Volume 9
Number 1
Year 2007
ISSN 1529-0905

Journal of BANGLADESH STUDIES

TABLE OF CONTENTS

From the Editor	**Syed S. Andaleeb**	**iv**
ARTICLES		
Education in Bangladesh: The Vision for 2025	**Manzoor Ahmed**	**1**
Commentary	**Munir Quddus**	**15**
Commentary	**James H. Williams**	**17**
Farmers' Willingness to Pay for Irrigation Water Under Government Managed Small Scale Irrigation Projects in Bangladesh	**Sonia Akter**	**21**
Changes in Socio-economic and Environmental Situations in the Delta Irrigation Project During 2000-2007: Policy Recommendations	**M. Fakrul Islam** **Wardatul Akmam**	**32**
Public Private Partnership for Efficient Port Operation: A Proposal for Chittagong Port Authority	**Dilruba Khanam** **M. Abu Misir**	**39**

Farmers' Willingness to Pay for Irrigation Water Under Government Managed Small Scale Irrigation Projects in Bangladesh

Sonia Akter

Abstract

The study attempts to determine the economic value of irrigation water in a government managed small scale irrigation project (GMSSIP) by eliciting farmers' willingness to pay (WTP) using contingent valuation method (CVM) in the form of single bounded closed ended WTP questions. Agricultural farmers in the study area, who currently largely depend on privately owned irrigation water supply, were asked for their preferences for a ground water based government managed irrigation water supply project in a small scale household survey. The estimated WTP for use of irrigation water from GMSSIP equals to Taka 1670 (US$ 23.85) per thirty decimal of land per cropping season, which is 12 percent of the average agricultural income of household per cropping season. Comparing estimated WTP for water in an existing government managed irrigation project, the study argues that ground water irrigation water is highly under-priced in Bangladesh. Furthermore, the study reveals that bid level, respondents' age, education, family size, number of income sources, ownership of farm land, management system of current irrigation scheme and decision to change cropping patterns if a government managed irrigation scheme is provided, have significant influence on farmers' WTP for GMSSIP. Based on the empirical findings, the study strongly advocates water policy reform in the agricultural sector in order to enhance efficiency and promote sustainability in water use.

Introduction

Bangladesh is an agricultural country with an area of only 144,000 km^2 where 132 million people live. The country receives intensive amount of rain water in the monsoon months (June - October) and suffers from water shortage during the dry season (November - April). The average annual rainfall is 2,300 ml which varies from 1200 ml in the west to 5800 ml in the northeast. Agriculture is the major water consumer sector in the economy which consumes approximately 80% of the total water. Groundwater is the major source of irrigation water during the dry season complemented by an abundant supply of rain water during the wet season. In order to achieve food self-sufficiency for an ever-growing population, the government invested an extensive amount of money in 'Flood Control Drainage and Irrigation (FCDI)' projects and ground water based small scale irrigation schemes. The major objective of these FCDI and small scale ground water based irrigation projects is to ensure water availability for Boro crop during the dry season. Under the existing system, non-volumetric price is charged for the use of irrigation water. Conceptually non-volumetric pricing refers to a pricing structure where water is billed in proportion to something other than the volume of water used (e.g., area irrigated or weight of crop produced). Water price is charged mainly based on the size of crop land and crop type. The price charged under government managed projects for supplying irrigation water is too low to affect farmers' cropping decision with a lower rate of collection.

Agricultural water pricing plays a significant role in promoting water use efficiency and cost recovery. Moreover, in a developing country like Bangladesh, appropriate pricing of irrigation is important for two reasons. First, widespread and increasing practice of Boro crop cultivation throughout the country during dry season creates enormous demand for groundwater. Failure to determine appropriate water price may lead to over utilization and over extraction of groundwater which will eventually cause a permanent decrease of the groundwater table. Secondly, irrigation water sector in Bangladesh is heavily subsidized and claim about 50% of development expenditure in the agricultural sector. In order to extend the irrigated area under government managed irrigation scheme without putting further pressure on the country's development budget, it is important that farmers' participation is ensured through appropriate charge for water.

The present study aims to contribute to agricultural water policy reform in order to enhance efficiency and to promote sustainability in water use. The study attempts to determine the price of irrigation water eliciting farmers' willingness to pay (WTP) in a government managed small scale irrigation project (GMSSIP) using contingent valuation method (CVM). Agricultural farmers in the study area, who currently largely depend on privately owned irrigation water supply, were asked to pay for use of irrigation water under GMSSIP in the study area. The estimated WTP for use of irrigation water equals to Taka 1670 (US$ 23.85) for per kani (thirty decimal) land per

cropping season which is 12 percent of the average agricultural income of household per cropping season. Furthermore, the study reveals that bid level, respondents' age, education level, family size, number of income sources, ownership of farm land, management system of current irrigation scheme and decision of changing crop if government managed irrigation scheme is provided have significant influence on farmers' willingness to pay for GMSSIP.

The rest of the paper is organized as follows. Section 2 discusses the relevant literature on CVM. Section 3 outlines the conceptual framework of the study. The fourth section gives a description of the case study area followed by a description of the general survey and sample characteristics in Section 5. General WTP results and output from the regression analysis are presented in section 6 followed by the conclusions and recommendations from the study in section 7.

Literature Review

No previous study has been carried out in Bangladesh to estimate the economic value of irrigation water using either market or non-market based valuation techniques. However, the issue of low water price and poor collection rate in large scale irrigation water projects has been addressed in several studies (Chakravorty, 2003; Hussain and Wijerathna, 2004). Hussain and Wijerathna (2004) demonstrate that the average water price charged in large scale irrigation water projects varies within the range of US$16-18 with an extremely poor collection rate of 5-15%. A report published by the Water Ministry of Bangladesh (2000) also indicates a very poor water price collection rate (3 to 10 percent) and concludes that cost recovery in such intensive infrastructure based irrigation projects is very poor.

The existing literature on irrigation water valuation provides few evidences where contingent valuation method has been applied to determine the true economic value of irrigation water. Tiwari (1998) reviewed the current issues in irrigation water pricing and presents a conceptual framework for economic valuation of irrigation water and provided the results of a case study on determining the economic value of irrigation water using both stated and revealed preference valuation techniques. The results indicated that farmers are willing to pay sums at least equal to the operation and maintenance cost and are able to pay up to the marginal value product of water. The maximum willingness to pay was found to be considerably less than the opportunity cost of irrigation water, indicating the unsustainable use of irrigation water at present. Tiwari used both the open and closed-ended questions. Closed ended WTP have been found to be related to respondents' gender, agricultural income, perceived water sufficiency, education, family size and landholding. On the other hand, variation in open- ended WTP was found significantly varying with the farmers' attitude towards paying fee, sex, education, migrating family members, family size and access to credit.

Another contingent valuation survey carried out by Giorgis (2004) in Ethiopia in the form of open ended WTP question for irrigation water revealed that access to credit create an opportunity for respondents to invest in necessary agricultural inputs, of which irrigation water is one. Thus those who tend to borrow are willing to pay more for irrigation water. Other variables that significantly influence farmers' willingness to pay for irrigation water are the respondent's education, quantity of fertilizer used in the preceding crop season, total revenue earned in the preceding crop year, the respondent's age, experience with irrigation and the size of cultivable land. Mallios and Latinopoulos (2005) used contingent valuation method in the form of closed ended WTP question to determine the factors contributing to WTP for irrigation water in Northern Greece. The study revealed that respondents' age, family size, number of family members working in agriculture, number of total boreholes in use, amount of annual irrigation water consumption and the nature of water shortage have a significant impact on farmers' willingness to pay for irrigation water.

Analytical Framework of the Study

The theoretical model of the study is based on standard microeconomic principles and empirical work cited in the literature review section. Theoretically, compensating variation or WTP for a program is known as the amount of payment by a consumer such that the utility after provision of the good or service remains the same as in the base case (without the program). Willingness to pay is an amount that compensates utility loss due to reduction in income by an improvement in the good or service in question and leaves the household on the same indifference curve. The existing literature on economic valuation of irrigation water indicates that farmers' WTP for irrigation water supply depends on income, socio-economic demographic characteristics (i.e. age, family size, education) and firming characteristics (i.e. size of crop land, amount of fertilizer use, experience with irrigation water). Based on the theoretical context of WTP outlined above and empirical findings on irrigation water valuation studies, the analytical framework of the

current study addresses the following constructs.

Let existing privatized irrigation water supply scheme be denoted by q^0 and the proposed government managed irrigation water providing scheme be denoted by q^1. The utility functions associated with the existing private irrigation water supply system and hypothetical GMSSIP can be written in the following form:

Existing Private Water Supply Scheme:

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

Hypothetical GMSSIP:

$$U^1 = v^1(q^1, I\text{-}M, F, S, e_1) \quad (2)$$

[e_0 and e_1 in equation 1 and 2 are the error terms distributed normally with mean zero and variance 1]

'I' denote yearly average household income; F stands for farming characteristics and S stands socio-economic characteristics of the respondent /household. 'M' is the WTP (money amount household is willing to trade off) for hypothetical GMSSIP. Farmer's decision of paying money for GMSSIP depends on the utility obtained from existing water supply scheme and variation in income level for attaining the hypothetical source. Respondent/household will agree to pay for irrigation water under GMSSIP if:

$$v^1(q^1, I\text{-}M, F, S, e_1) > v^0 (q^0, I, F, S, e_0)$$

Thus, WTP for irrigation water under hypothetical GMSSIP will satisfy the following equality:

$$v^0 (q^0, I, F, S, e_0) = v^1(q^1, I\text{-}M, F, S, e_1)$$

A dichotomous choice framework is the most common and popular form of CVM that is generally used for the type of valuation study depicted above. Logistic probability model is most commonly used to analyze dichotomous choice contingent valuation data. ,.The reduced form of a typical logistic probability model can be written in the following form:

$$\Pr[y_{i=1}] = \frac{e^{\beta' x}}{1 + e^{\beta' x}} \quad (3)$$

Where, prob [y_i=1] is the probability that a respondent says 'yes' to a specific bid amount. Beta (β) is a vector of variable parameters to be estimated, while x is the corresponding vector of explanatory variables. The error terms of the logit model are assumed to be normally distributed with zero mean and variance of one. The responses of the closed-ended WTP format question are recoded as 1 and 0 respectively for acceptance and rejection of bid values. This binary dependent variable is then modeled in respect of the bid amount plus other explanatory variables. Therefore, the statistical model of the current study can be expressed as:

$$\Pr[y_{i=1}] = \frac{e^{\beta_0 + \beta_1 BID + \beta_2 INC + \sum_{i=1}^{n} \lambda_i S_i + \sum_{j=1}^{m} \delta_j F_j}}{1 + e^{\beta_0 + \beta_1 BID + \beta_2 INC + \sum_{i=1}^{n} \lambda_i S_i + \sum_{j=1}^{m} \delta_j F_j}} \quad (4)$$

where,

(i) BID=bid level (taka per season per kani)
(ii) INC= yearly household income
(iii) S= Socio-economic and demographic characteristics
(iv) F= Firming Characteristics

Case Study Area

To capture the explanatory power of the different variables (discussed in the analytical framework section of the paper) on variation of estimated WTP, primary data need to be obtained from a representative sample using a fully structured questionnaire survey. However, the financial support available for the study was inadequate to conduct a large survey. As a result, the survey for the current study was limited to a case study in a fairly typical sub-district in Bangladesh known as Homna. The study site was selected based on information collected through a series of key informant interviews with the Director of Flood Forecasting and Warning Center in Bangladesh Water Development Board, officials at the Climate Change Cell in the Department of Environment, the Government of Bangladesh and policy planners in the Water Resource Planning Organisation (WARPO) and economists at Centre for Environmental and Geographic Information System (CEGIS).

The case study area (Nilakhi Union of Homna sub-district) is located in the south-east of Bangladesh in the district of Comilla. The area is approximately 70 km away from the Capital. The total land area of the study site is approximately 20,000 hectares and the resident population is 2, 56,052 (Population Census 2001). Table1 presents detailed characteristics of the study site. The geographical location of the case study area is presented in Map-1. Nilakhi Union is situated at the centre of the sub-district Homna. The survey was carried out in three villages of this union.

Major economic activity of this area is crop cultivation. Rice is the major agricultural crop. Other crops include jute, wheat, potato, mustard seed, onion, garlic, sesame, chilli and musuri (pulse). The total land area under cultivation equals to 16,700 hectares which is almost 80 percent of the total land area. The irrigated land covers an area of 7,730 hectares which accounts for 46 percent of the total cultivated land where the sole water source is locally pumped groundwater through shallow tube wells. The area is one of the food deficit areas in the region mainly as a result of water shortage for dry season agricultural activity. Farmers in this area largely depend on privately managed irrigation water supply for dry season crop growing which is highly inadequate compared to the demand. The demand for irrigation reaches its peak during the dry season for cultivation of Boro (HYV) paddy which requires a large amount of water supply. As a result, adequate supply of irrigation water during the dry season in the study area is considered as an important factor that influences food production.

Survey and Sample Characteristics

Survey Set-Up and Sampling Procedure

The target groups of the present survey were all categories of agricultural farmers; large, medium, small, and landless. Local interviewers, both male and female, carried out 300 face to face interviews using a fully structured household questionnaire in the second week of April 2006. The interviewers were carefully selected and thoroughly trained. They were also used for pre-testing of the questionnaire. The sample size was 10 percent of the total farm households (approximately 3,000) in Nilakhi union and 1 percent of the farm households (28,000) in the sub-district. The selection of households in each village followed a systematic random sampling method where every fifth household located along the right side of the main village road was interviewed. Only the head of the households (all male) were interviewed in this survey. Each interview lasted, on average, 15-20 minutes.

The questionnaire was designed on the basis of the overall conceptual framework of the contingent valuation method. The Questionnaire used in the survey included four sections, (i) socio-demographic characteristics (age, occupation, educational background, family size, sources of income, standard of living), (ii) type and scale of agricultural farming (how big is the cropland, height of the crop land, types of crops, cost of production), (iii) present source and nature of irrigation water (cost per unit, types of ownership, major advantages and disadvantages of the present irrigation water source) and (iv) WTP for irrigation water under the hypothetical GMSSIP. Farmers were offered a hypothetical GMSSIP in the following form:

> Government wants to bring this area (union) under central and extensive small scale irrigation water management system. If the scheme is implemented, every single village of this area will receive irrigation water all year round. Irrigation water will be extracted through deep tube well and will be carried to your farmland by underground pipelines.

After introducing the hypothetical product (GMSSIP), respondents were asked two 'willingness to pay' (WTP) questions. First, respondents were asked whether they were willing to pay 'in principle' for use of irrigation water per kani (thirty decimal of agricultural land) per season (cropping season consists of four months) under the GMSSIP. Those who said 'yes' were subsequently asked in the form of a dichotomous choice question whether or not they were willing to pay a specific bid amount. Eight different bid levels ranging from 500 (US$7.14) to 2500 (US$35.71) Taka/kani/season were used. In order to avoid 'payment vehicle bias', local and usual system of payment for irrigation water was used so that the farmers could understand the offered bid and formulate their answers easily. Furthermore, to avoid starting point bias, inherent to contingent valuation studies, pilot survey was carried out on a small group of 50 respondents of the same WTP question in an open-ended format. Taking into account the information obtained in the pilot survey, these bid amounts were selected and were randomly allocated among respondents.

Sample Characteristics

A summary of socio-economic and demographic variables of sample respondents is presented in Table 2. The table compares the key characteristics of the sample with the available national statistics to understand how representative is the sample of the overall population. In view of the fact that the current study includes only agricultural farm households, the matching of the sample key characteristics with the national population characteristics is not plausible. Although the comparison among the key socio-economic and demographic characteristics between current sample and national statistics presented in Table-2 does not indicate a 100 percent match, a fairly reasonable amount of representativeness is evident.

Of the three hundred respondents interviewed, the average household consisted of about seven family members. The average age of the respondent was around 45 years. A majority (96 percent) of the households interviewed was Muslims and the rest were Hindus. Half of the household heads interviewed during the survey were illiterate. Almost all respondents were the heads of their households and owned the houses they lived in. The majority of the houses were made of tin (both roof and walls) and a water-sealed latrine were the most common type of sanitary facility in the dwellings. Almost all of the households had electricity. Tube-well was one of the most common sources of drinking water for sample households. Leaves and cow dung were the main sources of energy.

Two thirds of the agricultural farmers interviewed were engaged in a secondary occupation, mainly trading or day laborer. The average annual household income was about 90,000 Taka (US$ 1373), while half the households had per capita income per month of Taka 1005 (US$ 15) which is slightly higher than the national per capita average rural income which is Taka 924 (USD 14) (HIES 2003). A majority of 80 percent of the farmers owned the land they cultivated. Around one third (38 percent) of the farmers included in the sample could be categorized as landless (owning less than 0.5 hectares of land) while the other two thirds could be categorized as marginal, small and medium farmers (average land holding ranged between 0.5 to less than 7.49 hectare)[1]. The majority of the farmers interviewed grew Boro crop in their farmland during the dry season. The farmers used irrigation water in their farmland mostly during dry season to grow Boro crop. Privately owned deep and shallow tube wells were the major sources of irrigation water supply. The majority (55 percent) of the respondents indicated a shortage of water during the dry season as the main problem with existing irrigation system, followed by problems such as 'current irrigation price being too high (15 percent)', 'irrigation pumps consumed too much electricity (15 percent)', and 'irrigation pumps got out of order sometimes (13 percent)'. More than two thirds (78 percent) of the respondents believed that a central irrigation system in the study area would solve the problem of irrigation water availability.

Contingent Valuation of Irrigation Water

WTP Results

A majority of the farmers (84 percent) replied positively to the first WTP question (WTP in principle). 43 respondents (14 percent of the sample) refused to pay in principle for use of irrigation water under GMSSIP. Those who were not willing to pay were subsequently asked in a follow up question as to why they would not do so. The most heard reason for not willing to pay was 'I do not have financial ability to pay money for irrigation water (income constraint, 78 percent), followed by reasons such as 'I do not use irrigation water' (2.4 percent), 'Large land owners should pay' (2.4 percent), and 'I do not think my money will be used properly' (2.4 percent). Respondents who refused to pay because of the reason 'I do not believe that my money will be used properly' are known as protest bidders in Contingent Valuation (CV) surveys. Protest bidders comprise less than 1 percent of the total sample.

The study obtained 257 valid observations from the second WTP question for GMSSIP. A (parametric) logistic probability model (described in Section 3) is used to estimate central tendency measures of WTP (Hanemann 1984; Gujarati 2005). The estimated WTP result is presented in Table 3. Estimation of a parametric logistic probability model reveals a mean WTP of Taka 1670 per kani (30 decimal land) per season (four months) for irrigation water which is 12 percent of average agricultural income of household per cropping season[2]. The average estimated WTP is higher than the current price level in an existing Government managed irrigation scheme. In the Borendro Development Organization, farmers pay Taka 85 for per hour irrigation water in their farm land. After estimating the total demand for water during the dry season for per kani (30 decimal farm land), the price paid by the farmers for use of irrigation water sums up to Taka 850 (USD 13)[3]. For a 10 percent confidence interval, the average irrigation water price paid by the farmers in the existing irrigation water project ranges between Taka 765 (US$10.9) to Taka 935 (US$13) which is substantially lower than what farmers are willing to pay in a hypothetical government managed irrigation water supply project.

Factors Explaining WTP for Irrigation Water

Stated WTP responses (n=257) are checked for determining factors. A stepwise backward binary multivariate logistic regression model (described in Section 3 equation 4) was estimated using various different firming and socio-demographic characteristics. However, the variables that have significant impact on farmer's willingness to pay for irrigation water under GMSSIP are the following:

(i) BID=bid level (taka per season per kani)
(ii) AGE=respondent's age

(iii) EDUC=respondents education level (primary school and higher=1, otherwise=0)
(iv) F_MEM=total members of the family.
(v) S_INC=number of income sources
(vi) OWN_LAND=ownership of farm land (respondents who own the land that they grow crop=1, otherwise=0)
(vii) OWN_IRRI=management system of current irrigation scheme (self managed=1, otherwise=0)
(viii) CROP_CHANGE=decision of changing crop if central irrigation system is provided (cropping decision will change=1, otherwise=0)

Table 4 summarizes the results of the estimated regression model. The model turned out to be significant at less than one percent level (see Table 4 for likelihood ratio test) which implies that the model (as a whole) is significantly different from the one with constants only. The regression model has predictive ability higher than 63%. The Wald test statistics (commonly used to test significance of individual logistic regression coefficients) turned out to be significant at less than five percent level for each independent variable.

As expected, the bid (BID) variable has significant and negative coefficient which indicates that the likelihood of accepting an offered bid amount increases as the bid amount goes down and vice versa. The variable 'AGE', as expected, has significant impact on variation in WTP for irrigation water under GMSSIP. This finding is highly consistent with the evidences provided by empirical literature. The positive sign of the coefficient of AGE variable implies, on an average and ceteris paribus, the older the farmer is the higher is the likelihood of accepting an offered bid level for secured supply of irrigation water round the year. This may be because the old farmers have more experience of water scarcity during dry season than younger farmers in the region and therefore, the likelihood of accepting a bid amount varies positively with age.

'Respondent's education level' (the variable EDUC) has a significant positive impact on the likelihood of accepting an offered bid amount for GMSSIP. This result is also consistent with theoretical expectation and empirical findings. Farmers who have completed at least primary school education exhibited higher likelihood of accepting an offered bid amount than illiterate farmers. This result indicates the universal fact that education enhances the awareness in value of scare environmental resources such as water. As expected, a positive relationship has been found between family size and likelihood of accepting offered bid amount for irrigation water under GMSSIP. The larger the family size, the greater is the food demand. Therefore, secured supply of irrigation water is more important for large households compared to small households.

Unlike the existing literature on contingent valuation of irrigation water, the current study failed to find any significant relationship of income with willingness to pay for irrigation water. The INC variable was dropped from the model during the backward estimation process. This is because of positive correlation of household income with a large number of explanatory variables in the model, i.e. INC (income) –EDUC (education), INC (income)-OWN_LAND (land ownership) and INC (income)-OWN_IRRI (ownership of water pump). The explanatory variable 'number of income sources (S_INCOME)' was created as a proxy to check the influence of household income on likelihood of accepting offered bid value as S_INCOME has been found to have a high positive correlation with yearly household income ($r=0.41$; $p<0.01$). This implies that households with higher income sources earn a significantly higher absolute income. The proxy variable S_INCOME turns out to be statistically significant with theoretically expected sign (positive).

Other than the household characteristics, the study illustrates some farming characteristics that influence likelihood of accepting an offered bid amount for irrigation water under GMSSIP. The ownership of farm land (OWN_LAND), as expected, had a positive sign. This implies that farmers who own the land that they cultivate are more likely to accept an offered bid amount. Furthermore, management system of current irrigation supply has been found to have a significant impact on farmers' WTP for irrigation water under GMSSIP. Farmers who own water pumps are less likely to accept the offered bid compared to farmers who do not own a water pump. Finally, change in cropping decision (CHANGE_CROP) after implementation of GMSSIP has a significant impact on variation in stated WTP. Farmers who cultivate a less profitable crop due to shortage of irrigation water and intend to change cropping pattern if irrigation water is available, are more likely to accept the bid level offered than farmers who already have access to sufficient water supply to grow the crop that they want.

Discussion and Conclusion

The aim of the current study was to estimate farmers' WTP for irrigation water under government managed

small scale irrigation water supply projects and to determine the factors that influence the variation in WTP. In a small scale household survey, carried out in mid 2006 in a fairly typical agri-based rural economy in Bangladesh, three hundred agricultural farmers were asked for their preference to pay for a hypothetical GMSSIP.

The study reveals a WTP of Taka 1670 per kani (30 decimal of land) per season (four months) for irrigation water under GMSSIP which is almost 12 percent of the average agricultural income of households per cropping season and is substantially higher than water prices charged in the existing government managed irrigation water supply projects. The regression model shows that the explanatory variables can reveal and explain the attitudes of the target population. A multivariate logistic regression model has been estimated based on closed ended WTP values for irrigation water. Explanatory factors such as bid level, respondents' age, education level, family size, number of income sources, ownership of farm land, management system of current irrigation scheme, decision of changing crop if government managed irrigation scheme is provided, included in the model turned out to be statistically significant with theoretically expected sign. Unlike the other existing contingent valuation literature on irrigation water, this study does not show any significant direct impact of household income on respondents' willingness to pay. However, an indirect relationship with annual average household income with WTP is established through a correlation test on income variable with number of income sources in the model.

The study reveals that under existing pricing structure, farmers are charged much lower price than what they are willing to pay in a region where irrigation water is a scarce resource. As a result, one of the most important policy implications of the current study is that there is a possibility to restructure the existing irrigation pricing system by taking into account the true economic value of irrigation water in order to ensure longer term water use sustainability and cost recovery of public investment projects. The result of the current study, furthermore, implies that a basic level of education is a key criterion for reform to take place successfully as our study indicates that education enhances farmers' understanding of the true value of water. The study also indicates that the success of revised pricing largely depends on the land ownership structure of the region as landowners are more likely to pay higher prices for secured irrigation water supply than the landless farmers.

Finally, as a methodological note, I would like to mention that the current study presents merely a case study and therefore, the results of the study should not be generalized for the country as a whole. Due to limited financial support, a more extensive survey to ensure representativeness of the sample was beyond the scope of the current study. Nevertheless, the study provides some guidance towards future agricultural water pricing structure by pointing to the fact that there is a wide dispersion between the existing market price of water and its true economic value.

Table 1 **Characteristic of Study Site**

Study Site	Villages: Miras, Baherkandi, Kolakandi Union: Nilakhi, Sub-district: Homna District: Comilla
Area	20 sq km
Population	21156.3
Agriculture Household	3,000
Literacy Rate	21.9 percent
Religious Group	Muslim 93.46 percent, Hindu 6.32 percent and others 0.22 percent.
Main Crops	Paddy, jute, wheat, potato, mustard seed, onion, garlic, sesame, chilli and musuri (pulse).
Land Use	Total cultivable land 1361.30 hectares; Fallow land 2.4 hectares; Single crop 49.93percent, double crop 43.07percent and treble crop land 7percent. Land under irrigation 698.45 hectares.

Source: Comilla Agricultural Census 1996

Table 2 **Comparison of key socio-demographic sample characteristics with national statistics.**

Variable	Sample Average	National Statistics
Household Number	300	
Head of the household (%)	93	
Respondent's Sex (% of male)	99.9	
Religion (% of sample Muslim)	96	90.38
Respondents Age (in years)	45	42
Median monthly income per capita (US$)	US$ 15	US$ 14
Educational Qualification (% illiterate)	54.2	60.95
Average family size (no of person)	6.81	5.19
Electricity connection (%)	90	18
Type of Latrine Used (use of sanitary latrine in %)	23	20.59
Drinking water (use of tube well in %)	98	95.75

Source: Author's calculation based on survey data and HIES Report, 2003

Table 3 **Mean WTP for values based on linear-logistic model**

	WTP for use of irrigation water (Taka/per kani/per season)
Mean WTP[1]	1670
Standard error[2]	246
n	257

Notes:

[1] The formula to calculate mean and median WTP based on linear-logistic regression is:
E(WTP) = -a/b, where a is the estimated constant and b the estimated slope for the bid level.

[2] The standard error of mean WTP is calculated as follows:

$$s = \sqrt{\mathrm{var}(-a/b)} = \left[\frac{1}{b^2}\left(\mathrm{var}(a) + \left(\frac{a}{b}\right)^2 \mathrm{var}(b) - 2\left(\frac{a}{b}\right)\mathrm{cov}(a,b)\right)\right]^{1/2}$$

where a is again the estimated constant (intercept) and b the slope of the bid level.

Source: Author's calculation based on model

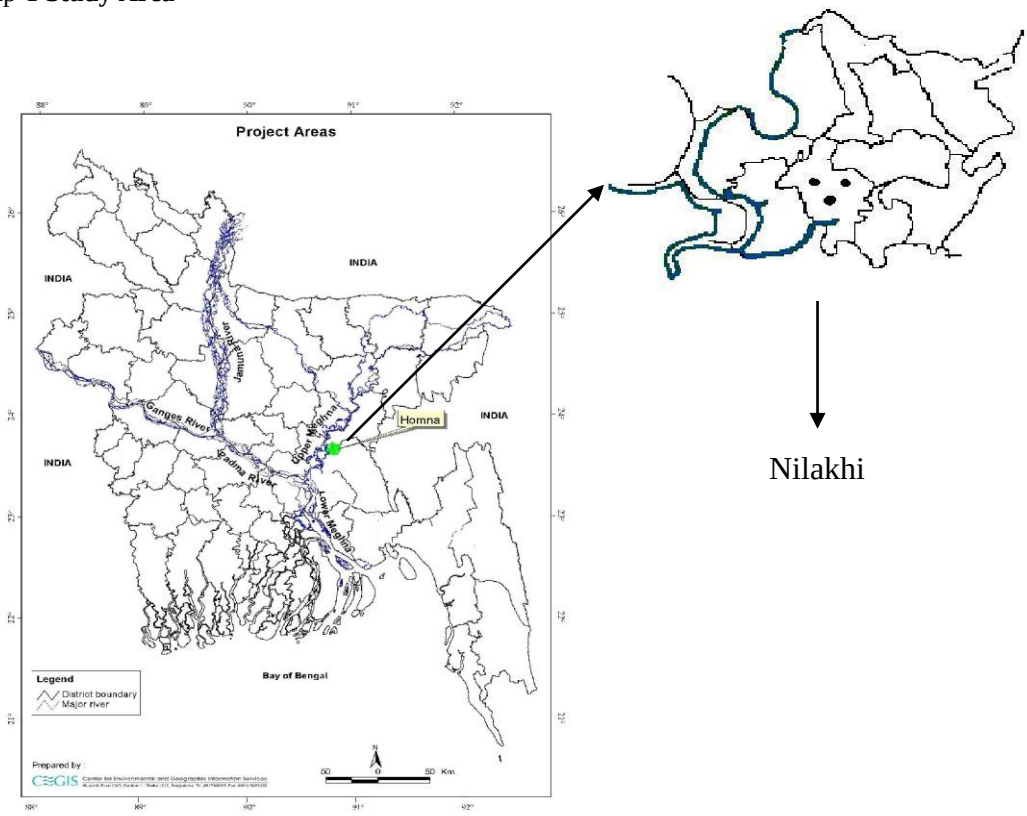
Table 4 **Estimated linear-logistic WTP model for Irrigation Water**

Variable name	Variable Description	Coefficient Values
BID	Bid level	-0.001*** (0.000)
Socio-economic and demographic characteristics		
AGE	Respondent's age	0.031* (0.019)
EDUC	Respondent's Education Level	0.993*** (0.414)
F_MEM	Number of Total Family Members	0.225** (0.089)
S_INC	Number of Income Sources	0.654*** (0.200)
Farming characteristics		
OWN_LAND	Ownership of farm land	1.858*** (0.709)
OWN_IRRI	Management System of Present Irrigation Scheme	-2.164*** (0.664)
CROP_CHANGE	Decision of Change in Crop	0.002*** (0.001)
CONSTANT	Constant	-3.886* (2.097)
-2 Log Likelihood		177.237
Chi-square		160.286 (8 d.f.; *p*<0.001)
Percentage correct predicted		63.4
Nagelkerke R-square		0.635
N		257

*p < 0.10; ** p < 0.05; *** p < 0.001

Source: Author's Calculation based on survey data.

Map-1 **Study Area**



ENDNOTES

1. Depending on the amount of land ownership, farms in Bangladesh are divided into five major categories. The categories are as follows:

Large farmer	7.5 acre and above
Medium farmer	2.5-7.49 acre
Small farmer	1.5-2.49 acre
Marginal farmer	0.5-1.49 acre
Land Less	0-0.49 acre

Source: Bangladesh Agricultural Census 1995

2. Yearly average agricultural income per household has been divided by 3 to calculate agricultural income per season.

3. In a 30 decimal farm land to cultivate BORO crop, farmers need to irrigate the land for approximately ten hours per season (over the period of ten weeks).

ACKNOWLEDGEMENT

I gratefully acknowledge the heartiest cooperation of Saria Chowdhury and Atikuzzaman Sohel. I, furthermore, would like to thank the team of interviewers in Bangladesh who collected the data as part of this research.

REFERENCES

Census Report (1995) Bangladesh Agriculture Census, Ministry of Agriculture, Dhaka, Bangladesh, http://www.bangladeshgov.org/moa/moa.html (12/06/2006).

Census Report (1996) Comilla Agricultural Census, Ministry of Agriculture, Dhaka, Bangladesh, http://www.bangladeshgov.org/moa/moa.html (12/06/2006).

Chakravorty, N. (2003). Water Pricing In Bangladesh: A Pro-Poor Framework Based on Two Surface Water Irrigation Projects in Bangladesh, Centre for Environmental and Geographic Information Services (CEGIS), Dhaka, Bangladesh

Govt. of the People's Republic of Bangladesh (2000) 'National Water Management Plan Project', Draft Development Strategy, Ministry of Water Resources, Vol. 5.

Gujarati, D.N. (2005) Basic Econometrics, McGraw-Hill, New York.

Hanemann, W.M. (1984) 'Welfare Evaluations in Contingent Valuation Experiments with Discrete Responses', American Journal of Agricultural Economics, 66 ; 332-41.

HIES Report (2003) Household Income and Expenditure Survey 2003, Bangladesh Bureau of Statistics, Dhaka, Bangladesh.

Hussain, I. and Wijerathna, D. (2004) Implications of Alternate Irrigation Water Charging Policies for the Poor Farmers in Developing Asia: A Comparative Analysis, International Water Management Institute, Colombo, Sri Lanka.

Mallios, Z., and Latinopoulos, P. (2001) An Application of Contingent Valuation for the Economic Assessment of Irrigation Water in a Greek Agricultural Area, http://www.soc.uoc.gr/iwa/iwa_papers/Mallios_Latin.doc (10/05/2006).

Tiwari, D. N. (2005) Determining Economic Value of Irrigation Water: Comparison of Willingness to Pay and Indirect Valuation Approaches as a Measure of Sustainable Resource Use, CSERGE Working Paper GEC 98-05.

W/Giorgis, T. (2004). Estimating Willingness to Pay for Irrigation Water: A Contingent Valuation Case Study on Small Scale Irrigation Schemes, paper submitted to the Second International Conference on the Ethiopian Economy organized by the Ethiopian Economic Association.

Sonia Akter
Department of Economics
North South University
12 Kemal Ataturk Avenue
Banani, Dhaka-1213
Phone: 8802 9885611-191
Fax: 8802 8823030
E mail: sonia.akter@anu.edu.au,