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Willingness to Pay for Improved Water Supply: A Policy Implications for Future Water Security

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Abstract: Despite recent improvements in ensuring access to safe drinking water, a huge number of people still do not have access to that safe water. Bangladesh achieved laudable success in achieving Millennium Development Goals including extension of water supply and sanitation coverage. The country would face more challenges as the number of semi-urban and urban dwellers grows each day, and grows at a faster rate. It is always difficult for a country like Bangladesh to become proactive to any apprehending challenges due to her limited financial strength. However, cost recovery approaches (CRA) for water supply services could reduce the burden. A typical CRA intends to recover the cost of investment (often only operating cost) through charging additional bills for the utility usages. Applicability of CRA can be determined by estimating the consumer's willingness to pay (WTP) for the intended intervension. WTP is a widely used economic tool to assess the economic value of of non-marketed commodities. This study investigated the consumers' WTP for an improved water supply system in a semi-urban area of Bangladesh. The study adopted a Contingent Valuation Method to estimate consumer's WTP for animproved water supply system as compared that of present condition. A total of 396 out of 11605 households were surveyed using a structured questionnaire. Presently, the residents (28% of the total) receive supply water twice a day and only 2 hours of running tap water with complains of high iron and arsenic content. A household consumes about 421 liters of water per day and pays only BDT 100 per month. About 65% of the surveyed households expressed their WTP for a safe and uninterrupted water supply. The average stated WTP is BDT 87.25 (± 91.92) per month in addition to the present water utility charges. The stated amount is only 0.49% of their monthly household income (BDT 18058) and less than 25% of the money (BDT 365.79/month) they currently spend for collection and purification of water for household consumption. Considering a present water coverage (28%) and revenue collection efficiency (80%), the stated extra money could earn about 150% of the present annual operation and maintenance cost.

Keywords: Contingent Valuation Method, Willingness to Pay, Water Supply, Water Security, Water Policy

1. Introduction

Contingent Valuation Method (CVM) often referred to as hypothetical or constructed market method is of widest use to estimate consumer preferences for non-market commodities (i.e. value of water quality) that do not have a well-defined market price [1-8] in the traditional market. In CVM proces people are asked to state their preferences on a public good, contingent on a specific hypothetical scenario and description of the good. Economic values are derived based on the stated choices for a hypothetical market created in the survey. Globally, CVM is by far the most preferred method of estimating the economic value of non-market public goods.

Bangladesh is not an exception. In Bangladesh, several studies were conducted to estimate the economic value/benefit of non-market goods like supply of arsenic-free drinking water [9-13], waste management [14-15], pollution cleaning-up [16],improvement of sewage [17-18] and irrigation facilities [19]. Thesestudies adopted the CVM method to estimate the consumer's willingness to pay for a certain non-market goods and services. Reference [9-10] evaluated the household's willingness to pay for arsenic-free safe drinking water supply, provision for piped water supply and installation of household/community based arsenic mitigation technologies by using CVM. Similarly, reference

[17] estimated the non-market economic benefits from the cleanup of Buriganga River stretching around Dhaka City; [191] determined the economic value of irrigation water in a government managed small scale irrigation project; [20] approximatedthe economic value of arsenic safe drinking water in rural Bangladesh, etc. However, none of these studies were focusing the CRA approach.

Historically, Bangladesh has been facing the challenge of providing safe drinking water to her citizens due toever polluting surface water and arsenic contaminated aquifers. Reference [21] reported that about nearly three fourth (74%) of the population has access to arsenic free drinking water. While, in urban areas only 24% of thepeople has piped water supply connection inside their house. Presently, the supply of drinking water is coming from tap water (mainly operated by public body), tube wells (both private and community owned) and surface waters (pond, river, canal and spring). Although water quality was considered as a notable issue for the drinking water purposes, hardly any monitoring systems exists in the water supply systems regardless of sources. Apart from the threats of arsenic exposure, recent trends of surface water contamination with poorly controlled industrial pollution along with climate predictions further indicates the importance of regular water quality monitoring. Based on this prioritized necessity, the government has attempted to establish water quality monitoring systems as well as to upgrade/extend the existing coverage of water supply through Department of Public Health Engineering (DPHE) even with numerous resource constraints [22-27]. The planned water supply coverage extension program requires to consider installation, operation and maintenance cost. Even with the present condition, the municipality is not earning revunes from water bills sufficient enough to cover the operating costs. Similar situations of low tarrifs and poor economic efficiency, are reported in other cases,particularly in urban settings [22-23]. Therefore, it requires to understandexisting problems, socio-environmental context, consumer's preferences and possibility of cost recovery. A well planned intervention directing to the needs and preferences of consumer could ease the decision for investment under budgetary limitations.

This study estimated the economic benefit of an improved water supply at Manikganj Municipality of Bangladesh. It assessed the amount of money the water users are willing to pay for the regular quality monitoring of the water they receive either from a home connection (tap) or point source. The study was conducted over two groups of water users–the piped and non-piped water users of Manikganj Municipality. The study outcome provides an important hint about the awareness of the people regarding the importance of improved and known water quality. The awareness and importance together was reflected in terms of monetary value-how much they are willing to pay. Moreover, influences of socio-economic conditions in the decision-making process also revealed. Furthermore, the study findings open the window of future planning for managing safe drinking water.

2. Study Area

Manikganj Municipality is the only urban area of Manikganj Sadar upazila under Manikganj district (figure 1). The Municipality consists of 9 wards, 50 mahallahs and 2 adjoining mauzas. It stretched over an area of 39.09 sq. km [28]. The Dhaleswari and the Kaliganga River are hydrographically important in the study area. The Municipality is inhabited by about 52,826 people living in 11605 household [28] with a population density of 1351/km^2 where male (52.03%) dominates over female (47.97%). The overall literacy rate of the municipality is about 66.55%. The main economic activities are small and medium industry, farming, trade and service. The health facilities of the municipality are largely centered around 5 hospitals, 10 clinics and 4 diagnostic centers. There are 4 colleges, 5 high schools, 6 Madrashas, 6 kindergartens and 11 primary schools (include govt., non-govt. and community primary schools). Besides, 1 technical school, 1 special school (for disabled children) are providing education.Manikganj municipality provides pipe water to her nearly one fourth of her total residents. The water department of Manikganj municipality is responsible for the water supply services. Presently, only 28% people are provided with pipedwater for about one and half hour/day. Most people depend on people has to depend on either stored water or the tube wells or the surface water for rest of the time. The area reported high arsenic and iron content in shallow tube well water. The intake water of the municipality water supply system (PWSS) usually contains 0.8 ppm of arsenic and 8 ppm of iron. The PWSS representative claims about 98% removal of arsenic and iron through their Rapid Sand Filtration (RSF) system.

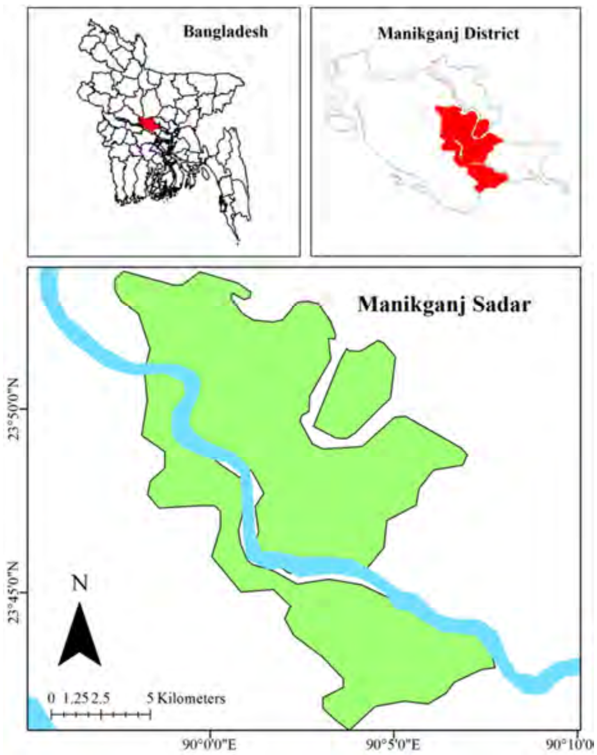

Figure 1. *Location map of the study area.*

Table 1. Comparative Analysis of the Performance of the Municipal Water Supply System Between Present and Past Conditions.

Indicator	Condition as of 2011	Codition as of 2006-07[1]
Average daily production (m^3/day)	5000	6849
Water coverage (% of population serviced)	28	36.2
Water availability (hours/day)	13	20
Per capita water consumption (m^3/capita/day)	100	264
Unit production cost (BDT. /m^3)	4.5	2.43
Average tariff (BDT. /m^3)	6	2.8
Revenue collection efficiency = Total billing/Total revenue collection (%)	80	58.75
Total O&M cost (BDT/year)	8100000	6080896
Operating ratio = Total O&M cost/Total billing	0.84	0.94
Complains received per month (no. of events)	700	700
Staff/1000 connections (no. of person)	8	9.7

At present, the production capacity of the municipal water supply system is about 5000 m^3/day. However, recent initiative of sedimentation tank extension is expected to expand the capacity of the PWSS to 6000 m^3/day. The overall demand and supply situation of water supply system is largely imbalanced. Database suggests that the daily water production capacity declines from over 6800 m^3/day (as of 2006-07) to approximately 5000 m^3/day. Simultaneously, the water coverage and per capita water consumption also reduced. On the flip side, average water tariff doubled due to the increase of O&M cost and unit production cost (nearly doubled) in last five years. However, despite the reduction of staff/1000 connection ratio, the managerial capacity showed substantial improvement. Status of revenue collection efficiency and operating ratio improved considerably. A comparative database of the performance indicators of PWSS between present condition and conditions as of 2006 are presented in Table 1.

3. Materials and Methods

The study adopted household questionnaire survey to achieve the objectives. About 396 households out of a total of 11605 households were surveyed with a semi-structured open ended questionnaire. The sample size was calculated with 95% Confidence Interval and 5% precision.

3.1. Sample Selection

Firstly, the study area was divided into clusters based on the polling centre that was used during the national parliamentary election in 2008. Each of the polling centers was treated as one cluster. Secondly, eighteen (18) clusters were selected in such a way that two clusters from each municipal ward being selected (9 wards x 2 = 18 clusters). Finally, equal number of households from each of those selected clusters were selected randomly (total number of samples divided by 18 to obtain the number of household to be selected from each of the cluster).

3.2. Data Processing, Tabulation and Statistical Calculation

To perform statistical analysis RGui-2.8.1 (http://www.r-project.org) and MS Excel software were used. Parametric test (t-test) for normally distributed independent data set was used to compare the findings of the study.

3.3. Logistic Regression Model

A logistic regression model was used to analyze the survey data of household's willingness to pay for water quality monitoring econometrically. The dependent variable was willingness to pay for the water quality monitoring (1 = willing to pay, 0 = not willing to pay). Five explanatory variables were used for the logistic model. The variables include the household income, education level of the respondents, an index score that reflects awareness and concern about water quality problem (awareness score), satisfaction with the present sources of water and monthly household expenditure for water. The index score (awareness and concern) was calculated based on the answers of 6 different questions related to awareness and concern about the water quality problem (presented in Table 2). The awareness score was calculated by taking the mean of the normalized score of each answer corresponding to the questions as of Table 1. The score for each answer was normalized after [29] and based on Eq. 1. The awareness score range from 0 to 1 where 0 indicates the minimum awareness and 1 corresponds to the maximum awareness.

Table 2. Variables Used to Compute an Index of Concern and Awareness About Water Quality Problem.

Variable	Value[2]
Advantages of water quality testing	No advantage = 0 Not necessary = 1 Safe = 2
Awareness about arsenic removal techniques	No = 0, Yes = 1
Responses to water quality problem	Do nothing = 0 Drink from alternate source = 1 Use water purification techniques = 2
Do they use contaminated water?	No = 1, Yes = 0
Do they consider unsafe water risky?	No = 0, Yes = 1
Do they believe slight deviation in water quality could do no harm?	No = 0, Yes = 1

$$x_{ij} = \frac{X_{ij} - \underset{i}{Min}(X_{ij})}{\underset{i}{Max}(X_{ij}) - \underset{i}{Min}(X_{ij})} \quad (1)$$

Where,

x_{ij} = normalized score for household i, question number j

X_{ij} = score for household i, question number j

$\underset{i}{Min}(X_{ij})$ = Minimum score for all household, question j

$\underset{i}{Max}(X_{ij})$ = Maximum score for all household, question j

[1] Bangladesh water utilities data book 2006-07, Benchmarking for Improving Water Supply Delivery, Water and Sanitation Program-South Asia, 2009.

[2] "0"=less awareness and concern, "1"=moderate awareness and concern, "3"=High awareness and concern

3.4. Validation of Estimated WTP

An alternative estimate was made to validate the estimated WTP. The alternate estimate was performed based on the information given in Table 4. While doing the estimation, the value of shifting to alternate water as response to water quality problem was computed based on the expenditure borne by the household for actions taken to get better quality water (i.e. collection and conservation of water from other sources that costs time, boiling of water that costs time, purchasing bottled or jar water that costs money, using water purification technologies that has initial fixed cost and regular maintenance cost, etc). The value of alternate water was calculated based on Eq. 2.

$$V_{aw} = C_{bj} + C_{tscw} + C_{tsbw} + C_{fbw} + C_{wf} \quad (2)$$

Where,
V_{aw} = Value of alternate water (BDT/month/household)
C_{bj} = Cost of bottled or jar water (BDT/month/household)
C_{tscw} = Cost of time spent for alternate water collection(BDT/month/household)*
C_{tsbw} = Cost of time spent for boiling water (BDT/month/household)*
C_{fbw} = Cost of fuel that used for boiling water (BDT/month/household)
C_{wf} = Cost of water purification (BDT/month/household)**
*= Considering the cost of unskilled labor
@ BDT 300/person/day (8 hourly)
**= Fixed cost + maintenance cost; considering 5 years life time of the water purifier (fixed cost/60)

4. Results and Discussions

4.1. Demographic Features of the Respondents

The outcome of this study is principally based on the information provided by the respondents where 92% households are male headed. The demographic features of the respondents are given in Table 3.

Table 3. *Demographic Features of the Respondents.*

Variable name		n	Result
Gender of the respondents (% of total)	Male	364	92%
	Female	32	8%
Average age of the respondents (year)		396	49 y 26d
Average family member per household (person/household)		396	4.33 (± 1.13)
Education of the respondents (% of total)	Below Secondary School	247	62.37%
	Secondary School and above	149	37.63%
Average earning memberper household (person/household)		396	1.27 (± 0.92)
Average dependent people per household (person/household)		396	3.09 (± 1.02)

4.2. Household's Economic Features

The majority of the respondent's occupation is business (29%). Service, farming, self employment, remittance earning are other occupationalsectors of the respondents. Households' income sources are shown in figure 2.

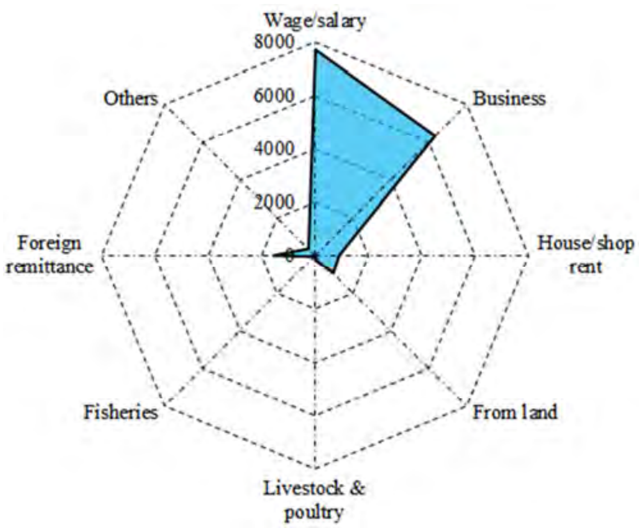

Figure 2. *Sources of household income.*

Average monthly household income and expenditure are BDT 18058 (median 13654) or USD 226 and 11708 (median 8345) or USD147 respectively. More than half (53%) of the income is spent for food. Household's average expenditure for water (estimated from all cost of water from all the sources) is only BDT 74/month that is only 0.6% of the total monthly expenditure.

4.3. Household's Water Sources

Less than half (47%) households are connected with the municipal water supply in their dwelling house or through public stand post. Despite being connected with the municipal water supply, majority of the household expressed their dissatisfaction (60.4%) about the quality of the water. The displeasure principally developed from the high amount of iron (*Fe*) content (70%), non-continuous supply (19%) and arsenic (*As*) content (7%).The households who are not connected with the municipal water supply depend on shallow (23%) or deep (9%) tube-well and surface water (21%). Overall, the per capita household water use was estimated 342 l/household/day. The usage of water by household is presented in figure 3.

4.4. Household's Concerns and Awareness for Water Quality

Almost all the households (99%) are concerned about the quality of water and consider using unsafe water as risky. However, more than a quarter (28%) households still use unsafe water. The households perceive that use of unsafe water is associated with health risks (47%), financial burden due to medication cost (44%) and even death (9%).The mean and the median of the household's awareness score was estimated 0.78 and 0.83 respectively. The awareness score suggests that the households are well aware and concerned about the water quality.

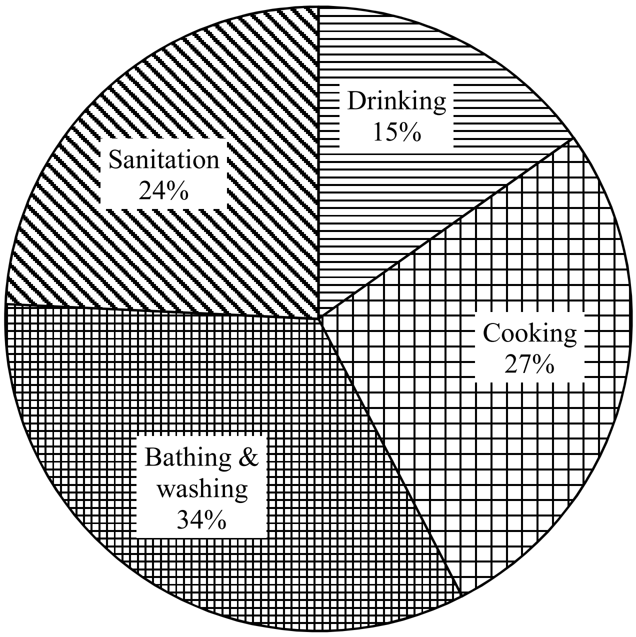

Figure 3. Household's water use pattern.

In response to deteriorated water quality, majority of the households (72%) showed feedback to solve the issue. About 26% of the households tend to use only tube-well water. Others practice boiling (19%), filtration (18%), reduction of water use (6%) and use of water purification tablet (2%). The feedback mechanisms against the poor water quality/accessibility of the municipal water supply costs money (for improved water purchase, fuel cost, installation and maintenance cost for water filtration), time for water collection from alternative sources, time for boiling etc. The summary of the costs for alternative water is presented in Table 4. The monetary equivalence of the cost of alternative water is about BDT 365.79/month which is equivalent to less than USD 5/month.

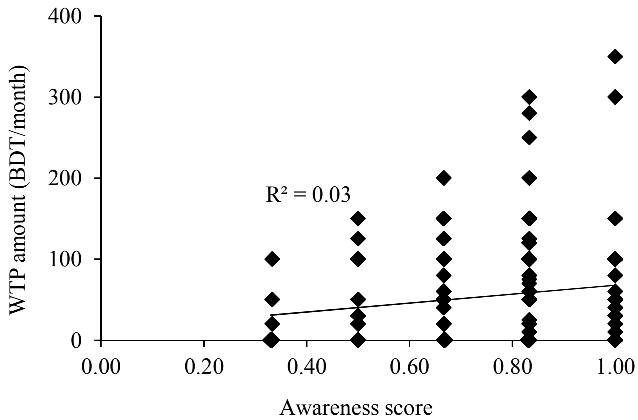

Figure 4. Relationship between WTP and awareness score.

Table 4. Cost of Alternative Water.

Variable name	n	Mean
Cost of alternative (Bottled/Jar/others) water (BDT/month/HH)	2	175
Time spent to collect alternate water (minute/day/HH)	36	18.9
Time spent for boiling water to make it safe (minute/day/HH)	80	45.9
Cost of fuel (used for boiling water), tablet (used as water purifier) and others (BDT/month/HH)	56	24.5
Cost (fixed cost) of installed arsenic removal technology (BDT/HH)	139	966.7
Maintenance cost of arsenic removal technologies (BDT/month/HH)	139	62

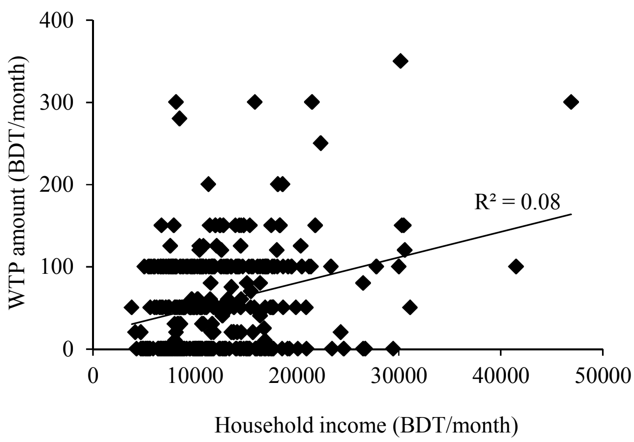

Figure 5. Relationship between WTP and Household income.

Households usually, verify the quality of water by visual observation (55%) and oral test (31%). Besides, very few households opted for formal quality check like use of laboratory test (2%) or testing kit (9%). Typically the households conduct water quality test once (46%) or twice (37%) in a year. Households spend BDT 170 for each water quality testing at laboratory.

4.5. Household's Willingness to Pay for Improved Water Supply

About 65 percentages of the households stated their willingness to pay additional money for an improved water supply.

The logistic regression model shows significant relationship between education level of the respondents and willingness to pay. The respondents whose level of education is up to SSC are more likely willing to pay for the improved water supply as compared to that of illiterate respondents. Literature also suggests that willingness to pay has association with the respondents' level of education [13, 30-31]. In contrast, the model does not show any significant relation between the household income, awareness score, satisfaction level with the present water source and monthly household expenditure for water with the willingness to pay. A typical respondent from the developing country has the tendency to cover up actual household income, and thus often fails to show any association with other variables. Similar limitation and findings were reported by [12-13]. However, [26] argued that household income plays an important role in WTP for improved water supply. The regression statistics are presented in Table 5.

The outcome suggests that decision for WTP is affected by the respondent's awareness about the water quality problem as well as their household income. The higher the awareness or the household income, the likelier the household will decide to pay for an improved water supply. The mean awareness score of the households willing to pay (0.81) is significantly higher than that of not willing to pay (0.74) at 99% confidence interval (*t-test;* $df = 396$, $P < 0.0001$). Similarly, the mean household income of the households willing to pay (12774) is significantly higher than that of not willing to pay (11574) at 95% confidence interval (*t-test;* $df = 362$, $P < 0.05$).

The mean stated amount of WTP is BDT 87.25 (minimum 10, maximum 350, median 100, standard deviation 91.92) or USD 1.09 per month in addition to the present water utility charges. The stated amount is only 0.49% of their monthly household income (BDT 18058) and less than 25% of the money (BDT 365.79/month) they currently spend for collection and purification of water for household consumption. The stated WTP amount displays insignificant correlation against both the corresponding awareness score and the household income. Figure 4 and 5 shows the relationships between the stated WTP amount and awareness score and household income respectively.

Table 5. *WTP: Results from Regression Model.*

Variable	Odds ratio	Standard error	Z	P-value
Household income[3]	1.36	0.53	0.79	0.43
Education of respondents (reference = illiterate)				
Below SSC	2.71	1.3	2.07	0.039
SSC and above	2.28	1.09	1.73	0.083
Awareness score	1.10	0.31	0.33	0.738
Satisfaction with the present water source (1 = Satisfied, 0 = Not satisfied)	1.11	0.37	0.31	0.76
Monthly household expenditure for water[3]	1.56	0.58	1.2	0.23
Number of observation = 211; LR chi2 (7) = 9.44; Prob > chi2 = 0.222				

The study reveals that the respondents are ready to pay additional money by any mode. The majority of the respondents preferred improved piped water that they can be collected directly from the tap. The respondents who denied paying any money for the proposed intervention considerthat, it is not necessary to pay extra money despite the water quality is bad (53%), government should do it is free of cost (17%), negative attitude to pay any (9%), do not have the financial ability (11%) and others (10%). Considering a present water coverage (28%) and revenue collection efficiency (80%), the stated extra money could accumulate about 150% of the present annual operation and maintenance cost.

3 Logarithomic value

5. Conclusion

Safe water supply is a huge challenge for the developing countries. Although Bangladesh claims her credit for significant advances in provisioning safe drinking water, the job is not done yet. Nearly a quarter of her population still remains beyond the coverage of safe drinking water. Recent plans and attempts for extension of water coverage or quality improvement require addressing budgetary limitations.A well-planned budget including cost-recovery options couldprovide solutions to the budgetary constraints. The findings ofthis study suggests that consumers are willing to pay additional money for an improved water supply. The additional money generated from cost recovery is sufficient enough to cover the expenses for operation and maintenance. This indicates that the government might select the priority areas and do consider for only the ininitial establishment cost and leaves the system running by its own. The outcome of this study clearly suggests the policy implications for the policymakers for ensuring future water security.

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