Field Note

Water and Sanitation Program

An international partnership to help the poor gain sustained access to improved water supply and sanitation services

# Willingness to Pay for Arsenic-free, Safe Drinking Water in Rural Bangladesh – Methodology and Results

## South Asia Region

Arsenic contamination of groundwater has adversely affected the access to safe drinking water sources for over 30 million people in Bangladesh. Alternative filtering technologies and development of different types of water distribution systems and sources are being proposed as possible solutions. This supply side focus has ignored the economic and institutional realities of propagating new technologies and approaches to ensure household access to safe drinking water. The Water and Sanitation Program sponsored an economic analysis of the preferences of villagers and their choices in terms of the proposed solutions. This comprehensive analysis was done by Dr. Smita Misra (SASES, World Bank) and Dr. B.N. Goldar (Institute of Economic Growth, New Delhi) in partnership with M. Jakariya of BRAC, a major NGO in Bangladesh who also conducted the household survey. The overall work was supervised by Junaid K Ahmad, WSP-South Asia.

The results of the study, presented to the government and other stakeholders, suggest that communities are not only seeking arsenic-free water sources but are also prepared to pay for alternatives that are as convenient as the traditional tubewell. 'Arsenic-free water but as convenient as the tubewell' seems to be the signal from communities. The study suggests that the preference for piped water is driven less by arsenic issues and more by convenience factors reflecting a growing structural change in the preferences of rural households for water services. This change is largely independent of the arsenic crisis but nevertheless strengthened by it.

This Field Note is based on the study and focuses on the study design and the methodology used.

# Willingness to Pay for Arsenic-free, Safe Drinking Water in Rural Bangladesh – Methodology and Results

## Background

In the context of the arsenic problem in Bangladesh, a study was recently undertaken to assess and analyze people's willingness to pay for arsenic-free, safe drinking water options. The study investigated the factors that influence demand for arsenic-free, safe drinking water among the rural population and examined preferences regarding household/community-based arsenic mitigation technologies. Primary data were collected in a survey of rural households. Piped water supply systems were a major focus of the study and, in this context, two important questions were posed: (i) how strong is the demand for piped water, as reflected in the willingness to pay for such a service? and, (ii) is piped water from alternate sources preferred to other typical arsenic mitigation technologies used for treating tubewell water? Some key results of the field survey, together with the main findings and policy recommendations, have been published in a separate note entitled, '*Fighting Arsenic, Listening to Rural Communities: Findings from a Study on Willingness to Pay for Arsenic-free, Safe Drinking Water in Rural Bangladesh*'.

This note is connected with the same study. It is somewhat more technical in nature and complements the other publication. It describes briefly the study design, particularly the methodology used for estimating willingness to pay (WTP), and presents the estimates of WTP obtained.

## Contingent valuation methodology

Contingent valuation (CV) methodology is best suited for assessing consumer preferences with respect to non-market commodities which currently do not have a well-defined market price. The methodology relies on stated preferences in surveys with specially designed scenarios for teasing out the demand for such commodities, assessing preferences and the willingness to pay (WTP). *(For a discussion on the CV methodology, see, among others, Mitchell and Carson, 1989)*. Economic values are derived from the choices observed in the hypothetical market created in the survey. The analysis is particularly helpful in guiding policies and future governmental actions.

The CV methodology has found wide application for valuation of natural resources, and in general for valuation of non-market goods. A number of studies have used this methodology for assessing people's willingness to pay for improved water supply. These include studies undertaken for rural areas of developing countries, for example, the studies undertaken by Briscoe *et al*. (1990) for Brazil, Singh *et al*. (1993) for rural areas of Kerala (India) and Altaf *et al*. (1992) for rural Punjab (Pakistan). *(For a review of the literature, see the paper, World Bank Water Demand Research Team, 1993)*.

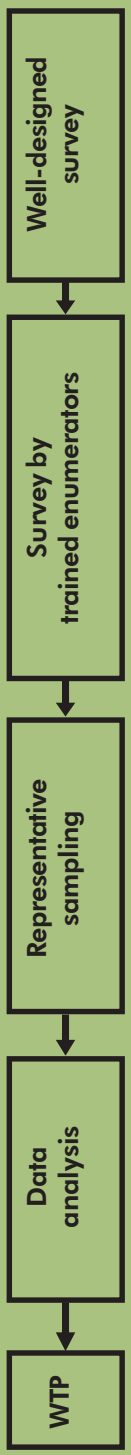
While CV is a useful methodology for valuation of non-market goods, it needs to be applied with ample care to obtain sound estimates of value. Proper questionnaire design and careful administration of the survey are important requirements for a good CV study. It is recognized that responses in a CV survey may be subject to bias of various kinds, and that such bias needs to be controlled through careful design. It is also recognized that for the estimate of value to be reliable the sample size must be fairly large. An additional point to be noted here is that in a CV survey (unlike other common socio-economic surveys) the role of the enumerator is crucial, a fact which underscores the need for adequate training of all enumerators.

## Application of the CV methodology for the study

In assessing willingness to pay for arsenic-free, safe drinking water in rural Bangladesh, state-of-the-art methodology for contingent valuation was applied (a brief discussion on the

Box 1

# Key steps in the study design




## Design of the WTP questionnaire

- A 'meaningful, realistic and plausible' questionnaire was designed to capture the WTP for arsenic-free safe drinking water
- Various 'biases' that are normally associated with such a survey were minimized
- 'Validity' checks for cross-checking the WTP values were especially designed using revealed preference criteria
- The draft questionnaire was reviewed externally
- Presentations were made at WSP-SA and BRAC (R&D)

## Pre-testing and training of enumerators

Testing questionnaire in the field

- *Draft questionnaire was pre-tested in three hydrogeologically representative locations to check the plausibility of the hypothetical scenario*

Training Enumerators

- *About 45 enumerators were specially trained to carry out the WTP survey*

## Actual survey by BRAC

- Survey was undertaken in three hydrogeologically representative districts with severe arsenic problems
- Stratified random sampling methodology was used to select villages within three identified *thanas*
- Stratified random sampling methodology was used to select households within the villages
- About 800 households were surveyed per district (in all about 2,900 households were surveyed)
- About 300 households were surveyed in an arsenic-free 'control' area

## Data analysis

- Appropriate econometric methodology (multinomial logit) was used for analysis of data and control of biases
- Relevant significant explanatory variables identified
- Preliminary results on WTP were presented and discussed before preparing the draft report

evolution of the CV methodology is detailed later in this field note). A CV survey of rural households was undertaken, using a large and representative sample. Using the survey data and applying an econometric model, the WTP for piped water systems has been estimated and analyzed. Estimates of WTP have been made for both standposts and domestic connections.

In applying the CV methodology for the study, a good deal of care was taken in regards to both questionnaire design and survey administration. This is discussed later.

## Survey method

Specially trained enumerators conducted in-person interviews with the respondents. Care was taken that the head of the household (usually a male) was interviewed along with female family members. Female members of the household were encouraged to answer questions related to their water sources and uses, as well as the convenience aspects.

## Elicitation method

The typical choices are either an open-ended elicitation method (which relies on the respondent to state the monetary amount he/she is willing to pay) or a closed-ended referendum type elicitation method (which offers a specific amount for the good being valued). The advantage of a closed-ended version is that it makes it more convenient for the respondent to consider the price options, especially when such a good is not available in the market. A closed-ended referendum type questionnaire format was used to elicit the WTP for piped water supply options – standpost/ domestic connection. The closed-ended question was followed by an open-ended question for eliciting the maximum WTP. The follow-up with an open-ended question was intentionally designed so that the estimate of average WTP obtained from the responses to the closed-ended question format could be crosschecked with the average of the stated maximum WTP of the respondents in response to the open-ended question.

## Payment method

The scenario for the payment method was carefully designed to minimize biases relating to the WTP elicitation. Details about the piped

water supply scheme for the village were provided to the respondent, before eliciting his/her share of contributions to an agency of choice. The respondent was first asked for his/her share of Operations and Maintenance (O&M) and capital cost contributions in cash. If unable to pay this in cash, the options of a part cash/part labor days or labor days only was offered. (The contribution towards O&M payment could be made only in cash).

### *Control of biases*

Repeated pre-testing and focus group discussions helped to minimize biases often associated with a CV study. Hypothetical/scenario mis-specification bias was minimized by constructing realistic and meaningful scenarios in accordance with the needs of the study. Specially designed cards were used to provide detailed information about the symptoms of arsenic contamination, the health risks, and the cost of treatment, both in the short-term and following prolonged use of contaminated water. Cards also provided detailed information about the different types of arsenic mitigation technologies currently being promoted in Bangladesh. The brand names of these technologies were intentionally withheld, to prevent any impression that the survey was promoting a particular technology. The piped water option was introduced only after seeking the respondent's most preferred choice among the arsenic mitigation technologies. Finally the choice between arsenic mitigation technologies and the piped water option was elicited.

Strategic Bias is typically introduced when the respondent tries to influence the price of the commodity being valued and the outcome of the study. Using a closed-ended referendum type elicitation format has controlled this bias. The referendum values are based on realistic O&M and capital costs, estimated using cost data of pilot piped water schemes being undertaken in Bangladesh. Further, a split sampling methodology was used to analyze responses to variations in the referendum values.

### *Validation of CV method*

While the CV questionnaire provides a direct estimate of the WTP, an indirect estimate can be calculated by using the revealed preference approach. To give an example; suppose a household shifts from tubewell to pond water because of arsenic contamination and spends time and money boiling the water to make it safe for drinking. Then the cost of boiling pond water for drinking purposes may be used as an indirect estimate of the household's willingness to pay for arsenic-free, safe drinking water.

The questionnaire had inbuilt sections on existing costs of arsenic-free, safe drinking water using revealed preference criteria: changes made in the source of drinking water, costs of time spent and distance travelled to collect water, cost of boiling pond water, etc. This information has been used to validate the WTP estimates obtained by applying the CV method.

## Field survey

The field survey, carried out during October-December 2001, covered about 2,900 households in rural areas of three hydrogeologically representative districts of Bangladesh: Chandpur (high water table area), Chapai Nawabganj (low water table area) and Barisal (coastal area). The three areas are also representative of the available water sources, current levels of water consumption and related convenience aspects. BRAC conducted the survey work, using trained supervisors for the job. Care was taken throughout the survey to ensure that the sample was representative and that the quality of data collected was high.

2,430 households were covered in the survey of arsenic-affected areas (about 800 per district). 300 households were covered in the arsenic-free, control area – 150 from Bolarhat *thana* in Chapai Nawabganj district and 150 from Commilla Sadar *thana* in Commilla district. In addition, 150 households were covered from Banaripara *thana* in Barisal district, which is an arsenic-affected area marked by a large-scale shift to public tubewells.

CV experts trained about 45 enumerators; the training was carried out at the BRAC office and in the field. Each enumerator filled in more than five questionnaires to establish an understanding of the methodology and the questionnaire itself, before being considered for the field survey. About 30 enumerators were selected for the final survey.

## Split sampling

As mentioned earlier, a closed-ended question format was used for value elicitation. As is common with studies of this nature, the format was coupled with split sampling. The total sample for the arsenic-affected (sample) area was divided into five sub-samples. Similarly, the total sample for the arsenic-free (control) area was divided into five sub-samples. Five different charges for public standpost and domestic connections were quoted during the interview, in five different sub-samples, and then the respondent was asked to make a choice between public standpost and domestic connection. A third choice was to reject both and continue to depend on present sources of water.

In the first sub-sample, the quoted charges for piped water were lower than the estimated costs of piped water supply (assuming that the villagers would bear about 10 percent of the initial capital cost and the full amount of O&M cost). In the fifth sub-sample, the quoted charges were higher than the estimated costs. In other sub-samples, the quoted charges fell in-between the two. The responses obtained, in terms of preference for standpost, domestic connection, or neither, provided the basic data which have been analyzed econometrically to estimate willingness to pay for piped water supply.

## Charges for piped water and household demand

One would expect that as the charges for piped water increase, the demand would decrease, and indeed, the survey responses clearly bring out this inverse relationship. The sub-samples in which higher charges were quoted had fewer respondents opting for piped water supply.

The survey data for arsenic-affected areas reveal that in the first sub-sample, in which the lowest prices were quoted, almost everybody opted for a piped water supply. On the other hand, in the fifth sub-sample, in which the highest prices were quoted, nearly 43 percent of households did not opt for a piped water supply.

At the middle range of charges (sub-sample 3), the proportion opting for standpost is 49 percent with 31 percent opting for a domestic connection. The remaining 20 percent of households did not want a piped

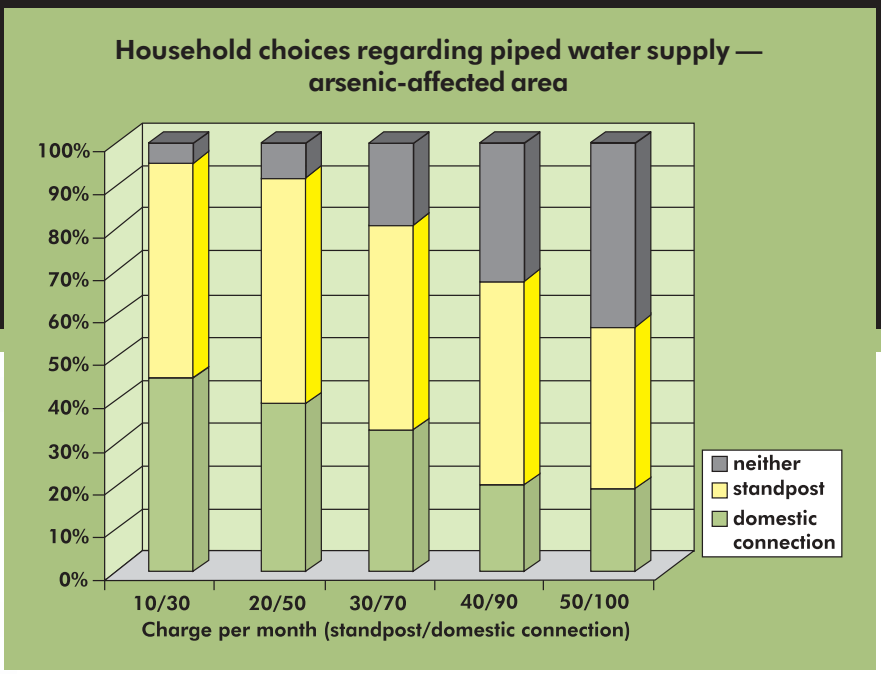
**Table 1**

**Charges for piped water quoted in the survey for different sub-samples**

| | Public standpost | | Domestic connection | |
|---|---|---|---|---|
| | O&M (Tk/month) | Initial capital cost (Tk) | O&M (Tk/month) | Initial capital cost (Tk) |
| Sub-sample 1 | 10 | 200 | 30 | 500 |
| Sub-sample 2 | 20 | 400 | 50 | 750 |
| Sub-sample 3 | 30 | 600 | 70 | 1,000 |
| Sub-sample 4 | 40 | 800 | 90 | 2,000 |
| Sub-sample 5 | 50 | 1,000 | 100 | 3,000 |

*One Bangladesh taka = approximately US$ 0.017 (as on August 2002).*

Figure 1




water supply at the charges quoted. The ratio of households opting for domestic connection to those opting for standpost is 1:1.5. Taking the three middle prices (i.e. sub-samples 2, 3 and 4), the relevant ratio is 1:1.6.

## Multinomial logit model for explaining household preferences

A multinomial logit model has been applied to the survey data to explain household preferences for piped water supply and derive estimates of willingness to pay for such a service. Since a closed-ended value elicitation format has been used in which the respondents are asked to make a choice between more than two options (standpost, domestic connection, or neither of them), the use of multinomial logit model for econometric analysis of preferences is appropriate. The multinomial logit model has been used for studying demand for public tap and private piped water connection in the study of Briscoe *et al*. (1990) for rural areas of Brazil and in a recent study undertaken by the Research Triangle Institute (2001) for the Kathmandu valley, Nepal. This model has been applied in a number of other contingent valuation studies.

The results of the multinomial model for the arsenic-affected areas indicate that the demand for piped water goes up with income and declines with hikes in charges for a piped water supply. The results also indicate that the higher the awareness and concern for arsenic contamination (measured by an arsenic score constructed from nine arsenic-related variables), the greater the inclination to opt for piped water supply. Another inference that can be drawn from the results is that convenience and health benefits are important considerations in household demand for piped water. There is also an indication that education (above 10$^{th}$ grade) raises the demand for domestic piped water connection. Further, those households in which the head is a farmer or businessman are relatively more likely to opt for piped water supply, than those households where the head is an agricultural laborer or manual worker.

The estimate of the multinomial logit model for arsenic-free areas yields results similar to those for the arsenic-affected area. Income and prices for the services are important in determining the household demand for piped water.

Convenience is also an important consideration for those households opting for piped water connection. Education above 10$^{th}$ standard seems to increase the demand for domestic pipe water connection. The occupation of the head of household is also an important factor in determining demand for piped water.

## Estimates of willingness to pay for piped water

For arsenic-affected areas, the estimated mean willingness to pay for standpost is Tk 51 per month towards O&M cost and Tk 960 towards initial capital cost; for domestic connection it is Tk 87 per month towards O&M cost and Tk 1,787 towards initial capital cost.

The estimates of WTP for Chandpur are somewhat higher than those for Chapai Nawabganj and Barisal. This seems attributable to the relatively higher average income levels in Chandpur and greater concern for the arsenic problem.

The estimated mean WTP of poor households (monthly household income up to Tk 3,500) is Tk 44 per month plus an initial payment of Tk 838 for public standpost and Tk 68 per month plus an initial payment of Tk 1,401 for domestic connection. As would be expected the estimated WTP for non-poor is significantly higher.

As a ratio of their income, households are on average willing to spend 1.1 percent of monthly income for O&M charges for standpost. Poor households are willing to spend 1.9 percent of their monthly income towards O&M charges for standpost. As regards the initial capital cost, households are on average willing to pay 1.7 percent of their annual income towards initial capital cost for standpost.

Turning to domestic connection, households are willing to spend an

**Table 2**

**Estimated mean willingness to pay — arsenic-affected area**

| | Public standpost | | Domestic connection | |
|---|---|---|---|---|
| | O&M (Tk/month) | Capital Cost (Tk) (one-time payment) | O&M (Tk/month) | Capital Cost (Tk) (one-time payment) |
| **Districts** | | | | |
| Chapai Nawabganj | 48 | 913 | 79 | 1,625 |
| Barisal | 49 | 927 | 83 | 1,716 |
| Chandpur | 55 | 1,043 | 99 | 2,038 |
| All | 51 | 960 | 87 | 1,787 |
| Poor | 44 | 838 | 68 | 1,401 |
| Non-poor | 59 | 1,119 | 112 | 2,318 |
| All | 51 | 960 | 87 | 1,787 |
| **WTP as percent of income (for capital cost annual income is taken)** | | | | |
| **Districts** | | | | |
| Chapai Nawabganj | 1.3% | 2.0% | 2.1% | 3.6% |
| Barisal | 1.1% | 1.7% | 1.9% | 3.2% |
| Chandpur | 1.0% | 1.5% | 1.8% | 3.0% |
| All | 1.1% | 1.7% | 1.9% | 3.2% |
| Poor | 1.9% | 3.0% | 2.9% | 5.0% |
| Non-poor | 0.8% | 1.2% | 1.5% | 2.6% |
| All | 1.1% | 1.7% | 1.9% | 3.2% |

*Source: Estimated from survey data.*

**Table 3**

**Ratio of willingness to pay to estimated actual supply cost — arsenic-affected area**

| | Public standpost | | Domestic connection | |
|---|---|---|---|---|
| | WTP for O&M | WTP for Capital Cost | WTP for O&M | WTP for Capital Cost |
| Poor | 126% | 16% | 110% | 13% |
| Non-poor | 169% | 21% | 181% | 22% |
| All | 146% | 18% | 140% | 17% |

*Note: The estimated O&M costs are Tk 35 per month for standpost and Tk 62 per month for domestic connection. The estimated capital costs are Tk 10,500 per family for domestic connection and Tk 5,250 per family for standpost. These cost estimates of piped water supply are based on cost information in respect of some on-going piped water supply projects in Bangladesh.*

average of 1.9 percent of their monthly income towards O&M charges. Poor households are willing to spend 2.9 percent of their monthly income towards O&M charges. Such households are willing to spend about 5 percent of their annual income for the initial capital cost of a domestic piped water connection.

The mean WTP more than covers the actual O&M costs of piped water supply (estimate based on cost information of on-going schemes). The average WTP for standpost is about 46 percent higher than the actual O&M costs and for domestic connection the WTP is 40 percent higher than the actual O&M costs. In poor households, their mean WTP for standpost covers the O&M cost by more than 26 percent and their mean WTP for domestic connection exceeds the actual cost by 10 percent.

In respect of willingness to share capital cost of piped water supply projects, the estimates of mean WTP for both poor and non-poor households are more than 10 percent of the actual capital cost (estimate based on cost information of on-going schemes). The mean

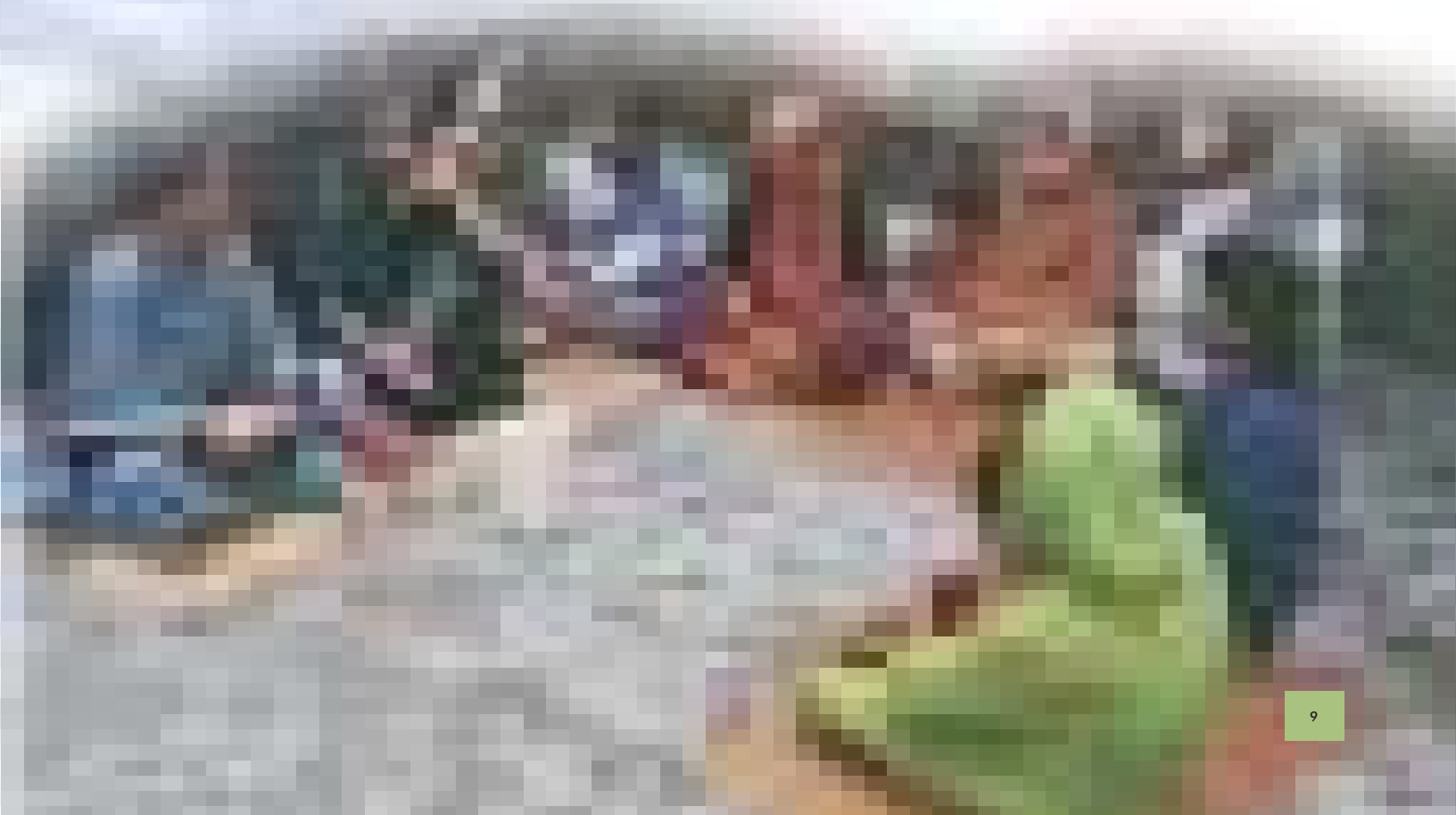


**Table 4**

**Estimated mean willingness to pay — arsenic-free area**

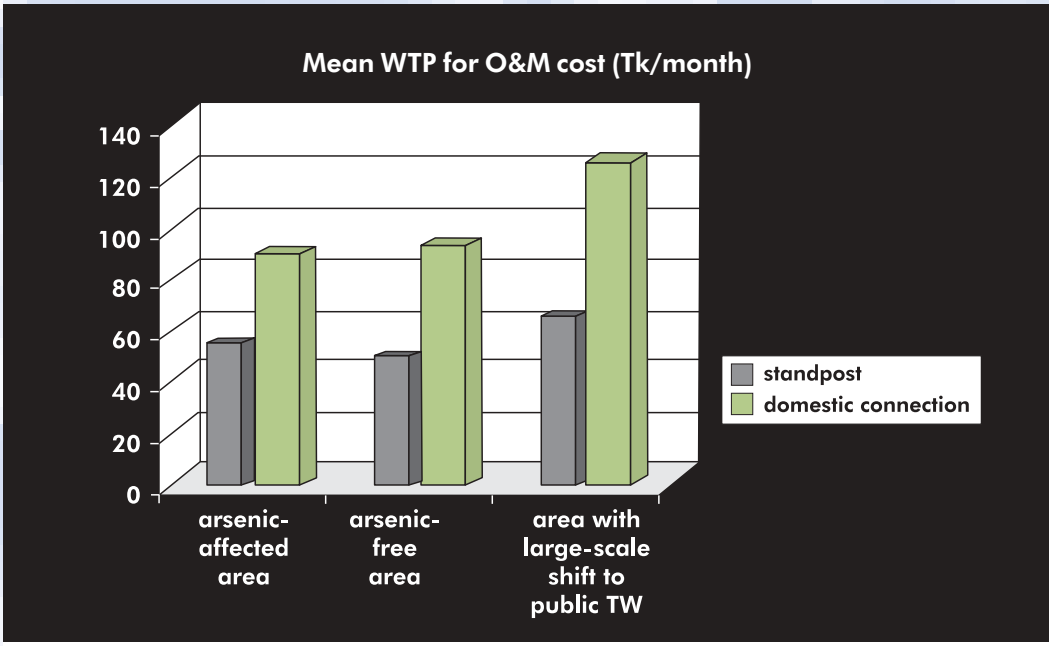
| | Public standpost | | Domestic connection | |
|---|---|---|---|---|
| | O&M (Tk/month) | Capital Cost (Tk) (one-time payment) | O&M (Tk/month) | Capital Cost (Tk) (one-time payment) |
| Poor | 39 | 785 | 67 | 1,310 |
| Non-poor | 56 | 1,135 | 122 | 2,385 |
| All | 46 | 937 | 91 | 1,775 |
| **WTP as percent of income (for capital cost annual income is taken)** | | | | |
| Poor | 1.7% | 2.8% | 2.9% | 4.7% |
| Non-poor | 0.7% | 1.3% | 1.6% | 2.6% |
| All | 1.0% | 1.7% | 2.0% | 3.2% |

***Source: Estimated from survey data.***

for all households is 18 percent of the capital cost for standpost and 17 percent of the capital cost for domestic connection. Poor households are willing to pay on average 16 percent of the capital cost of standpost and 13 percent of the capital cost of domestic connection. In rural water supply projects, 10 percent is often used as the share of capital cost to be borne by the households. The WTP estimates indicate that the rural households of Bangladesh would in general be willing to pay this percentage of the capital cost of piped water supply projects. Indeed, the estimates of WTP point to the possibility of recovering much more than 10 percent of capital cost from rural households.

The estimates of WTP obtained for the arsenic-free (control) area are similar to those obtained for the arsenic-affected areas. The estimates of WTP obtained for the arsenic-affected areas with large-scale shifts to public tubewells, are somewhat higher in comparison to both the sample and control areas. Evidently, a strong demand for piped water supply exists not only in the arsenic-affected areas but also in (i) the areas free from arsenic contamination, as well as (ii) the areas where construction of public tubewells (deep tubewells) have already provided access to arsenic-free, safe drinking water.

**Figure 2**



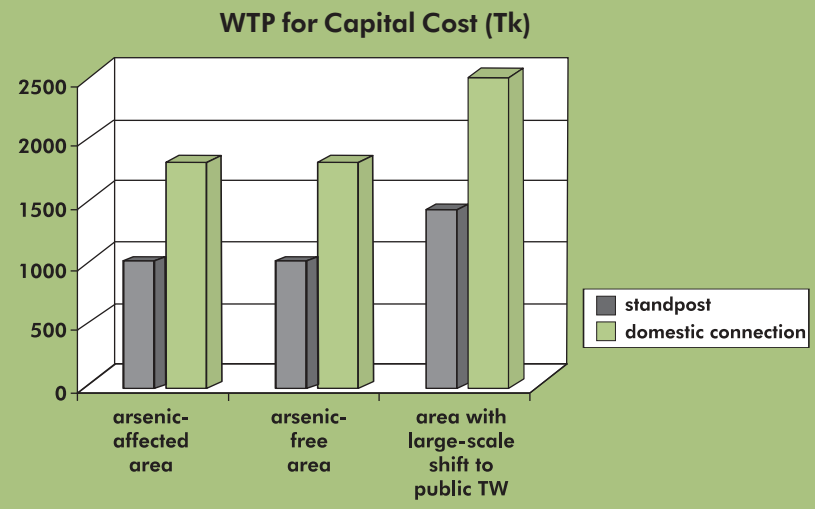



Figure 3

## Value of arsenic-free drinking water

Piped water is a composite good embodying quality, convenience, time saving, etc. The estimated value of piped water in arsenic-affected areas has a component that relates to arsenic. An interesting methodological question is how to net out the arsenic-free component from the overall value of piped water.

The study has made an estimate of the value of arsenic-free water out of the overall value of piped water. For this purpose, the mean WTP for piped water is estimated for those households in arsenic-affected areas that rank relatively high (above median) in terms of the arsenic score (reflecting awareness and concern); this estimate is then compared with the mean WTP for the control (arsenic-free) area. The difference is taken as an estimate of WTP for arsenic-free water. An alternate approach taken is to use the multinomial logit model (estimated for the arsenic-affected areas) to obtain an estimate of WTP for piped water for a household with no awareness and no concern for the arsenic problem (i.e. the arsenic-related variables set at zero, others at sample mean), and then make a comparison to the mean WTP for piped water for households that rank relatively high in terms of the arsenic score.

The arsenic-free component is found to be 9 to 14 percent of the value of piped water in arsenic-affected areas in the case of standposts and 9 to 19 percent in the case of domestic connection. Combining the two estimates according to the preferences expressed by households for standposts and domestic connection, the estimated value of arsenic-free water is found to be in the range of Tk 10 to 13 per month.

As a proportion of income, the willingness to pay for arsenic-free water is rather low, being in the range of 0.2 to 0.3 percent. This is probably reflective of the long latency period of arsenicosis and high personal discount rate for the future among rural households (Poulos and Whittington 2000). Other factors explaining the low value of arsenic-free water may be risk perceptions similar to those detected in most risk studies: "it will not happen to me or my family members", etc.

## Validation of WTP estimates

To validate the estimate of the value of arsenic-free water based on the contingent valuation approach (also known as the direct approach), an alternate estimate has been made by the revealed preference approach (i.e. the indirect approach). Under the revealed preference approach, the following components have been valued and aggregated to get an estimate of the value of arsenic-free water:

- How many people have shifted their drinking water source because of arsenic contamination and are now spending more time collecting water? What is the value of the extra time being spent?
- How many people have shifted to tanks, ponds or other sources and are boiling water to remove bacteriological contamination? What is the value of time spent and fuel used in boiling water?
- How many people had to install a new tubewell, or sink the existing well deeper, because of arsenic contamination? What costs did this incur?

The most important cost item is the extra time being spent for collection of drinking water, when households changed their source because of arsenic contamination. The average distance increased from 84 feet to 556 feet. The time spent increased from 9 minutes to 27 minutes per day. The valuation of the extra time has been done on the basis of wage rate (taking into account the age-sex distribution of the person who generally collects drinking water for the family).

The total cost obtained by adding the three items listed above comes to Tk 12.5 per household per month. It may be appropriate to exclude from the calculations those households whose tubewells were found to be safe, since they would not be required to incur any defensive expenditure. When this is done, the average cost comes to Tk 16.2 per household per month.

Clearly, the estimate of the value of arsenic-free water obtained by the revealed preference approach is broadly in agreement with the estimate made by the contingent valuation approach, and thereby provides validation of the estimate by the latter approach.

## Conclusions

The estimates of WTP obtained in the study clearly indicate the strong preference for piped water supply in both the arsenic-affected, and the arsenic-free areas. The estimated mean WTP of all households taken together exceeds the actual O&M costs of supplying piped water. Even for poor households, their WTP is on average more than the O&M cost of piped water supply, both for public standpost and domestic connection.

The estimated WTP towards capital cost is more than 10% of the actual capital cost, which is often taken as the stipulated share of beneficiaries in rural piped water supply projects. The WTP estimates indicate that the rural households of Bangladesh would in general be willing to pay this percentage of the capital cost of piped water supply projects, and there is a possibility of recovering from them more than 10% of the capital cost.

The estimate of value of arsenic-free water out of the total value of piped water is found to be in the range of Tk 10 to 13 per month. This is rather low in comparison to the average income of rural households (0.2 to 0.3 percent). The low WTP for arsenic-free water is probably a reflection of the long latency period of arsenicosis and high personal discount rate for the future among rural households. This may also have to do with insufficient awareness of the serious health effects of arsenic contamination and low risk perceptions among rural households.

The finding that the value of arsenic-free water is low implies that arsenic mitigation technologies which cost much more than Tk 10 to 13 per month but do not provide the convenience, time saving, and other such benefits associated with piped water, would find little acceptance among rural people in Bangladesh.

## What is contingent valuation?

The contingent valuation method (CVM) is used to elicit people's preferences when markets are absent, imperfect or incomplete. It is most commonly used for the valuation of public goods and in particular for the quantification of benefits from an improvement in the quality of environment. It offers a direct, intuitively appealing means of estimating the economic benefits of an improved water supply. Rather than attempting to infer from the behavioral information how much value an individual places on improved water services, one simply asks outright how much the individual or the households would be willing to pay for them. The technique derives its name from the fact that the value estimates are contingent on a hypothetical scenario that is presented to the respondents for valuing.

The contingent valuation method is also known as the 'stated preference' method or the 'direct approach' because people are directly asked to state or reveal their preferences. The other possible approach to valuation is to infer the preferences or values from the actual behavior (how much people pay for houses — the hedonic price method, or travel to an environmental amenity — the travel cost method). These can be classified as 'revealed preference approach', 'surrogate market approach' or 'indirect approach'.

## Applications of CVM

The first recorded contingent valuation study was undertaken in 1961 by Davis, who used a contingent valuation questionnaire to estimate the benefits of outdoor recreation in the Maine woods (Davis, 1963). The next major study was conducted in 1969 by Hammack and Brown, who carried out a contingent valuation survey among hunters to assess their willingness to pay for the right to hunt water fowl or willingness to accept compensation to give up their right to hunt water fowl. Since these early beginnings, the CVM has been used extensively. By the mid-1990s, there were more than 1,600 documented works on the CVM.

Since the early 1970s, the CVM has been used to measure the benefits of a wide range of environmental goods, including recreation, amenity value, scenery, wetlands, air and water quality, forest conservation and wildlife. As well as valuing environmental goods, many contingent valuation studies were designed to test for potential bias of the method, or the results obtained were compared with the results of other studies as a means of external validation of contingent valuation.

The CVM was initially applied in developing countries primarily in two areas: (i) water and sanitation, and

(ii) recreation, tourism and national parks. The areas of application of CVM have been growing, and now include surface water quality, health and biodiversity conservation. The CVM has been used for assessing willingness to pay (WTP) for improved water supply (piped water) in a number of studies conducted for developing countries. These include studies for Brazil (Briscoe, Furtado de Castro, Griffin, North and Olson), Pakistan (Altaf, Whittington, Jamal and Smith), India (Singh, Ramasubban, Bhatia, Briscoe, Griffin and Kim), Nigeria (Whittington, Lauria and Mu), Southern Haiti (Whittington, Briscoe, Mu and Barron), Uganda (Whittington, Davis and McClelland), Costa Rica, Ghana, Laos, Morocco, Nepal, Kenya, Philippines, and Zimbabwe.

There have been several contingent valuation studies on groundwater quality. But none of them were concerned with arsenic contamination. This study for rural Bangladesh is the first one in which the CVM has been applied in the context of arsenic contamination of groundwater. This is also one of the very few studies undertaken on people's willingness to pay for piped water supply in Bangladesh.

### *Evolution of contingent valuation methodology*

The initial version of the contingent valuation studies conducted by Davis (1963) and Randall *et al*. (1974) concentrated on incentive and free-rider issues, with psychometric issues treated as incidental problems that would disappear when the subjects had a positive incentive to be truthful. Davis employed an open-ended protocol (the subject was asked to state his/her maximum willingness to pay). Randall employed a sequential bidding protocol in which the subject was asked for a series of votes on referendums (take-it-or-leave-it for a quoted price, done repeatedly for a series of prices) converging to a WTP number. Several arguments were put forward by Randall and associates for use of the sequential bidding protocol

## Methodology adopted in this study

**For this study on the willingness to pay for arsenic-free safe drinking water in Bangladesh, the single referendum protocol has been applied, coupled with split sampling, which is the state-of-the-art methodology for value elicitation. The referendum question has been followed by an open-ended question with a view to obtaining more information than would be obtained from a double-referendum format.**

**Guided by the vast literature that has amassed on the question of bias in contingent valuation studies, considerable care has been taken in the designing of the questionnaire to minimize the biases. To give an example, the hypothetical scenario constructed is such that the respondent has little incentive to behave strategically. Also, in the scenario, the service delivery institution is that of the respondent's choice, so that willingness to pay should not be affected by any arbitrarily imposed service delivery institution.**

**A significant methodological contribution made by the study is the procedure adopted for 'netting out' the arsenic value from the overall value of piped water. This methodology proposed and applied here can have many other applications for breaking up the overall value of an environmental good into the values of its different components or attributes.**

rather than an open-ended protocol. The referendum format was viewed as simpler and less subject to misinterpretation than the open-ended format. Despite the arguments for the sequential bidding protocol, the most commonly used protocols in the early 1980s were the open-ended or used payment cards, the latter requesting a choice from a series of ranges.

The referendum protocol stripped of the sequential bidding feature so that the subject was offered a single bid that varied across subjects according to an experimental design, was reintroduced by Bishop and Heberlin (1979) and Hanemann (1984). The protocol was developed further in some studies conducted in the later half of the 1980s. By 1993, the referendum protocol with a single bid, or in some applications with a followup bid known as double-referendum, had eclipsed the open-ended protocol. A blue-ribbon panel assembled by the National Oceanic and Atmospheric Administration (NOAA) to assess the reliability of CVM endorsed the single referendum protocol as the preferred procedure for contingent valuation study.

It is known that the single referendum protocol is statistically inefficient compared to the open-ended protocol, requiring a substantially larger sample to achieve the same level of precision. It also needs more complex econometric techniques to derive estimates of WTP. Yet the referendum protocol has found widespread and relatively uncritical acceptance. This is because the analysts feel that this protocol is easier for the respondent to answer and is incentive compatible, thus relatively free from strategic bias. Also it is felt that the referendum method mimics political referendums, which are an accepted mechanism for social choice.

The contingent valuation literature of the last two decades has devoted a great deal of attention to methodological issues, particularly to the issue of biases of various kinds in the responses obtained to the valuation question. Many studies have tested for the biases (hypothetical/scenario mis-specification bias, strategic bias, etc.). The findings of those studies have been useful in gaining a better understanding of the magnitude and direction of the biases. This has helped in better appreciation of the psychometric issues in contingent valuation and in better designing of questionnaires so that the biases could be minimized. Thanks to the studies undertaken, some biases are not considered biases any more. It is now expected that an individual's WTP will be subject to the amount of information provided to him/her about the environmental good to be valued. Also, it is expected that the mode of payment (tax, donation, or user fee) will influence the individual's WTP.

In recent years, there has been a trend to include in contingent valuation research expertise from other disciplines, such as market research, survey research, social psychology and cognitive psychology. The use of experimental economics is becoming increasingly important in investigating various methodological issues.

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