpose of Irrigation

Gonzalez-Alvarez *et al.* (2006) created a proxy for the cost of irrigation water in Georgia from a sample of Georgia irrigators by investigating the marginal cost of pumping groundwater. They then combined that proxy with agronomic and climatic variables to estimate the response of agricultural water use to differences in the marginal cost of irrigation. The results showed that pumping costs were a significant determinant of water use, and imply that agricultural water use would be moderately affected by institutional changes that would explicitly price water.

Amador-Ramírez *et al.* (2007) had completed a research on regional production of dry chili pepper (*Capsicum annuum* L.) is usually limited by an inappropriate weed management. Traditionally, weeds are mainly controlled by mechanical means such as cultivation and hand hoeing increasing production costs. The purpose of this research was to: (1) evaluate the efficacy of pre-plant-incorporated, pre-emergence, and post-emergence herbicides and (2) estimate the net profit of weed control treatments. In 2004, all herbicide treatments reduced weed density in comparison to the mechanical weeding 135 DAP, although trifluralin treatments were the less effective among herbicide treatments. In 2005, weed control with herbicides was similar to the mechanical weeding treatment, even though plots conventionally sprayed with oxyfluorfen showed the lowest weed dry matter. Whereas plots treated with oxyfluorfen through furrow irrigation showed the highest marketable yield in 2004.

Wichelns (2003) had found that water resource professionals have many opportunities to contribute to policy discussions regarding agricultural productivity. Often those discussions are focused on increasing the output generated with limited water supplies, such as maximizing the "crop per drop" or improving irrigation efficiencies, either at the field level or throughout a river basin. Policy discussions involving water resources in developing countries can be enhanced by placing greater emphasis on the roles of non-water inputs and resource constraints in farm-level production and marketing decisions. Three categories of policies that lie outside the water resource realm, but have substantial impacts on water use and agricultural productivity, are examined: (1) policies that modify farm-level input and output prices directly; (2) international trade policies; and (3) policies that modify key institutions, such as land tenure and the sources of investment funds.

Alauddin and Quiggin (2008) high population pressure and the rapid pace of human activity including urbanization, industrialization and other economic activities have led to a dwindling supply of arable land per capita and a process of agricultural intensification in South Asia. While this process has significantly increased food production to feed the growing population, it has also entailed considerable damage to the physical environment, including degradation and depletion of natural resources and unsustainable use of land and water resources. This paper employs the analytical tools of economic theory, environmental and ecological economics to model the impact of irrigation in South Asia. It underscores the need for an eclectic approach to policy responses stemming from private and common property rights theories, externality theory and sustainability theory with a view to environmental zing agricultural development.

DeJonge *et al.* (2007) In this study, the CERES-Maize crop model was used in conjunction with Apollo, a shell program, to evaluate potential improved yield in a central Iowa cornfield on a spatially and temporally variable basis. Five years of historical yield and weather data were used to calibrate the model over 100 spatially variable grid cells for non-irrigated conditions in the 20.25 ha field. This calibrated model then used 28 years of historical weather data to simulate three irrigation scenarios: no irrigation, scheduled uniform irrigation, and precision irrigation. Irrigation improved yield by at least 500 kg ha^{-1} in half of the years simulated. Precision irrigation showed slightly lower yields than scheduled uniform irrigation. Assuming use of a center pivot system, irrigation showed economic returns in only one of the 28 years included in the study. High capital costs were the leading restrictor of economic feasibility.

Mushtaq *et al.* (2007) Ponds are small reservoirs that allow farmers in irrigated areas to capture rainfall, store surplus water from irrigation canals, and conserve water from other sources. Though ponds have been used widely in irrigated areas for many years, recent increases in the construction of ponds due to growing water shortages and government policies generate interest in understanding effectiveness of investing in ponds. They examined the economics of small, medium, and large ponds. All sizes of ponds were profitable with healthy internal rates of return, positive net present values and benefit–cost ratios larger than 1. However, when the imputed cost of family labor was included, small and medium ponds fail to justify investment. Overall, larger ponds offer higher economic benefits than small and medium ponds. Efficiency gains can be achieved by constructing large ponds, which were also economically viable.

Schoengold and Zilberman (2007) the post-World War II era has witnessed a drastic increase in irrigation activities that have contributed substantially to the massive growth in agricultural production that enables humanity to feed its doubling population. However, a distinction has to be made between the overall positive contribution of irrigation to agricultural productivity and economic welfare and the significant amount of misallocation and mismanagement of resources that have accompanied the expansion of irrigation. In many cases, water resources have been overdeveloped; there has been overspending on capital; and significant costs in terms of loss of ecosystems, extinction of fish species, and contamination of water sources. This chapter provides an economic perspective on the contribution of irrigation and water resources to past agricultural development and future water resource management.

Humphreys *et al.* (2006) Australian rice growers are under considerable pressure to increase water use efficiency to remain profitable and avoid soil salinization. In particular, profitability is threatened by decreasing water availability and certainty of supply and by increasing water price, as a result of environmental and National Competition Policy agendas.

Future increases in rice field water productivity will come from greater yields through breeding for increased cold tolerance, precision agriculture and improved crop establishment, and from reduced water use due to reduced duration of ponding. A key challenge of the next decade will be to increase cold tolerance to the extent that deep water ponding for low temperature protection is no longer required, possibly allowing a complete shift away from ponded culture and reducing irrigation water requirement.

While increasing the water productivity of rice is important, water productivity and profitability of the entire cropping system is of ultimate importance. Growing winter crops after rice and permanent bed systems offer potential benefits of increased productivity of crops traditionally grown in rotation with rice and increased cropping diversity and flexibility. Irrigation water productivity is also being improved through on-farm and regional technologies such as on-farm recycling systems and automatic data acquisition and control systems in irrigation supply systems.

Dillon *et al.* (2006) Reported that two case studies explained the role, value, limitations and policy requirements for storing reclaimed water in aquifers for indirect reuse. The first case involves aquifer storage and recovery of water, the product of tertiary treated municipal sewage effluent, via a single injection and recovery well at Bolivar, South Australia. The recovered water, like the source water for injection, is used for unrestricted irrigation of horticulture. A limestone aquifer at a depth of 100 to 160 m confined by clay and containing brackish groundwater provides the storage zone. In the second case, located at Alice Springs, trials are proceeding to assist in the design and establishment of a soil–aquifer treatment system which will allow water derived from secondary treatment of municipal sewage effluent to be stored in an unconfined alluvial aquifer for irrigation of horticulture. Intermittent infiltration from basins provides supplementary water treatment. In each case, the motivations, choice of methods, required investigations, public consultation processes, and economics of subsurface storage are presented. The lessons learned that may assist with development of policies to facilitate environmentally sustainable subsurface storage of water in water reuse projects are discussed.

Dunn *et al.* (2003) Abstractions of surface and groundwater for irrigation in Scotland are currently subject to control in only two small catchments. Under the terms of the EU Water Framework Directive, it will be necessary to introduce new legislation to control abstractions elsewhere. To help in the development of appropriate policy for Scotland a study has been carried out to examine the significance of irrigation and the effectiveness of different types of control strategies in terms of the economics of potato cropping and stream hydrology in Scotland. This paper presents the findings of the hydrological study and highlights some of the spatial and temporal issues that need to be considered in the selection of control mechanisms, if they are to be successful in achieving objectives for environmental improvement.

Chakravorty and Umetsu (2003) This paper develops a spatial model for a water basin that allows for surface water allocation and reuse of the water that is lost. The analytical solution suggests specialization of production over space—upstream farmers use canal water and downstream farmers pump groundwater that is lost upstream. Groundwater emerges as an endogenous “backstop”. The empirical results suggest that when traditional conservation technologies are used, optimization over the entire basin leads to a significant increase in aggregate output, project area and water use. Somewhat counter-intuitively, rents from water decrease if farmers switch from traditional to modernirrigation technology.

Berbel *et al.* (2000) Linear programming (LP) has been widely used to solve company resource allocation problems. The technique's ability to predict how companies will adjust to changes in a variety of exogenous factors is well known, and when used at company level, it enables us to avoid aggregation problems. The decision-maker's objective in this type of research is to maximize profit estimated as gross margin. The researchers apply the LP model to three farms in three different irrigation units that, they believe, provide a representative sample of Spanish irrigated agriculture.

2.2 Impact of Irrigation

Miranda *et al.* (2007) had proposed that Environmental impacts associated with inland shrimp farming may be attenuated by using its effluent for crop irrigation. The objective of this study was to evaluate melon (*Cucumismelo* L.) yield and changes in soil chemical characteristics, in response to irrigation with low-salinity shrimp farm effluent, and to compare the results with freshwater irrigation. The following treatments were applied: two sources of water for melon drip irrigation (shrimp effluent and river water) as main factors and two nitrogen doses applied through fertigation (120 and 90 kg N ha^{-1}) as sub-factors. There were no significant differences among treatments regarding melon yield and fruit quality. Compared to river water, effluent irrigation decreased pH, calcium, and magnesium levels in the soil, increasing the exchangeable sodium ratio (ESR).

2.3 The Cost of Irrigation Water

Shah *et al.* (2009) urged that “Getting prices right” is the silver bullet widely advocated to developing countries in fighting waste, misallocation and scarcity of water. In the vast, poverty-stricken Indo-Gangetic basin, however, high surrogate water price is driving out small-holder irrigation. With rising diesel prices, most small-holders who use borewells for irrigation find effective water use cost soaring, obliging them to economize on water use even by quitting irrigated farming. Electrified borewell owners, far fewer, face low marginal cost but have to contend with stringent electricity rationing. Public irrigation systems grossly under-price irrigation, but these are getting marginalized despite massive government and donor investments.

Tarrass *et al.* (2008) suggested that water is a vital aspect of hemodialysis. During the procedure, large volumes of water are used to prepare dialysate and clean and reprocess machines. This report evaluates the technical and economic feasibility of recycling hemodialysis wastewater for irrigation uses, such as watering gardens and landscape plantings. Water characteristics, possible recycling methods, and production costs of treated water are discussed in terms of the quality of the generated wastewater. A cost-benefit analysis is also performed through comparison of intended cost with that of seawater desalination, which is widely used in irrigation.

Bethune *et al.* (2008) Compared the net present costs of two approaches for managing irrigation-induced deep percolation under border-check irrigated pasture: (1) conversion from border-check irrigation to sprinkler irrigation to minimize deep percolation and (2) installation of a subsurface drainage system to extract excess deep percolation under the existing border-check system. Results for a dairy farm in northern Victoria, Australia, showed that conversion to sprinkler irrigation was the more cost-effective approach. The net present cost of the second approach varies across an irrigation landscape, depending on the most suitable subsurface drainage and disposal system that could be used for a particular location. Where an aquifer was high yielding and of low salinity and thus drainage water was suitable for reuse on farm, tubewells drainage and farm reuse of drainage water provides a viable alternative to conversion from border-check irrigation to sprinkler irrigation. Where tubewell drainage or farm reuse was not feasible, sprinkler irrigation was more cost-effective than border-check irrigation with subsurface drainage.

Kaldellis and Kondili (2007) Found that increased water demand due to economic growth, irrigation needs, declining precipitation levels and over-abstraction of groundwater are all factors that create fresh water shortage problems in the Aegean Archipelago islands. In order to face pressing needs, water is transported by ships from the mainland or other neighboring islands at a high cost. The objective of the present work is to analyze the current status of water shortage problem in the Hellenic islands and to provide reliable data concerning the water quantities being imported in the areas of Cyclades and Dodecanese. Furthermore, information concerning the cost of water transport in these areas is given. In parallel, the promising solution of desalination plants powered by renewable energy sources is proposed as a feasible, sustainable and cost-effective method for the water shortage problem of the Hellenic Aegean islands.

DeJonge *et al.* (2007) conducted a study on the improvement of yield of corn. In that study, the CERES-Maize crop model was used in conjunction with Apollo, a shell program, to evaluate potential improved yield in a central Iowa cornfield on a spatially and temporally variable basis. Five years of historical yield and weather data were used to calibrate the model over 100 spatially variable grid cells for non-irrigated conditions in the 20.25 ha field. That 2calibrated model then used 28 years of historical weather data to simulate three irrigation scenarios: no irrigation, scheduled uniform irrigation, and precision irrigation. Irrigation improved yield by at least 500 kg ha^{-1} in half of the years simulated. Precision irrigation showed slightly lower yields than scheduled uniform irrigation. Assuming use of a center pivot system, irrigation showed economic returns in only one of the 28 years included in the study. High capital costs were the leading restrictor of economic feasibility.

2.4 Irrigation Efficiencies for Distributing Water to Crops

Yu *et al.* (2008) proposed that improvement of water use efficiency (WUE) in crops is important for almost all agricultural practices around the world. Numerous studies have addressed WUE on a grain yield basis, but few on a photosynthesis basis and a biomass basis. Based on a 2-year field experiment (2002–2004), they analyzed wheat WUE not only on grain yield basis, but also on photosynthesis basis and biomass basis, and then discussed the effects of irrigation regimes on wheat WUE. They found that: (1) irrigation regimes had considerable effects on wheat transpiration, total evapotranspiration, and canopy temperature; (2) wheat WUE ranged 2.1–3.3 μmol CO_2/mmol H_2O on a photosynthesis basis, 1.0–2.6 kg m^{-3} and 1.1–2.1 kg m^{-3} on a biomass and a grain yield basis, respectively. The maximum WUE appeared during the jointing and the milking stage, when suitable water management could be crucial to improve wheat WUE; (3) it was hypothesized by farmers and local water managers that more water supply over the conventional irrigation regime during the growing season could significantly increase both WUE and grain yield of the winter wheat in the north China plain (NCP). However, their results showed that with the increase of irrigation times and amount of irrigation water per growing season, wheat WUE was generally decreased and grain yield was not increased, although the evapotranspiration was significantly increased. Reduction in irrigation times and amount of irrigation water could be considered for saving water in the NCP; (4) WUE of winter wheat at photosynthesis and biomass levels were positively related with WUE at grain yield level.

CHAPTER 3

METHODOLOGY

CHAPTER 3

METHODOLOGY

The present experiment consisted of evaluation of prepaid irrigation program comparison with private irrigation program at farmers field.

3.1 Description of the experimental site

The experiment conducted during *boro* season (January-April) at 17 union of Thakurgaon upazilla, Thakurgaon.

3.1.1 Location

The study area was located $25^0 57'$N between latitude and $88^0 15'$E longitude. It is surrounded by Dinajpur district on the south, Panchagarh district to the east and India on its west and north sides. It is a part of the Himalayan plain land as shown in figure 3.1.

3.1.2 Soil type

The soil of the experimental field was sandy loam.

3.1.3 Weather and climate

The average highest Temperature of this experimental site was 33.5^0 celsius and average lowest was 10.5^0 C. Average rainfall is 2536 mm. The weather of the experimental field was characterized by high temperature, high relative humidity and heavy rainfall.

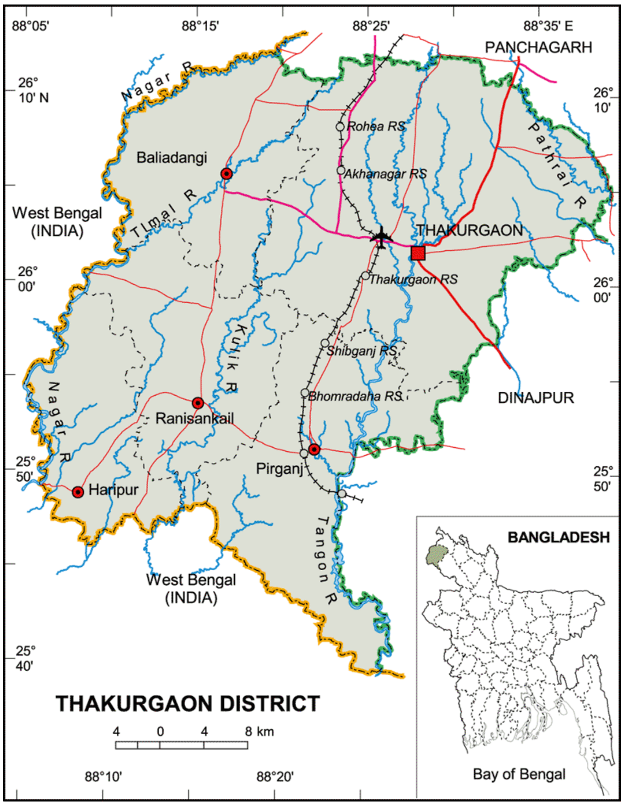

Figure 3.1: Location of Thakurgaon district in Bangladesh

3.1.4 Irrigation programs

Three irrigation programs were designed to conduct the experiments in agricultural field, such as

1. Prepaid-meter system (DTW)
2. Traditional system (DTW)
3. Shallow system (STW)

3.2 Conduction of the experiment

Plots were selected to determine the time taken by the deep tubewell in prepaid meter system. The area of the plot was measured with tape. Such operations were done in several times to calculate the average speed of operation. The materials or equipments used for the field experiment were listed in the following table.

3.3 Preparation of seedling nursery and seed sowing

Seedlings were raised in farmers field. The land was puddle with a power tiller and cleaned & leveled with ladder. Then the sprouted seeds were sown in the nursery bed. Seedlings were taken care properly. Weeds were removed and irrigation was given in the seedling nursery when necessary.

3.4 Land preparation

The experimental field was first opened with a tractor drawn rotavator. Due to rainfall the land was saturated with water. Therefore, there was no need of irrigation and puddle thoroughly by repeated ploughing with a power tiller and subsequently leveled by laddering. Weeds and stubble were cleaned off from individual plots and finally plots were leveled by wooden plank. For prepaid meter and private irrigation program land preparation remain same.

3.5 Fertilizer application

Fertilizer was applied at the time of final land preparation. The nitrogen, phosphorus, potassium, sulphur and zinc fertilizer were applied in the experimental plots in the form of urea, triple super phosphate, murate of potash, gypsum and zinc sulphate, respectively.

The entire amount of triple super phosphate, murate of potash, gypsum and zinc sulphate were broadcast and incorporated into the soil at final land preparation.

3.5.1 Fertilizer application rate per hectare

Fertilizer used in these fields were urea 172 kg ha^{-1}, TSP 52 kg ha^{-1}, MOP 82 kg ha^{-1}, Gypsum 58 kg ha^{-1} and Zinc sulphate 7.50 kg ha^{-1}.

3.6 Transplanting

Three plots were selected for transplanting rice. Transplanting was done manually for the prepaid and private irrigation program.

3.7 Weeding

The weeding was done by hand in the farmer's field. First weeding was done at 20 days after transplanting (DAT). Then second and third weeding was done manually at 25 and 55 DAT. The field was kept weed free from the very beginning of transplanting up to harvesting of the crop.

3.8 Irrigation

Irrigation was applied in the experimental field to maintain a constant level of standing water.

3.9 The Smart Card Based Prepaid Meter Irrigation Charge Type Program

The next and the latest, modern prepaid irrigation program of BMDA is the smart card based prepaid meter irrigation charge type program. In this program a prepaid meter is connected to the deep tube well panel board. The meter connects between the energy meter and the starter of the deep tube well. The prepaid meter is operated by the prepaid or user cards. Pre-condition to operate the prepaid meter is the user card must have required amount of money. Otherwise the meter fails to complete the electric circuit up to the starter of the deep tube well. The farmers of the concern deep tube well collect the user card from the BMDA Zonal offices by paying the price of the user card, which is nominal and very few in amount.

At the time of supplying the user card the concern farmer’s photograph and a serial number is attached to the card by the zonal office against the name of the farmer. So, there is no fear of losing the card. The card can recharge minimum 50000 times after issue. Generally, a farmer recharges his card on average 30 to 40 times in a year. So, one card is enough for a farmer to use it for several years. The additional equipments which are required for operating the prepaid system are discussed below:

Figure 3.2: Prepaid meter card

3.9.1 A prepaid meter

The prepaid meter is the key element of the prepaid smart card based prepaid meter irrigation charge system. It works as the cash box for collecting irrigation charge. When pre-paid meter detects that power is consumed less than 100 watt and more than meter’s self-consumption it runs in the power consumption mode and no charge is applied to the farmers. Only for lighting in the pump house this load is applicable.

For operating the pump of the deep tube well the load is minimum 12 to 18 Kilowatts, which requires operating amount of money. The prepaid meter is calibrated hourly basis according to the irrigation charge deduction fixation. So, to run the pump the user or prepaid card is required. During the time of running prepaid meter deducts money from prepaid card with respect to time. It deducts money according 1 to 5 second interval. If the using prepaid card process required amount of money the pump runs as the desire of farmer. After finishing the total amount of money from the card the pump stops. In the BMDA the hourly operating cost is Tk. 85/-. The prepaid meter has the large memory. It preserves the all user card’s data with respect to time and money.

3.9.2 The initialization card

This card is used to initialize the prepaid meter. The BMDA issues the initialization card with hourly consumption of money and send to the Zonal offices to initialize the prepaid meter connected with the deep tube well. If this initialization card insert in the slot of prepaid meter the initialized and the prepaid meter is ready to deduct money according to the calibrated hourly consumption. On the other hand if sometimes it is required to change the rate of irrigation charge, after inserting the desirable hourly rate of consumption initialization card only for one time the hourly consumption rate changes.

3.9.3 The parameter card

This card is used for changed prepaid meter parameter which is initialized in first time (Meter number and consumption data will no change such as total time consumption, total money consumption, Total power consumption etc). Using this card it also can set the clock time, set Maximum limit value of user card, running time after pull out the card, clear all data of meter exclusion tariff and meter no etc. according to BMDA requirement. The BMDA issues parameter card to enable necessary options.

3.9.4 The user card

This card is used by the farmer to operate deep tube well. This card is rechargeable it may be recharged about 50,000 (Fifty thousands) times. Different amount of money can be recharged according to the requirement of the farmer. User card can recharge from Mobile Vending station or Mobile Vending Unit from the dealers. Farmers can receive irrigation water by inserting the user card in the slot of the prepaid meter of the deep tube well. If it is possible second or third or next number of farmer wants to receive irrigation water from the same deep tube well without stopping the pump. In this case if first farmer pulls his card from the slot of the prepaid meter, the prepaid meter deducts additional 20 seconds irrigation charger from the pulling card and the pump continues running up to 20 seconds. If the next farmer inserts his card within 20 seconds the pump continues running if the inserted card has money, otherwise the pump stops after 20 seconds. This is one of the main elements of the prepaid system.

3.9.5 The checking card

The checking card is used for collecting data from the Pre-Paid Meter according to date and meter number, like- total time consumption, total money consumption, total power consumption etc. and this data will upload to the vending station that is in the zonal office. The zonal office or the vending station sends it to the district offices and head quarter. The data receiving section in head quarter is called the System Master Station (SMS). All data save in the server computer in different columns for different mode according to the report formats.

3.9.6 The Data Eraser card

Data Eraser Card is used for removing the whole record from the meter. Using this card the BMDA removes just meter record only. The BMDA uses this card when the meter record memory becomes full or may be at the time of closing the financial year.

3.9.7 The large capability card (LCC)

This is one type of checking card with large memory. If any time the whole data is required to know then this card is used to collect data from the specific deep tube well. Generally, the suspected deep tube well which seems to tempering of meter and other problems occurs then to find out the real fact this large capability card is used. This card is capable to collect the whole life data of user's card with using time, date and irrigation charge of a prepaid meter. By uploading the data of large capability card the problem of meter can be find out whether it is tempered or not.

3.9.8 The mobile vending unit (MVU)

Mobile Vending Unit is a small device which serves to MVU dealer purposes. An MVU dealer is an authorized person of BMDA. Dealer recharges his MVU from Vending Station or zonal office. Then the dealer recharges user card of farmers according to their necessary. Charge value, the identity of the user card and similar like minimum 8000 (Eight thousand) records can store in MVU. When the dealer will go to Vending Station for recharge his MVU the present stored data of MVU (which he charged to the farmer) automatically uploads into the Vending Station or zonal office computer and then to System Master Station or head quarter server/Main Station. So it can easily detect from the main station/vending station that how much money, how many times user card recharges according to time and date etc. The charging amount displays in the MVU screen. After recharging cards from the MVU the remaining amount of the MVU shows in the display. When this value is zero then MVU cannot recharge user cards. MVU can charge the user cards at the same amount which is recharged from Vending Station. There is no chance to charge user card additional amount.

3.9.9 The vending station (VS)

The zonal office computer section is called the Vending Station. Vending station issues, charges/ recharges and checks the MVU, user card or any kind of card. To serve this purposes it may be needed an additional device such as card reader/writer etc. Every vending station is separate from the other. When one station issues / initializes a Pre-paid meter, Pre-paid card, initialization card, user card/farmer card, checking card, large capability card, data eraser card, Mobile vending unit etc. from a Vending Station those instrument are not worked within another Vending Station area.

3.9.10 System master station (SMS)

This is the main station which installed in Head Quarter of BMDA. Four Server Computers with necessary software are installed there and all vending station data upload to the four server computer using parallel process. If anyone server damaged/burn then there is no effect to other server. Any of the server computers may replace the other data.

3.9.11 The sub system master station (Sub-SMS)

This is a sub-main station which installed in Regional/District office. This station monitors its respective zone/Upazilla Vending Stations. This sub-SMS observes the issue of MVU and recharge/charge of MVU, every day declaration of irrigation charge value, Issue of pre-paid card etc.

The above are the main requirements for operating the smart card based prepaid meter irrigation charge system. The popularity of smart card based prepaid irrigation charge type irrigation program is increasing day by day. The program is easier to the female also. For this reason the BMDA select the female operator for operating the deep tube wells.

Figure 3.3: The procedure of inserting prepaid card in the slot of prepaid meter

By using the cited equipments the smart cart based prepaid meter irrigation charge type program for operating the irrigation equipments of the BMDA is successfully working in the field, so government and private higher officials now and then visit the prepaid irrigation program.

Figure 3.4: Prepaid meter board with Ameter and voltmeter

The BMDA has the expert setup in the zonal and regional offices. Those strengths always work hard for performing the good position of the prepaid irrigation in the field level. Besides this in Head Quarter of BMDA there also have some of the experienced higher officials. They always watch about the performance of the field staffs. If any discrepancy is found out the BMDA take necessary action to rectify the discrepancies immediately.

3.10 Grain yield (t ha^{-1})

Rice yield was measured after harvesting from each plot. The grain was threshed from the plants, cleaned, dried and then weighed carefully. Dry weight of grains of each plot was converted into grain yield t/ha. The panicles were threshed, grains were dried and processed and the yield was recorded after adjusting its moisture content to 14% by using the following formula**:**

$$\%\ \text{Moisture content} = \frac{(\text{Fresh weight} - \text{Oven dry weight})}{\text{Fresh weight}} \times 100$$

So,

$$\text{Adjusted yield at 14\% moisture content} = \frac{(100 - \%\ \text{MC})}{86} \times \text{W}$$

Where,

MC= Percent moisture content of the grain

W=Fresh weight of grain

A BCR is the ratio of the benefits of a project, relative to its costs, expressed in monetary terms.

3.11 Benefit-cost ratio (BCR)

A benefit-cost ratio is an indicator, used in the formal discipline of benefit-cost analysis that attempts to summarize the overall value for money of a project.

$$\text{BCR} = \frac{\text{Gross return}}{\text{Production cost}}$$

3.12 Amount of water (L/kg)

Amount of water can be measured by different ways. Two ways are used for measuring the amount of water.

$$\text{Discharge of water } (\text{m}^3\ /\text{s}) = \frac{\text{Amount of water (L)}}{\text{Time (s)}}$$

Trajectory method,

$$\text{Discharge of water } (\text{L}\ /\text{s})\ ) = \frac{0.0174\ \text{D}^2\text{x}}{\sqrt{\text{y}}}$$

Here,

D = Diameter of the pipe (m)

X = Horizontal distance from the crown of the pipe to the end point of flow

Y = Vertical distance from the end of the flow and where it falls vertically in the ground level.

CHAPTER 4

RESULTS AND DISCUSSION

CHAPTER 4

RESULTS AND DISCUSSION

This chapter represents the result and discussions of the amount of irrigation in the prepaid and private irrigation system, Yield of rice per hectare, Amount of water need for yield 1 kg of rice.

4.1 Irrigation cost under prepaid and private irrigation program

In *boro* season irrigation is essential for rice production. Irrigation cost for different irrigation program, shown in fig. 4.1. It was observed that the irrigation cost of prepaid irrigation system, Traditional system and Shallow system were 4200, 6200 and 15000 Taka per hectare, respectively. From the figure it was observed traditional system and shallow system were costly than prepaid system. In other words, the prepaid system was 72% and 32% less costly than shallow system and traditional system, respectively.

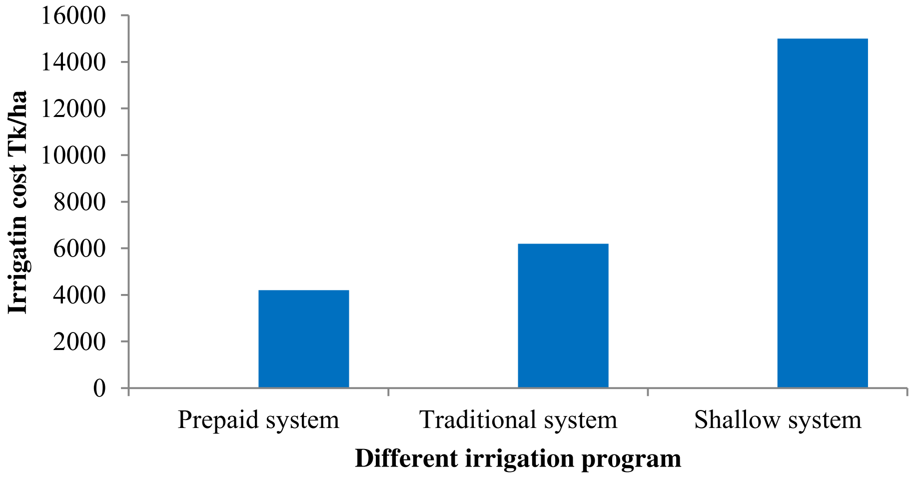

Figure 4.1: Irrigation cost in different irrigation program

4.2 Production cost under prepaid and private irrigation program

Due to different irrigation program production cost is varied in different system as shown in Figure 4.2. It was observed that the production cost of prepaid irrigation system, Traditional system and Shallow system were 62845, 64845 and 73645, respectively.

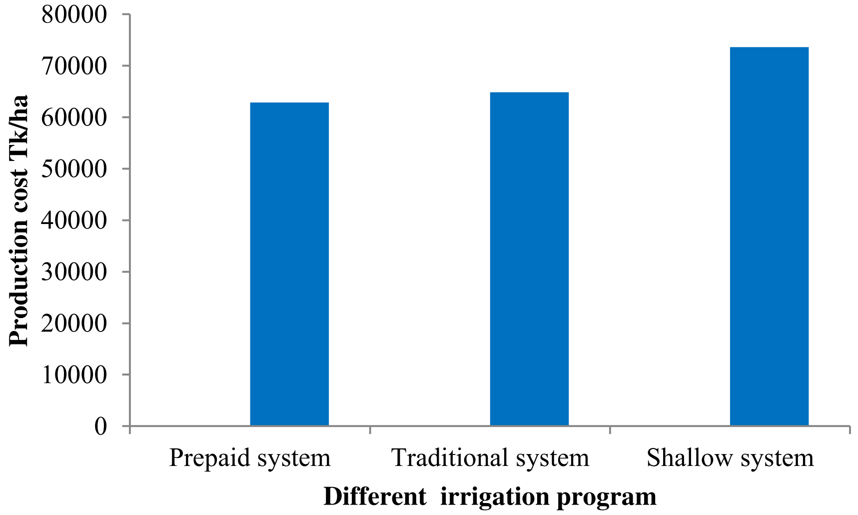

Figure 4.2: Production cost under prepaid and private irrigation program

4.3 Yield of rice at different irrigation program

Yield at different irrigation program shown in Figure 4.3. It was observed that the yield of rice in Prepaid and Traditional irrigation was higher than the Shallow system due to proper management of water.

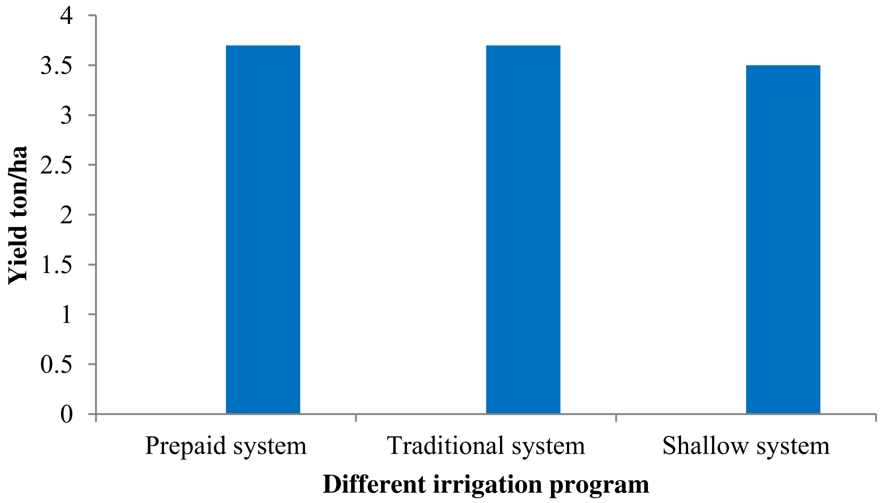

Figure 4.3: Yield of rice at different irrigation program

4.4 Irrigation cost at prepaid irrigation system in different plot

Irrigation cost at prepaid irrigation system in different plot was shown in Figure 4.4. It was observed that the lowest cost was 3900 and highest was 4400 Tk/ha at plot number 6 and plot number 7, respectively. The average cost was 4200 Tk/ha.

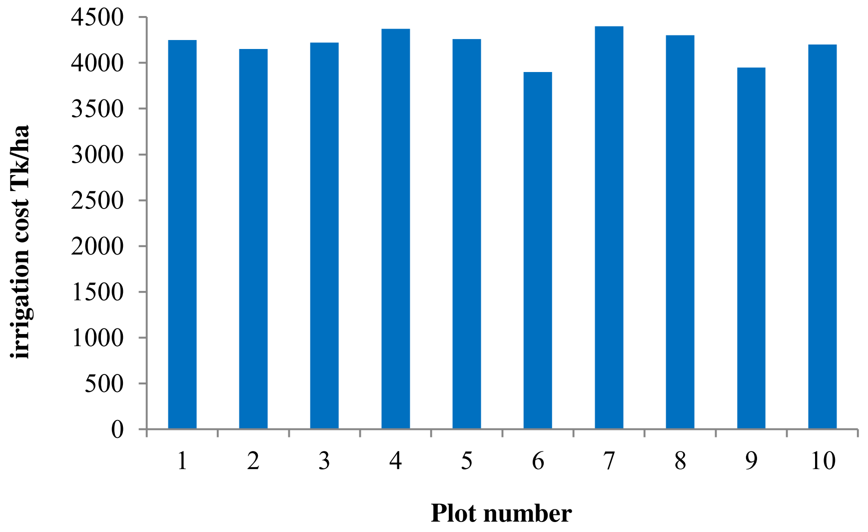

Figure 4.4: Irrigation cost at prepaid irrigation system in different plot

4.5. Irrigation cost at Traditional irrigation system in different plot

Irrigation cost at Traditional irrigation system in different plot was shown in Figure 4.5. It was observed that the lowest cost was 5220 and highest was 7400 Tk/ha at plot number 3 and plot number 7, respectively. The average cost was 6200 Tk/ha.

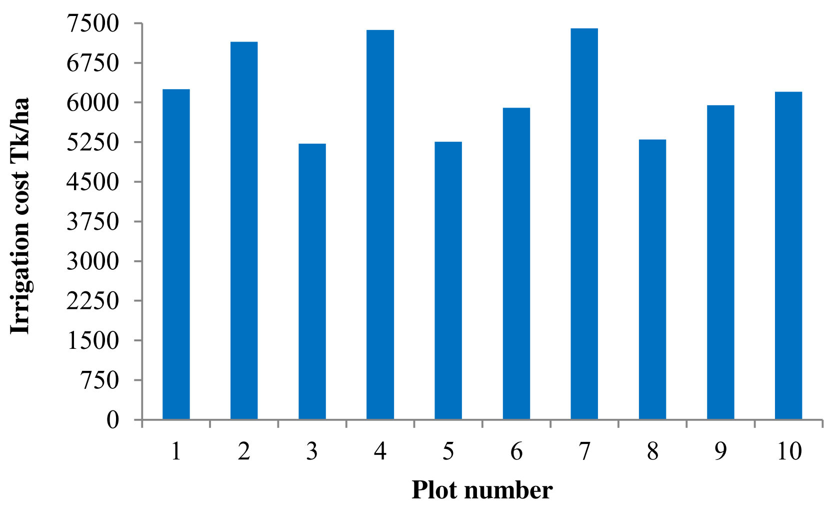

Figure 4.5: Irrigation cost at Traditional irrigation system in different plot

4.6 Irrigation cost at Shallow system in different plot

Irrigation cost at Shallow system in different plot was shown in Figure 4.6. It was observed that the lowest cost was 13200 and highest was 16670 Tk/ha at plot number 7 and plot number 5, respectively. The average cost was 15000 Tk/ha.

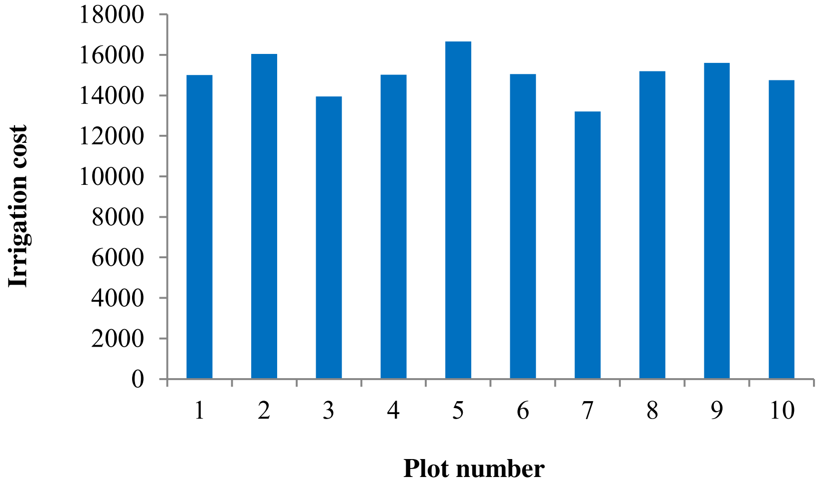

Figure 4.6: Irrigation cost at Shallow system in different plot

4.7 Benefit-cost ratio (BCR)

Benefit cost ratio at different irrigation system was shown in Figure 4.7. A benefit-cost ratio is an indicator, used in the formal discipline of benefit-cost analysis that attempts to summarize the overall value for money of a project. It was observed that the benefit cost ratio was high in prepaid meter system due to low irrigation cost.

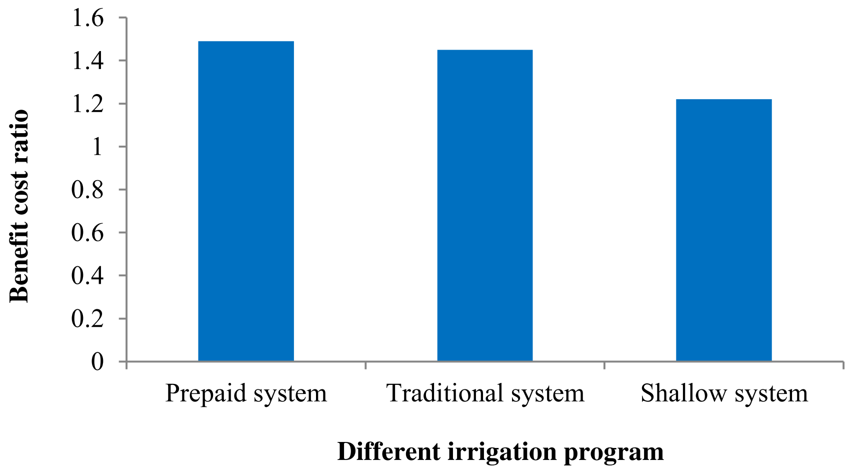

Figure 4.7: Benefit-cost ratio (BCR) at different irrigation program

4.8 Amount of water required.

Water required for yield 1 kg of *boro* rice under prepaid and private irrigation program shown in Figure 4.8. It was observed that low amount of water required for the prepaid meter system.

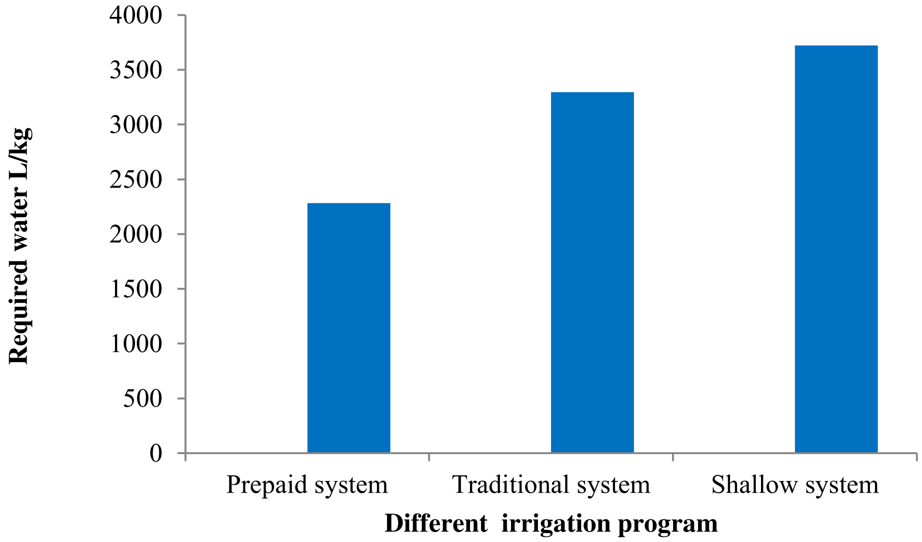

Figure 4.8: Water required under prepaid and private irrigation program

CHAPTER 5

CONCLUSION

CHAPTER 5

CONCLUSION

The field data of the two irrigation programs were analyzed and compared. The prepaid irrigation program found better than the private irrigation program. Irrigation costs per hectare rice production were Tk. 4200 and Tk. 6200 for prepaid and private irrigation program, respectively. It was also found that about 32% more irrigation water required in the private irrigation program. This excess amount was the additional burden to the farmers. About 620 cubic meter water lost per bigha in the private irrigation program, which affects the eco-system. The benefit –cost ratios of the prepaid and private irrigation program were found to 1.49 and 1.45, respectively, in the study area which was more than the private irrigation program. The farmers could earn more profit from the prepaid irrigation program. The production cost per hectare was found lower (prepaid-Tk.62845, private- Tk.64845) and benefit was found higher (prepaid-Tk.31003, private-Tk.29003) in the prepaid irrigation program. It was also found that about 31% income was saved in the prepaid irrigation program. The obtained results finally confirmed that the prepaid irrigation has the positive impact for cultivating *Boro* rice economically and environmentally.

Recommendations

Based on the study, the following recommendations were-

To improve the prepaid irrigation program,

(i) Required to development the prepaid meter card

(ii) More detail study should be done.

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APPENDICES

APPENDICES

Appendix 1: Cost of production under prepaid and private irrigation program

Activity	Prepaid system, Tk/ha	Traditional system, Tk/ha	Shallow system, Tk/ha
Seedling raising	3860	3860	3860
Land preparation	8000	8000	8000
Transplanting	7265	7265	7265
Basal fertilizer	7300	7300	7300
Fertilizer application	195	195	195
Insecticide application	4200	4200	4200
Weeding	3500	3500	3500
Irrigation	4200	6200	15000
Harvesting	11000	11000	11000
Carrying	5610	5610	5610
Threshing	5215	5215	5215
Winnowing	2500	2500	2500
Total production cost, Tk/ha	**62,845**	**64,845**	**73,645**

Appendix 2: Effect of irrigation system on gross return, net return and benefit cost ratio (BCR)

Treatment	Input cost, Tk/ha	Return from grain, Tk/ha	Return from straw, Tk/ha	Gross return, Tk/ha	Net return, Tk/ha	Benefit cost ratio (BCR)
Prepaid system (DTW)	62,845	91,848	2,000	93,848	31,003	1.49
Traditional system (DTW)	64,845	91,848	2,000	93848	29003	1.45
Shallow system	73645	88350	1900	90250	16,605	1.22

Appendix 3: Irrigation cost for prepaid meter system (DTW)

Plot number	Irrigation cost (Tk/ha)	Benefit cost ratio (BCR)
1.	4250	1.492
2.	4150	1.495
3.	4220	1.493
4.	4370	1.489
5.	4260	1.492
6.	3900	1.500
7.	4400	1.489
8.	4300	1.491
9.	4200	1.500
10.	3950	1.499
Average	4200	1.493

Appendix 4: Irrigation cost for Traditional system (DTW)

Plot number	Irrigation cost (Tk/ha)	Benefit cost ratio (BCR)
1.	6250	1.446
2.	7150	1.426
3.	5220	1.469
4.	7370	1.421
5.	5260	1.468
6.	5900	1.454
7.	7400	1.421
8.	3300	1.468
9.	6200	1.450
10.	5950	1.453
Average	6200	1.447

Appendix 5: Irrigation cost for Shallow system

Plot number	Irrigation cost(Tk/ha)	Benefit cost ratio(BCR)
1.	16050	1.208
2.	13950	1.243
3.	15020	1.225
4.	16670	1.198
5.	15060	1.224
6.	13200	1.256
7.	15200	1.222
8.	15600	1.215
9.	14500	1.233
10.	14750	1.230
Average	15000	1.225

Appendix 6: Water required for yield 1 kg of rice under prepaid and private irrigation program

Plot number	Average irrigation required (L/kg) *boro* rice		
	Prepaid	Traditional system (DTW)	Shallow system
1.	2156	3425	3760
2.	2200	3313	3648
3.	2281	3438	3773
4.	2171	3353	3688
5.	2402	3495	3830
6.	2325	3356	3691
7.	2313	3400	3735
8.	2238	3381	3716
9.	2353	3471	3806
10.	2295	3325	3660
Average	2283.4	3294.7	3723.18