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RESEARCH REPORT

No. 2005-RR3

Household Demand for Improved Water Services in Ho Chi Minh City: A Comparison of Contingent Valuation and Choice Modeling Estimates

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This report assesses the willingness of people in Ho Chi Minh City, Vietnam to pay for improvement in their water supply system. It also investigates what aspects of water supply, such as quality and water pressure, are most important. The study was carried out in response to the growing number of water supply problems in the city. It was also done to highlight the need for 'consumer demand' to be given priority in water supply planning.

Many of the households surveyed already had to do a lot – and spend a lot of money – to cope with the unreliable, poor-quality public water supply they currently use. The report also finds that people are on average willing to pay between VND148,000 and VND175,000 for improvements in their water supply; that households without piped water are more willing to pay for improved services than those that already enjoy a fixed supply; and that 'non-piped' households place more importance on water quality than water pressure.

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Library and Archives Canada Cataloguing in Publication

Pham, Khanh Nam

Household demand for improved water services in Ho Chi Minh City:
A comparison of contingent valuation and choice modelling estimates

(Research report, ISSN 1608-5434, 2005-RR3)
Co-published by the International Development Research Centre.
Includes bibliographical references.
ISBN 1-55250-164-7

1. Water-supply – Economics aspects – Vietnam – Ho Chi Minh City
2. Water quality management – Vietnam- Ho Chi Minh City

I. Tran Vo Hung Son
II. Economy and Environment Program for Southeast Asia.
III. International Development Research Centre (Canada).
IV. Title
V. Series: Research report (Economy and Environment Program for Southeast Asia); 2005-RR3.

HD1698.V5K42 2005 333.9’12’09597 C2005-980092-5

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February, 2005

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EEPSEA is supported by the International Development Research Centre (IDRC); the Swedish International Development Cooperation Agency (Sida); and the Canadian International Development Agency (CIDA).

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ACKNOWLEDGEMENTS

We would like to express our sincere appreciation to Prof. Dale Whittington, University of North Carolina at Chaper Hill; Dr. Wiktor Adamowicz, University of Alberta; Dr. Fredrik Carlsson, University of Goteborg; and Dr. David Glover, Director of EEPSEA, Singapore, for their valuable comments on our study proposal and analysis, and to Mr. Truong Dang Thuy, University of Economics HCMC, for his help with the survey.

All opinions, findings, conclusions, or recommendations expressed in this report are those of the authors and do not necessarily reflect the views of EEPSEA. The authors alone remain responsible for any errors in this paper.

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HOUSEHOLD DEMAND FOR IMPROVED WATER SERVICES IN HO CHI MINH CITY: A COMPARISON OF CONTINGENT VALUATION AND CHOICE MODELING ESTIMATES

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EXECUTIVE SUMMARY

Urban water utility authorities in Ho Chi Minh City are facing difficulties in valuing the benefits of improved water service projects. This study used a contingent valuation model and a choice model to estimate household preferences for water services.

Single-bounded dichotomous choice questions were asked to derive households' willingness to pay for possible improvements in water services; the choices included higher water quality and reliable water pressure. In the choice modeling survey, non-piped households (i.e. those not connected to central water supplies) were presented with a series of choice sets, each containing one water project option, defined by water quality levels and water pressure levels. The results showed that the amount that households were willing to pay for improved water services was higher than the sum of their existing water bills plus coping costs (incurred by coping behaviors like collecting, pumping, treating, storing or purchasing water). The marginal values for the water quality attribute were much higher than for the water pressure attribute. The welfare estimates obtained from contingent valuation and choice modeling were fairly similar.

Without knowing the costs of providing various service improvements, we cannot recommend specific improvements. However, we have established that (survey) households in HCMC have a clear preference for improvements in water quality over water pressure and a substantial willingness to pay for it and this is important information for policy-makers and for future research.

1.0 INTRODUCTION

Water service providers are often under pressure to improve domestic water services, without having the expertise necessary to assess how valuable these improvements would be to consumers. Economic analysis can play an important role in this regard (Altaf, Jamal & Whittington, 1992). In developing countries, many master plans of new treatment plants and distribution systems unquestionably take the engineer-dominated supply approach while the nature of water users' needs is neglected. Criticisms of this approach focus on the failure of such programs which ignore the demographic and financial realities (Whittington et al, 1993). From the mid-1980's, a new vision based on the demand-oriented approach has emerged. This new approach asserts that water utility bodies need to understand actual household water use behavior and the observed ability and willingness to pay for improved water services (Whittington et al, 1990).

In Vietnam, frequent failures with respect to urban water improvements have been costly experiences. While many domestic water projects have been approved to be quickly launched into operation, a lack of understanding of household demand for water, household demographics, financial status, and household water use behaviour on the part of the provideres have resulted in failed projects and frustration at both ends. The final result is that the people's demand for reliable water services has not been met (Water Supply Company, 2002). Households in Ho Chi Minh City (HCMC) are using unreliable, poor quality piped water and paying relatively cheap monthly water bills. Many households also use non-piped water e.g. from tube-wells, for their daily domestic needs.

In this study, we estimated household preferences for an improved water service in Ho Chi Minh City using the discrete choice Contingent Valuation (CV) Model and Choice Modeling (CM). We also aimed to compare welfare estimates of CV and CM methods. The CM outcomes are often theoretically considered as providing more policy relevant information, for example, marginal willingness to pay for attributes of projects and preferences for a set of scenarios. (See Adamowicz, 1998a and Bateman et al., 2002) for further discussions on comparison between CV and CM.) We used CV, which is more traditional than CM, to crosscheck the CM outcomes. In the last two decades, CV studies have been undertaken to value various aspects of water uses (Carson & Mitchell, 1987; MacRea & Whittington, 1988; Whittington, Lauria & Mu, 1991; Bachrach & Vaughan, 1994; Choe et al., 1996; Koss & Khawaja, 2001; Whittington et al, 2002). Considering a wider context than just water uses, it is evident that only a few studies compare CV and CM (Boxall et al, 1996; Adamowicz et al, 1998a; Hanley et al, 1998).

The rest of this paper is organized as follows:- in Section 2, we describe the background of the study; in Section 3, we briefly introduce the analytical framework and discuss the underlying economic theory and the design of CV and CM experiments; results are presented and discussed in Section 4; and finally, Section 5 summarizes our findings and presents some policy implications.

2.0 BACKGROUND

Ho Chi Minh City is the biggest city in Vietnam, covering an area of approximately 2,000 square kilometers with a current population of about 5.5 million. The state-owned utility board, called the Water Supply Company (WSC), is responsible for service provision in Ho Chi Minh City, which includes public taps and private connections in households and enterprises. As of August 2003, the WSC controlled 321,537 private connections in Ho Chi Minh City (WSC, 2004). So far, private companies are not allowed to do business in this sector.

Currently, Ho Chi Minh City has sufficient surface and ground water to meet its present needs (World Bank, 2004). There is no water shortage even in the dry season. However, while the demand for domestic water is estimated at 1,250,000 cubic meters per day, the existing piped water capacity can only meet around 70 per cent of this demand.

Lack of capital and ineffective management has limited the city's ability to utilize existing water resources to provide its population with clean and safe water. Most of the water pipelines in the city were installed over 30 years ago and have been seriously deteriorating. As a result, estimates of water loss are in the order of 30% to 40% (WSC, 2004). It is widely perceived that there is significant heterogeneity in the taste, smell, color, and cleanliness of water in different parts of the city. In certain areas of the city, households without piped water rely on alternative sources of water, such as private wells and tanker truck vendors. The number of uncontrolled private wells may account for nearly 400,000 cubic meters per day (WSC, 2002).

Households tend to make quite substantial investments to address the problems associated with the unreliable, poor quality public piped water supply. Electric pumps are often used to extract water from the private wells or to suck water out of the distribution system to fill storage tanks on the roof of the house. Drinking water is often filtered and boiled. Sometimes bottled water and water bought from vendors are used as a last resort (see details in section 4.1). These coping activities are expected to affect household preferences for improved water projects (Pattanayak et al, 2004).

3.0 THE MODELS

3.1 Analytical Framework

Respondents were divided into two groups: households with existing piped water service and households without piped water service. Single-bounded dichotomous choice questions were asked of both groups to derive household willingness to pay for an improvement in water services, which included higher water quality, and higher water supply reliability. Choice Modeling (CM) was conducted only for households without piped water connections because they were the group for which service improvements were most likely to have the greatest impact. They were presented with four choice sets, each containing one improved water project option, which was defined by water quality levels and water pressure levels, and the status quo option.

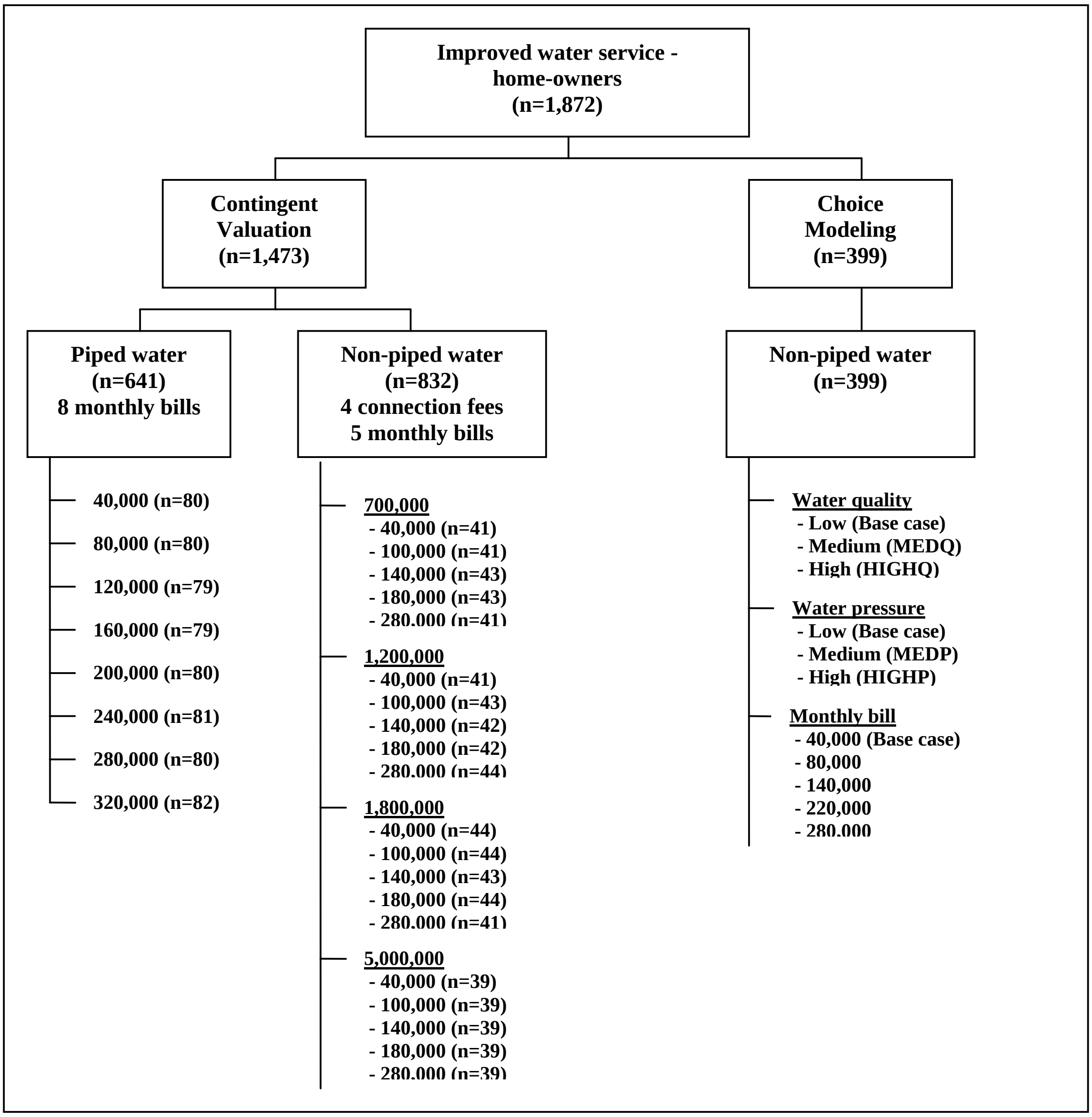


Figure 1. Analytical framework[1]

3.2 Contingent Valuation Model (CVM)

3.2.1 The Design

Among various elicitation formats, the single-bounded dichotomous choice question was chosen to obtain a household's willingness to pay for a proposed improvement of water services. Carson, Groves & Machina (1999) argues that the close-ended single bounded format is incentive compatible when a survey is perceived by respondents as a potential source of influence on policy decision-making. (In CVM, it is important to provide respondents with incentives to reveal their true willingness-to-pay (WTP). Incentive compatibility is one of the important characteristics of a CVM design.)

[1] The exchange rate was 15,400 VDN = 1 USD at the time of the survey in September 2003.

Split-sample designs were undertaken separately for piped and non-piped households. ("Piped" households are connected to the municipal water supply. "Non-piped" households are not connected and get their water from wells, water vendors or other sources.) For households without piped water services, a connection fee and a monthly water bill were introduced to the respondent. Therefore, among other factors, the willingness to pay of a household depends on both the connection fee and monthly water bill. Unfortunately, there is no welfare measurement model that captures two different compensating surpluses (Freeman, 2003). Therefore, working on the assumption that the capital market in Ho Chin Minh City (HCMC) works competitively[2], the connection fee was amortized by a social discount rate of 12%[3] to the monthly bill as the only cost variable. Based on the information gained from focus groups and pretest surveys, we set the bid vector such that it followed the rule that "the highest price should typically be rejected by 90-95% of the respondents" (Kanninen, 1993). Eight prices were used in the discrete question for households with piped water services. Four connection fees and five monthly bills were used for households without piped water services (see Figure 1).

Considering statistical requirements for the models (Bateman et al, 2002), the sample size for households with piped water was decided at 640 respondents (8 bids *80 respondents for each bid). Similarly, the sample size for households without piped water was 800 respondents (4 connection fees*5 monthly bills*40 respondents for each split price package). Respondents facing the dichotomous choice questionnaire were randomly assigned one of the initial bid amounts.

The payment vehicles could be (1) higher total monthly water bills, (2) higher per person monthly water bills, or (3) higher cost per cubic meter of a fixed volume of water. Based on pretests and focus group discussions, the higher household monthly water bill was finally chosen because it is actually the way respondents think when they have to compare the costs of using the improved water service and the benefits of that service. (See Figure 2 for the shortened WTP question.)

If the piped water system I described above goes ahead, assume that this piped water is the only source of water your family is going to use. A typical household in HCMC would use about 23 cubic meters per month so we assume that this will satisfy your family's water needs too. This would mean that a family like yours would have a monthly water bill of [……………] VND. Would your family willing to pay for this improved water services? 1=Yes→ go to C2 0=No→ go to C3

Figure 2. The Contingent Valuation Question

3.2.2 The Modeling

The general form of the discrete choice CV model applied in this research follows the approach suggested by Hanemann (1984). V_{ij}, utility of household *j* for an improved water service in the state *i* = 1 (i = 0 for the status quo) is the function of

[2] This assumption was based on the fact that credit accessibility for home-owners in Ho Chi Minh City for household expenses is generally provided by the bank (CIEM, 2004).

[3] This discount rate was estimated from the ADB's guidelines for project appraisal in developing countries and a case study of Vietnam (ADB, 1999).

attributes of the existing and offered water source and the household's socioeconomic characteristics:

$$V_{ij} = V_i(M_j, \mathbf{z}_j, \varepsilon_{ij}) \tag{1}$$

where M_j is the j^{th} household's discretionary income, z_j is the vector of household characteristics and attributes of the resource, and ε_{ij} is unobserved preferences. The binary choice CV question will force the respondent to choose between the improvement of water service at the required monthly bill *t*, and the status quo.

To measure welfare, this study used the logarithmic utility model. While the random utility model with a linear income function assumes that the marginal utility of income is constant across scenarios posed by the CV questions, the logarithmic utility model allows the marginal utility of income to vary across utility states as money income changes.

The probability of responding 'yes' to the proposed scenario is as given below. (See Haab and McConnell, 2002, for a detailed process of model development.)

$$P\left[Yes_j\right] = P\left[(\alpha_1 z_j + \beta\ln(M_j - t_j) + \varepsilon_{1j}) \geq (\alpha_0 z_j + \beta\ln M_j + \varepsilon_{0j})\right] \tag{2}$$

$$\text{or} \quad P\left[Yes_j\right] = P\left[(\alpha z_j + \beta\ln\left(\frac{M_j - t_j}{M_j}\right) + \varepsilon_j \geq 0\right] \tag{3}$$

Assuming the random variable ε_j is distributed normally with mean zero and variance σ^2, we have the standard normal probability of a 'yes' response:

$$P\left[Yes_j\right] = \Phi\left[\left(\alpha z_j + \beta\ln\left(\frac{M_j - t_j}{M_j}\right)\right)\Big/\sigma\right] \tag{4}$$

The term $\ln\left(\frac{M_j - t_j}{M_j}\right)$ is called composite income. The parameter vector $\{\alpha/\sigma, \beta/\sigma\}$ can be estimated by running a probit on the data matrix $\left\{z_j, \ln\left(\frac{M_j - t_j}{M_j}\right)\right\}$ and allows to calculate the mean WTP: $E_\varepsilon\left[WTP_j\right] = M_j\left[1 - \exp\left(-\frac{\alpha}{\beta}z_j + \frac{1}{2}\frac{\sigma^2}{\beta^2}\right)\right]$ (5)

$$\text{and median WTP:} \quad MD_\varepsilon\left[WTP_j\right] = M_j\left[1 - \exp\left(-\frac{\alpha}{\beta}z_j\right)\right] \tag{6}$$

There are several techniques to calculate the confidence intervals of mean and median WTP such as the Delta method (Greene, 2000), Bootstrapping, and the Krinsky and Robb procedure (Haab & McConnell, 2002; Bateman et al, 2002). We applied the Delta method in this study.

We also used the Turbull estimator (Carson et al, 1994; Haab & McConnell, 2002) to estimate the WTP of non-piped households for improved water services at each connection fee. The Turnbull WTP results provide a better understanding of how household preferences change as the connection fees change.

3.3 Choice Modeling (CM)

3.3.1 The Design

CM is a stated preference technique in which respondents choose their most preferred resource use option from a number of alternatives. In a CM experiment, individuals are given a hypothetical setting and asked to choose their preferred alternative among several alternatives in a choice set, and they are usually asked to do so for several choice sets. Each alternative is described by a number of attributes, which are the subject of analysis, including a monetary attribute (see Figure 3.) The respondent makes trade-offs between the levels of one attribute and the levels of other attributes implicitly weighing and valuing the attributes within the choice sets. CM allows one to understand and model how individuals evaluate product attributes and choose among competing offerings.

The attributes and levels of attributes were developed using the results from two focus group discussions and a pretest of 47 sample households. The focus groups were used to determine the attributes (see Blamey et al., 1998 for detailed discussions on the typical procedures) by addressing the following issues: definition of attributes, number of levels for an attribute, levels of monetary attributes, wordings, and the impact of photographs. The results showed that respondents considered two functional attributes of an alternative when choosing a water service: water quality and water pressure. Levels of these attributes were qualitative expressions[4] decided on by the focus groups.

In the survey, respondent households were informed that it would be possible to connect to and use a piped water service and that they would have to pay a higher monthly water bill in return. Respondents were also told that the volume of water used in a month would be fixed according to their household demand. Respondents were given clear explanations of the attributes i.e. water quality and water pressure, and the levels of these so that they could understand the choice set. They were also told that there were two options available for the use of domestic water in Ho Chi Minh City: to continue with the current situation, or to connect to and use piped water services. Respondents were then presented with four choice sets showing various options for their water uses (See Figure 3 for a sample choice set. There were 32 choice sets in total). The options in the choice sets were defined using three different attributes: water quality, water pressure, and household monthly water bill. Before answering the choice sets, respondents were faced with framing questions, which reminded them to keep in mind the improved water service embedded in an array of substitute and complementary goods (Rolfe & Bennett, 2000).

[4] See Blamey et al (1998) for a discussion on the advantages and disadvantages of qualitative and quantitative expressions of levels.

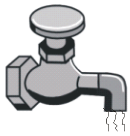
	Connection	Status quo
Water quality	 (Drink straight from tap – high quality)	  (Boil and filter before drink – low quality)
Water pressure	 (Strong pressure)	 (Low pressure)
Total household monthly water bill	140,000 VND	40,000 VND
CHOOSE ONLY ONE ⇒	☐	☐

Figure 3. An example of a choice set

3.3.2 The Modeling

Choice modeling shares a common theoretical framework (i.e., the use of the indirect utility function) with other environmental valuation approaches in the random utility model (McFadden, 1973). Facing alternatives that present trade-offs among attribute levels, each individual seeks to maximize her own utility as shown in the following equation:

$$U_j = \max V(A_j, y - p_j c_j) \qquad (7)$$

Where maxV is maximum utility V; c_j is an alternative combination j (profile j) as a function of the vector A_j; p_j is the price of each profile; and y is the household's income.

The individual chooses (on behalf of his household) the profile j if and only if:

$$V_j(A_j, y - p_j c_j) > V_i(A_i, y - p_i c_i) \quad \forall\ i \neq j \qquad (8)$$

Suppose that the choice experiment consists of M choice sets, where each choice set, S_m, consists of K_m alternatives, such that $S_m = \{A_{1m}, \ldots, A_{Km}\}$, where A_i is a vector of attributes. From equation (8) we can then write the choice probability for alternative j from a choice set S_m as:

$$P\{j| S_m\} = P\{ V_j(A_{jm}, y - p_jc_j) + \varepsilon_j > V_i(A_{im}, y - p_ic_i) + \varepsilon_i\} = P\{ V_j(\ldots) + \varepsilon_j - V_i(\ldots) > \varepsilon_i; \forall i \in S_m\} \tag{9}$$

McFadden (1973) argued that if the error terms in the above equation are independently and identically distributed with a Type I extreme value distribution (a Gumbel distribution), the choice probability for alternative j will be as follows:

$$P(j) = \frac{e^{\lambda Vj}}{\sum_{i \in S} e^{\lambda Vi}} \tag{10}$$

The conditional logit model in equation (10) is the most common model used in applied work (Adamowicz, Louviere & Swait, 1998b).

In this study, the estimated utility function V_j takes the form as follows:

$$V_j = \alpha + \sum \beta_k X_k \tag{11}$$

where α is an alternative specific constant, β is a coefficient and X is a variable representing an attribute. The utility function may take another form if socio-economic variables are included. Because these variables are invariant across alternatives in the choice set, they have to be estimated interactively with α or one of the attributes X:

$$V_j = \alpha + \sum \beta_k X_k + \sum \alpha S_h + \sum \beta_k S_h X_k \tag{12}$$

where S represents socio-economic variables.

Once the parameter estimates have been obtained through equation (12), welfare estimates are obtained through the equation (13), which is described by Adamowicz, Louviere & Williams (1994):

$$CS = -\frac{1}{\beta_M}\left[\ln \sum_j e^{V_{j0}} - \ln \sum_j e^{V_{j1}}\right] \tag{13}$$

where β_M is the coefficient of the money attribute (marginal utility of income), and V_{j0} and V_{j1} represent the initial and subsequent states.

The marginal willingness to pay for a change in attribute is given by the equation:

$$MWTP_j = -\frac{\beta_j}{\beta_M} \tag{14}$$

3.4 Sampling Strategy and Questionnaire

We used the 1999 population census as the sampling frame, which covered 22 districts of Ho Chi Minh City and around one million households (General Statistics Office, 2001). Expert interviews and pretests showed that the research population did not constitute a homogeneous group. Households in different areas had different water use status and demographics that could affect their preferences for the proposed scenario. Stratified random sampling was thus applied to obtain a representative sample. Ho Chi Minh City was stratified into 22 non-overlapping sub-populations i.e. districts. Wards[5] were randomly selected from each district. After a ward was selected to be included in the sample, sub-wards and then households were randomly chosen.

The survey was conducted simultaneously in the chosen areas and all interviews were face-to-face for each household (the sampling unit). Heads of household or their wives were interviewed – as women commonly take charge of home practices, they were considered reliable sources of information about their household's water use behavior.

The household CV and CM questionnaires were developed using the results from four focus groups, two for CV and two for CM, and a pretest of 47 households. The questionnaires consisted of four sections. The first section introduced the background of the survey to the respondents. Section 2 covered the socio-economic profile of the household such as number of persons, household size, number of women, age, gender, education, occupation, and household income. Section 3 asked about household water use and sanitation such as type of water source, type of water used, monthly water bills, coping activities, type of waste services, and the capital and O&M costs of different water-related investments. Section 4 was on stated preference exercises. The CV questionnaire included a detailed account of existing domestic water services, a full scenario of the improved water services, including payment vehicles, and a single-bounded WTP question. The CM questionnaire provided a similar background as the CV questionnaire but the scenario focused on explaining attributes of the piped water project and the choice sets.

4.0 RESULTS

4.1 Profile of Respondents

4.1.1 Socio-economic Characteristics of Households

Table 1 provides basic information on sample households. A typical respondent is female, 45 years old, with around nine years in school, and living with a family of five other people. The mean household size of the connected households, who typically reside in the center of HCMC, is larger than that of the unconnected households implying a migration to the center of the city. Monthly water bills take up around three per cent of total monthly expenditure of piped water households. This figure is relatively lower than the international statistic of around five per cent (United Nations, 2000), for an equal volume of water used. The monthly water costs of non-piped water households are not available here due to lack of information on the health effects of (and therefore, costs of consuming) underground water.

In general, household income levels are low. For example, about 78% of the households reported income levels of less than 5,000,000 VND per month, which translates to less than US$1.6 per capita per day for an average household. The average

[5] In Ho Chi Minh City, a district is divided into sub-units called wards. A district may have around 10 wards (minimum is 6 and maximum is 22).

household monthly income of the connected households was higher than that of the unconnected households, reconfirming the fact that the access to piped water tends to favor the rich (United Nations, 2000).

Table 1. Social and water use profiles of survey households

Description	Variable	Piped water	Non-piped water
		Mean (Std.)	Mean (Std.)
Socio-economic characteristics			
% of female respondents	FEMA	67 (47)	0.57 (0.49)
Household size (N)	HHSIZE	6.5 (3.4)	5.7 (2.8)
Number of children in the household (N)	NCHILD	1.0 (1.2)	0.9 (1.1)
Years in school of respondent (years)	EDU	9.7 (3.9)	8.5 (3.9)
Age of respondent (years)	-	45.5 (13.6)	44.1 (13.2)
Type of house: 1 = more than 2 floors, 0 = otherwise	HOUSE	0.17 (0.37)	0.03 (0.17)
Household monthly income ('000 VND)	HHINC	4,204 (3,206)	3,723 (2,426)
Own a fridge: 1 = yes, 0 = no	FRIDGE	0.88 (0.51)	0.60 (0.48)
Location of house: 1 = household locates in area 1, 0 = otherwise	LOCA	0.49 (0.50)	0.35 (0.47)
Monthly expenditure ('000 VND)	-	2,745 (1,857)	2,096 (1,210)
Water use profile			
Use of private well-water (1 = yes, 0 = no)	-	0.12 (0.3)	0.82 (0.4)
Use of vendor water (1 = yes, 0 = no)	-	-	0.10 (0.3)
Volume of water used (m^3)	-	31.8 (21.7)	-
Monthly water bill ('000 VND)	-	83.8 (79.7)	-
Use of bottled water to drink (1 = yes, 0 = no)	BOTTLE	0.07 (0.3)	0.21 (0.4)
Use of filter (1 = yes, 0 = no)	FILTER	0.12 (0.3)	0.23 (0.4)
Use of tank to store water (1 = yes, 0 = no)	TANK	0.62 (0.5)	0.92 (0.3)
Use of pump (1 = yes, 0 = no)	-	0.43 (0.5)	0.83 (0.4)
Waste discharge (1 = flushing to sewer, 0=else)	SANIT	0.35 (0.5)	0.16 (0.4)
Perception on water service			
Health: 1 = water is perceived safe or neutral, 0 = otherwise	HEALTH	0.33 (0.47)	0.20 (0.40)
Water pressure: 1= pressure is perceived strong or normal, 0 = otherwise	PRESS	0.63 (0.48)	-
Water outage, 1 = water is always available 24/7, 0 = otherwise	AVAIL	0.67 (0.46)	0.75 (0.43)

4.1.2 Water Use Characteristics and Perceptions

Table 1 also shows household perceptions of water services and water use characteristics, which are categorized by source of water, volume, monthly cost, supplement facilities to cope with problems in existing water services, and sanitation. Three kinds of main water sources are presented, namely private wells, bottled and vendors.

Although piped water households use piped water, some of them also use water from private wells as a supplement source and bottled water for drinking purpose. Their reported average volume of water use is quite close to the WSC estimate, which is around 35 cubic meters (WSC, 2002). Besides, they spend money on coping facilities such as pumps, tanks and filters to address the problems of sub-standard piped service.

More than a half of these households own tanks for water storage to cope with low water pressure and water outage. Nearly half have invested in pumps to suck water from the main pipe and pump it up to the tank on the roof of the house. Sanitation services of connected households are better those of non-piped households, mainly due to their higher incomes and most of them reside in the urban areas. However, only about one-third of these households flush waste discharge to sewers, causing potential contamination of underground water in the dense urban areas.

As for non-piped water households, most of them use water from private tube-wells, which require them to be equipped with electric pumps. They cope with water problems more than the connected households do. Purchasing bottled water and water from vendors are expensive solutions for those who cannot rely on wells. Most of them have tanks, which are simply used to store water sucked from wells. Boiling and filtering are two popular activities to treat water before drinking or cooking. All the survey households reported that they boiled their water before drinking it.

Table 2 presents estimates on four common forms of coping behaviors. The pumping costs comprise the current cost of putting in a new well, cost of electric pump and cost of electricity. The costs for wells and electric pumps were amortized into monthly costs based on a lifespan of 10 years and 3 years, respectively. The cost of electricity was calculated based on information from focus groups and key informant interviews. The treatment costs consist of boiling and filtering costs. We estimated the boiling cost based on the volume of electricity consumed in boiling. The cost of a filter was amortized into the monthly costs based on an assumed 5-year lifespan of the filter. Storage costs are based on the amortized monthly cost of tanks. Purchase costs are for bottled water, and water from vendors or other sources. These costs are reported by the respondent. As shown in Table 2, the average coping costs of a non-piped water household is threefold the coping costs of a piped water household.

Numbers in the table are average costs for a household, for example, the average pumping cost for a piped water household is 16,000 VND. Coping costs include pumping, treatment, storage and purchase costs. However, a household may have pumping cost but may not purchase water. The average coping cost was calculated based on the proportion of households with different kinds of costs.

Table 2. Average monthly coping cost in thousand VND

Costs	Piped water household	Non-piped water household
Pumping costs	16	31
Treatment costs (filter & boil)	16	18
Storage costs	10	7
Purchase costs	52	62
Average coping costs	25	75

4.2 Determinants of Willingness-to-pay Responses of Households

A household's willingness to pay for an improvement in water services would be a function of the proposed change in the attributes of the services, and of all other factors which influence the household's valuation of that change (Whittington et al, 2002). We hypothesize that the probability of responding "yes" to a proposed improvement scenario in water services is a function of three categories: (1) respondent and household characteristics; (2) perceptions of water problems; and (3) coping activities. The descriptions of these explanatory variables are presented below.

The first category of the explanatory variables encompass household size, number of children living in the family, composite income, and ownership of refrigerators (fridges). Those below 12 years old are defined as children in this study. This variable may have a positive or negative effect on the "yes" response depending on the household's affordability for substitute expenditures such as children's education, food, etc. The composite income, as shown in Section 4.2, includes both household income and the bid, and has the same sign as income. The variable 'fridge' was used for non-piped water households to identify those who could easily pay the connection fee. The scenario was that the respondent faced two bids: a one-time payment connection fee and a monthly bill. In the welfare measurement, connection fees were amortized and added up with monthly bills. However, in reality, a "yes" response depends on how large the connection fee is which in turn depends on the household's affordability to make a one-time payment of money. We captured the latter by using a proxy – ownership of fridge. We chose education level and gender of respondents as representative variables. Age was not included because respondents made decisions for the whole family, not just for themselves as individuals.

The second group of the explanatory variables relates how respondents perceive their water usage in terms of health effect, water outage and water pressure. The third group concerns the coping activities of respondent households in treating water service problems. For non-piped water households, the variable for 'ownership of tank' was not applied because there was a high level of homogeneity in this factor. The location of the house (*loca*) was a dummy variable, and referred to two main areas in Ho Chi Minh City: groundwater in area 1 is aluminous at different levels and ground water in area 2 is non-aluminous. We expected households in area 1, which included districts 6, 7, 8, 11, Nha Be, and Binh Chanh, to be more willing pay for the project scenario. The variable for sanitation (*sanit*) was included since if waste discharge goes to a septic tank, it may affect the quality of water in a private well by the endosmosis process.

We used the binary discrete choice models (see section 3.2.2) separately for piped water and non-piped water households. The results are presented in Table 3. Given the null hypothesis that the parameter β of the composite income and $\propto_i$ of other exogenous variables are equal to zero, we used the chi-square table for 11 degrees of freedom at the 95% confidence interval, which equals 19.67, to reject the hypothesis. The signs of the coefficients of both piped and non-piped water models all make sense, except for the *health* variable. In this case, answers for the questions on perceptions on the health effects of piped water are not homogeneous. In the case of non-piped water, the health effects are clearer and easier to perceive.

For piped water households, four coefficients – *hhsize*, *nchild*, *press* and *composite income* – are statistically significant at 99% level of confidence. The coefficient *gender* is statistically significant at 95% level of confidence. The probability of a "yes" increases with increases in household size, composite income and the incidence of male respondents. It decreases when water pressure is perceived as strong or normal, and with increases in the number of children in the household. Here, there seems to be a trade-off between the monthly water bill and other expenditures for children for households with a limited budget.

As for non-piped water households, three coefficients – *fridge*, *bottle* and *composite income* – are statistically significant at 99% level of confidence. The coefficient *avail* is statistically significant at 95% level of confidence. The probability of a "yes" response decreases with increases in the availability of water, in that a household with a private well that rarely runs out of water will have a lower probability of a "yes" response. The probability of a "yes" increases with increases in the composite income and if the household owns a fridge. As mentioned earlier, ownership of a fridge is a proxy for the affordability of a one-time payment connection fee. The probability of a "yes" also increases for households using bottled water for drinking purposes.

Table 3: Estimated parameters of the logarithmic utility model

	Piped-water service	**Non-piped water service**
Composite income	7.21 (0.000)	5.45 (0.000)
CONSTANT	-0.17 (0.491)	-0.76 (0.704)
Respondent and Household characteristics		
EDU	0.96E-03 (0.947)	0.32E-03 (0.979)
GENDER	0.23 (0.045)	0.15 (0.106)
HHSIZE	0.07 (0.000)	0.02 (0.185)
NCHILD	-0.18 (0.000)	0.05 (0.277)
HOUSE	0.23 (0.109)	0.04 (0.880)
FRIDGE	-	0.30 (0.002)
LOCA	-	0.13 (0.199)
Perceptions of water problems		
HEALTH	0.05 (0.626)	-0.15 (0.195)
AVAIL	0.16 (0.202)	-0.27 (0.023)
PRESS	-0.41 (0.000)	-
Coping activities		
FILTER	0.03 (0.846)	-
TANK	0.28 (0.016)	-
BOTTLE	-	0.35 (0.002)
SANIT	-	-0.09 (0.481)
Log-likelihood	-371	-516
Chi-squared	131	111
Number of observations	641	832

Note: p-values in parenthesis

4.3 Contingent Valuation Results

The WTP question for non-piped water households have vectors for two bids; the connection fee and the monthly water bill. So far, there are no models for this kind of WTP question from past research. One approach is include the two costs as separate variables. However, this would probably create problems in welfare measurement.

(Equation 2 in section 3.2.2 implies that there is only one cost variable, t, which is a trade-off for consuming the given goods or services.) Another approach is to convert the connection fee into a monthly cost and add it to the monthly water bill as one cost variable. This approach also poses a problem: there is a change in the payment vehicle. In the CV experiment, the respondent makes a choice based on a proposed one-time payment connection fee while in the welfare measurement, the connection fee is treated as a monthly amortization. These two payment vehicles would be seen as comparative on the assumption that the capital market in HCMC allows all households equal access to credit in paying for the connection fee. In other words, the government would need to guarantee a household's right of access to credit for the installment of tap water service.

The logarithmic utility model, with the assumption that the error term is normally distributed, was used to estimate the parameters shown in Table 3. Substituting these parameter values and the mean values of covariates in Table 1 into equations (5) and (6), we have estimates of the mean and median values of WTP for improved water services. The results are presented in Table 4. Values at 95% confidence intervals are also given. As mentioned earlier, we also used Turnbull estimates for non-piped water households to see the WTPs at various connection fee levels. The Turnbull WTP estimates are shown in Table 5.

Table 4. Estimated mean and median WTP in thousand VND

	Piped water households	**Non-piped water households**
Mean WTP	108 [26 – 191]	94 [11 – 176]
Median WTP	148 [74 – 221]	154 [91 – 218]

Note: 95% confidence interval in parenthesis. (The range is an indication of the accuracy of the welfare measures in the WTP.)

Table 5. Turnbull estimates for non-piped water households

Connec-tion fee	**700**		**1,200**		**1,800**		**5,000**	
Monthly bill	**Share of Yes (%)**	**Turnbull WTP**	**Share of Yes (%)**	**Turnbull WTP**	**Share of Yes (%)**	**Turnbull WTP**	**Share of Yes (%)**	**Turnbull WTP**
40	88	5	83	7	84	6	46	22
100	63	24	58	25	59	25	44	3
140	54	14	41	25	40	27	26	25
200	42	23	36	10	27	24	21	10
280	27	42	21	43	22	15	15	14
		108		110		97		74

For piped water households, the mean WTP for the proposed improved water service is 108,000 VND. The median WTP is 148,000 VND.

For non-piped water households, the mean WTP for connection to and use of improved water services is 94,000 VND. The median WTP is much higher at 154,000 VND. We chose the median WTP estimates for discussion for these were more sensible and robust than the mean WTP (Bateman et al, 2002).

The Turnbull estimates of WTP, given different connection fees, ranged from 74,000 VND to 108,000 VND. The higher the connection fee, the lower the monthly bill that the household is willing to pay. Although the Turnbull estimates are not directly comparable with parametric estimates, we can clearly see that there is no large divergence between parametric and non-parametric results in this study.

4.4 Choice Modeling Results

Two different multinomial logit models were estimated using the data from the survey. The first model (Model 1) shows the importance of choice set attributes in explaining a respondent's choice of two options; to continue in the current situation, i.e. using water from private wells, or to connect to the pipeline system. Attributes were described using effect codes. These codes are constructed for three level attributes by coding the first two levels as dummy variables, and the third as -1 (Adamowicz, Louviere & Williams, 1994). For example, the effect code for level 1 is created as follows: if the alternative contains the first level selected, level 1 = 1; if the alternative contains the second level, level 1=0; if the alternative contains the third level, level 1 = -1. In this way, the coefficent of the base level is the negative sum of the coefficients of the other two levels.

The second model (Model 2) includes both socio-economic variables to correct the heterogeneity in preferences. These variables are set to interact with an alternative specific constant (ASC). Utility is determined by the levels of the three attributes in the choice sets (cost, water quality, and water pressure). Therefore, the model provides an estimate of the effects of a change in any of these attributes on the probability that the project or status quo scenario will be chosen.

The parameter estimates of these models are presented in Table 6. In Model 1, the explanatory power of the model is relatively high (McFadden R-squared statistic is 26.99 percent). Coefficients for all attributes are statistically significant at 99% level of confidence and have the expected sign, except for the medium pressure variable (MEDP). The effect of the constant is positive and statistically significant at 99% level of confidence, indicating that if everything else is held constant, it is more likely that a household will maintain the status quo. The coefficient of the cost attribute is negative and statistically significant, indicating that for each thousand dong increase in a household's monthly bill, the probability of choosing piped water service over the status quo decreases by 0.02 (2%).

The results for Model 2 are shown in the third column of Table 6. Among the covariates, only the INCOME variable interacted with the alternative specific constant for the improved project alternative and is statistically significant at 99% level of confidence. Consistent with expectations, this interaction shows that respondents were more likely to support the improved water service project if they had a higher income.

Table 6: Multinomial logit models and marginal WTP with a change in each attribute

Variables	Descrip-tion	Model 1 Effect codes		Model 2 Effect code & ASC interaction	
		Coeff. (p-values)	**Marginal WTP (thousand VND)**	**Coeff. (p-values)**	**Marginal WTP (thousand VND)**
CONSTANT		2.7 (0.000)	-	4.7 (0.000)	-
COST	Monthly water bill	-0.02 (0.000)	-	-0.02 (0.000)	-
MEDQ	Medium water quality	0.6 (0.000)	33	0.8 (0.000)	41
HIGHQ	High water quality	1.7 (0.000)	87	1.9 (0.000)	94
MEDP	Medium water pressure	0.2 (0.100)	-	0.4 (0.004)	18
HIGHP	Strong water pressure	0.9 (0.000)	48	1.1 (0.000)	57
SEX	Gender of respondent	-	-	0.2E-01 (0.8451)	-
AGE	Age of respondent	-	-	-0.2-02 (0.5706)	-
INCOME	Monthly household income	-	-	-0.2E-03*** (0.2E-04)	-
Summary statistics					
Log-likelihood		-1568		-1362	
Chi-squared		1168		1233	
McFadden R^2		0.3		0.3	
Observations 399 samples (see Figure 1) x 8 lines/samples		3192 (0 skipped)		2941 (255 skipped)	

Estimates of implicit prices for each of the non-monetary attributes are shown in Table 6. These estimates indicate that, for example, households are willing to pay 33,000 VND per month for a change from the status quo to a medium quality of water and about 48,000 VND per month for strong water pressure.

However, these implicit prices do not provide welfare estimates of compensating surplus. The array of compensating surplus can be estimated by setting up multiple alternative scenarios. Table 7 presents the current state and four scenarios for the improved water service project and the corresponding estimated WTP for each scenario.

Estimates of compensating surplus (CS) are calculated using the following equation:

$$CS = -\frac{1}{\beta_M}(V_C - V_P) \tag{15}$$

where β_M is the marginal utility of income; V_C represents the utility of the current situation, and V_P represents the utility of the piped water project.

For Model 1 (Model 2 has a similar utility function, adding covariates), the utility function associated with the current situation is:

$$V_C = \alpha + \beta_{COST}.COST + \beta_{MEDQ}.MEDQ + \beta_{HIGHQ}.HIGHQ + \beta_{MEDP}.MEDP + \beta_{HIGHP}.HIGHP \quad (16\ )$$

The utility function associated with the specific levels of the attributes describing the changed scenario is:

$$V_P = \beta_{COST}.COST + \beta_{MEDQ}.MEDQ + \beta_{HIGHQ}.HIGHQ + \beta_{MEDP}.MEDP + \beta_{HIGHP}.HIGHP \quad (17)$$

Table 7: Estimates of household willingness to pay (thousand VND/month)

Scenario	**Description**	**Model 1**	**Model 2**
Current situation	Water quality of private wells is not good, need to boil and filter before drinking. Water pressure from in-house tanks is low.	-	-
Scenario 1	Good water quality, boil before drinking. Moderate water pressure.	-	83
Scenario 2	Good water quality, boil before drinking. Strong water pressure.	122	122
Scenario 3	Excellent water quality, drink directly from tap. Moderate water pressure.	-	137
Scenario 4	Excellent water quality, drink directly from tap. Strong water pressure.	170	175

Estimates of willingness to pay for the four scenarios are presented in Table 7. These are marginal estimates, showing willingness to pay for a change from the current situation. When estimating willingness to pay in Model 2, all of the socio-economic variables were set to their mean levels.

Calculating the compensating surplus (CS in equation 15) yields a negative sign, indicating that to maintain utility at current level V_C, given an improvement in water service, e.g. Scenario 4 in Model 1, a household's income must be reduced by 170,000 VND per month. Hence, the willingness to pay per household for a piped water project in Scenario 4 is equal to 170,000 VND.

4.5 Comparing WTP Estimates

Before discussing WTP results, it makes sense to take a look at the total cost of water. The total monthly water costs of piped water households comprise monthly water bills and coping costs. Given the estimated coping costs of 25,000 VND for piped water households (see Table 2) and the monthly water bill of 83, 800 VND (see Table 3), the average monthly expenditure for water is 108,800 VND. The total monthly water costs of non-piped water households comprise only coping costs, which is 75,000 VND on average.

The WTP estimates of piped and non-piped water households obtained through the CV method are not different although the latter have to pay connection fees. However, comparing combined WTP and water costs gives different results. The median WTP of piped water household for the improved water service is 148,000 VND (see Table 4), which is 35% higher than the average monthly water costs. For non-piped water households, the median WTP is double the average monthly water costs. Therefore, we can conclude that the relative WTP of non-piped households is much higher than the relative WTP of piped households.

The CM method gives some important WTP estimates. Estimates of marginal WTP for attributes of the water services, as shown in Table 6, demonstrate that non-piped households pay more attention to water quality than water pressure. For example, in Model 2, willingness to pay for excellent water quality is 94,000 VND while willingness to pay for strong pressure is 57,000 VND. These households appear to be more concerned about the quality of the good than the convenience of the water service.

There are few studies that compare CV and CM. Boxall et al (1996) show higher CV estimates compared with CM estimates of welfare changes on recreational moose hunting from changes in forest management practices and conclude that the results are sensitive to the choice of model. Adamowicz et al (1998a, p.11) compare CV and CM methods in measuring passive values and show that “once error variance is taken into account, the preferences over income between the two approaches are not significantly different”. Hanley et al (1998) found that welfare estimates of the conservation of Environmentally Sensitive Areas in Scotland using both CV and CM methods were fairly similar. In this study, the WTP estimates of non-piped households in the CV method are comparable with the WTP estimates for Scenario 4 in the CM method since both described the improved water service as providing excellent water quality and strong water pressure. In this study, the CM estimate is a little bit higher than the CV estimate. However, considering the confidence interval of the CV estimate, we can conclude that the difference between CV and CM estimates in this study is not significant.

While the CV and CM estimates are not significantly different, further research is clearly needed to confirm the validity of the results and methods in the developing country context as well as to test the sensitivity of both CV and CM estimates to the choice of the functional form (the WTP results from both CV and CM may depend on how the utility models are created).

5.0 CONCLUSION

This study applied the Contingent Valuation (CV) and Choice Modeling (CM) methods to measure households' preferences for improved water service. The willingness to pay ranged from 35% higher to more than double the existing water costs of households. The willingness to pay of a household in Ho Chi Minh City for improved water services was higher than the sum of the current average monthly water bill plus coping costs. Moreover, our results showed that the marginal values for the water quality attribute were much higher than for the water pressure attribute. To our knowledge, this is the first study to compare CV and CM results in the context of domestic water. The results also showed that welfare estimates obtained from both methods were fairly similar.

One interesting question is how WTP estimates, which were 148,000 VND and 154,000 VND for piped and non-piped households respectively, in the CV method and 175,000 VND for non-piped households in the CM method, could be compared. Piped households were willing to pay 3.5% of their monthly income for improved water service and the rate for the non-piped households ranged from 4.1% to 4.6%, depending on the CV or CM results. These figures are slightly lower than the international average for actual water bills, which is around 5% of household monthly income (United Nations, 2000), for an equal volume of water used. The demand for improved services in Ho Chi Minh City is modest because, in a sense, these households have already made the capital investments (i.e. coping behaviors) necessary to obtain better services.

A key policy implication of the results of this study is that policymakers can choose from a set of scenarios, which includes different levels of attributes and WTP estimates for each attribute, to design an improved water service project for Ho Chi Minh City. Policymakers have to consider the investments required, the service outcomes (i.e., how good the water quality and water pressure are), and the amount households are willing to pay for improved services. In addition, policymakers need to be aware that socio-economic characteristics and water use patterns of households will influence the willingness to pay for better water services. Without knowing the costs of providing various service improvements, we cannot recommend specific improvement measures. What we can state with clarity, nonetheless, is that survey respondents express a clear preference for improvements in water quality over water pressure and a considerable willingness to pay for it.

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