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Farmers' Willingness to Pay for Improved and Salinity Free Irrigation Water in Anowara Upazila, Chattogram, Bangladesh

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Abstract

The economy of Bangladesh partially depends on the agricultural sector. Anowara Upazila (sub-district) primarily comprises the farming community. As a result, agriculture plays a vital part in the local economy. In this study, farmers' willingness to pay (WTP) is determined to evaluate the economic value of irrigation water for a hypothetical Wide Scale Irrigation Water Management System (WSIWMS). This project will reduce irrigation water waste by stopping illegal private irrigation schemes. A double-bounded closed-ended format was employed to elicit the WTP of the farmers. It was found through the study that the majority of farmers used a private irrigation system to irrigate their land. Most farmers in the area expressed willingness to join this network since farmers faced water salinity problems throughout the year, especially in the dry season. The surface water used for irrigation contains a high salinity level due to salinity intrusion. Additionally, lack of irrigation water is another issue farmers encounter during the dry season. Moreover, compared to the current irrigation costs, the predicted WTP per Kani/season (1 Kani is equivalent to 17280 square feet of land) was 1214 taka (US$ 14.28). The estimated WTP was lower than the present cost of irrigation in the study area. This cost was around 12% of farmers' families' average monthly household income. The study revealed that income, revenue sources, education level, farmland ownership, and irrigation management influenced farmers' WTP. Empirical findings will aid the authority in applying proper agricultural measures to improve production efficiency and promote water sustainability in the coastal areas of Bangladesh.

Keywords: *Coastal area, Irrigation water, Salinity, Willingness to Pay (WTP).*

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বাংলাদেশের অর্থনীতি আংশিকভাবে কৃষি খাতের ওপর নির্ভরশীল। আনোয়ারা উপজেলা মূলতঃ কৃষক সম্প্রদায় নিয়ে গঠিত। ফলস্বরূপ, কৃষি স্থানীয় অর্থনীতিতে একটি গুরুত্বপূর্ণ ভূমিকা পালন করে। এই সমীক্ষায়, কৃষকদের অর্থ প্রদানের ইচ্ছা একটি অনুমানমূলক ওয়াইড স্কেল ইরিগেশন ওয়াটার ম্যানেজমেন্ট সিস্টেম এর জন্য সেচের জলের অর্থনৈতিক মূল্য মূল্যায়ন করার জন্য নির্ধারিত হয়। এই প্রকল্পটি অবৈধ ব্যক্তিগত সেচ প্রকল্পগুলি বন্ধ করে সেচের জলের অপচয় হ্রাস করবে। কৃষকদের অর্থ প্রদানের ইচ্ছা বের করার জন্য একটি ডবল-বাউন্ডেড ক্লোজ-এন্ডেড ফর্ম্যাট ব্যবহার করা হয়েছিল। সমীক্ষার মাধ্যমে এটি পাওয়া গেছে যে বেশিরভাগ কৃষক তাদের জমিতে সেচ দেওয়ার জন্য একটি ব্যক্তিগত সেচ ব্যবস্থা ব্যবহার করে। এলাকার বেশিরভাগ কৃষক এই নেটওয়ার্কে যোগ দিতে ইচ্ছুক ছিলেন কারণ কৃষকরা সারা বছর জলের লবণাক্ততার সমস্যার সম্মুখীন হয়, বিশেষ করে শুষ্ক মৌসুমে। সেচের জন্য ব্যবহৃত ভূ-পৃষ্ঠের পানিতে লবণাক্ততার অনুপ্রবেশের কারণে উচ্চ লবণাক্ততা থাকে।

উপরন্তু, শুষ্ক মৌসুমে কৃষকদের মুখোমুখি হওয়া আরেকটি সমস্যা হল সেচের পানির অভাব। অধিকন্তু, বর্তমান সেচ খরচের তুলনায়, প্রতি কানি/মৌসুমে পূর্বাভাসিত অর্থ প্রদানের ইচ্ছা (১ কানি ১৭২৮০ বর্গফুট জমির সমতুল্য) ছিল ১২১৪ টাকা (১৪.২৮ মার্কিন ডলার)। আনুমানিক অর্থ প্রদানের ইচ্ছা উক্ত এলাকায় সেচের বর্তমান খরচের চেয়ে কম ছিল। এই খরচ ছিল কৃষক পরিবারের গড় মাসিক পারিবারিক আয়ের প্রায় ১২%। গবেষণায় দেখা গেছে যে, আয়, রাজস্বের উৎস, শিক্ষার স্তর, কৃষিজমির মালিকানা এবং সেচ ব্যবস্থাপনা কৃষকদের অর্থ প্রদানের ইচ্ছাকে প্রভাবিত করে। এই গবেষণার অভিজ্ঞতামূলক ফলাফলগুলি বাংলাদেশের উপকূলীয় অঞ্চলে উৎপাদন দক্ষতা উন্নত করতে এবং পানির টেকসইয়তাকে উন্নীত করার জন্য যথাযথ কৃষি ব্যবস্থা প্রয়োগে কর্তৃপক্ষকে সহায়তা করবে।

1. Introduction

Irrational water use for drinking, domestic activities, industrial and agricultural purposes is a concerning issue for the present world [1, 2]. On the other hand, agricultural operations are critical for rural communities' economic sustainability, social cohesion, and irrigation water are essential for increasing agricultural productivity [3]. In developing countries such as India, Morocco, and Bangladesh, irrigation accounts for more than 90% of total water consumption, with agricultural water use accounting for estimated three-quarters of global water consumption [4]. Groundwater remains one of the most important sources of irrigation in some Asian and African countries where surface water supplies are insufficient and surface water quality is unsuitable for irrigation of agricultural lands. Irrigation coverage has been dramatically enhanced during the previous three decades to boost worldwide food production [5]. Bangladesh is an agricultural country reliant on freshwater supply for sustainable agricultural production [6]. Approximately, 80% of irrigation water comes from groundwater in Bangladesh, which appears to be climbing [6].

The coastal region of Bangladesh consists of 19 districts and covers around 20% of the total land area, which encompasses 30% of the total cultivable land area.

More than 35 million people reside in the country's coastal areas and directly or indirectly depend on agricultural production for their food supply and livelihood [7, 8]. However, with the rise of salinity in soil and water, people of coastal regions are experiencing a scarcity of freshwater for cultivation [5, 7, 9]. Notable agricultural lands were abandoned as the non-saline water for irrigation was scarce in the coastal region of Bangladesh [6, 7, 10]. Anowara, a sub-district of Chattogram in Bangladesh's coastal region, is affected by salinity and the people are in considerable physical and economic distress due to the excessive salinity in the soil, surface and groundwater Datta et al. [11]. Paul and Jabed [12] found out that the primary cause of financial hardship in that area is a lack of freshwater in Anowara Upazila due to salinity contamination in the surface and groundwater. Also, the high cost of irrigation water is another leading cause of the irrigation problem. The rural areas of this Upazila contain a sizable population of individuals involved in agriculture for livelihood. Irrigation of this Upazila depends on local surface water sources, including canals and rivers. However, a scarcity of fresh water forced some farmers to give up farming.

In a developing country like Bangladesh, proper irrigation water management is critical since the extensive use of groundwater for irrigating and expanding the growth of crops throughout the dry season places a tremendous strain on groundwater. Most of the farmers in our country are below the poverty line [13]. So they cannot afford the personal irrigation system. In that case, the government and people combined irrigation systems can play an important role. However, irrigation water valuation is necessary to plan and establish government-peoples joint irrigation plants. Irrigation water valuation is a neglected research sector in our country. The majority of Bangladeshi studies on irrigation water deal on water quality [14-18]. Some studies are found about irrigation water valuation for neighboring countries such as India, Pakistan, and Nepal [19-21]. Biswas and Venkatachalam [19] stated that farmers are willing to spend higher than they currently do. The same result has been found by Joshi et al. [20] and Reid Bell et al. [21].

The Willingness To Pay (WTP) for irrigation water and the viability of developing an irrigation water supply project in Anowara have never been evaluated in any previous study. So, irrigation valuation-related studies are needed. Researchers have utilized the Contingent Valuation technique to assess the worth of environmental amenities [22], which builds hypothetical markets for commodities with no market value [13, 23-25]. This study aimed to estimate WTP for the improved and salinity-free irrigation system for the farmers in Anowara Upazila under the Chattogram district of Bangladesh. The key objective of conducting this study is to estimate WTP for improved and salinity-free irrigation water supply in Anowara Upazila and identify significant socioeconomic variables that affect willingness to pay. This study will help inform policy-makers to reform the irrigation water policy in the coastal area of Bangladesh.

2. Methodology

The study was conducted in Anowara Upazila under Chattogram District of Bangladesh from August to December 2021.

2.1 Description of the study area

Anowara is a coastal Upazila (sub-district) in the Chattogram district. The Anowara Upazila has a total area of 164.13 km^2. It lies between the latitudes of 22°07' and 22°16' north and the longitudes of 91°49' and 91°58' east. The average temperature in Chattogram is 25.3 °C. About 2889 mm of precipitation falls annually [26]. Agriculture is the primary source of income for most people. Around 50% of the land is suitable for yearly two cultivation [27]. Anowara Upazila is divided into 11 Union parishad, i.e., Bairag, Barakhain, Barasat, Burumchhara, Battali, Chatari, Haildhar, Juidandi, Paraikora, and Roypur (Figure 1). There are 81 villages inside the Unions. The overall population of the Upazila was 259022 people. There are 49966 households, of which 37350 are farmers, with a literacy rate of 47.04%. The major rivers that pass through Anowara are the Karnafully and Sangu**.** In Anowara Upazila, the total temporary cultivated land is 8067 ha, and irrigated land is 6681 ha [27].

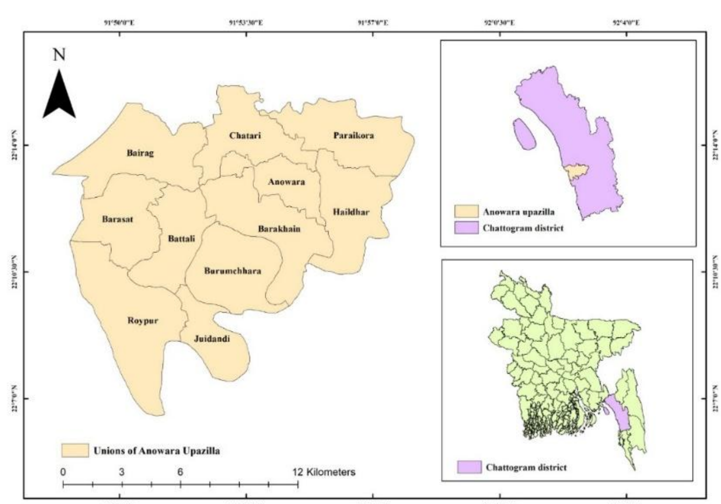


Figure 1. Study map of Anowara Upazila, Chattogram, Bangladesh.

There were eleven Anowara Upazila unions, but only ten of them were chosen to conduct this study. The unions were chosen based on the Department of Agricultural Extension's water salinity information and the local people's opinion of their irrigation water problem as determined from Focus Group Discussions (FGD). We excluded Bairag union from our analysis due to the union's hilly terrain, which is not used for agricultural production. There are 34061 farmer households in the ten unions representing our study population [27].

2.2 Conceptual framework of the willingness to pay

The Contingent Valuation Method (CVM) is frequently used as a standard method for evaluating the values of natural resources and the environment that are not in use or marketable. This technique establishes a hypothetical market for potable water of acceptable quality and provides individuals with a suggested price for the commodity. The responses of individuals to proposed prices or bids are determined by their utility maximization [13, 24, 28-32]. Contingent valuation (CV) is a social survey in which participants are informed about a particular environmental issue whose values are not recognized by market-based instruments. The CV surveys are used to elicit individual viewpoints, societal attitudes, and inclinations toward a particular environmental improvement and its nonmarket merits. Respondents are frequently questioned about their willingness to pay to evaluate the impact of a proposed project on public welfare (WTP). The aggregated economic welfare value is determined when the mean WTP value is multiplied by the number of customers who benefited from the intervention. Throughout the welfare aggregation process, various affecting factors must be considered. This study focuses on the valuation of the irrigation water supply in Anowara Upazila through the CV method by measuring WTP and finding out the region behind the irrigation problem.

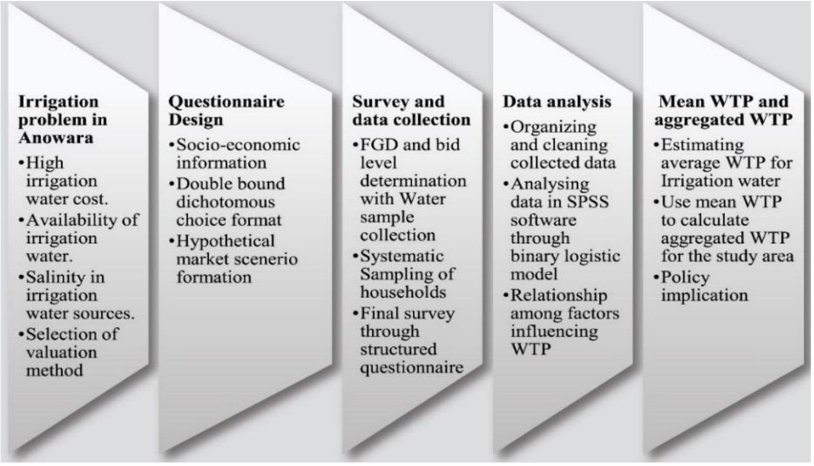


Figure 2. Framework of valuation of irrigation water in Anowara Upazila, Chattogram, Bangladesh.

The overall processes identify irrigation problem objectives, create a questionnaire, collect data, analyse data, and estimate mean and aggregated WTP (Figure 2). Each broader phase will include several central aspects of WTP influencing factors and calculation methods. Based on standard principles and empirical work cited in the literature, Farmers' willingness to pay for irrigation water supply is influenced by their income, socioeconomic demographic features (e.g., age, family size, education, and firming characteristics (i.e., size of cropland, amount of fertilizer use, experience with irrigation water) [13].

Following the study of Akter [13], a private irrigation water supply scheme represented as a^0 and the proposed government-managed irrigation water providing scheme represented as a^1. So, the utility function of private irrigation and the hypothetical "Wide Scale Irrigation Water Management System (WSIWMS)" can be written in the following two forms:

1. Present private irrigation water supply:

$$U^0 = v^0\,(a^0, I, F, S, e_0) \quad (1)$$

2. Hypothetical WSIWMS:

$$U^1 = v^1\,(a^1, I-M, F, S, e_1) \quad (2)$$

(e_0 and e_1 in equations 1 and 2 are the errors terms distributed normally)

Where, I is average monthly household income, F is farming features, and S is household socioeconomic characteristics. Households are willing to trade off a hypothetical WSIWMS for 'M' (money). The farmer's decision to pay for

WSIWMS is influenced by the usability of the current water delivery system and the change in revenue levels for obtaining the hypothetical source of water. Respondent/household will agree to pay for irrigation water under WSIWMS if:
$v^1 (a^1, I-M, F, S, e_1) > v^0 (a^0, I, F, S, e_0)$

So, when farmers receive more utility from WSIWMS than the private scheme, then farmers are interested in joining this irrigation program.

On the other hand, The WTP bid value is correlated with some farm characteristics and the socio-economical factor. To determine this, binary logistic regression is used. Influencing factors are age, sex, education, family size, and household income. The dichotomous choice model was used to conduct CV surveys for this investigation. The Dichotomous Choice format, according to Calia and Strazzera [33], is the most extensively used approach in contingent valuation due to its ease of application in data collection. When using this elicitation method, the respondent has to state YES or NO when asked if she or he is willing to pay a given amount for the public benefit. The double-bound approach allows for rectifying a faulty initial bid vector selection.

2.3 Water sample collection

Water samples were obtained from the study region to ascertain the water's salinity and determine irrigation water quality. A total of 54 samples were collected from 3 irrigation sources which were Sangu River, Parki Khal, and Borkol Khal (Figure 3).

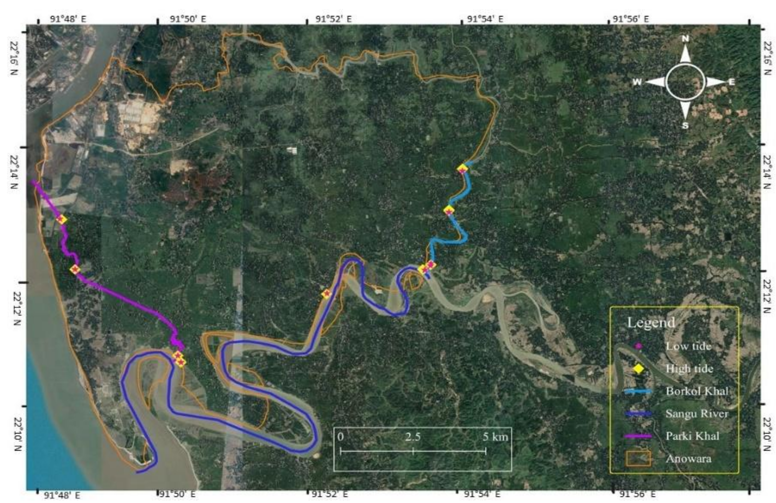


Figure 3. Irrigation water source's sample collecting point in Anowara, Chattogram, Bangladesh.

We collected water samples from each water source in a systematic way. First, we selected the location for collecting water samples. We selected three spots for each water source. After that, we collected 3 samples from every spot in both high and low tide. So, we got 18 samples from each water source from 3 spots, where 9 samples were in high tide and 9 in low tide (Figure 4). Following this process, we collected the remaining water samples from the other two sources. Finally, we got 54 water samples from those 3 irrigation water sources. Water samples were collected from salinity, the mass in grams of dissolved inorganic particles in one kilogram of water [34], often determined by the water's electrical conductivity. Electrical conductivity (EC) is a water property directly connected to its salinity level. The water samples were sent to the Soil Research Development Institute, Regional Laboratory, Chattogram, to determine the concentration of salinity through electrical conductivity measurement.

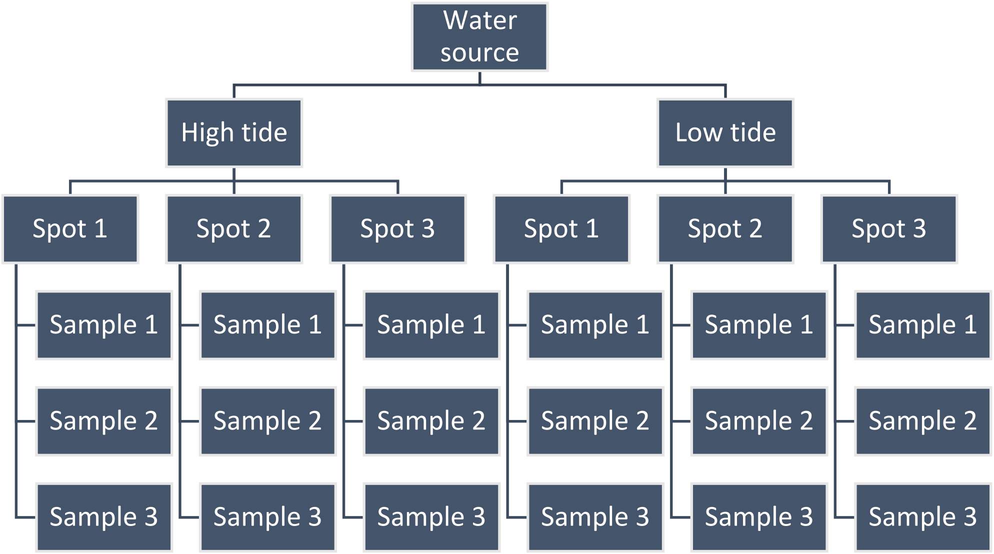


Figure 4. Process of water sample collection from the irrigation water source in Anowara, Chattogram, Bangladesh.

2.4 Sampling procedure and data collection

This study has purposively chosen ten Unions of Anowara Upazila for household selection, but the representative households were randomly sampled. All types of major, medium, small, and landless farmers were surveyed in this study. The Anowara Upazila Department of Agricultural Extension counts farmers' homes. To calculate sample size, Cochran [35] formula was used.

When the population is infinite [36] (1),

$$n_o = \frac{z^2pq}{e^2} \qquad (1)$$

$$= \frac{(1.96)^2 \times (0.5) \times (0.5)}{(0.05)^2}$$

$$= \frac{0.9604}{0.0025}$$

$$= 384$$

Where, n_o is the sample size, z is the selected confidence interval level of 1.96, p is maximum variability equal to 50% or 0.5, q is (1-p) which is 0.5, and e is the desired level of precision which is 0.05.

However, it was pointed out that the sample size could be reduced slightly if the total population was known [36]. Larger populations tend to have more information available than smaller ones. Cochran [36] proposed a correction formula for calculating the final sample size is given below (2)

$$n = \frac{n_o}{1+\frac{(n_{o-1})}{N}} \qquad (2)$$

$$= \frac{384}{1+(\frac{384-1}{34061})}$$

$$= \frac{384}{1.011}$$

$$= 379.82$$

$$= 380$$

Where N is the population size (34061), and n_o is the sample size derived from equation (1). So the final sample size is 380 households for the questionnaire survey is determined using Cochran [35] formula with a 95% confidence interval and precision level of ±5%.

Anowara is an agriculture-oriented Upazila. So before starting face-to-face interviews, we collected union essential farmers' lists from the Upazila Agricultural Extention Department. The number of farmers was not equally distributed. However, to ensure that the data collected represents the farmer population, we needed to classify sample numbers based on the farmers in each union (Table 1).

Table 1. Union basis farmer sample list for a face-to-face interview in Anowara Upazila, Chattogram, Bangladesh.

Union name	Total Farmer household number	Selected farmer household number: $\left(\frac{\boldsymbol{Union's\ total\ farmers}\ \times \mathbf{100}}{\boldsymbol{Upazila\ Total\ farmers}}\right) \times \mathbf{380}$
Anowara sadar	1693	19
Barakhain	4428	49
Barasat	4257	47
Burumchhara	3051	34
Battali	3632	41
Chatari	2891	32
Haildhar	3638	41
Juidandi	2565	29
Paraikora	3123	35
Roypur	4783	53
Total	34061	380

The study was planned based on the farmer's contribution to the irrigation plant. More than one individual farmer from the same household was excluded throughout the interview process. Farmers are chosen based on their household location rather than their land location. Each farmer's house was chosen using a systematic sampling approach, with every ninth household located along the right side of the main village road being interviewed. The sampling interval was obtained by dividing the total sample households by the average number of households in the ten unions [13, 23, 37, 38]. Each interview lasted about 15-20 minutes on average.

We conducted informal focus group discussions (FGDs) before household surveys to define hypothetical baselines, variable selection, questionnaire design, and initial and final bid selection for determining WTP [13, 23, 37, 38]. The focus group discussions (Table 2**)** ensured that necessary revisions were made to the hypothetical scenario, which will be conveyed to respondents about irrigation water supply in the future. In this study, four informal FGDs were conducted in four Unions of Anowara Upazila, such as Battali, Haildhar, Paraikora, and Roypur. All of the participants were male farmers of different age groups. Each FGD consisted of an average of 18 participants. Based on the information gathered from FGD, the maximum and lowest bid amounts were decided. The benefits of the irrigation water project were explained to respondents to participate in the survey process.

Table 2. Focus group participants selected minimum and maximum bid levels in Anowara Upazila, Chattogram, Bangladesh.

	Union				
	Battali	**Haildhar**	**Paraikora**	**Roypur**	**Total**
Number of the Farmers	18	19	17	18	72

The conversation centered on land ownership, own irrigation system, times of agriculture, water salinity, demand for irrigation water, the possible amount of WTP, and socio-economic situation. The study used the data from the FGDs to estimate the lowest-level bid for season/Kani[1] at BDT 1200 (US$14.11) and the highest-level bid at BDT 2000 (US$23.52). The procedure of distributing irrigation water to the participants was discussed in depth in order for them to have a better knowledge of the hypothetical market scenario, and their subsequent questions were also answered. Following the bid levels determined by FGDs, a survey with a structured questionnaire was launched. Hypothetical, strategic, starting point and knowledge bias were all reduced by using these FGD to define the WTP situation and provide a detailed overview of the processes involved to participants [13, 39].

2.5 Questionnaire designing and data collection

The questionnaire was constructed using the contingent valuation methods conceptual framework as a guide. Three sections were included in the survey: (i) Irrigation water and associated information (cultivation times, cost of production, cost, type of ownership, significant advantages and disadvantages of the current irrigation water source), and (ii) WTP for irrigation water under the hypothetical irrigation plant. (iii) Includes socio-demographic information (age, occupation, educational background, family size, sources of income).

After introducing the hypothetical product to the respondents, two WTP questions were administered (WSIWMS). First, respondents were asked if they would pay 'in principle' under the WSIWMS for irrigation water per Kani for every cropping season. Those who said 'Yes' were then asked if they were willing to pay a specific bid amount in the form of a dichotomous choice question. The bid amounts were classified into four classes such as 1200 BDT/Kani/season (US$14.11), 1500 BDT/Kani/season (US$17.64), 1800 BDT/Kani/season (US$21.17), and 2000 BDT/Kani/season (US$23.52).

[1] 1 Kani equals 30 decimals or 17280 square feet of lands.

The bidding path is depicted in Figure 5 for each 'Yes' or 'No' response to a matching bid. If the respondent was unwilling to pay, socio-economic data were collected and the subject was questioned about the reason.

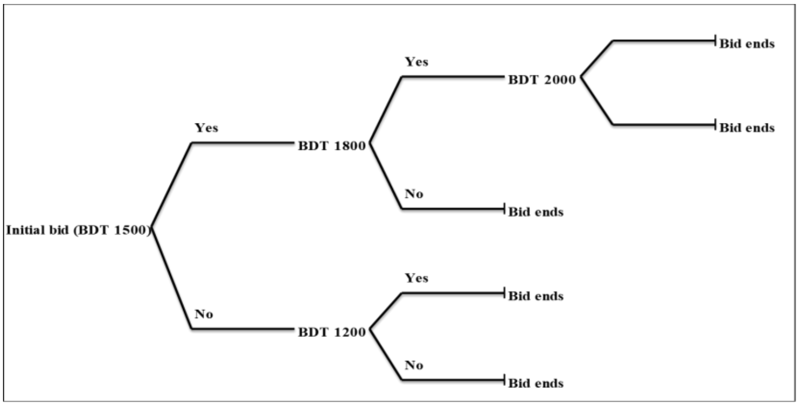


Figure 5. Bidding path for valuation of irrigation water in Anowara Upazila, Chattogram, Bangladesh.

2.6 Mathematical theory to estimate mean WTP

A simplified process suggested by Honu [40] was employed to estimate the mean WTP for irrigation water for Anowara Upazila. This process allowed incorporating the WTP of the sample respondents willing to pay less than the minimum bid level of BDT 1200 monthly. A modified formula was derived to estimate the mean WTP by following the four steps mentioned below [40].

1. Data collection on respondents' willingness to pay in ascending order of three bid levels and calculated acceptance and rejection frequencies for each offered bid, followed by cumulative acceptance and rejection frequencies.
2. Determination of the upper bound for WTP at each bid level and frequency class.
3. Calculated the WTP class average and associated frequencies for each class average
4. Determination of the mean WTP using the following formula

Mean WTP = $\sum[(f_r - ub_{wtp})/100]\bar{X}$

Where, f_r = **Cumulative frequency of rejection**

ub_{wtp} = **WTP upper bound of the previous class**

$\bar{X}$ **= average of WTP class for each bid =** $\frac{\text{highest wtp of the class} - \text{lowest wtp of class}}{2}$

2.7 Elimination of biases

This study needed to address strategic bias, Information bias, starting point bias, and payment vehicle bias and remove those biases using a suitable way (Table 3).

Table 3. Bias removing procedure in data collection of Anowara Upazila, Chattogram, Bangladesh.

Name of bias	Way of removing
Strategic bias	Further questions were asked to elicit the reasons for agreeing to a specific offer level [41].
Information bias	Describe the plan in detail to the respondent in their native language and respond to their subsequent questions about the proposed intervention [40].
Starting and ending point bias	FGD was conducted in four unions, as is customary in contingent valuation research. These bid amounts were determined using data gathered during the FGD [13].
Payment vehicle bias	Farmers were allowed to analyze the offered bid and develop responses using a local and familiar payment method for irrigation water [13].
Embedding effect	Various irrigation water supply solutions were supplied to the farmers who responded to lower the WTP of irrigation water's embedding impact.

2.8 Descriptions of variables

Numerous research conducted using the Contingent Valuation (CV) technique to improved irrigation water supply found that socio-economic criteria such as income, education, occupation, family size and income sources influenced respondents' WTP [13, 23, 41, 42]. Additionally, the existing water source problem, present cost, and the demand for more significant water quality influenced people's WTP [13]**.**

Table 4. The significant variables influencing farmers' WTP for irrigation water in Anowara, Chattogram, Bangladesh.

Major Factors	Variables	Description
Land and irrigation	Land ownership	Owner of the land.
	Times of cultivation	How many times a year do they cultivate their land?
	Own irrigation system	Have they owned a personal irrigation system?
	Salinity problem	Did they face any salinity problems on behalf of irrigation?
WTP	Willing to contribute financially	If the respondent is willing to pay for irrigation water supply.
	Offered bid amount	If the respondent accepts or rejects the offered bid.
Socio-economic information	Age of the respondent	Age of the respondent in years.
	Income sources	The number of earning people in the same household.
	Household income	The total monthly income of the respondent's household in BDT.
	Family size	The total number of people living in the household.
	Gender	Male or female
	Education	The level of education respondents has
	Occupation	The respondent is unemployed, self-employed, businessman, government or private service holder

The variables listed in Table 4 were utilized to analyze the data and determine the factors impacting WTP. Descriptive statistics were produced by analyzing all of the sample data. However, 296 respondents agreed to contribute to this irrigation plan out of 380 respondents.

2.9 Process of data analysis

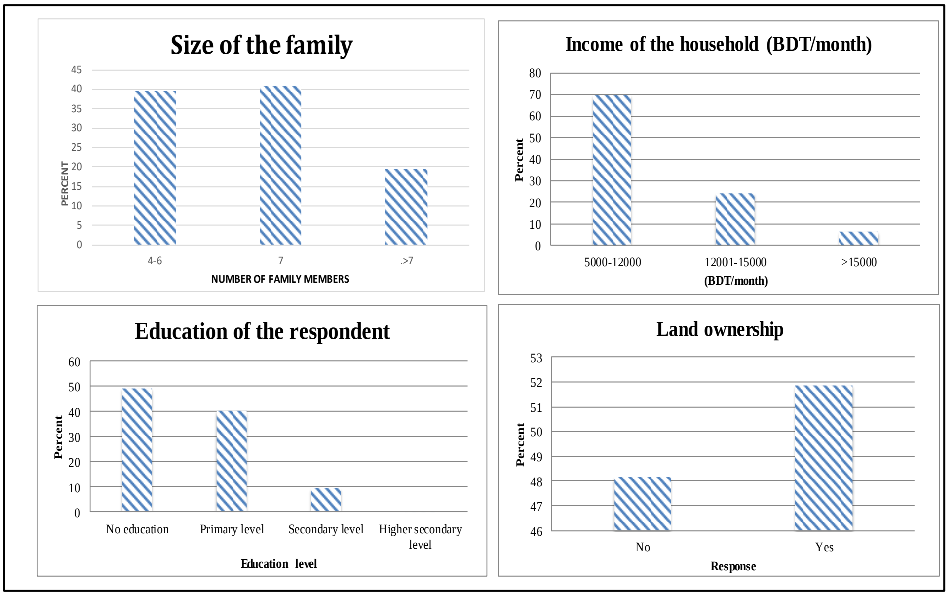
Studies have applied a binary logistic model of CVM to nonmarket commodities and identified critical factors influencing WTP. The WTP model is chosen based on the purpose and the variables employed in the study [37, 41, 43]. The data were analyzed using a binary logistic regression model to identify the relevance of the factors influencing WTP. In order to execute the binary logistic model, IBM SPSS version 25 was employed. We used Microsoft Excel 2010 and a structured questionnaire survey for the initial data entry and organization. In the next stage, IBM SPSS version 25 software was used to classify and code the qualitative data categories. Because the binary logistic model was used to analyze the data during conceptualization, the dependent and independent variables were established. We examined the willingness to pay in four models for each bid tier (BDT 1200, BDT 1500, and BDT 1800). There were just two choices for the dependent variable, "Willingness to help financially" or "No," in the first model. The irrigation issue, land ownership, and agriculture duration were independent variables. Using Pearson's chi-square test, each independent variable was compared to the dependent variable to evaluate the significance of each one. An analysis of binary logical regression on the relevant variables using the willingness mentioned above to pay and bid levels as the only independent variables. The interconnection between socio-economic and irrigation problems was examined as the last step. The mean WTP and aggregated WTP were determined following the mathematical theory outlined in section 2.6. The total WTP for Anowara's farmer households was calculated using the mean WTP. Before beginning the regression analysis, we checked for multicollinearity using the Variance Inflation Factor (VIF) before beginning the regression analysis. As the mean VIF was 1.46, a number below 10, it was determined that multicollinearity was not an issue.

3. Results and Discussion

3.1 Socio-economic characteristics of the respondents

The average household consisted of about six family members of the 380 respondents interviewed. The average age of the respondents was around 42 years. Moreover, all the respondents were male. In our country, most male farmers are the head of their households [13]. About half of the respondents were illiterate.

Moreover, about 90% of respondents did not cross the primary education level. The majority of farmers (51%) cultivated their lands (Figure 6). The average monthly household income is about 10431 BDT. Nevertheless, our country's average household monthly income is 15988 BDT [44]. As a result, the respondent's monthly income is lower than our national average. However, 80% family had one earning person in their family. However, the mean monthly household income was slightly high in small families (4-6 people) and farmers who cultivated their land.



[Note: BDT= Bangladesh taka.]

Figure 6. Socio-economic characteristics of the farmer respondents in Anowara, Chattogram, Bangladesh.

3.2 Land and existing irrigation factors

Most of the lands of Anowara were suitable for cultivation three times per year. So, it represented that proper management could make this Upazila a food bank. Family size and mean household income have opposite relations. It indicates that household income is high in small-sized families and lowest in large families (Table 5). Moreover, large families suffer more irrigation problems than small size families. However, more than 50 percent of farmers used a private irrigation system for their cultivation, and also only 10 percent of people had their irrigation system. For irrigation of their land, they had to pay more than 2000 BDT per season/Kani. More than half of the respondents faced water salinity problems during a cultivation year. Those farmers faced more salinity problems using the river or khal as a source of irrigation water (Table 5). On the other hand, farmers with irrigation systems faced fewer salinity problems than others. In contrast to the private irrigation system, river and dam using farmers faced more salinity problems (Table 5). Also, the highest 40% of farmers who do not have a personal irrigation system suffered a shortage of irrigation water and high prices.

More than 90% of the respondents faced different types of irrigation problems. About 143 respondents (37.6% of the sample) faced water shortages and a high value of irrigation water problems. Furthermore, 15.8% and 24.7% of respondents separately addressed water shortness and high-value problems. Also, 49% (12.9% of the sample) of people addressed irrigation pump problems during cultivation time. In contrast, farmers who used the river or khal as an irrigation source faced a lower problem than other users. About 60% of the farmers suggested making soil drainage systems for irrigation water supply comparing concrete-based drainage.

Table 5. Correlation between socio-demographic and land-specific information of Anowara Upazila, Chattogram, Bangladesh.

		Household income	Salinity problem (%)		kind of irrigation problem (%)				
		Mean BDT	**No**	**Yes**	**A shortage of water during the dry season**	**The current irrigation price is too high**	**Irrigation pumps got out of order sometimes**	**A shortage of water during the dry season; Current irrigation price being too high**	**No response**
Land ownership	**No**	9372	42	58	16	23	8	34	19
	Yes	11416	37	63	16	26	17	41	0
Source of irrigation water	**River / khal**	10098	34	66	20	25	12	37	7
	Dam	9632	32	68	21	42	21	0	16
	Private	10787	44	56	12	23	13	42	10
Own irrigation system	**No**	10522	38	62	16	24	13	40	7
	Yes	9641	54	46	18	31	10	13	28
Size of the family (Number)	**4-6**	12755	46	54	15	25	13	40	8
	7	8852	38	62	15	26	11	37	10
	.>7	9000	28	72	19	22	16	35	8

3.3 Contingent valuation and WTP result of irrigation water

Most farmers (91.1%) responded favorably to the first WTP question regarding their willingness to receive irrigation water. However, 8.9% of the farmers in the area were not interested to get this. In response to second question, 296 farmers agreed to contribute to irrigation water under the WSIWMS project. In a follow-up inquiry, those unwilling to pay were then asked why they were unwilling to do so. The most often cited reason for refusal to pay was 'do not have the financial means to pay for irrigation water (5.78%), followed by 'I have access to my irrigation water source' (8.67%) and 'I am not certain that my money will be spent wisely (1.23 percent). Respondents who refused to pay because they believed their money would be spent appropriately are called protest bidders in CV surveys. Protest bidders account for fewer than 1% of the sample size [13, 28].

The calculation reveals that the farmers of Anowara Upazila were willing to pay BDT 1214 per season/per Kani to irrigation water for their cultivation. The total farmers' household of ten selected unions in Anowara was 34061**.** The aggregated WTP was BDT 41,350,054. The average estimated WTP was lower than the current price level in an existing irrigation system. Thus, if the government is able to complete this WSIWMS project within 41,350,054 BDT, both farmers and government authorities will gain.

Most CVM research is undertaken in underdeveloped countries [22, 32, 45], on WTP for drinking water under improved water supply conditions. Few of them are on the valuation of irrigation. Considering CVM surveys conducted in developing countries which are the most comparable to this paper [13, 23, 30, 31, 46], have calculated the economic worth of irrigation water or increased irrigation under a variety of CVM scenarios (Table 6).

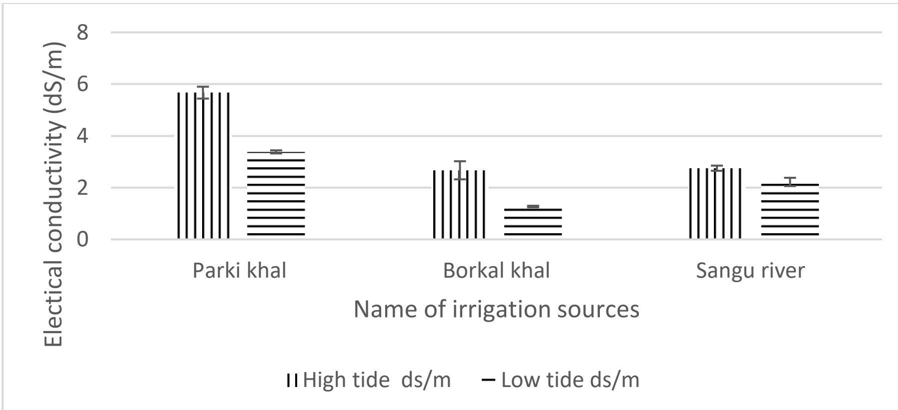
Table 6. Summary of some CVM studies worldwide about the valuation of irrigation water.

Study area	Influencing factor	Mean WTP	Reference
Homna, Comilla, Bangladesh	- Respondent age, - Respondent education, - Respondents' family size, - Number of income sources, - Ownership of farmland	Per season, 1670 Taka (US$ 27.83) per Kani (30 decimal).	Akter [13]
Addis Ababa, Ethiopia	- Farm's location, - Respondent Education, - Number of years with irrigation experience, - Total annual yield value	- Single-bounded model ETB 39.57 (US$ 3.44)/ hectare/year, - The bivariate-probit ETB 39.10 (US$ 3.40)/hectare year. - ETB 39.72 (US$ 3.45) from the interval-data model. - ETB 35.35 (US$ 3.07) from the open follow-up question.	Weldesilassie et al. [31]

Study area	Influencing factor	Mean WTP	Reference
Tamil Nadu, India	- Income - Age - Amount of land	218.50 Indian Rupees (US$ 4.46) per hectare per annum	[23]
Malaprabha, Karnataka, India	- Age - Gender - Crop income - Education - Family size	INR 219/acre/year (USD 2.94)	[19]
Rajapani, Rupandehi district, Nepal	- Water source to paddy field distance - Health condition - Sexual orientation	USD 77.13 per ha per year	[47]

3.4 Irrigation water quality in Anowara Upazila, Chattogram, Bangladesh

More than 50% of the respondents opined about salinity problems in irrigation water, especially in dry seasons. We collected 54 samples from three water sources which were popular irrigation sources. We collected water samples at high and low tides. And also, from different locations. From the result, the water source indeed contained high-level salinity. Parki khal had a high salinity level at both high and low tide, 5.68dS/m* and 3.38ds/m, respectively. Among the three irrigation water sources, Borkal khal had the lowest salinity. It was 2.67dS/m at high tide and 1.27dS/m at low tide. During high and low tides, the Sangu River had a moderate salinity. It was 2.75ds/m at high tide and 2.22dS/m at low tide (Figure 7). Another study by Datta et al. [11] showed the same result for these three irrigation water sources, where Parki Khal and Sangu rivers contained higher salinity than Borkol khal.



Note: ds/m= Deci Siemens per meter.

Figure 7. Average water salinity level in three irrigation water sources in Anowara Upazila, Chattogram, Bangladesh.

3.5 Factors affecting WTP for irrigation

The determinants of stated WTP answers (n=380) were examined. The predictive power of this regression model was greater than 86 percent.

Table 7 Estimated binary logistic WTP model for improved and salinity-free irrigation water in Anowara Upazila, Chattogram.

	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
							Lower	Upper
Farming characteristics								
Land ownership	0.992	0.494	4.031	1	**0.045**	2.697	1.024	7.106
Own irrigation system	-4.159	0.806	26.593	1	**0.000**	0.016	0.003	0.076
kind of irrigation problem (2)	1.222	.0701	3.042	1	0.081	3.394	0.860	13.403
A shortage of water during the dry season., The current irrigation price is too high.	4.996	1.291	14.966	1	**0.000**	147.764	11.760	1856.707
Salinity problem	0.920	0.461	3.988	1	**0.046**	2.509	1.017	6.191
Socio-economic and demographic characteristics								

	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
							Lower	Upper
Education of the respondent (Primary level)	1.026	0.503	4.159	1	**0.041**	2.789	1.041	7.473
Number of income sources (2 Sources)	2.162	0.914	5.596	1	**0.018**	8.688	1.449	52.100
Income of the household (12000-15000 BDT/month))	2.705	1.150	5.530	1	**0.019**	14.948	1.569	142.415
Income of the household (More than 15000 BDT/month)	17.687	6611.672	.000	1	0.998	48031218.936	0.000	.
Constant	0-.894	0.527	2.877	1	0.090	0.409		
Variable(s) entered in step 1: Land ownership, Own irrigation system (Y/N), kind of irrigation problem, Salinity problem, Education of the respondent, Number of income sources, income of the household (BDT/month).								

This model takes 95% confidence interval level. However, land ownership, own irrigation system, types of problem, education level of the respondent, number of income sources and household income significantly impacted farmers' willingness to pay for irrigation water under WSIWMS (Table 7).

A respondent's level of education had a major impact on whether or not they will accept a bid amount from WSIWMS. Additionally, this outcome aligns with theoretical and empirical research [13]. Farmers with at least a primary school education were likelier than their illiterate counterparts to accept a bid amount. This finding demonstrated the general truth that education raises people's appreciation for the scarcity of natural resources like water. Because of this correlation, farmers were more likely to accept a bid for irrigation water under WSIWMS if they had more than one source of income. The whole family's income rises due to a rise in the source of income. Since these households had two earners, they were eight times more motivated to invest in better irrigation (Table 7). The willingness to pay for irrigation water is strongly influenced by farmer income. Farmer revenue rose due to improved crop yield, so they accepted a lower bid amount for better irrigation than anticipated. Akter [13] stated the same findings in another study conducted in Homna, Cumilla.

In addition to agricultural features, the research showed how specific farming factors influence the acceptance of a bid amount for irrigation water under WSIWMS. As predicted, farmland ownership (land ownership) had shown an upward trend. This showed that farmers who owned the cultivated land were more inclined to accept a bid amount (Table 7). Landowners and farmers who face salinity problems offer more than twice as many salt issues in exchange for upgraded irrigation systems. WTPs for irrigation water has been significantly affected by the WSIWMS because of the current irrigation supply management system. That means farmers who owned water pumps were less likely to accept the offered bid than farmers who did not own a water pump (Table 7). Because water owner farmer rent their water pump to other farmers who do not have their water pumps. Akter [13] found the same result for those farmers who had their irrigation system.

Anowara's farmers faced two significant challenges, e.g., lack of irrigation water and the high cost of irrigation. According to (Table 7), farmers were eager to take advantage of this initiative because the bid amounts were lower than the current irrigation costs. This Experiential (B) is higher than the salinity problem because around 90% of farmers faced a shortage of irrigation water in the dry season and high irrigation prices, but around 50% faced water salinity problems.

Table 8. Factors related to different bid levels in farmers' willingness to pay in Anowara, Chattogram, Bangladesh.

Name of Variables	**1200 BDT**			**1500 BDT**			**1800 BDT**		
	B	**Sig.**	**Exp (B)**	**B**	**Sig.**	**Exp (B)**	**B**	**Sig.**	**Exp (B)**
Own irrigation system (Y/N)	-3.256	**0.00**	0.039	-0.563	0.741	1.757	- 12.97	0.998	0.010
Salinity problem	0.887	**0.009**	2.428	-0.496	0.352	.609	7.009	0.620	0.611
A shortage of water during the dry season., The current irrigation price is too high.	1.941	**0.001**	6.963	-0.002	0.998	.998	18.94	0.966	1688.9
Education of the respondent (Primary level)	-0.282	.0413	0.521	1.638	**0.004**	4.325	- 0.660	0.584	0.517
Income of the household (12000-15000 BDT/month)	-3.752	**0.000**	0.023	3. 80	**0.000**	589.642	16.27	0.994	11705.5
Income of the household (More than 15000 BDT/month)	-5.171	**0.000**	0.006	4.812	**0.000**	122.934	21.19	0.992	16053.9
Variable(s) entered in step 1: Own irrigation system (Y/N), kind of irrigation problem, Salinity problem, Education of the respondent, Income of the household (BDT/month).									

That means irrigation systems, salinity issues, irrigation type, and respondent household income substantially impacted respondents' willingness to pay bids at $1200. Salinity-affected farmers were interested two times more in paying 1200 BDT than non-affected farmers (Table 8). Furthermore, some farmers were seven times more interested in paying 1200 BDT amount who faced both a lack of enough water and high price problems. It was also less appealing to individuals who already had an irrigation system. On the other hand, higher-earning families were not interested in paying 1200 BDT.

On the other hand, the study observed a distinct scenario with a bid amount of 1500 BDT. In this scenario, educational level and household income positively correlated with this bid value (Table 8). Compared to individuals with no education, those with primary education were four times more interested. The exact relationship existed in monthly household income. Individuals became more interested in bidding on those items when household income improved. However, no significant variable was associated with accepting the bid of BDT1800 (Table 8). Most respondents rejected this figure because it was similar to current irrigation costs.

4. Conclusion and Recommendation

4.1 Conclusion

Irrigation has increased agricultural productivity internationally by allowing for increased crop and livestock varieties and providing predictable output. Expanding agricultural productivity requires irrigation. This study aimed to ascertain farmers' willingness and ability to pay for enhanced irrigation services in Anowara Upazila and identify the factors influencing people's willingness and ability to pay for improved irrigation services. This study aimed to determine farmers' WTP for irrigation water under small-scale irrigation water supply projects and to discover factors associated with WTP variation. The study estimated that the WTP for irrigation water under the WSIWMS were BDT 1214 (US$ 14.24) per Kani for every crop season, which was significantly less than the current cost of irrigation. It indicates that farmers and government will gain if the government can finish this WSIWMS project in BDT 41,350,054. Education level, total household income, number of income sources, farmland ownership, existing irrigation system, and salinity impacted the WTP. Unlike prior contingent valuation research on irrigation water, this study revealed no indication of a significant direct effect of respondents' family size or crop patterns on their WTP. Additionally, the salinity issue was a significant factor in farmers' interests. As a coastal area, the people confronted salt issues throughout the dry season, which harmed their agricultural productivity.

The current study's findings imply that at least a primary education level is necessary for reforming the existing irrigation system. Additionally, it reveals that improved pricing highly depends on the region's land ownership structure since landowners are more likely than landless farmers to pay higher prices for scarce irrigation water supplies. However, some farmers were disinclined to have their irrigation systems installed. After the study, the farmers' primary motivation for participating in this WSIWMS project is to save money on irrigation and have a secure irrigation system.

This study's drawback is that, due to time and resource constraints, the next step of doing a cost-benefit analysis of the scheme based on the study's findings was not carried out. Researchers could measure WTP throughout two different seasons (wet and dry) in order to investigate seasonal variations in WTP, as this was not taken into account in this study.

4.2 Recommendation

The government planning authority should complete this irrigation project within the amount of BDT 41,350,054. Moreover, it needs to investigate why surface water sources were contaminated with salinity and take proper steps to reduce this situation. However, extracting groundwater for irrigation is not an environment-friendly solution. So, it is needed to find a sustainable way to irrigation water supply, which can be applied to all coastal areas of Bangladesh.

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