Bangladesh J. Environ. Sci., Vol. 44, 57-62, 2023 **@ BAED ISSN 1561-9206**

ECONOMIC EVALUATION OF IRRIGATION PRACTICES OF BORO RICE GROWERS IN SOME SELECTED AREAS OF SUNAMGANJ DISTRICT IN BANGLADESH

M. E. Haque*, S. I. Shaon[1], A. H. M. S. Islam[1] and M. S. Rahman[1]
Agricultural Economics Division, Bangladesh Rice Research Institute, Gazipur-1701
[1]Dept. of Agricultural Economics, Bangladesh Agricultural University, Mymensingh-2202
*Corresponding author's email: enamulbau10@gmail.com

ABSTRACT

The present study was conducted in some selected areas of the Sunamganj district of Bangladesh. The main aim of this study was to investigate the present irrigation practices for Boro rice farmers and compare profitability under different methods of irrigation. The primary field data were collected through interviewing from 100 Boro rice farmers (landless, small, medium, and large farmers). The study revealed that most of the farmers (38.1%) used surface water (beel) for irrigation purposes. As water-lifting devices, they mainly used the Low Lift Pump (LLP), the Shallow Tube Well (STW), and traditional equipment for irrigation by the respondents of 75%, 16.36%, and 8.65%, respectively. Due to the high cost of irrigation pumps, 73.68% of respondents rented irrigation from the pump owners. Total input cost for STW was Tk. 35,751; for LLP, it was Tk. 31,251; and for traditional equipment, it was Tk. 34,076. The gross return (Tk. 73,137) was the highest for STW users, but the highest BCR (benefit-cost ratio) was in the LLP irrigation method, which was 2.28 due to a lower cost than STW. The lowest BCR was in the traditional irrigation system, which was 2.01. The BCR of the STW irrigation system was 2.04. The average water productivity of STW was 0.452 kg/m^3. For diesel engines, the average water productivity was 0.446 kg/m^3, and for electric engines, the average water productivity was 0.458 kg/m^3. The average water productivity of LLP was 0.413 kg/m^3, which is lower than STW. The average water productivity of the traditional method in the study area was 0.397 kg/m^3, which is lower than both the STW and LLP methods.

Key words: Water productivity, boro rice, irrigation

Introduction

There are three distinct growing seasons viz. *Aus*, *Aman*, and *Boro*allow for year-round rice production in Bangladesh. In general, from December to April, when boro rice is cultivated, the dry condition prevails through the country. Farmers generally use surface water sources including rivers, canals, and ponds, as well as groundwater sources like shallow and deep tube wells as main sources for irrigation. The pressure on freshwater resources around the world is rising to previously unheard-of levels due to rising populations, food shortages, expanding economies, and inadequate water management. The greatest notable change in Bangladeshi agriculture over the past 25 years has likely been groundwater irrigation. The groundwater development project in Dinajpur district under the northwest region was initiated in 1962 with the installation of 381 deep tube wells (DTW). It was reported that there were 1,378 DTWs, about 40,331 shallow tube wells (STW), and 66,400 hand tube wells (HTW) under operation by different user groups but that they failed to bring all cultivable lands under irrigation. In 2004, 6,047 DTWs, 70,000 STWs, and other modes of irrigation were used in the area, which covered almost 57% of the total irrigable area (BMDA 2011). The remaining 43% of the irrigable area was planned to be covered under the DTWs installation project named 'Groundwater model study for DTW installation project in Barind area'. In recent years, the Barind Multipurpose Development Authority (BMDA) has installed more than 10,000 DTWs in the Barind area of the northwest region. In addition, quite a large number of STWs have been installed in this region by private initiatives (Ahmad *et al*., 2014). In Bangladesh, rice production increased from 25.09 million metric tons in 2000-01 to 37.8 million metric tons in 2020-21 (BBS, 2021). The need for irrigation in Bangladeshi agriculture, however, is dramatically rising from season to season as a result of the country's shifting climate. Due to the current climatic change, irrigation is now required both in the *kharif* season and the late monsoon. Farmers have been motivated to gradually switch away from high-risk monsoon farming due to the rapid proliferation of small irrigation equipment. The average area of Boro rice has increased substantially in the last 20 years (Akter and Jaim, 2002).

Table 1. Irrigation equipment used in 2020-2021

Mode of operation	Irrigation technologies			
	DTW	STW	LLP	Total
Diesel	2254	1068253	173267	1243774
Electric	35484	289521	14059	339064
Solar	-	-	-	2853
Others	-	-	-	294
Country total	37738	1357774	187326	1585985

Source: BADC, 2022

In Bangladesh, 94% of the irrigated land is covered by tiny and moderate irrigation schemes. A recent survey by BADC found that the country's water is raised by 37738 deep tube wells, 1357774 shallow tube wells, 187326 low lift pumps, and a significant number of indigenous water raising devices. Because of its tremendous production and profitability, boro rice is especially well-liked in Bangladesh. The variety is wholly dependent on irrigation water, however, as it is grown in the dry season when there is little or no rainfall. Thus, it is crucial for this sector to identify and use the most effective and sustainable irrigation solutions. There have been some small analyses of irrigation sustainability in the case of Boro rice production; therefore, the subsequent study is necessary for fulfilling the following objectives:

1) to investigate water sources for irrigation methods used in Boro rice production and its utilization.
2) to analyze present irrigation practices for Boro rice production and
3) to compare their profitability and water productivity.

Materials and Methods

The five upazilla from Sunamgonj districts named Dakshin Sunamganj, Dowarabazar, Derai, Jagannathpur, and Chhatak were selected purposively as Boro rice production is concentrated in these areas during the period of 2021-2022. From the list of boro rice-producing farmers, supplied by the upazilla agricultural officer, a total of 100 farmers were selected randomly, 20 from each upazilla, by using a simple random sampling technique. Data were collected by the researchers themselves through interviews with the selected respondents. Then all the collected data were summarized and scrutinized carefully. Moreover, data entry was made on the computer, and analyses were done accordingly. Total input cost calculated by summation of all fixed cost and variable cost. The gross return was calculated by simply multiplying the total volume of output of Boro rice with the per-unit price received by the farmers. The BCR is a relative measure that is used to compare benefit per unit of cost. The BCR is estimated as a ratio of gross returns to gross costs. The formula of calculating BCR (undiscounted) is shown below:

$$\text{BCR} = \frac{Gross\ Return}{Gross\ cost}$$

To determine water productivity (WP), it was needed to know the total hours of operation of an engine or motor in a whole season. The hours of engine operation depends on many factors, such as capacity of engine-pump, availability of electricity, availability of diesel, planting time duration within a command area, rainfall, size of command area etc. The exact number of hours of operation was almost impossible to derive from the equipment owners or drivers. But it is possible to determine how much water was applied in a season based on the quantity of fuel consumed and discharged by a method of irrigation in a season. Water productivity may be defined as the ratio between amounts of water applied and the amount of crop produced from a land in a season. In other words, water productivity means the amount of water needed to produce one unit of crop.

$$\text{Water Productivity (WP)} = \frac{\text{Total yield(kg)}}{\text{Amount of water used for irrigation (m3)}}$$

Results and Discussion

The groundwater resources used as irrigation purposes in boro rice cultivation is presented in Table 2. The dam at BADC (nearly 0.95%) was used the least for agriculture, while Beel (38.1%) was the main source of irrigation water in the Sunamganj district. Besides the second and third positions of the river (20.01%) and groundwater (19.05%) for the source of irrigation water that was used in the Sunamganj district. Khal (12.38%), pond (7.62%), and shallow depression (duba) (1.9%) were the alternative sources of small-scale irrigation. The majority of farmers in Dowarabazar upazila (52.17%) irrigated their fields utilizing khal water. Water from the BADC dam (4.35%) and a pond (4.35%) was used in very small quantities. Moreover, farmers irrigated their fields using beel water (13.04%) and river water (Surma River, 26.09%). Groundwater (95.83%) was more frequently utilized in Dakshin Sunamganj upazila than minor depression (duba), which was only utilized by 4.17%. The most frequently utilized source in Deraiupazila was beel (64.71%), followed by river water (Kalni River) (29.41%) and a tiny depression (duba) (5.88%). Most farmers in Jagannathpur upazila (47.62%) utilized river water (Etakhula River) for irrigation. Only a little portion of the khal's water (4.76%) and the pond (19.05%) were utilized by farmers. Beel water (28.57%) was also used by farmers for irrigation. Beel water, commonly referred as Hourwa Beel, was used more commonly in Chhatak upazila (86.96%) than pond water (13.04%) (Table 3).

Table 2. Sources of irrigation water in Sunamganj district for producing boro rice

Source of irrigation water	Number of respondents	% of respondent
Beel	40	38.1
River	21	20.0
Groundwater	20	19.05
Khal	13	12.38
Pond	8	7.62
Small depression (Duba)	2	1.9
Dam of BADC	1	0.95
Total	105 *	100.00

Table 3. Sources of irrigation water uses in different upazilas of Sunamgonj district

Source of irrigation water	Number of respondents (% of respondent)				
	Dowarabazar	Dakshin Sunamganj	Derai	Jagannathpur	Chhatak
River	6 (26.09%)	-	5 (29.41%)	10 (47.62%)	-
Khal	12 (52.17%)	-	-	1 (4.76%)	-
Pond	1 (4.35%)	-	-	4 (19.05%)	3 (13.04%)
Small (Duba)	-	1 (4.17%)	1 (5.88%)	-	-
Beel	3 (13.04%)	-	11 (64.71%)	6 (28.57%)	20 (86.96%)
Dam of BADC	1 (4.35%)	-	-	-	-
Groundwater	-	20 (95.83%)	-	-	-

Data source: Field survey- 2022; Total number of respondents: 100 (* *some farmers used more than one source for irrigation water*)

Irrigation Equipment Used: The farmers in Sunamgonj district mainly used LLP, STW and traditional equipments for providing irrigation water in boro rice field. Amongst the different pumps they used the LLP (75% farmers) than that of other equipments (Table 4). The study also noted that the use of LLP was about 5 times higher than that of STW and nine times higher than traditional equipments, respectively.

From Table 4, it was found that Low Lift Pump (75%) and Shallow Tube Well (16.35%) were used as irrigation equipment in the highest numbers. On the other hand, traditional equipment likes don, and swing baskets were used the lowest (8.65%).

Irrigation equipment usage pattern in Sunamganj district: From Table 5, it was observed that 100 percent of farmers used STWs in Dakshin Sunamganj upazila, while in the other four upazilas named Dowarabazar (86.36%), Derai (91.30%), Jagannathpur (86.96%, and Chhatak (94.74%), farmers were used LLPs because surface water was always available. Some farmers used two types of equipment (LLP and traditional equipment) at a time because they cultivated both low- and high-land crops together.

Mode of Operation of the Power Operated Irrigation Equipment: It was revealed (Fig. 1) that most of the machines run by diesel (56.84%) operated machine due to electricity load shading on this area during *boro* season. The percentage of electricity operated machine was (37.89%) which was higher than the Kerosene (5.26%) operated machine. The lowest number of equipment was operated by Kerosene (5.26%).

Table 4. Irrigation equipment used in Sunamganj district

Irrigation equipment use	Number of respondents	% of respondent
LLP	78	75
STW	17	16.35
Traditional equipment	9	8.65
Total	104*	100

Data source: Field survey-2022; Total number of respondents: 100 *(*some farmers used two types of equipment for irrigation at a time because they cultivated both in low land and high land together)*

Table 5. Irrigation equipment used in different upazila in Sunamganj district

Upazila	Number of respondents			% of respondent		
	LLP	STW	Traditional equipment	LLP	STW	Traditional equipment
Dowarabazar	19	-	3	86.36	-	13.63
Dakshin Sunamganj	-	17	-	-	100	-
Derai	21	-	2	91.30	-	8.69
Jagannathpur	20	-	3	86.96	-	13.04
Chhatak	18	-	1	94.74	-	5.26

Data source: Field survey-2022; Total number of respondents-100

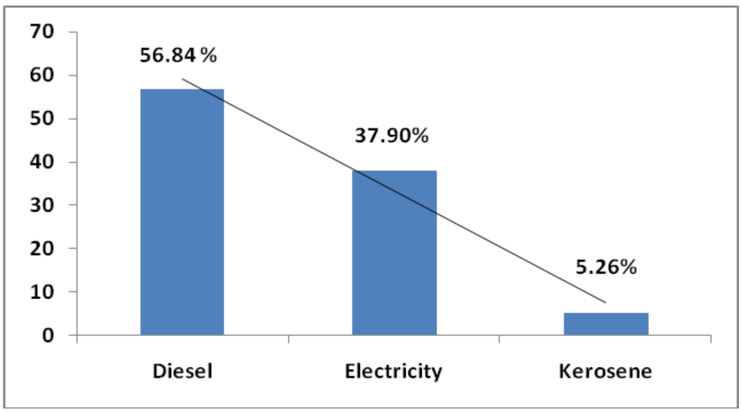

Fig. 1. Mode of operation of the power-operated irrigation equipment in Sunamganj district (expressed in percent respondents)

Most of the machines were rented from pump owners (73.68%) while own machines were only 24.21%. Some machines (2.11%) were taken from organizations like BADC as presented in Table 6. From the above discussion it was found that large-scale farmers were the most likely to possess their own equipment, followed by some medium-scale farmers. Yet, small and landless farmers borrowed equipment in exchange for cash, paddy, or both from other people. These machines were typically run for about 14 hours a day, from morning to evening. For irrigation water, Beel was a source that the majority of respondents (38.1%) rely on. For irrigation, 75% of respondents utilized LLP. The majority of farmers cannot afford to buy irrigation equipment due to its high price. So, most of the machines were taken from the pump owners (73.68%) for irrigation in the study area.

Table 6. Ownership of the power operated irrigation equipment in Sunamganj district

Ownership of irrigation equipment	Number of respondents	% of respondent
Rented from pump owner	70	73.68
Own pump	23	24.21
Rented from other organizations	2	2.11
Total	95*	100

Data source: Field survey-2022; Total number of respondent: 95 *(*5 respondent out of a total of 100 respondents did not use power-operated irrigation machine rather than used own manually operated traditional equipment)*

Economic Analysis of Irrigation Systems: Total input cost was calculated by summation of all fixed cost and variable cost. Total input cost for STW was Tk. 35751, for LLP: Tk. 31251, and for traditional, Tk. 34076. Total input cost was highest for STWs farming system due to the higher cost of its irrigation system than others (Table 7). The gross return was calculated by simply multiplying the total volume of output of Boro rice with the per-unit price received by the farmers. The gross return from the STW user was Tk. 73137, from the LLP user was Tk. 71423, and from the traditional farmer was Tk. 68578. Gross return was highest for STW users (Table 7). The net return was obtained by deducting the total cost from the total return. Per hectare net return of Boro rice production from STW users was Tk. 37386, from LLP users it was Tk. 40172, and from traditional farmers it was Tk. 34502. Net return was highest for LLP user. The gross return was highest for STW users, but the highest BCR (benefit-cost ratio) was in the LLP irrigation system, which was 2.28 due to the lower cost of irrigation systems than STW. The lowest BCR was in the traditional irrigation system, which was 2.01. The BCR of the STW irrigation system was 2.04. The BCR rate is changing every year because the price and production of yield, as well as seasonal costs, vary every year. Here in the selected study areas, BCR was greater than 1, which means the revenue from the Boro rice production was economically satisfactory (Table 7).

Table 7. Per hector average cost and benefit of Boro Rice production under different irrigation system

Items		Unit	LLP	STW	Traditional
Irrigation cost	Diesel	Tk.	1997	1785	-
	Electricity	Tk.	625	1890	-
	Labor	Tk.	1500	2500	4500
	Machinery rental	Tk.	2138	2621	-
	Equipment maintenance	Tk.	1245	1328	3147
Total irrigation cost		Tk.	7505	10124	7647
Other input cost ***		Tk.	23746	25627	26429
Total production cost		Tk.	31251	35751	34076
Gross return		Tk.	71423	73137	68578
Net return		Tk.	40172	37386	34502
BCR			2.28	2.04	2.01

Data source: Field survey- 2022; Total number of respondents: 100 (***other cost includes total fixed cost and total variable cost. Total variable cost includes labor cost, seed cost, power tiller cost, cost of urea, TSP, MP, fertilizer and insecticide cost, weeding cost. Total fixed cost includes land use cost and interest on operating capital).

Water Productivity (WP): To determine water productivity (WP), the entire number of hours an engine or motor ran throughout the course of a season was required to be known. The number of hours an engine runs depends on a number of variables, including the engines capacity, the pump's availability of power or fuel, the length of time plants are planted within a command area, the amount of rainfall, the size of the command area, etc. The average WP of STW in the study area was 0.452 kg/m3. For diesel engines, the average WP was 0.446 kg/m3, and for electric engines, the average WP was 0.458 kg/m3. The average WP of LLP in the study area was 0.413 kg/m3, which is lower than STW. The average WP of the traditional method in the study area was 0.397 kg/m3, which is lower than both the STW and LLP methods (Table 8).

Table 8. Average WP of irrigation methods used in the study area

Irrigation methods	Water Productivity(Kg/M^3)
STW	0.452
LLP	0.413
Traditional methods	0.397

Source: Field survey, 2022

Water productivity for an electric engine was higher than for a diesel engine. The reason was that the pump owner had to pay a fixed bill to the electricity-supplying authority based on pump-engine capacity. For this reason, they run their engines for a longer period of time compared to diesel engines, and they always try to store sufficient water in the field and avoid any breakdown of the engine or motor that would hamper pumping of water. The BCR for LLP users is 2.28, which is higher than STW's (2.04), and the BCR was 2.01 for traditional method users. That means the Boro rice production with LLP is a profitable business in the study area. This LLP irrigation method is gaining popularity in the country very quickly due to its low cost potential. Although good opinions came out of the sample farmers, the higher yield and higher income encouraged them to continue Boro rice cultivation with LLP.

Conclusion and policy recommendations

The effectiveness of LLPs are more affordable and energy-efficient than shallow tube wells (STW) in Sunamgonj. LLPs are also rather simple to run and maintain, which is beneficial in research areas where access to technical know-how or spare parts is scarce. LLPs may also experience changes in the level of the water table, which may have an impact on their capacity to raise water.

However the study may suggest some recommendations as follows:

- The government should do all in its power to encourage farmers to use contemporary irrigation technology for Boro rice cultivation.
- Distributing irrigation equipment as subsidized price and krishi loan at lower interest.
- Government or other organization can starts irrigation projects keeping the provision for irrigation service charge.

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