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Comparative analysis of alternative irrigation payment methods during Boro rice season in Bangladesh

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Executive Summary

Rice is crucial for food security in Bangladesh as the country can be characterized both as one of the largest consumers and also the largest producers of rice in the world. Rice is grown throughout the year in Bangladesh, but the largest share of production comes from the irrigation-based summer paddy season, locally termed as Boro paddy. Boro paddy is completely dependent on irrigation, which means that the optimal yield of those varieties is critically dependent upon adequate irrigation. In Bangladesh, the service of irrigation is mainly delivered by pump owners who themselves may or may not be cultivators. Three major types of pumps such as diesel or electricity run deep tube-well (DTW), shallow tube-well (STW), and low lift pump (LLP) are typically found for irrigation operations throughout the country. Additionally, solar power-based pumps are also being installed in the country since past few years. Against such a backdrop, this report sheds light on the existing mode of irrigation service along with payments observed in different agroecological zones of Bangladesh. Based on field surveys and Focus Group Discussions (FGDs) with water buyers, pump owners, and government officials, four types of payment contracts have been identified. These observed payment contracts are determined on the basis of (1) land area, (2) machine rent, (3) duration of irrigation, and (4) crop share. Depending on the mode of contract, variation in irrigation charge is prevalent. For example, in order to irrigate one hectare of land during the Boro season, a farmer may have to incur a cost anywhere between BDT 13,249 and BDT 29,055. From the point of view of both pump owners and water buyers, the irrigation charge tends to be the lowest in the contract based on per land area, whereas it tends to be the highest in the contract based on per hour. In the case of solar and electric based irrigation services, irrigation charges are comparatively lower than diesel pumps. Costs of Boro rice production may be reduced if solar-based irrigation systems can be adopted as indicated in the findings.

1. Introduction

Rice is the main source of food supply in Bangladesh, and a major portion of the rice is produced and supplied during the Boro[1] rice season. Boro rice requires intensive care, and it is highly sensitive to fertilizer, pesticides, irrigation application, and other intercultural operations. Cultivation of this crop is fully dependent on irrigation. In Bangladesh, irrigation is primarily done using deep tube-wells (DTW), shallow tube-wells (STW), or low lift pumps (LLP) and are mainly run using diesel and electricity. According to the latest Minor Irrigation Survey Report, 36,955 DTWs, 14,09,689 STWs, and 2,04,391 LLPs were operated in Bangladesh in 2020-21. Notably, about 74 percent of the irrigation equipment was operated by diesel, and the rest of the 26 percent of the equipment was operated by electricity. About 73 percent of the total cultivated area was irrigated by groundwater and the remaining 27 percent area was irrigated by surface water (BADC, 2020). Additionally, solar pumps have recently been introduced in some areas of the country as an alternative to fossil fuel-based irrigation systems.

In spite of the economic importance and contribution to the rice production and food supply for Bangladesh, there is no fixed operation and rent payment method for pump-operated irrigation systems. Some principles and rates of irrigation rent are fixed by an Upazila irrigation committee prior to the start of the Boro season, but in reality, such principles and irrigation charges are not applied. Field investigation and monitoring activities are not performed by the committee for the implementation of their decisions. As a result, different pump operation and irrigation rent payment methods are applied by pump owners in different areas of the country. In fact, one can find separate methods followed by individual pump owners within the same Union/Upazilla for separate or even for the same type of irrigation pumps.

The aim of this report is to present a concise narrative of the irrigation water market and various modes of contract followed in the case of irrigation during the Boro season in different agroecological zones of Bangladesh. The specific questions that this report deals with include documenting the types of contracts prevalent in the irrigation water market and comparing irrigation charges across the types of contracts. Moreover, the report compares how the charges for irrigation have changed in the case of diesel-operated pumps in the recent couple of years.

2. Methodology

This report has mainly used primary data collected through field surveys in 7 districts of Bangladesh, namely Mymensingh, Tangail, Cumilla, Dinajpur, Barguna, Khulna, and Satkhira districts. These above states districts have been chosen on the basis of availability of different types of irrigation pumps following the latest Minor Irrigation Survey Report and BADC website. After choosing the districts, the research team has further identified the Upazilas (sub-district) where the concentration of a particular type of water pump is high. Afterwards, the respective Upazila Agriculture Office (UAO) was interviewed as regards which village to study. Following the suggestions of the UAO, the research team went to the selected village and conducted FGDs. In each of the study areas, 15 water buyers and 5 pump owners were surveyed. Information on the mode of contract, pump categories, and water charge is obtained from both the surveyed farmers and pump owners. Additionally, FGDs were conducted with

[1] Boro season begins in November-December to March-April.

representative farmers, pump owners, local Agricultural Officers, representatives of BADC, a Sub-Assistant Agriculture Officer (SAAO), and a local government administrator (Upazila Chairman).

3. Results and discussions

Overall, four types of irrigation contracts were identified by this study. These types are: (1) fixed charge per unit of area (seasonal contract), (2) fixed machine rental charge per unit of land (seasonal contract), (3) fixed charge per hour, and (4) crop share agreements (seasonal contract). In all cases, the irrigation rate is fixed based on the rate for Boro irrigation season in the previous year or is determined based on demand/supply conditions prevailed at the local irrigation market situation in the current year. In these cases, the rate is fixed based on the verbal mutual agreement made between the pump owner and the water buyers, and the rent is paid in cash several times during the irrigation season and after the harvest of the crop. The total number of payment installments varies from water buyer to water buyer based on the mutual understanding between the pump-owner and water-buyer. In exceptional cases, the irrigation charges are paid fully during the irrigation season. All the methods are discussed below.

(1) **Fixed charge per unit of area (seasonal contract):** In this method, a fixed charge for irrigation based on local land units (mainly bigha, katha, and khanda) is determined before the beginning of the season of Boro rice cultivation for the full season. This method is followed for almost all electric operating DTW, STW, and LLP, as well as for solar pumps throughout the country. This fixed charge per area method is also used for some of the diesel operated DTWs, STWs, and LLPs in some parts of the country. In this method, water delivery to the paddy field is fully managed through the pump operator (driver), or water delivery man (field man) recruited by the pump owners or pump operating authority (association).

(2) **Fixed machine rental charge per unit of land (seasonal contract):** Fixed machine charge is used mainly for some diesel operating DTW, STW, and LLP in some areas of the country. In this case, a fixed rate per unit of land has to be paid by the water buyers for only renting the machine from the pump owner, but the diesel has to be bought by the user as necessary at their own cost. Since the users are using their own diesel, water delivery and management to their paddy field is generally done by the water buyers themselves.

(3) **Fixed charge per hour:** In this case, buyers purchase water from pump owners according to the requirement of irrigation in their paddy field at an hourly rate. So, this method is more common when the demand for irrigation is more irregular. In this method, pump operation and diesel costs are maintained by the pump owners, and the water buyers have to pay only the irrigation charges in cash at a fixed rate per hour. Water delivery is managed through the services of both the pump-owners and the water-buyers.

(4) **Crop share agreements (seasonal contract):** The crop share method for the payment of pump irrigation is followed for all types of diesel and electric pumps (DTW, STW, and LLP), but mainly in the Tangail district of Bangladesh. This system was developed in the Tangail region and started from the beginning of the expansion of the pump irrigation system in that region, and it is still active there. After the harvest, one-fourth of the cultivated paddy is given to the pump owners as irrigation charges which is collected from the land to the pump owners' homes at their own cost. Supply of

irrigation water to paddy field is fully maintained through pump operator (local named 'driver')/water delivery man (local named 'field man') appointed by pump owners/operation authority on the basis of seasonal contractual method. It was informed by the users in that region, that they do not find this system satisfactory, and they are interested to adopt the seasonal fixed charge method. But steps are not taken yet by the concerned authority of the government to reject the crop share method and implement the seasonal fixed charge method for payment of irrigation cost. Water buyers under the crop share method has a perception for not being able to harvest the entire produce from the plot under Boro paddy production. Their argument is the foregone paddy could have been stored and sold later at a higher price. Taking such opportunity costs into account, farmers tend to perceive that the irrigation cost that they incur is higher than the cost they would have incurred if a different mode of payment were followed.

Sl. no.	Method of rent payment		Rent received by pump owner			Rent paid by water buyers		
			No.	Amount (BDT/ha)	Standard deviation (SD)	No.	Amount (BDT/ha)	Standard deviation (SD)
1.	Fixed charge (seasonal)*		18	12981	6376	39	13249	6958
2.	Fixed machine charge (seasonal) (Dinajpur)	Rent in cash	5	12449	2841	10	12663	1903
		Cost for diesel		-	-		11433	3813
		Total		-	-		24096	3734
3.	Per hour fixed charge (Khulna)		4	28627	6186	6	29055	3469
4.	Crop share (Tangail)		5	25980	1217	10	26851	7633
5.	Solar pump (Barguna)		3	14203	4813	9	14244	2851

Table 1: Payment method and charges for irrigation in Boro rice

* See appendix for district wise variation in payment in the case of fixed charge method

Source: Findings from field survey data collected in 2022

In Table 1, irrigation charges per hectare for Boro rice cultivation across all payment methods is shown. Irrigation charges per hectare as received by pump owners was estimated to be the lowest (BDT 12,981/hectare) for the seasonal fixed charge method. The seasonal contract for fixed machine rental is even lower (BDT 12,449/hectare) but it does not include the diesel costs incurred by the water buyers. The highest irrigation charges as received by the pump owners was calculated at BDT 28,627 per hectare for the per hour fixed charge method. The rent per hour varies between BDT 90-120 and on an average 282 hours of operation is required to irrigate one hectare of land. The second highest rent is observed by the seasonal crop share method at BDT 25,980/hectare. It has been calculated that to irrigate one hectare of land under this method, about 1269 Kg paddy were paid out and the price of paddy varied between BDT 18.75 - BDT 21 per Kg.

When calculated from the irrigation charges as reported by water buyers, per hectare charges as paid by the water buyers were the lowest (BDT 12,663) for the seasonal fixed charge method and the highest was BDT 29,055 for the per-hour irrigation charge method. BDT 26,851/hectare and BDT 24,096/hectare were estimated for the crop share method and seasonal fixed machine charge method,

respectively. In the case of solar pumps, water buyers pay BDT 14,244 per hectare for irrigation. The average payment rate of solar pumps for pump owners was counted based on the whole of an irrigation field area, but the payment was considered for the water buyers as per small irrigation plots belonging to individual users under the field. Besides, the pump owners and water buyers were considered separate respondents for the determination of their payment rate. So, for these reasons, a minor variation in payment rate between the pump owner and water buyers were revealed, but these two sources of information provided similar estimates across these different categories[2]

From Table 1, it can be seen that irrigation charge is highest in the case of per hour payment method and lowest in the case of fixed charge seasonal contract method. The reason of high irrigation charge in the case of per hour contract is that fuel cost is borne by the pump owners. The variation in irrigation charge depending on method of contract is likely to cause variation in costs of production and accordingly in profit margin of water buying farmers. Arguably, the payment method that costs less is beneficial for the water buying farmers. Although one might argue that cheap irrigation may lead to overuse of ground water; yet such concern was ruled out by the water buyers as they said that over irrigation has little to do with yield increase. Moreover, they reported that they do not over irrigate their fields because irrigation costs rise proportionately with usage.

Comparison of Irrigation Cost for Water Buyers of the Diesel Pump

Based on information from the Boro season in 2022 and 2023 collected from water buyers of diesel operated DTW, STW, and LL pumps, irrigation costs were compared between two years. Following the Ukraine Russia war, fuel price started to increase and as a result diesel price in Bangladesh was adjusted. The diesel price/litre at the start of Boro rice season 2022 was BDT 66/litre, but within one season the price of diesel increased three times to BDT 77/litre, BDT 80/litre and BDT 85/litre. Information was collected from same water buyer of DTW, STW and LL pump for Boro season 2022 and 2023 in the study areas of Kolaroa upazila in Satkhira district, Birol upazila in Dinajpur district, and Dumuria upazila in Khulna district. It was revealed that higher irrigation cost for production of Boro rice occurred in the season of 2023 compared to the 2022 season due to the increase of diesel price and pump operation costs. The government took that decision to reduce the subsidy level in diesel imports. Besides, in several cases, low rainfall and long drought duration during Boro rice season are also responsible factors for increase in irrigation cost as well as pump rent.

[2] However there is a general tendency for water-sellers to under-report the irrigation charges and water-buyers to over-estimate, so find in the table that irrigation charges as paid by the users were slightly higher than the amount received by the pump owners for all the payment methods.

Sl. no.	Study area	Type of diesel pump	Payment method	Boro rice season	Diesel cost			Pump rent			Total payment		
					Diesel cost/ha (BDT)*	Cost variation between 2022 and 2023 (BDT)	% of cost increase	Rent/ha (BDT)	Rent variation between 2022 and 2023 (BDT)	% of rent increase	Rent/ha (BDT)	Rent variation between 2022 and 2023 (BDT)	% of payment increase
1	Birol, Dinajpur	STW	Fixed machine charge (seasonal)	2022	11520	8745	77	11270	3440	34	22789	12185	55
				2023	20264			14710			34974		
2	Dumuria Khulna	LLP	Fixed machine charge (seasonal)	2022	16509	10729	62	9324	4014	67	25833	14743	63
				2023	27238			13338			40575		
3	Dumuria Khulna	LLP	Per hour fixed charge	2022	-	-	-	29055	13429	48	-	-	-
				2023	-			42484			-		
4	Kolaroa Satkhira	DTW	Fixed machine charge (seasonal)	2022	-	-	-	23673	6292	28.33	-	-	-
				2023	-			29965			-		

Table 2: Comparison of irrigation cost between 2022 and 2023 Boro rice season

Source: Findings based on the data collected in 2022 and 2023

N.B. The pump rents reported for LLP with per hour fixed charge and DTW with fixed machine charge in row 3 and 4 are inclusive of diesel costs.

*The quantity of diesel per hectare was calculated from how much diesel was used to irrigate a given plot of a farmer and the quantity was then multiplied by the diesel price of the respected year to get diesel cost per hectare. For example, in Dinajpur, roughly 140 litre diesels were required in 2022 and the average price was BDT 82 per litre; however, in 2023 roughly 184 litres were required, and the average price was BDT 110 per litre. In Khulna (for fixed machine charge), roughly 217 litre diesels were required in 2022 and the average price was BDT 75 per litre; however, in 2023 roughly 247 litres were required, and the average price was BDT 110 per litre.

In season 2023, the water buyers who were advanced and had financial solvency purchased diesel for the entire Boro rice season at once. Their purchase price was relatively lower as they bought before the price hike and stored the purchased diesel in a plastic drum. For those who could buy diesel prior to price rise, the cost was about BDT 65-70 per litre and for those who bought diesel in the Boro season of 2023 paid BDT 85-110 per litre. The diesel cost in 2023 increased to the rate of BDT 110/litre.

It was observed that variations in irrigation charges across various water buyers' land were influenced by several social and physical factors. These factors generally are: close relation between pump owner and water buyer; size of irrigation land of boro rice under a user; size of irrigation field area under an irrigation pump; situated distance of irrigation land of Boro rice from pump; position and soil quality of irrigation land which influences necessity of water delivery in a rice land; financial solvency/status of water buyer; ownership of pump (single private ownership/farmers, association ownership); type of pump operated diesel/electricity (DTW, STW, LLP); number of operating pump in irrigation area; timely and at a time/large amount payment of user; irregular and frequently payment of water buyer; level of rainfall and duration of drought in Boro season; etc.

Table 2 shows the comparison of cost of irrigation in Boro paddy season across the districts and three different pumps that are run by diesel. The comparison has been made in respect of diesel cost, pump rent, and total payments. In Dinajpur, for STWs, the increase in diesel cost has been 77 percent, for pump rent the increase has been 34 percent. Thus, total payment has risen 55 percent in a period of one year. Likewise, the increase in diesel cost LLPs in Khulna has been 62 percent and increase in pump rent was 67 percent, resulting in an increase of 63 percent in total payment. For the hourly fixed charge payment method in the case of LLPs in Khulna it can be seen that pump rent rose about 48 percent. In the case of DTWs, operated in Satkhira district, pump rent has been reported to have increased by nearly 28 percent between 2022 and 2023. Based on Table 2, it can be said that following the rise in diesel price, irrigation charges/costs has increased substantially in all study areas across pump types and payment types. The largest increase has been observed in case of STWs in Dinajpur-the area where ground water irrigation is highly prevalent.

4. Conclusion

Irrigation is an important input for Boro rice production and the cost of irrigation also represents a significant portion in the cost of production of Boro rice. In the wage of changing climatic condition e.g., reduced rainfall and lowering groundwater levels, Boro production has become even more dependent on irrigation in Bangladesh. The majority of the water pumps are run by diesel in the country and there are considerable variations in irrigation charge depending on the payment methods. In this study, four payment methods have been identified on the basis of the findings of the surveys and FGDs that took place across the country. One notable aspect is that although irrigation charge tends to differ across these payment methods, but still the methods have been practiced in respective villages for a very long time. This report further analyzed how irrigation costs changed in the case of Boro paddy production following the rise of diesel price hike in 2022. Evidently, the diesel price hike has led to substantial increase, e.g., 28-63 percent increase in irrigation costs in a year. This leads to a higher cost of production of Boro rice, and in turn, the profit margin of Boro rice growers may have reduced if the increase in the retail market price of rice is not transmitted to farmers proportionately. Costs of Boro rice production may be reduced if solar-based irrigation systems can be adopted; however, it is to be made sure that an adequate amount of water is available to farmers' fields at an appropriate time.

Appendix

Table A1. Variation in the irrigation payment rate across the surveyed districts and pump types

District	Method of rent payment and pump type	Rent received by pump owner			Rent paid by water buyers		
		No.	Amount (BDT/ha)	Standard deviation (SD)	No.	Amount (BDT/ha)	Standard deviation (SD)
All	Fixed charge (seasonal)	18	12981	6376	39	13249	6958
Mymensingh	Fixed charge (seasonal) Electric Pump - DTW	5	9880	0	10	9880	0
Cumilla	Fixed charge (seasonal) Electric pump - LLP	5	8744	2486	10	7361	477
Barguna	Fixed charge (seasonal) Solar Pump - LLP	3	11115	8902	9	11938	3519
Satkhira	Fixed charge (seasonal) Diesel Pump - DTW	5	21439.6	663	10	23687	4390

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