

## **Households' Willingness to Pay for Improved Tap Water Services in Karachi, Pakistan**

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## Abstract

Access to safe water is one of the major challenges facing households in Karachi, the most populated city of Pakistan. There are a wide range of factors that contribute to unsafe water and inefficiencies in water supply in Karachi, but one of the most significant is the poor infrastructure in piped water supply system. Thus, there is a need to develop water supply infrastructure for improving the tap water services. Currently, government is providing a subsidy on water services with flat rate tariff based on floor areas of domestic properties. As improvements in the tap water services will result in higher cost of the service, the cost recovery is the key requirement for providing the improved water services that can be sustained over time. Thus, there is a need to examine the demand and willingness to pay for improved water services, which will help the policy makers in designing an appropriate water tariff structure for generating sufficient revenue to cover the cost of improved water services.

This study uses a contingent valuation method to estimate the average WTP for improved tap water services with continuous supply of tap water that is of good quality and potable without boiling or any other treatment. The study examines the WTP and its determinants by using single and double bound dichotomous choice elicitation questions. Three models, namely, probit model, interval data model and bivariate probit model, are estimated using household level data from Block 4 and Block 7 of Gulshan-e-Iqbal Town in Karachi. A sample of 373 households was randomly selected from the study area, and data were collected by surveying households and conducting in-person interviews using structured questionnaire.

The results show that the average WTP is in the range of Rs. 604 – 734 per month by households whose income is less Rs. 20,000 per month. The results show that the average WTP increases as the income level increases. The overall average WTP from all income classes is in the range Rs. 1,922 – 2,126 per month whereas the current average bill paid is Rs.703 per month. These results show that the households are willing to pay much more than what they currently pay for a safe and regular water supply service. This study recommends investment in infrastructure projects that improve the water supply services in the city. The study presents the evidence that cost recovery is possible by increasing tariffs for higher income households. A major implication of this study is imposition of cross subsidization.

*Keywords:* Non-market valuation, Contingent valuation method, safe water, Willingness to pay, Karachi.

*JEL Classification:* Q53, L95

## 1. Introduction

Access to safe water is a basic need for human survival and health. Water is one of the most important commodities for households, who use it for drinking and many other important household activities including cooking a meal, washing dishes, bathing, laundry, cleaning, and watering the home gardens. Households need safe water and its availability on regular basis. Irregular and uncertain access to safe water affects not only these activities directly but also households' health and workforce productivity indirectly. Thus, households give great importance to water, its quality and regular supply.

Karachi is the most populated city of Pakistan with population over 13 million in 2010 and is among top ten mega-cities of the world (Government of Pakistan, 2010). Insufficient access to safe water is one of the major challenges facing households in Karachi city due to its burgeoning population and increasing demand for water. According to City District Government Karachi (2007), only 60 percent of the households in Karachi are connected to piped water supply, provided by the city government through the Karachi Water & Sewerage Board (KWSB). Furthermore, water is delivered on schedule for only four hours per day, which is often irregular and uncertain in many locations due to poor infrastructure and inadequate maintenance of piped water supply system. Given the water shortage in the city, the residents buy water from private water tankers.

In addition to inadequate quantity of water, the quality of water is also a big issue. According to Pakistan Council of Research in Water Resources (PCRWR, 2007), water in Karachi is unsafe to drink as it is mostly contaminated with Coliforms and *E. coli*. PCRWR (2007) collected water samples from major parts of Karachi and found that 93 percent of the water samples were unsafe as they were contaminated with Coliforms and *E. coli* (86 percent) and had excessive level of mineral and elements (7 percent). Water provided to households in Karachi is unsafe to drink because it is not properly treated and is contaminated as a result of the leakage of sewage and industrial waste through damaged pipes. For drinking purpose, some households boil water, filter water, or purchase bottled water. Due to unawareness and other reasons, many households are not able to adopt these coping activities, and continue to face health issues caused by unsafe water. PCRWR (2007) reports that every fifth citizen in Pakistan suffers from illness caused by unsafe water. Thus, there is a need to address the issue of both quantity and quality of water.

There are a wide range of factors that contribute to water supply inefficiencies and unsafe water in Karachi, but one of the most significant is the poor infrastructure in piped water supply system. The existing water supply network in Karachi is over 100 years old and has become outdated and defective. According to a study conducted by Asian Development Bank (ADB, 2004), capital expenditure per connection in Karachi is only US\$7 per year, which is one of the lowest in the region. It is US\$78 in Delhi, US\$140 in Dhaka, and the average expenditure in major Asian cities is US\$88 (ADB, 2004). Furthermore, only 0.3 percent of the water connections are metered in Karachi and the remaining connections (99.7 percent) are charged with flat rate tariff based on floor areas of domestic properties, resulting in unchecked high consumption of water by the connected households. The main reason of low expenditure on water supply infrastructure is insufficient revenue generated from collection of water bills, which does not even cover operations and maintenance costs. The estimated average tariff per cubic meter of water in Karachi is only US\$0.07, which is one of the lowest

in the region. The average tariff in the region based on selected Asian cities is US\$0.24 (ADB, 2004). The estimated average tariff rate is computed as total revenue from tariff divided by total consumption of water. Thus, the reasons for a low tariff rate in Karachi include flat tariff rate based floor area, low collection efficiency (54 percent), and unchecked high consumption of water by the connected households. Given the poor infrastructure in the piped water supply system, Karachi needs more funds for improving tap water supply infrastructure as well as for its operation and maintenance in order to improve the water efficiencies and water quality in the city.

Considering the importance of access to safe water, the government has been making efforts to improve the tap water services in Karachi. In July 2013, KWSB has launched a water supply project, named K-IV Project, in collaboration with the China International Water and Electric Corporation (CWE) with aims to augment the water supply and to improve the quality of water in Karachi in near future. Currently, the government is providing a subsidy on water services with flat rate tariff based on floor areas of domestic properties in Karachi. According to a study by Briscoe *et al.* (2005) the subsidized tariff benefits more to those living in higher income areas rather than the poor. As improvements in the tap water services will result in higher cost of the service, the cost recovery is the key requirement for providing the improved water services that can be sustained over time.

As water is a basic need, appropriate pricing policy must take into account how much consumers place value and are prepared to pay for improvement in the tap water services, which varies depending on household income and other factors. Thus, there is a need to examine the demand and willingness to pay for improved tap water services by different income classes of households, which will help the policy makers in designing an appropriate water tariff structure for generating sufficient revenue to cover the cost of improved water services.

Estimation of willingness to pay also provides the information on the monetary value of the benefits from improving the access to safe of water. This information is useful for policy makers in making investment decisions based on benefits and costs of improvement of water services. Furthermore, in developing countries, policy makers generally do not give its due consideration to investment for the provision of improved water supply schemes as they assume that the public is unwilling to pay a higher tariff and the cost of the project will fall onto the already heavily burdened national exchequer unless a donor or lending agency proposes to fund the service provision. Failure to designing proper pricing policy for water services in the past has resulted in under-investment, poor maintenance, slow progress in extending coverage, and wastage of water. Therefore, estimation of the willingness to pay will be useful for policy makers in making efficient investment decisions as well as in designing pricing policies for sustainable management and provision of water services that will improve the welfare of the society.

The objective of this study is to evaluate the households' willingness to pay (WTP) for improved tap water services by different income classes of households in Karachi. This study uses contingent valuation method (CVM) and uses the single and double bound dichotomous choice elicitation techniques. WTP is estimated by probit model, interval data model and bivariate probit model using survey data from sample households connected to tap water services in Karachi.

The remainder of this paper is organized as follows. The next section presents a brief literature review. Section 3 specifies the model of this study. Section 4 presents the estimation methods. Section 5 describes study area, sampling and data collection methods. Section 6 presents the empirical results of the study. Finally, Section 6 draws conclusion and offers their policy implication.

## 2. Literature Review

CVM became popular for valuation of infrastructure projects in developing countries after Whittington (1987) who specifically used CVM as a tool for helping to evaluate water supply projects. According to Birol *et al.* (2006), more than 5000 CVM studies have been conducted in over 100 countries to examine water related issues and other resource. Cities for which such studies have already been conducted include Dhaka (Chowdhry, 1999), Calcutta (Guha, 2007), central Tanzania (Kaliba *et al.*, 2002), Colombo (Jones *et al.*, 2006), Khulna (Gunatilake & Tachiiri, 2012). Such studies have also been conducted in Pakistani cities including Abbottabad (Haq *et al.*, 2007), Hyderabad (Sattar & Ahmad, 2007), Peshawar (Khan, 2010), and one for rural Punjab (Altaf *et al.*, 1992). Presented below is a summary of a few of these studies.

Bogale and Urgessa (2012) estimated willingness to pay of rural households for improved water service in Haramaya district, Ethiopia. The study administered double bounded dichotomous choice method, and data were analyzed using the bivariate probit model. It was revealed that households expressed a mean WTP of 27.30 cents per 20 liters. Main determinants of WTP were household income, education, sex, time spent to fetch water, water treatment practice, quality of water and expenditure on water, and age of the respondent.

The factors that explained citizens' willingness to pay in Ado Ekiti (Olajuyigbe & Fasakin, 2010) were main source of domestic water used by household, access to improved source of water, distance from main source to house, average time spent to fetch water, adequacy of supply, quantity of water used per person per day, quantity of water purchased per day, incidence of water borne diseases, performance of water providing institution and average amount spent on water during the dry season. There are several other studies that have been conducted all around the world that have given similar results.

Banda *et al.*, (2007) used a tobit model to analyze factors affecting the probability that a household is willing to pay for both improved quantity and quality of water in rural area of South Africa. The study found that households' income, availability of water, households' access to a tap and water per capital, monthly water consumption were significant determinants of WTP.

Lema & Beyene (2012) studied WTP for improved water services in Goro-Gutu district of Eastern Ethiopia. The study uses both binary and ordered probit models to examine the determinants of willingness to pay. The estimated mean and median willingness to pay was found to be Birr 6.83 and 5.87 per household per month.

A study by the World Bank shows that contingent valuation correctly predicted 91% of the decisions of investments in piped water system (Cropper and Alberini, 1998). Wattage *et al.* (2000) argue persuasively that contingent valuation (CV) is the most all-encompassing way to measure the benefits of water quality improvement investments.

Review of the previous studies show that there are a number of elicitation techniques and econometric models to estimate WTP. CVM is used for recovering the information about willingness to pay by direct questions. There are different types of elicitation techniques in CVM to elicit WTP information. The closed-ended dichotomous choice techniques have become credible approach in CVM studies (Haab and McConnell, 2002). Therefore, this study uses dichotomous choice closed-ended questions.

With dichotomous choice closed-ended questions, most commonly used techniques are single-bound and double-bound dichotomous choice questions. In single-bound dichotomous choice, respondent is asked only once about WTP and is expected to answer yes or no. In this case, WTP can be estimated by probit model. In the double-bound dichotomous choice, respondent is asked a follow-up question contingent upon the response to the initial question. Hanemann, Loomis and Kanninen (1991) showed that a follow-up question significantly increases the statistical efficiency of willingness to pay estimates. In this case, WTP can be estimated by interval data model. However, the literature indicates that the respondent is likely to change or adjust the value of WTP when the second question is asked. To address this issue, bivariate probit model was used to estimate WTP. However, Haab and McConnell (2002) raises the concern that the researcher has to decide whether to rely on the WTP based on initial or follow-up response. Thus, with dichotomous choice closed-ended questions, most of the previous studies have used one of the following models: probit model, interval data model and bivariate probit model. For checking robustness of the results, the present study uses these three econometric approaches, namely, probit model, interval data model and bivariate probit model, to estimate the WTP for improved tap water services in Karachi.

### **3. Model**

This study measures the willingness to pay (WTP) for improved tap water services to households in Karachi. There are two broad categories of approaches to measure the willingness to pay: stated preference and revealed preference. Stated preference approaches, such as contingent valuation methods, use survey techniques to elicit willingness to pay and allow the researcher to evaluate the benefits of specific changes or improvement in a service. Revealed preference approaches, such hedonic pricing models and averting expenditure methods, are based on actual observable choices that allow the value of improvement in service to be directly inferred from those choices (Tietenberg and Lewis, 2012). As mentioned in the introduction, tap water is delivered only four hours per day to the connected households, and the water is generally unsafe in Karachi. This study aims to measure the willingness to pay for a service with continuous supply of tap water that is of good quality and potable without boiling or any other treatment. As there are no households receiving such service in Karachi, this study uses contingent valuation method of stated preference approach to measure the WTP for improved tap water services.

This section presents the economic theory WTP in the context of CVM (Haab and McConnel, 2002), and specifies econometric model of WTP function.

### 3.1 Economic Theory of WTP

Consider a household who maximizes a utility function subject to a budget constraint, and the household's indirect utility function is as follows:

$$V = V(p, q, y) \quad (1)$$

where  $p$  is the vector of the prices of the market commodities,  $q$  is the status of tap water services acquired by the household, and  $y$  is the household income.

Denote  $q_0$  as the existing status of tap water services received by the household, and  $q_1$  as the improved status of tap water services. In this study, improved status is represented by a scenario such that the household will receive continuous water supply with sufficient pressure, and the water will be of good quality and potable without boiling or any other treatment. The value of the change to household in monetary terms is represented by the Hicksian measure, the compensating variation  $C$  which satisfies:

$$V(p, q_1, y - C) = V(p, q_0, y) \quad (2)$$

As the change in  $q$  from  $q_0$  to  $q_1$  is an improvement in the tap water services and raises the household's utility level,  $C$  would be positive. In this case,  $C$  measures the household's willingness to pay (WTP):

$$V(p, q_1, y - WTP) = V(p, q_0, y) \quad (3)$$

WTP is the maximum amount of money the household will pay in exchange for the improvement in the tap water services from  $q_0$  to  $q_1$ . Solving Equation (3) for WTP provides WTP function:

$$WTP = WTP(p, y, q_0, q_1) \quad (4)$$

The WTP function in Equation (4) indicates that WTP depends on the prices of the market commodities ( $p$ ), the household income ( $y$ ), the existing status of tap water services acquired by the household ( $q_0$ ), and the improved status of tap water services ( $q_1$ ).

### 3.2 Econometric Specification of WTP Function

For estimating WTP function using cross sectional household level data, we need to specify econometric model. We assume that the all households face the same prices of the market commodities ( $p$ ) and the same improved status of tap water services ( $q_1$ ). Thus, WTP varies across households depending on the household income ( $y$ ) and the existing status of tap water services ( $q_0$ ). Furthermore, household's WTP may also be affected by other household characteristics. Thus, the econometric model for WTP is specified as:

$$WTP = e^{x\beta + \varepsilon} \quad (5)$$

where  $x$  is the vector of explanatory variables,  $\beta$  is the vector of unknown parameters, and  $\varepsilon$  is the error term representing the unobserved other factors. In Equation (5), the exponential WTP function ensures that the predicted WTP is positive and thus does not provide any negative predicted values of WTP. This property is important as WTP is the maximum amount of money the household will pay in exchange for the improvement in the tap water services. For estimating WTP function, Equation (5) can be re-written as:

$$\ln(WTP) = x\beta + \varepsilon \quad (6)$$

In this study, the explanatory variables for the above econometric model include dummy variables for different income classes, number of hours of water per week received by the household, household's rating for water quality, residence type (single or double storied house), and block of study area. Further details of these variables are presented in the results.

#### **4. Estimation Methods**

The purpose of contingent valuation method is to estimate individual WTP for changes in the quality of goods or services. This section describes methods for estimating the WTP function specified above. Estimation method depends on how the information on WTP is elicited. This section describes elicitation techniques and methods for estimating the WTP function used in this study. We follow the estimation methods given in (Haab and McConnell, 2002) and Lopez-Feldman (2012).

##### **4.1 WTP Elicitation Techniques**

CVM is used for recovering the information about willingness to pay by direct questions. There are different types of elicitation techniques in CVM to elicit WTP information. These include: open-ended question, bidding games, payment cards, closed-ended single-bound dichotomous choice question, and closed-ended double-bound dichotomous choice questions. Among these, the closed-ended dichotomous choice techniques have become credible approach in CVM studies (Haab and McConnell, 2002). Therefore, this study uses both single-bound and double-bound dichotomous choice closed-ended questions.

In the single-bound dichotomous choice question format, the respondent is asked whether he or she would be willing to pay a certain monthly charge for improved tap water services. In this format, each individual is offered a single bid value and is expected to answer yes or no. The individual would answer yes if his/her WTP is greater than the offered bid amount, and would answer no if his/her WTP is less than the offered bid amount.

In the double-bound dichotomous choice, the respondent is followed up by a second question about willingness to pay contingent upon the response of the first question. The second question would be asked with a higher bid amount if the answer to the first question is yes, or with a lower bid amount if the answer to the first question is no. The respondent is expected to answer yes or no to the second question.

## 4.2 Estimation Methods with Single-Bound Dichotomous Choice

WTP function in Equation (6) for an individual  $i$  can be written as:

$$\ln(\text{WTP}_i) = x_i\beta + \varepsilon_i \quad (7)$$

In the single-bound dichotomous choice question format, the respondent is asked whether he or she would be willing to pay a certain monthly charge for improved tap water services. In this format, each individual is offered a single bid value and is expected to answer yes or no. The individual would answer yes if his/her WTP is greater than the offered bid amount, and would answer no if his/her WTP is less than the offered bid amount.

$$\text{WTP}_i \geq \text{bid}_i \text{ if the answer is yes}$$

$$\text{WTP}_i < \text{bid}_i \text{ if the answer is no}$$

Denote  $y_i = 1$  if the answer is yes and  $y_i = 0$  if the answer is no. The probability of  $y_i = 1$  is a function of the explanatory variables and can be written as:

$$\Pr(y_i = 1 | x_i) = \Pr(\text{WTP}_i > \text{bid}_i) \quad (8)$$

$$\Pr(y_i = 1 | x_i) = \Pr(\ln(\text{WTP}_i) > \ln(\text{bid}_i)) \quad (9)$$

Plugging Equation (7) into Equation (9) yields:

$$\Pr(y_i = 1 | x_i) = \Pr(x_i\beta + \varepsilon_i > \ln(\text{bid}_i)) \quad (10)$$

$$\Pr(y_i = 1 | x_i) = \Pr(\varepsilon_i > \ln(\text{bid}_i) - x_i\beta) \quad (11)$$

For probit model, it is assumed that the error term  $\varepsilon_i$  has a normal distribution  $N(0, \sigma^2)$ . In this case, Equation (10) can be written as:

$$\Pr(y_i = 1 | x_i) = \Phi\left(\frac{x_i\beta}{\sigma} - \frac{\ln(\text{bid}_i)}{\sigma}\right) \quad (12)$$

where  $\Phi(\cdot)$  denotes the standard cumulative normal distribution function. There are two approaches to estimate this model. The first one is to use Equation (12) and apply maximum likelihood estimation methods to estimate  $\beta$  and  $\sigma$ . The other approach, which we use in this study, is to directly estimate the probit model with  $x_i$  and  $\ln(\text{bid}_i)$  as explanatory variables, which can be estimated in STATA or any other software. In this case, we obtain the estimates of  $\beta/\sigma$  and  $-1/\sigma$  after estimating the probit model (see Equation (12)). For the results of probit model, denote  $\hat{\beta}/\hat{\sigma}$  as the vector of coefficient estimates associated to each one of the explanatory variables and  $-1/\hat{\sigma}$  as the coefficient estimate on  $\ln(\text{bid}_i)$ .

The expected value of WTP can be computed for individuals with given values of explanatory variables  $\tilde{x}$  as:

$$E(WTP|\tilde{x}) = e^{\tilde{x}\hat{\beta}+0.5\hat{\sigma}^2} = e^{-\frac{\tilde{x}\hat{\beta}/\hat{\sigma}}{-1/\hat{\sigma}}+0.5\hat{\sigma}^2} \quad (13)$$

## 4.2 Estimation Methods with Double-Bound Dichotomous Choice

In the single-bound dichotomous choice question format, the respondent is offered a single bid value and is expected to answer yes or no only once. In the double-bound dichotomous choice, the respondent is followed up by a second question about willingness to pay contingent upon the response of the first question. Denote  $\text{bid}_1$  as the bid amount in the first question. The second question would be asked with a higher bid amount ( $\text{bid}_{2(\max)}$ ) if the answer to the first question is yes, or with a lower bid amount ( $\text{bid}_{2(\min)}$ ) if the answer to the first question is no. The respondent is expected to answer yes or no to the second question.

With double-bound dichotomous choice questions, WTP can be estimated either by the interval data model or by a bivariate probit model.

### 4.2.1 Interval Data Model: Ordered Probit Model

This section describes estimation method by the interval data model (also referred to as ordered probit model) with double-bound dichotomous choice questions format. Given the responses of two questions, the bounds on the WTP depend on the answers to the two questions:

$WTP \geq \text{bid}_{2(\max)}$  if the responses are yes and yes

$\text{bid}_1 < WTP \leq \text{bid}_{2(\max)}$  if the responses are yes and no

$\text{bid}_{2(\min)} < WTP < \text{bid}_1$  if the responses are no and yes

$WTP < \text{bid}_{2(\min)}$  if the responses are no and no

The probability of each one of the possible response sets given above is given by:

#### 1. Yes and Yes:

$$\Pr(y_{1i} = 1 \text{ and } y_{2i} = 1 | x_i) = \Pr(WTP > \text{bid}_{2(\max)}) \quad (14)$$

Following the procedure described in Section 4.1, Equation (14) can be written as:

$$\Pr(y_{1i} = 1 \text{ and } y_{2i} = 1 | x_i) = \Phi\left(x_i \frac{\beta}{\sigma} - \frac{\ln(\text{bid}_{2(\max)})}{\sigma}\right) \quad (15)$$

## 2. Yes and No:

$$\Pr(y_{1i} = 1 \text{ and } y_{2i} = 0 | x_i) = \Pr(\text{bid}_1 < WTP < \text{bid}_{2(\max)}) \quad (16)$$

$$\Pr(y_{1i} = 1 \text{ and } y_{2i} = 0 | x_i) = \Phi\left(x_i \frac{\beta}{\sigma} - \frac{\text{bid}_1}{\sigma}\right) - \Phi\left(x_i \frac{\beta}{\sigma} - \frac{\text{bid}_{2(\max)}}{\sigma}\right) \quad (17)$$

## 3. No and Yes:

$$\Pr(y_{1i} = 0 \text{ and } y_{2i} = 1 | x_i) = \Pr(\text{bid}_{2(\min)} < WTP < \text{bid}_1) \quad (18)$$

$$\Pr(y_{1i} = 0 \text{ and } y_{2i} = 1 | x_i) = \Phi\left(x_i \frac{\beta}{\sigma} - \frac{\text{bid}_{2(\min)}}{\sigma}\right) - \Phi\left(x_i \frac{\beta}{\sigma} - \frac{\text{bid}_1}{\sigma}\right) \quad (19)$$

## 4. No and No:

$$\Pr(y_{1i} = 0 \text{ and } y_{2i} = 0 | x_i) = \Pr(WTP < \text{bid}_{2(\min)}) \quad (20)$$

$$\Pr(y_{1i} = 0 \text{ and } y_{2i} = 0 | x_i) = 1 - \Phi\left(x_i \frac{\beta}{\sigma} - \frac{\text{bid}_{2(\min)}}{\sigma}\right) \quad (21)$$

The parameters of the model  $\beta$  and  $\sigma$  can be estimated by maximum likelihood estimation method using the above probability functions given in Equations (15), (17), (19), and (21). In this study, the model is estimated using the “doubleb” command in STATA 11. Given the maximum likelihood estimates  $\hat{\beta}$  and  $\hat{\sigma}$ , the expected value of WTP can be computed for individuals with given values of explanatory variables  $\tilde{x}$  as:

$$E(WTP | \tilde{x}) = e^{\tilde{x}\hat{\beta} + 0.5\hat{\sigma}^2} \quad (22)$$

### 4.2.2 Bivariate Probit Model

Like the interval data model, the bivariate probit model is another method for two-response surveys with double-bound dichotomous choice questions. The bivariate probit model was initially introduced by Cameron and Quiggin (1994). It was argued that when the individuals are asked two questions, the respondents may reconsider about their WTP and the distribution of WTP may change from initial question to the follow-up question. The bivariate probit model allows for the possibility of different distributions of WTP across the initial and follow-up question while the interval data model assumes the same distribution of WTP during initial question and the follow-up question.

In the bivariate probit model, the two dichotomous choice responses are simultaneously modeled as single-bounded, i.e. two correlated WTP equations with jointly distributed normal error terms. The bivariate probit model relaxes the restrictive assumptions of the interval data model and solves the problem of potential bias caused by these assumptions. We use probit because it allows for non-zero correlation, while the logistic distribution does not. In the bivariate probit model, the WTP functions for an individual  $i$  can be written as:

$$\ln(WTP_{1i}) = x_i\beta_1 + \varepsilon_{1i} \quad (23)$$

$$\ln(WTP_{2i}) = x_i\beta_2 + \varepsilon_{2i} \quad (24)$$

It is assumed that the error terms,  $\varepsilon_1$  and  $\varepsilon_2$ , are normally distributed with mean zero and respective variances  $\sigma_1$  and  $\sigma_2$ , and have a bivariate normal distribution with correlation coefficient  $\rho$ . The bivariate probit model was estimated by the maximum likelihood estimation technique using “biprobit” command in STATA 11.

As the distributions of WTP are likely to be different across the initial question and follow-up question, the researcher has to decide which distribution to use for estimating WTP even after estimating the both distributions in the bivariate probit model. As used in most of the CVM studies, we use initial distribution of WTP as given in Equation (23). After estimating the bivariate probit model, the expected value of WTP can be computed for individuals with given values of explanatory variables  $\tilde{x}$  as:

$$E(WTP|\tilde{x}) = e^{\tilde{x}\hat{\beta}_1 + 0.5\hat{\sigma}_1^2} = e^{-\frac{\tilde{x}\hat{\beta}_1/\hat{\sigma}_1}{-1/\hat{\sigma}_1} + 0.5\hat{\sigma}_1^2} \quad (25)$$

## 5. Data

### 5.1 Study Area

Karachi lies on Pakistan's southern coast, on the Arabian Sea just northwest of the Indus River Delta. It is also the principal seaport and financial center of Pakistan. The city consists of 18 towns, which are governed by elected municipal administrations responsible for infrastructure planning, development facilitation, and municipal services which include water, sanitation, solid waste, repairing roads, parks, street lights, and traffic engineering. The KWSB is a public sector organization responsible for production, transmission and distribution of water services to the citizen of Karachi. Of these 18 towns, Gulshan Town is a main residential area of the city, with a population of over a million people (Maps are given in Figures 1 and 2).



Figure 1: Map of Pakistan

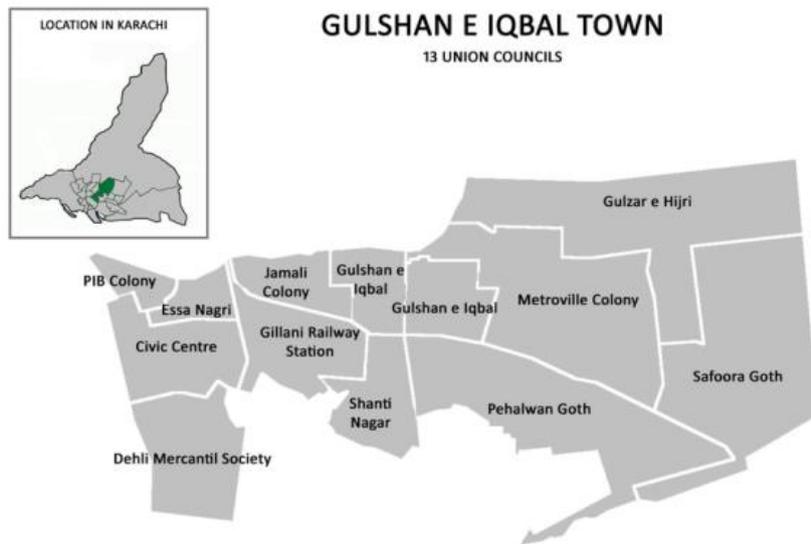


Figure 2: Map of Gulshan-e-Iqbal Town in Karachi

## 5.2 Sample and Sampling Strategy

Given the geographical expanse of the city, a meaningful number could not have been estimated with a sample size of 373 household if the entire city was surveyed. The sample was thus restricted to two neighborhoods in just one town in the city: Gulshan-e-Iqbal. Out of the 2879 households connected to the piped water services, a sample of 373 would be representative at 5% margin of error. Gulshan-e-Iqbal is selected because the town is a major residential town in the city and is known for its income and ethnic diversity. Within the town, Block 4 and Block 7 have been selected. Both the towns are similar in terms of size (Figure 3); however bill collection in Block 4 is lower than in Block 7 (Table 4.1). Choosing two locations, which although adjacent, but with its unique neighborhood characteristics, will help ascertain if location is also a major determinant of WTP.

A total sample of 400 was collected using random sampling. Starting at a certain location surveyors were asked to knock at every fifteenth house on their left, alternating between left and right at every turn. In case of non-response, they were asked to knock on the next door. As some of the respondent did not answer to question on income, the final dataset for the analysis was with 373 observations.



Figure 3: Map of Block 4 and 7, Gulshan-e-Iqbal, Karachi

Table 1: Block-wise Revenue Collection

	Total Number of Bills	Total Receipt (Rs./month)
Block 7, Gulshan-e-Iqbal, Karachi	2201	7712460
Block 4, Gulshan-e-Iqbal, Karachi	2678	6473321

### 5.3 Questionnaire and Data Collection Method

While designing the questionnaire (Appendix A) an attempt was made to minimize strategic, hypothetical and compliance biases which may arise from CV survey. To minimize strategic bias, an introductory statement was read to all respondents before interviewing began to clarify the purpose of the survey. Hypothetical bias is unlikely to occur since the service in question is familiar to all respondents of the town. In order to reduce compliance bias, the survey was carefully designed and interviewers were trained. The questionnaire includes the following sections: existing water supply situation, incidence of water related diseases, CV questions on willingness to pay, and household characteristics and income.

#### Contingent Scenario

As given in the questionnaire, for eliciting the WTP, the respondents were informed about the contingent scenario. Improved status of tap water services is represented by a scenario such that the household will receive continuous water supply with sufficient pressure, and the water will be of good quality and potable without boiling or any other treatment.

#### Payment Vehicle and Bid Values

In the present study, we have chosen monthly water bill as payment vehicle for WTP. Households were asked whether they are willing to pay a certain monthly charge for improved water supply services. The questionnaire uses double-bounded dichotomous choice questions, where respondents were followed up by a second question contingent upon the response of the initial bid. To obtain a preliminary guess about the WTP distribution we conducted a pilot study to determine bid values. Very low bids elicited all “Yes” responses and very high bids elicited all “No” responses. The current bid structure gave a varied combination of the two. Table 2 presents the initial bid values and bid values in the follow-up question. The level of initial bid was randomly assigned to each household.

Table 2: Bidding Structure

$bid_1$	500	1000	2000	4000	5000
$bid_{2(max)}$	1000	2000	3000	5000	7000
$bid_{2(min)}$	250	500	1500	2500	3000

Survey was done with double-bounded dichotomous choice questions which had two questions with initial bid and a follow-up bid to be used for estimating the interval data model and bivariate probit model. For estimating the probit model with single-bound dichotomous choice, only initial bid was considered in the analysis.

#### Data Collection Method

A household survey, as opposed to telephone interviews, was conducted keeping in view the suggestions from the NOAA panel report (Arrow *et al.*, 1993). Data were collected by surveying households and conducting in-person interviews using structured questionnaire (Appendix A). The survey was conducted on weekends and public holidays in December

2012 so that household heads could be found at home. Eleven interviewers were trained for data collection. Each interviewer conducted an average of 15 interviews a day. Fifty percent of the questionnaires were answered by household heads. However, it was made sure that all respondents were above the age of 18 years.

## 6. Empirical Results

This chapter presents the empirical findings of our contingent valuation survey, and discusses the results obtained. Both descriptive analyses and econometric analysis is used. In the descriptive analyses, coping behavior and costs are analyzed along with a summary statistics of household income and expenses. In the econometric analysis, estimation results from the interval data model and bivariate probit model are presented. Finally, we estimate the mean willingness to pay.

### 6.1 Descriptive Statistics

#### 6.1.1 Importance of Water

The households were given the list of selected social services (Health, Road, Power, School, Telephone and Water) and were asked to rank in accordance with their priority of need: 1 being the most important, 6 being the least important. Survey results show that 37 percent of the respondents rated water as the most important public utility (Figure 4). Each utility was assigned a score according to the ranking given by the respondents' rankings. According to the scores, overall, water ranks second after health (Figure 5). This shows that water is an essential need of the public.

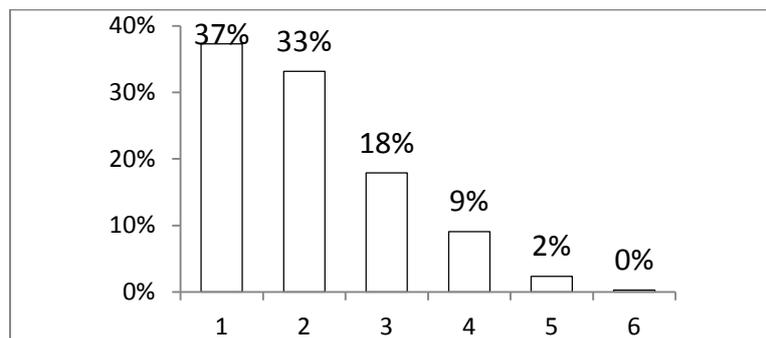


Figure 4: Ranking of Water

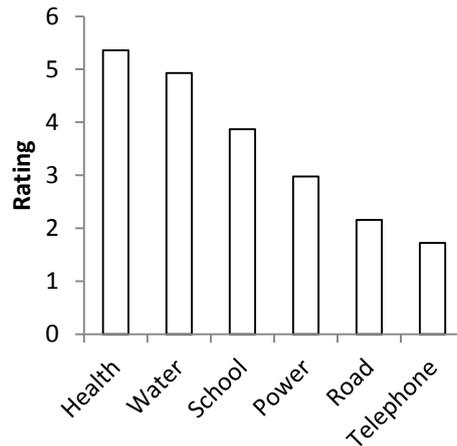


Figure 5: Ratings of Various Social Services

### 6.1.2 Water Services and Coping Behavior

According to the study, the surveyed households receive 27 hours of water supply in a week on average. When asked to rate their satisfaction from current piped water supply and its various aspects on a scale of 1 to 5 (1 being the lowest), it is revealed that users were only moderately satisfied with current water supply (Figure 6). Inadequate and unreliable water supply has made consumer to move towards more reliable alternatives. In order to meet the daily water needs consumers on one hand need to use alternative water sources such as mineral water, water tankers and boring wells; while on the other, they need to treat water due to unreliability of its quality. The Venn diagram in Figure 7 shows the percentage of people using Water Tankers, Boring wells and Mineral Water. Eighty percent of the households run motors to pump water from the lines, or to pump water from wells. Ten percent of the respondents have a well installed. On average, respondents also run their electric motors for 3 hours/day. Twenty three percent of the households use water tankers to meet their water requirements while the 50% of households drink mineral water (Figure 7). Only 10 % of the respondents did not use any of these alternate water sources. As the quality of the water is not reliable, 60% of the households use some form of water purification method. Figure 12 shows the percentage of people who treat water with some purification method to make it drinkable.

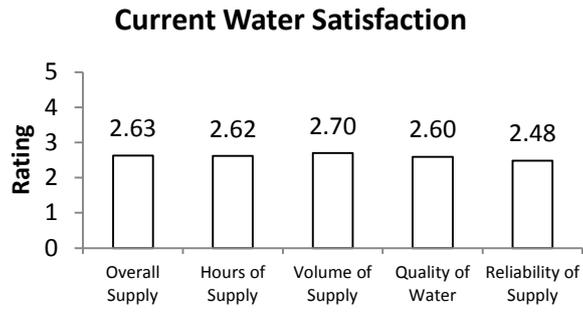


Figure 6: Water Satisfaction Level

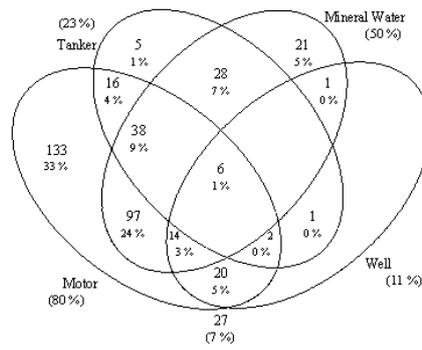


Figure 7: Coping Behavior

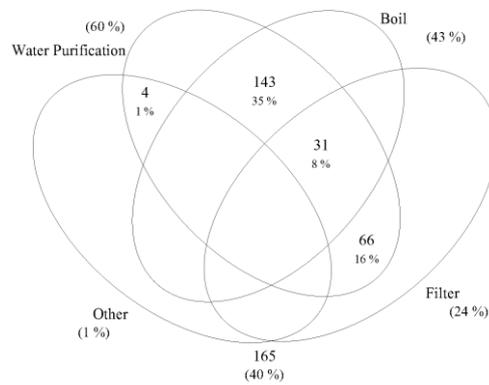


Figure 8: Water Treatment Methods

## 6.2 Regression Results

To estimate WTP, three models are estimated: probit model, interval data model and bivariate probit model, as explained in Section 4. For examining the determinants of WTP, these models include the following explanatory variables: dummy variables for different income classes, number of hours of water per week received by the household, household's rating for water quality, residence type (single or double storied house), and block of study area (Block 4 or Block 7 of Gulshan-e-Iqbal town in Karachi). Four income classes were defined based on household's monthly income in the following ranges: less than Rs. 20,000; Rs. 20,000 – 50,000; Rs. 50,000 – 100,000; and greater than Rs. 100,000. Given these four income classes, three dummy variables were created for all other income classes except the lowest income class, which is represented by the intercept (constant) of the regression model.

Table 3 presents the regression results of the three models. The results of all models show that dummy variables of income classes are statistically significant at 1% or 5% level of significance and the sign is positive as expected. This result is consistent with economic theory, which states that demand for a particular commodity depends on income. Results indicate that higher income households are willing to pay more amount for an improved tap water service than lower income households. Availability of water in terms of number of hours of water per week received is statistically significant. Results show that the household who receive more hours of water are willing to pay relatively less amount. Satisfaction of water quality perceived by households is also statistically significant. Results show that the household who are relatively less satisfied with the existing water quality are willing to pay relatively more amount. Residence type is significant in interval data model. Its positive sign indicates that the households with double-storied house are willing to pay more amount as compared to those with single-storied house. Regression results show that the natural log of bid amount is statistically significant at 1% level of significance and its sign is negative. This result is consistent with the economic theory. The probability of yes-responses decreases as the bid amount increases.

## 6.3 Average WTP for Improved Tap Water Services

The average WTP estimates based on results of three models are presented in Table 4. The table presents the average WTP for improved tap water services for each of the four income classes and the overall average from all income classes. The results show that the average WTP is in the range of Rs. 604 – 734 per month by households whose income is less Rs. 20,000 per month. The results show that the average WTP increases as the income level increases. High income households whose income is at least Rs. 100,000 per month are willing to pay up to in the range of Rs. 3567 – 5277 per month. The overall average WTP from all income classes is in the range Rs. 1,922 – 2,126 per month. This amount is almost three times higher than the current average bill paid (Rs. 703 per month).

Table 3: Regression Results

VARIABLES	Probit Model	Interval Data Model	Bivariate Probit Model	
			Initial Response	Follow-up Response
Constant	5.408*** (6.850)	6.223*** (17.04)	5.545*** (7.017)	0.813*** (2.608)
Income Class 1	0.589** (1.977)	0.786*** (2.851)	0.630** (2.096)	0.813*** (2.608)
Income Class 2	0.875*** (2.880)	1.078*** (3.831)	0.909*** (2.956)	1.079*** (3.414)
Income Class 3	1.573*** (4.838)	1.776*** (5.910)	1.664*** (5.019)	1.631*** (4.908)
Hours of water	-0.00474* (-1.839)	-0.00590** (-2.515)	-0.00504* (-1.922)	-0.00572** (-2.298)
Water quality satisfaction	-0.136** (-2.058)	-0.113** (-1.985)	-0.129* (-1.950)	-0.0802 (-1.328)
Residence type	0.224 (1.336)	0.344** (2.351)	0.237 (1.408)	0.361** (2.293)
Block	0.0310 (0.188)	0.101 (0.712)	0.0467 (0.282)	0.116 (0.773)
ln(bid <sub>1</sub> )	-0.808*** (-8.696)	-	-0.836*** (-8.834)	-
ln(bid <sub>2</sub> )	-	-	-	-0.597*** (-5.266)
Observations	373	373	373	373

z-statistics in parentheses

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

Table 4: Average WTP in Rupees per Month for Different Income Groups

	Probit Model	Interval Data Model	Bivariate Probit Model
Less than Rs. 20,000	734	604	722
Rs. 20,000 - 50,000	1,520	1325	1534
Rs. 50,000 - 100,000	2,165	1774	2,141
Greater than Rs. 100,000	5,140	3567	5,277
Overall Average	2,116	1,922	2,126

## 7. Conclusions and Policy Implications

This study uses a contingent valuation method to estimate the average WTP for improved tap water services and to examine the determinants of WTP using single and double bound dichotomous choice elicitation questions. Three models, probit model, interval data model and bivariate probit model, are estimated using household level data from Block 4 and Block 7 of Gulshan-e-Iqbal Town in Karachi. The results show that the overall average WTP from all income classes is in the range Rs. 1,922 – 2,126 per month whereas the current average bill paid is Rs.703 per month. These results show that the households are willing to pay much more than what they currently pay for a safe and regular water supply service.

A high WTP clearly indicates that the people want delivery institutions responsible for water supply to come up with projects that ensure a reliable and regular water supply and that they would be willing to pay for that particular purpose. The result of the study shows that the demand for improved water services is significantly related to the income of the household. This study shows that a significant increase in water price is economically feasible as long as the poor households are properly subsidized.

The present study has focused on the demand side, studying about situation and attitude in water use, socio-economic condition, and people's willingness to pay for improved water supply service. However, this study does not deal with the institutional weakness of the KWSB or issues of bill collection and financial management. Increasing tariffs is thus a necessary but not a sufficient condition of making water delivery more efficient. The study is restricted to Blocks 4 and 7 of Gulshan-e-Iqbal town in Karachi. The findings of this study cannot be directly applied to other towns without first comparing other socioeconomic characteristics.

This study presents a strong case for investment in infrastructure projects that improve the water supply services in the city. The study presents strong evidence that cost recovery is possible by increasing tariffs for higher income households. A major implication of this study is imposition of cross subsidization. The water utility will need to determine what mechanism should be used to implement subsidies.

## Appendix A: Questionnaire

*This interview is made to you to undertake a research for the partial fulfillment of the award of MS degree in economics. I would like to know the existing water supply situation of the town, the problem you faced and your reaction to possible improvement of the drinking water service. Your response will help policy makers to formulate an informed policy about improved water supply service. The interview will take a few minutes and the answers will be completely confidential and strictly for academic purpose. Thus, please answer the questions honestly and as truthfully as you can.*

### Section I: Current Water Supply Usage

1. Do you use a KWSB water line?

Yes       No

2. Do you pay the water bill? \_\_\_\_\_

**If No, thank the respondent for his time, and finish the interview.**

3. Please list the following services in order of importance (list as first, second, etc)

_____ School	_____ Water
_____ Health	_____ Road
_____ Power	_____ Telephone

4. What is your household's main source of water for bathing and washing clothes, etc?

Piped water from KWSB line       Water Tankers  
 Shared Public tap in neighborhood       Boring Well  
 Other (Please Specify):

5. Do you use any other sources of water for bathing and washing clothes, etc?

Piped water from KWSB line       Water Tankers  
 Shared Public tap in neighborhood       Boring Well  
 Other (Please Specify):

6. What is your household's main source of Drinking Water?

Piped Water from KWSB line       Water Tankers  
 Mineral Water       Shared Public Tap in neighborhood  
 Boring Well       Other (Please Specify):

7. Do you use any other sources of water for drinking water?

- Piped Water from KWSB line
- Mineral Water
- Boring Well
- Water Tankers
- Shared Public Tap in neighborhood
- Other (Please Specify):

**If respondent answered KWSB, go to Q 8.**

- 8. What is your average monthly water bill? \_\_\_\_\_
- 9. How many hours of water supply do you get weekly? (Please enter a number)  
\_\_\_\_\_
- 10. At what time is the water available? \_\_\_\_\_
- 11. Do you run an electric motor to pump water from the line? \_\_\_\_\_

**If Yes**

- 12. How long ago did you install your motor? \_\_\_\_\_
- 13. How much did it cost you? \_\_\_\_\_
- 14. What is your annual maintenance cost on the motor? \_\_\_\_\_
- 15. How long do you run the electric motor daily for piped water?  
\_\_\_\_\_
- 16. Rate your satisfaction of the following aspects of water supply?

	<b>Not at all satisfied</b>	<b>Slightly satisfied</b>	<b>Somewhat satisfied</b>	<b>Very satisfied</b>	<b>Extremely satisfied</b>
Overall Satisfaction					
Hours of Supply					
Supply Volume					
Water Quality					
Reliability of Supply					

**If respondent answered Water Tankers, go to Q 17, otherwise proceed to next Section**

- 17. Are water tankers easily available? \_\_\_\_\_
- 18. On average, how much do you spend on private water tankers in a month?  
\_\_\_\_\_

19. What do you think of the quality of water that this supply delivers?

<b>Very Clean</b>	<b>Quite Clean</b>	<b>Varies</b>	<b>Not very Clean</b>	<b>Very Dirty</b>
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**If respondent answered Boring wells, go to Q 20, otherwise proceed to next Section**

20. How much did it cost to install the well? \_\_\_\_\_

21. How long do you run the electric motor in a day for well water?  
\_\_\_\_\_

22. How long ago did you install your well motor?  
\_\_\_\_\_

23. How much did it cost you? \_\_\_\_\_

24. What is your annual maintenance cost on the well motor?  
\_\_\_\_\_

25. What do you think of the quality of water that this supply delivers?

<b>Very Clean</b>	<b>Quite Clean</b>	<b>Varies</b>	<b>Not very Clean</b>	<b>Very Dirty</b>
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**If respondent uses Mineral Water, go to Q 26, otherwise proceed to next Section**

26. On average, how much does your household spend on drinking water in a month?  
\_\_\_\_\_

## Section II: Health

27. Do you use any purification method (such as boiling) before you drink piped water?

Yes       No

28. Which purification method do you use? \_\_\_\_\_

29. If " No", what is the reason?

- |   |   |
|---|---|
| <input type="radio"/> The water is clean  | <input type="radio"/> The water is not clean but it is expensive and time consuming |
| <input type="radio"/> I do not know whether there is purification method or not | <input type="radio"/> Though the water is not good it is harmless                   |

Other: \_\_\_\_\_

30. What diseases have affected any members of your household over 12 years old, in the last six months?

- |  |   |                                      |
|--|---|--------------------------------------|
| <input type="checkbox"/> Diarrhea        | <input type="checkbox"/> Malaria                | <input type="checkbox"/> Typhoid     |
| <input type="checkbox"/> Cholera (Haifa) | <input type="checkbox"/> Feces with Blood/Mucus | <input type="checkbox"/> Hepatitis A |
| <input type="checkbox"/> Other: _____    |   |                                      |

31. Have any children in your household below the age of 12 had any of these conditions in the last six months?

- |  |   |                                      |
|--|---|--------------------------------------|
| <input type="checkbox"/> Diarrhea        | <input type="checkbox"/> Malaria                | <input type="checkbox"/> Typhoid     |
| <input type="checkbox"/> Cholera (Haiza) | <input type="checkbox"/> Feces with Blood/Mucus | <input type="checkbox"/> Hepatitis A |
| <input type="checkbox"/> Other: _____    |   |                                      |

32. What is the average medical expense of your household? \_\_\_\_\_

**Section III: WTP**

33. Your household currently pays Rs. \_\_\_\_ per month in water tariffs to K.W.S.B. However, water availability times and water pressure etc. are unsatisfactory. If you were to receive supply with sufficient pressure, and the water will be of good quality, potable without boiling or any other treatment 24 hrs a day, would you be willing to pay **Rs. 500** per month? Note that this amount would be in addition to your current monthly household expenditures, but if you are paying money to purchase water from a source other than K.W.S.B, that amount would be deducted from your current monthly household expenditures. This would also include electricity cost to run motors, gas costs to boil water etc.

- Yes       No

**If Yes,**

34. Will you be willing to pay **Rs. 1000**?

- Yes       No

**If No?**

35. **Why not?**

- |   |   |
|---|---|
| <input type="radio"/> You are satisfied with existing service | <input type="radio"/> You cannot afford |
| <input type="radio"/> You don't want to pay                   | <input type="radio"/> Others: _____     |

36. **Follow up Question:** Will you be willing to pay **Rs. 250**?

- Yes       No

**Section IV: Socio-economic Characteristics**

37. Type of Residence

- Single Storied house       Double Storied house

38. Household Size? \_\_\_\_\_

39. Employment of Household Head

- Unemployed       Street Vendor/Small Informal Business       Government Employee
- Own Business - Industrial       Private Employee       Own Business - Services
- Other

40. Average Monthly Household Income

- Less than RS. 10,000       RS. 10,000 - 20,000       RS. 20,000 - 50,000
- RS. 50,000 - 100,000       Greater than RS. 100,000

41. How much do you spend on the following items per month?

Food : \_\_\_\_\_       Gas: \_\_\_\_\_

Electricity: \_\_\_\_\_       Transport: \_\_\_\_\_

**Surveyor Information:**

**Questionnaire ID:** \_\_\_\_\_      **Time:** \_\_\_\_\_      **Date:** \_\_\_\_\_

**Surveyor Name:** \_\_\_\_\_

**Respondent Information:**

**Name:** \_\_\_\_\_      **Phone:** \_\_\_\_\_      **Gender:** \_\_\_\_\_

**Relation to household head:** \_\_\_\_\_      **Age:** \_\_\_\_\_

**Address:** \_\_\_\_\_

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