Mekelle University

College of Business and Economics

Department Of Economics

Households' Willingness to Pay for Improved Water Supply Services in Mekelle City, Northern Ethiopia

By:

Saleamlak Fentaw Getahun

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Principal Advisor: Woldegebrel Abrham (PhD)

Co-advisor: Desalegn Beyene (MSc.)

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Mekelle University, Ethiopia

Declaration

I, Saleamlak Fentaw, do hereby declare that the thesis entitled **"Households' Willingness To Pay For Improved Water Supply Services in Mekelle City, Northern Ethiopia"** submitted in partial fulfilment of the requirements for the award of the degree of Master of Science in Economics (Development Policy Analysis) to College of Business and Economics, Mekelle University, through the Department of Economics, is my original work and it has not been presented for the award of any other degree, diploma, fellowship or other similar titles, of any other Universities or Institutions.

Saleamlak Fentaw Getahun

Id. No. CBE/PR106/04

Signature: _____

Date: 24/05/2013

Place: Mekelle University, Mekelle, Ethiopia

Certification

This is to certify that this thesis entitled **"Households' Willingness to Pay for Improved Water Supply Services in Mekelle City, Northern Ethiopia"** is an authentic work of Mr. **Saleamlak Fentaw Getahun**, Id. No. CBE/PR106/04, who carried out the research under my guidance, certified further that to the best of my knowledge the work reported here does not form part of any project report or thesis on the basis of which a degree or award was conferred on an earlier occasion by this or any other candidate.

Principal Advisor	**Co- advisor**
Woldegebrel Abraham (PhD)	Desalegn Beyene (MSc.)
Signature: _____	Signature: _____
Date: _____	Date: _____

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Abstract

Good quality, reliable and affordable supply of drinking water is a basic need for human life. However, many people in LDCs are lacking this safe and quality water. Since Ethiopia is one of these LDCs its urban and rural area population does not have access to such attributes of water. Therefore, reliability and quality are crucial for household water supply. In this study the CVM was used to analyze the determinants of households' WTP for improved water services by applying the single bounded dichotomous choice value elicitation format. The study used cross-sectional data collected from 215 randomly selected sampled households from Mekelle city. The CV survey responses were analyzed through descriptive and econometric analysis using Probit and Tobit as empirical models.

The CV survey results revealed that 199 (98.51%) of the respondents were willing to pay a positive amount for improved water services.

Thus if the proposed water improvement scheme is implemented, in addition to satisfying the water needs of the households, the city's utility management can collect more revenue from the sale of improved water. The CV survey results also show that the mean WTP of households for the proposed improved water service is between 29.60 cents and 51.51 cents per jerry can depending on the method used.

The results from the test statistics show that sex of the respondents, Education of the respondents, monthly income of the household, and satisfaction of the existing service significantly affects both the probability of households' WTP for improved water services in the Probit model and the maximum amount they are willing to pay in the Tobit model.

Therefore, policy makers need to take in to consideration these socio-economic and demographic factors and some other attributes of water in designing the improved water supply system of the city.

Key words: Willingness to pay, Contingent valuation methodology, improved water Supply services, Mekelle city

Acronyms

BoFED	Tgray Bureau of Finance and Economic Development
CV	Contingent Valuation
CVM	Contingent Valuation Method
JMP	Joint Monitoring Programs
LDCs	Least Developing Countries
MCA	Mekelle City Administration
MWTP	Maximum Willingness to Pay
MoWR	Ministry of Water Resource
NOAA	National Oceanic and Atmospheric Administration of the USA
UN	United Nations
UNEP	United Nations Environmental Program
UNICEF	United Nations (International) Children's' Fund
WHO	World Health Organization
WSSA	Water Supply and Sewerage Authority
WTP	Willingness to Pay

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Chapter One

Introduction

1.1 Background

Water is one of the most valuable natural resources vital to the existence of any form of life. An adequate supply of safe and clean water is the most important precondition for sustaining human life, for maintaining ecosystems that support all life and for achieving sustainable development (Topfer, 1998). Therefore, Safe drinking water is an essential component of primary health care and has a vital role in poverty alleviation. There is a positive correlation between increased national income and the portion of population with access to improved water supply. According to World Bank (1994) as cited by Simiret W.et al, 2011, an increase of 0.3% investment in household access to safe drinking water generates 1% increase in GDP. Unreliable supply and shortage of water affect life of human beings in various ways. Emphasizing the importance of water, Nielson (2004) contends that safe drinking water is not just a luxury. It often makes the difference between life and death.

Although ready access to clean and safe water is taken for granted in industrialized countries, in poor countries large proportions of both urban and rural households do not have access to safe water (Ian W.et al, 2000).The proportion of the population that uses improved drinking water sources varies significantly by country and region. It is clear that Sub-Saharan Africa is not on track to meet the target; in 2008 40% of the total population still lacked access to improved drinking water sources, as compared to 51% in 1990. In this region 20% of rural dwellers still rely on surface water sources and access to piped water supplies has decreased in urban areas. Between 1990 and 2008, the urban population in Sub-Saharan Africa more than doubled. While overall urban coverage levels have stayed just above 80%, access to piped supplies decreased by 13 percentage points from 68% in 1990 to 55% in 2008. Still, over half of the 126 million urban dwellers that gained access did so through using piped supplies on premises (42 million) and public taps (23 million) (UNICEF and WHO 2011).

Even if Ethiopia is frequently said to be the 'water tower of North-East Africa' there is a pervasive problem of safe and clean water. Both the urban and rural water supply and sewerage coverage in Ethiopia are low. According to the 1994 WSSA statistical review, the urban coverage for water supply, excluding Addis Ababa, was 65.3% and that of rural areas was 15%. Even though current figures show improvement in coverage of water supply, there is a great variation in official Government of Ethiopia figures and internationally accepted Joint Monitoring Programme (WHO and UNICEF) figures due to lack of reliable data. Official reports show access to water supply at 68.5 % - 81.5 %for urban and 65.8% for rural. Access to sanitation facilities is reported to be 60%. The same report highlights hand washing practice at 7% and open defecation at about 15%. The JMP figures, however, show that Ethiopia has among the lowest rates of safe water coverage in the world with only 41%. Out of this 31% of the rural and 96% of the urban population is using an improved drinking water source. The national sanitation coverage is only 11% out of which 27% urban and 8% of the rural population are using an improved sanitation facility (Water Aid, 2011-2016). The problem is not only in terms of coverage it is multidimensional; acute in terms of quality, distribution and frequency of interruption in the supply of water in both rural and urban areas of the nation.

To improve access to safe clean water, the government of Ethiopia has prepared a water and sanitation policy document as an integral part of the country's water management policy. This document clearly indicates the right of every Ethiopian to get access to adequate and quality water to satisfy their basic needs in order to achieve rapid socio economic development through better health care and productivity (MoWR, 1999). In this document, to improve the financial base needed for water development projects and other public undertakings, cost recovery mechanism was considered as one of the basic drinking water project financing mechanisms

Mekelle city, located in northern Ethiopia, is the capital of Tigray region. It is the fourth largest city in Ethiopia, the largest in Tigray. Water supply in Mekelle does not meet demand, and sanitation coverage needs to improve. Many households, schools and health institutions often lack water and basic sanitation facilities, which has had drastic implications for the public health (Andrea C. et al, 2009).

According to MCA (2008), the main source of the City's water supply is ground water from 17 boreholes that ranged from 32- 250 meters deep. Water consumption in 2008 was 30 liters per capita per day which is less than half of 75 liters set by the World Bank in 2007 for dwellers in mid-sized African cities like Mekelle. Sanitation facilities in Mekelle consist mainly of pit latrines and pour-flush latrines with septic tanks. A 2005 household survey conducted by the Urban Institute indicates that more than half the population used dry-pit latrines, and a third of the population used flush toilets connected to septic tanks. As of 2007, Mekelle still did not have a sewerage system (Andrea C. et al, 2009).

1.2 Problem Statement

Water and urbanization are closely linked that the problem of safe and clean water inhibits further urbanization and improvement of standard of living. The situation becomes most drastic when we take urban areas in the developing world where governments are the only stakeholders, with very limited financial resources, in the water supply sector. Thus, the crisis of improved water services in urban areas exacerbates the already poor living and working conditions, which in turn aggravates urban poverty. Most towns and cities in Ethiopia are good indicators of this problem. The fast growing towns and cities are not coupled with improved water and sanitation services that make an urban area decent and suitable for its residents.

Mekelle city is one of those cities with a lot of shortcomings in the water supply sector. Demand outstrips supply in the city; the existing supply couldn't satisfy the demand of the fast growing population in the city. Both frequency of service interruptions and the average duration of an interruption are surprisingly high. Piped water supply may be interrupted for a couple of weeks with a higher frequency throughout the year. Water loss and non-revenue water are included as key water supply problems of the city (Andrea C. et al, 2009). The circumstance is stunning especially for some city districts like Dagmamsal and Hawlti where the residents have already adapted the problem. The researcher himself is one of the victims of this water shortage problem as a dweller in the city for the last 20 months. Because of the stated problem, the active labor force is wasting its significant time by fetching water from unimproved sources which has a negative implication in the production sector and the quality of water from those sources is also deteriorating. One way of improving water quality is expanding the piped water system, i.e.

water supply through a household connection. It is the final and most effective way of reducing the transmission of water borne diseases (Hutton and Haller, 2004).

As indicated by Medhin (2006) since piped water supply is not a natural system as it is a man-made infrastructure, it needs huge amount of money and effort to make it quite accessible in both quantity and quality. The investments (to build, operate, sustain and maintain) turn water to an economic good and not only as a social service. Due to lack of finance and trained manpower, however, governments of poor countries have limited potential to make water easily accessible to its people. Therefore, the public utilities have to come up with a new paradigm shift from their supply-driven policy to demand-driven based on the willingness to pay of consumers.

As pointed out above drinking water and sewage services are generally provided by either a local government agency or a regulated firm. In either case, explicit decisions must be made as to the appropriate mix of service quality and price. Water service interruptions can occur due to unexpected emergencies or system failures, as well as for planned maintenance. The expected frequency, timing, and duration of interruptions can be affected by the capital investments and operations of the supplier, with higher levels of service generally being attainable through higher costs and hence higher prices. For wastewater, the analogous issue concerns overflows: reducing the expected frequency and time to repair overflows incurs a cost, which translates into higher prices for customers. To determine the appropriate level of these services attributes relative to price, information is needed on the value that customers place on each attribute (Hensher et al, 2005).

The present water pricing policy in the city contemplates on the supply-driven approach and seems to ignore the demand-driven approach which takes consumers' preferences as measured by their willingness to pay (WTP). The residents are saying **"why we suffer from water problem while we have the ability and willingness to pay for it".** The realization of such policy decisions should also focus on the demand as opposed to supply side there by adjusting pricing mechanisms and considering the willingness to pay of the residents for the purpose of cost recovery. Valuation of water service is the key component of an appropriate incentive for balanced and coordinated investment development in the different parts of the city. Furthermore the need to fill the gap of information on the demand side for policy purpose is timely. Hence,

research on the demand side in order to realize the essential substance of the value of water service is vital. This research therefore endeavors to examine some of the factors that affect the willingness to pay for improved water services in Mekelle, Ethiopia. It also aims at presenting empirical estimates (regression elasticities) to specify and explain the impacts of some factors on the willingness to pay for improved and sustainable water supply in the same area.

1.3 Objectives of the Study

The main objective of this study is to investigate the valuation of improved sustainable water supply services measured by willingness to pay using the contingent valuation method in Mekelle City. The specific objectives are:

- To elicit households' willingness to pay for improved water services from hypothetical market scenario using CVM;
- To examine determinants of households' willingness to pay for improved water services in Mekelle city;
- To use WTP responses to calculate aggregate benefit;
- To draw concluding remarks and policy implications to the existing situations of the city.

1.4 Significance of the Study

Due to big investment, operation and maintenance costs it is hardly possible for the Government to provide safe potable water services free of charge. The water service users are required to pay for the service they get from the improved source. Thus, information on the amount of money the service users are willing to pay for the improved service is essential for improved water development projects. In this study, the amount of money the residents of Mekelle city are willing to pay for water services they get from the improved system and factors that determine their willingness to pay would be assessed. Therefore, the findings of this study give useful information for project planners that can be used as an input for water development projects of the city. Generally, the study can be an important additional input for different stakeholders working in the water supply sector.

1.5 Scope and Limitation of the Study

Even though users of the improved water service include public bodies, commercials, and industrial users, this study, however, deals only with improved water services of households in Mekelle city using cross-sectional data at a point in time. The water use by public bodies, commercials, and industrial sectors in the city are not addressed in this study, it is, therefore, beyond the scope of this study. The sample size is also limited to 215 respondents from four kebeles of the city administration because of time and budget constraints.

1.6 Organization of the Paper

The remaining part of the paper is organized as follows. The second chapter deals with theoretical and empirical literature review followed by the third chapter which is devoted to the data source and research methodologies. Chapter five provides descriptive analysis, estimation results and discussions. Finally in chapter six, the study provides conclusions and policy implications.

Chapter Two

Review of Related Literature

2.1 Theoretical Review

In this sub-section a review of the literature on economic valuation of environmental resources will be presented. The section also deals with the theoretical foundation for the techniques that economists developed for valuation of natural resources and the environment.

2.1.1 Non-Market Valuation

Theory of environmental resources valuation has encouraged economists, both in intensity and scope, in valuing an increasing number of environmental goods and services around the world. Increasing complexities, in designing procedures and analytical structure, have enhanced the optimism of economists about using non-market valuation as a basic instrument to assist decision-making. Practically, non-market valuation faces a critical problem in understanding how people perceive these services and how they value changes on the genetic, species, regional and global scale. (Hanley et .al, 1997)

Depending on various circumstances, economists place total economic value on either stock or flow of natural resources. Total economic value (TEV) can be divided into three main components, namely, the use value, option value, and non-use value. The use value refers to the direct benefits human beings obtain from environmental resources. The option value reflects the value individuals give to the future uses of environmental resources. That is, it indicates individual's willingness to preserve environmental assets for the future uses even if s/he does not use these resources currently. The non-use value reflects that people are willing to pay to improve or preserve environmental resources that they do not use and will never use. Thus, total willingness to pay for environmental resources is the sum of the use value, option value and nonuse value (Tietenberg, 2003).

2.1.2 Valuation Methods

Theoretically, the total value/ benefits of some environmental improvement such as improved water can be classified into two categories.

Total Economic Value = Use Value +Non-use Value. Use value comprises direct and indirect value, which is simply "value in use", option value, quasi-option value and bequest value. For example, people use a clean river for swimming, boating, drinking or bathing. An environmental resource is said to have a quasi-option value if the future benefits it might yield are uncertain and depletion of the resource is effectively irreversible. In brief, one would be willing to pay to preserve the resource simply because it might prove valuable at some time in the future. Option value was seen to arise when an individual was uncertain as to whether he would demand a good in some future period and was faced with uncertainty about the availability of that good. Non-use values also comprise of bequest value and existence value. Consequently, even if a certain environmental good has neither use value nor option value, people can still protect it because they believe that all creatures have the right to exist, hence, the existence value.

Economists have, in recent decades, developed various valuation techniques to estimate the value that consumers place on public goods. These methods can be distinguished on the basis of the process by which they retrieve people's preferences (Brima I. 2003).

- Non-preference methods, which include shadow cost method (opportunity costs) and implicit valuation.
- Revealed preference methods, which include Travel Cost Method (TCM), Hedonic Pricing Method (HPM), Averting Behaviour Method and Production Factor Method.
- Expressed Preference Method (direct approach). Survey method using Contingent Valuation Method (CVM) is an example for this category.

2.1.2.1 Non-Preference Methods

This method suggests that water works may lead to a drop in the ground water level as well as altering the ecosystem and its productive potential. Under such circumstances, consumer price must be set to reflect not only the production costs but also the costs in terms of the

environmental impacts of resource extraction. The price must equal the marginal opportunity cost, which is also equal to the long run marginal cost, plus the external cost of water extraction and forgone benefits of future users. The price must be set in such a way that poor people can also afford the service and at the same time sustainability is maintained. But it must be noted that this approach is beyond the scope of this study due to the fact that long run marginal cost and marginal opportunity cost requires extensive information on externalities and the forgone benefits.

2.1.2.2 Preference Methods

The Revealed and Expressed Preference methods are explained in this sub section. In circumstances where markets for environmental goods are absent, not fully developed, or there are no alternative markets, it becomes impossible to value the impact on the environment of a particular project by using the market. Given this condition, it is possible to estimate implicit values for such goods or services by means of the price paid for another good that is marketed. Three valuation techniques that are commonly used are the HPM, TCM and CVM.

Hedonic Pricing Method

The hedonic pricing approach has been used extensively to estimate the value of property and housing prices (Blomquist and Worley 1981; Rosen 1974). It assumes that a good (or service) can be fully characterized by its attributes, that consumers have very good information on the attributes of goods, and that price differentials reflect the values of different attributes of goods. For example, in housing markets, the price of a house can be broken down into the value of its main attributes, that is, physical structure, age, number of rooms, neighborhood characteristics, quality of neighborhood schools, accessibility to work, crime rates, and perhaps some measure of the quality of local drinking water, air quality, noise pollution, and aesthetic views. Assuming each of these attributes has an associated implicit price, the market price of the property is equal to the sum of the implicit prices, multiplied by measures of the attribute. The application of the hedonic pricing method to capture the effect on prices of improvements in environmental quality requires observations of sufficiently varying quality levels within the confines of a single housing market (Leggett and Bockstael 2000).

Korman (2002) notes the limitations of the hedonic pricing method for valuing water quality improvements in Famagusta, Cyprus, mainly on account of the fact that water quality did not vary sufficiently across the single markets or locations. The method could still be applied if the geographical domain of the analysis were extended to capture more variation in water quality. Water is, however, not location specific (Whitehead and Van Houtven 1997), and everyone generally has access to the same level of water quality at the village or even regional level.

Travel Cost Method

Analysts rely extensively on the travel cost method to place a value on outdoor recreational locations such as national parks and fishing and hunting sites. This method relies on observations of people's behavior, particularly expenditure for transportation and other trip-related expenses incurred when traveling to and from the site of interest. Moreover, it calculates the benefits derived from the specific site and uses this information to find optimal levels of service provision (Bishop and Heberlein 1990).

The method is, however, more appropriate for valuing recreational sites than for estimating the WTP for improved water services. In fact, households often use various alternative sources to maintain a certain level of water quality, for example, municipal and private tankers for non-drinking water and private vendors and bottled water for drinking purposes. Measuring the value of the time spent carrying water from the specific site may not provide a complete picture, and other non-transportation costs (for example, investments in storage and pumps to cope with intermittent and poor quality public water) should be considered. In this respect, the travel cost method can be seen as a special case of averting expenditure in that it focuses on a particular type of expense only, namely, travel. Though likely to provide a lower bound (or conservative) estimate of the WTP only, the method may still be a practical and easier alternative to the more demanding methods discussed in the following sections (see Whittington, Mu, and Roche 1990 for an application to water provision in Kenya)

Contingent Valuation Method (CVM)

When market data are unavailable or unreliable, economists can use alternative estimation methods that rely on hypothetical market conditions which typically use survey to inquire about individuals WTP for some environmental policy initiative.

The CVM involves asking people directly what they would be WTP or WTA compensation for change in preferences and the method is called contingent valuation for it is contingent on the hypothetical market. The CVM is preferred to the revealed preference methods for it includes both use and non- use values and survey responses to WTP or WTA hypothetical questions go directly to the monetary measures of utility change (Perman et al., 2003, p. 420). Further the CVM has ease of flexibility and therefore, it is the only technique theoretically capable of estimating the benefits produced by water quality improvements, including non use values. Thus based on the reasons mentioned above CVM is employed for this study. But it has its own limitation relative to the other stated preference method such as choice experiment (CE). For example CVM is not doing better than CE in measuring the marginal value of changes in the characteristics of environmental goods. Further the CE may avoid some of the response difficulties of the CV such as a Yea- saying tendency of respondents in dichotomous choice design and incentive incompatibility (Perman et al, 2003).

The major steps involved in using CV Survey

1. Designing and administering a CV survey that elicits individual's value for a good or service.
2. Analyzing WTP responses
3. Estimating aggregate benefits and total revenue
4. Evaluating the CVM exercise (validation tests)

Even if CVM is being used by different researchers, it has associated biases. According to Titenberg (1998) as cited in Bah's work, a major concern with the use of CVM is the potential for survey respondents to give biased answers. The major types of biases are:

- **Strategic Bias**: this occurs when a respondent does not reveal his/her true preference of the good or service, i.e., he behaves strategically with the hope to "free ride".

- **Information Bias**: this can arise either as a result of providing too little information about the choice offered or from misleading statements by the interviewer.

- **Compliance Bias**: this happens when respondents in a particular cultural context feel it inappropriate to answer some kind of questions in specific ways or may attempt to give answers that they think will please the enumerator. This form of bias can result in substantial differences between reported and true WTP values.

- **Hypothetical Bias**: the potential error induced by confronting the individual with an imaginary situation, i.e., people would not behave the same way in actual market.

- **Starting Point Bias**: this occurs when the respondent's WTP amount is influenced by a value introduced by the scenario.

- **Sampling (interview and respondent) Bias*:*** this occurs when the very character of the interview or interviewer may influence responses. For example, if the interviewer in some way portrays the environmental good as morally desirable, or if the interviewer is highly educated (or attractive) then the respondent may feel inhibited about expressing a low WTP bid.

However, despite the above-mentioned biases, the CVM generally has many advantages. According to Hoevenagel (1994), the CVM has the following strong advantages over the other methods,

The applicability of this method is larger compared with other valuation methods in terms of completeness.

- It is able to measure a wide range of goods, including those not yet supplied in a manner consistent with economic theory.
- The method can measure non-use values.

- CVM has been judged to be superior due to its potential validity and ease with which the method can be implemented.

Contingent valuation (CV) elicitation formats

The most widely used elicitation formats in CV surveys are open-ended, bidding game, payment card and single (double) bounded dichotomous choice (Hanley et al., 1997).

I. **Open-ended format** –a CV question in which respondents are asked to provide the interviewer with a point estimate of his/her WTP; it has the advantage of relative computational easiness and counter starting point bias. But the method is associated with a large number of respondents' non-responses and protests zero bids. Mitchell and Carson (1989) further argue that the method is difficult since respondents faced to pick a value out of the air without some form of assistance.

II. **Closed-ended approaches** (dichotomous choice question)-asked respondents whether they would pay a stated amount for the good in question by providing intervals in which the respondents WTP lies. This method is advantageous over open-ended question format in eliciting WTP because of the simplicity of "yes "or "no" answers for the respondents and thus reduce incentives for strategic responses (Bateman et al., 1992). It has also advantage of being much more similar to the choice that individuals are asked to make in real markets when faced by market prices. However it suffers from starting point bias, shortage of information, reducing efficiency and requirement of large sample to estimate benefits as maximum WTP is not directly obtained from this format. This study uses both closed ended (double-bounded) and open- ended formats.

III. **Bidding game** – is a CV question format in which individuals are iteratively asked whether they would be willing to pay a certain amount, by raising (lowering) the amount depending on the respondents WTP for the previous offered amount. It has a better efficiency than closed-ended format because it has a potential to elicit the respondents maximum WTP (Cummings et al., 1986) and that the iterative process helps the respondents to fully consider the value of the good in question (Hoehn and

Randall, 1987). But the method exhibits very strong starting bias and may be boring to the respondents and thus they may give answers only to avoid additional questions.

IV. **Payment card**-is a CV question format in which individuals are asked to choose a WTP point estimate (or an interval) from a list of values predetermined by the surveyors and shown to the respondent on the card. This method is better than open-ended format as it could be simpler for the respondents and large proportion of responses could be obtained. However, the method requires the respondent to be literate that makes it of little use in developing countries where a considerable proportion of the population is illiterate.

In general all methods that we have discussed, either stated or revealed preference methods for non- market valuation, that are used for measuring the benefits of water related public goods have their own strength and shortcomings. As indicated above the revealed preference methods are used to estimate people's WTP for environmental public goods from actual consumer behavior and hence failed to capture non-use values of environmental resources and thus are inadequate for assessing new policy initiatives (Young, 2005, p. 156). But the stated preference methods such as CVM is used to estimate both use and non-use values and also used to estimate values of proposed new policies (Young, 2005, p.152) , and this indicates that CVM can measure the total economic value of improved water projects. That is the reason why in 1979 the U.S.A. Water Resource Planning Council recommended the CVM as an acceptable method for estimating the benefits of water resource projects (Young, 2005, p.135). Therefore CVM is the appropriate method for valuing improved water supply of Mekelle city.

2.2 Empirical Review

Different studies, in the water supply sector, have been conducted in different times by different researchers using the contingent valuation methodology to elicit households' willingness to pay for improved water services. Some of them can be revised as follows.

Yibeltal Bantie (2011) used the CVM to examine the determinants of households' WTP for improved water services in Motta town. The elicitation method used in this study was double-bounded dichotomous choice followed by open–ended questions. Households' WTP for

improved water service was analyzed by estimating the Probit and the Tobit models. The explanatory variables quality of water being used dummy (1 if not safe to drink or poor), reliability of the existing water service dummy (not reliable=1), education dummies (both primary and tertiary education), income of the household, wealth of the respondents and their years of stay in the town were significant factors that affect positively households' probability of saying 'Yes' to initial bid offered to them. Initial bid offered to households, age of the respondents and source of water being used by households have negative expected sign and have significant effect on the probability of saying 'Yes' to the proposed initial bid. The results from the Tobit model showed that the quality of water (1 if poor), reliability (1 if not reliable), education dummies (primary, secondary and tertiary educations), income and years of stay in the town positively and significantly affects the maximum amount household willing to pay. The variables responsible organ (1 if government), source of water (piped=1) and age have the expected negative sign with a statistically significant influence on the maximum willingness to pay of households.

Mourato and Day (1998) estimated value of water quality in the Beijing Metropolitan local rivers using the CVM survey analysis. A carefully designed CV questionnaire was administered with a random sample of 999 people in the Beijing area. The study reported the annual average WTP per household to maintain water quality in all rivers in Beijing metropolitan region to be US $22.

Gossaye Fanta (2007) used the CVM to examine the determinants of households' WTP for improved water services in Debre-Zeit town. The elicitation method used in this study was single- bounded closed-ended followed by open–ended questions. Households' WTP for improved water service was analyzed by estimating the Probit and the OLS methods. The coefficients of age, household size, volume of water used, reliability of existing water services, the starting bid, and household average monthly income had the expected signs and were statistically significant. The coefficients of education dummy, quality dummy, gender dummy, and satisfaction dummy variables had the expected signs but were not statistically significant.

A similar study was also made by Medhin (2006) using a CV survey on household demand for improved water services in Addis Ababa. This study used 250 sample households and the single-bounded format with open-ended follow up questions was elicitation methods used in this study. She used Probit and Tobit models to analyze the determinants of households' WTP for improved water services. In the Tobit model income, education and satisfaction facility were found to have a positive sign and significant, where as perceived quality, age and water related diseases were negative and significant at the standard level of significance. Concerning the Probit model, income, education, marital status water related diseases and years of stay in the area positively affect the probability of accepting the initial bid. The findings further indicated that the mean WTP was found to be 20 cents per Baldi (20 liters container) from single bounded probit model estimates and 15.79 cents per Baldi from the open-ended format.

Tsegaye (2005) used CVM by applying double-bounded format to elicit the WTP of fishermen to the improvement of Lake Chamo. The mean WTP is birr 4.63 per month. His analysis showed that there is a positive and significant correlation between WTP and income of households, educational level of the respondent, and the dummy variable Chamo. However the response is negatively and significantly correlated with the age, and sex of the respondent (male).

Terefe (2000) adopted the CVM and travel cost (TC) models to estimate benefits from establishment of park around Tis Abay waterfalls. He analyzed the responses by multiple linear regression, Tobit and Probit models and the results revealed that, for the visitors' benefits, the CV produced higher estimates than the TC estimates as the CV estimates consider the non-use value of the commodity to be valued unlike the TC estimates. The findings showed that conducting successfully the CVM and TCM surveys would give useful information on users demand for the public good.

Mitchell and Carson (1989) conducted a study to determine the national benefits of fresh water pollution control in America and estimating the aggregate benefits of meeting the goals of clean water act using data from a national CV survey. They regressed total WTP on water quality level, disposable income, taste; water based recreational use (dummy) and environmental attitude (dummy). The result shows that all the coefficients are reasonable in sign and all significant,

confirming the importance of peoples attitude towards their WTP for improvement in the public good.

Tsegabirhan (1999) used CVM for investigating farmers WTP for irrigation water in Tigray,Ethiopia using OLS and Orderd Probit regression models. The study estimates WTP of small holder farmers for irrigation water particularly for small scale irrigation schemes. The survey results included the main irrigation seasons and the whole year which depends on 0.25 hectares of irrigable land. The study used a sample of 82 out of 1071 household heads. The findings of the study showed that 90% of the respondents were willing to pay up to birr 600 for the main irrigation system alone. The study further indicates that credit availability, education and fertilizer supply are major determinants of respondents' WTP. In addition, due to smaller sample size the estimated sample variance increases which could be why many of the variables were found statistically insignificant.

In general these and other CVM empirical studies on water quality improvement and other non-marketable environmental goods and services in developing economies in general and Ethiopia in particular imply that the CVM can be successfully applied to low income countries.

Chapter Three

Research Methodology

3.1 Description of the Study Area

Mekelle city is one of the fast growing cities of Ethiopia serving as the capital city of Tigray National Regional State. The total area of the city is 19,200km^2. And it is located in the north part of Ethiopia some 783 km far from Addis Ababa. The city is the center of many federal, regional and international organizations. According to the regional bureau plan and finance population projection, the projected population estimate based on the population census of 2007, is a total population of 272,519 out of which 132,474 (48.6% male) and 140,045 (51.4% female) with average population growth of the city is 4.7%. This rapid population growth is attributable to a combination of factors including continued migrations from the rural areas and natural growth (BoFED, 2012).

Geographically, it is located between altitudes of 2000 - 2200 m above sea level and has a weina-dega agro-ecology zone (medium high land climatic condition). The city is found in 39`28'' east & 13`28'' north with rainy and dry seasons as the two important seasons of the city and its average annual rainfall is 618.3mm/year, this rainy season is characterized as erratic, unreliable and unevenly distributed throughout the year. And has an average mean temperature of 19`c. (WRDF, 2008).

3.2 Water Supply Situation of the City

According to Mekelle city water supply service office, the main source of water for the inhabitants is ground water and the city has started to use piped water in 1949 E.C. In the same year, a pipe line connected to the Palace and the Hospital has been introduced for the first time in the city's history.

Now Mekelle city is giving its water supply service for 34273 customers from 22 boreholes. There are also 75 public tabs giving service for those who have not private connections. The water supply service office has the second largest customers, next to Addis Ababa, in the country. The city, in this year, has also signed a water supply project which costs about 3.4

billion birr with a foreign company for a dam construction that is believed to sustain the supply taking in to account population projections. The coverage has reached 65% in 2011; still supply is lagging behind despite the good performance of the city. As indicated in the problem statement, Water leakage is the main problem for the supplier. About 20% of the produced water, on average, leaks because of different reasons. For example, in 2012, the city has produced 6,110,000 m^3 of water and has consumed 4,397,537 m^3 with a leakage of the difference between the two figures, which is 1,712,463 m^3 (28%).

3.3 Water Tariff Structure of the City

The city water supply service office has revised its tariff structure starting from January, 2013. The price has increased in each consumption blocks. The new tariff structure of the city is summarized as follows.

Table 1: Current tariff structure of the city

Consumption blocks (m^3/Month)	Tariff in birr/m^3 for household connections	Tariff in birr/M^3 for Businesses, Public bodies, and Industries
0.1-5 m^3	**4**	**6**
5.1-10 m^3	**5**	**8**
10.1-20 m^3	**8**	**10**
20.1-50 m^3	**10**	**12**
50.1-100 m^3	**12**	**15**
>100 m^3	**15**	**20**

Source: Mekelle city water supply service office, planning section 2013

Note that the above pricing technique is called progressive pricing. But the price of water from public tabs is not based on progressive pricing, which is 4 birr/m^3 constant over each block.

3.4 Data Source and Type

Both primary and secondary data are employed in this research. The *primary data* includes socio-economic characteristics of the respondents and the CVM responses to estimate the mean WTP. Thus, the studies mostly relied on primary cross-sectional data for the time period of 2013 that are obtained from a contingent valuation survey. The study is also supplemented with

secondary data from the Ministry of Water and Energy (MoWE), Mekelle city Water and Sewerage services, the Web, and other relevant sources.

3.5 Sampling Design and Procedure

The sample for the study was drawn, randomly, from three kebeles of Mekelle city. After selecting these kebeles, we have randomly selected 215 sample households from these kebeles and 215 face to face personal interviews have been administered using structured CV questionnaire. Out of the interviewed sample households, 202 responses have been found usable and this amount is used for the final analysis.

3.6 Questionnaire Development and the Elicitation Format Used

The preparation of the CV Survey questionnaire generally followed the Mitchell and Carson techniques (1989) with minor modification that suits it to the study area. The questionnaire was conducted face to face and enclosed 87 questions for the three parts of the CVM framework. The questionnaire included an opening preamble paragraph that explains why the study is conducted (see Appendix 3). It is believed that this opening paragraph will reduce strategic bias.

According to the recommendations of international NOAA panel found in Portney (1994), we considered the following most important points to design the CV questionnaire.

- The interview should be done in person;
- Willingness to pay should be about a future event and not one that already occurred; and
- The hypothetical facts provided to the respondents must be precise, understandable and constant across the sample.

After designing the draft questionnaire pilot survey was conducted in the three selected kebeles of the city by drawing a random sample of five households from each kebeles and a total of 15 household heads were interviewed under this pre-test which was done by two experienced interviewers and the researcher himself.

The pilot survey provided us with two important inputs used for the final survey.

- ✓ To Take minor modifications in the final structure of the questionnaire to make it quite easy to understand and to put income related questions at the end of the questionnaire because of the reluctance shown by the respondents to respond on these questions
- ✓ To Set starting bids to be used for the closed-ended dichotomous choice questions

Accordingly, the elicitation questions were left open-ended during the pilot survey to get information from where and which price to start the willingness to pay questions. Hence, to consider this answer difference, we took the three most frequently said figures/modal values which were 20, 30, and 40 cents. The researcher used these prices as starting bids for the willingness to pay questions. These starting prices were randomly distributed in all the sample households interviewed. Households interviewed in the pre test were not included in the main survey.

The focus of the questionnaire was on the estimation of the households' willingness to pay for improved piped water supply. Studies like Yibeltal Bantie (2011) and Jonse Bane (2005) used the double bounded CV elicitation format but the studies found that double bounded value elicitation technique does not improve statistical efficiency over single bounded format. These studies identified small sample as the main reason for the loss of efficiency of the double bounded elicitation format. This study, therefore, used the single bounded elicitation format with an open ended follow up question, as it minimizes the strategic bias, and makes the decision most efficient to calculate values of households WTP for improved water services. Thus, using single bounded elicitation format has the advantage of giving better information on households' maximum willingness to pay.

Hence, the final version of the survey questionnaire designed for this study has three sections as indicated below.

I. Questions related with Households' water usage practices and present water supply situations
II. Willingness to pay questions using single-bounded dichotomous choice elicitation format
III. Household characteristics and income related questions

3.7 Model Specification

Given the nature of the data, two econometric models are used in the determinate analysis one of which is a Tobit model used to identify factors affecting the maximum amount a household is willing to pay for the improved water supply service and for dichotomous (yes/no) responses to the initial bid (β_i*) posed to the respondent, the Probit model better fits the problem at hand.

3.7.1 The Probit Model

The Probit model is among the most widely used members of the family of generalized linear models in the case of binary dependent variables. This model specifies an indirect utility function for each respondent assuming that the representative household gains utility from improvement in water services and the two possible levels of environmental quality involved are the status quo and a specific level of improvement. Hence, the main objectives of estimating econometric (or parametric) models in WTP surveys are to calculate mean WTP for the improved environmental good and to allow insertion of respondents' socio-economic factors into WTP functions. Such incorporation of individuals' socio-economic variables into the CV model helps the researcher to gain information on validity and reliability of the CV results and increase confidence in application of results obtained from the CV empirical analysis (Habb and McConnell, 2002).

The basic model to analyze dichotomous responses based on the random utility theory was developed by Hanemann in1984. The central theme of this theory is that although an individual knows his/her utility certainly, it has some components, which are unobservable from the view of the researcher. As a result, the researcher can only make probability statement about respondent's 'yes' or 'no' responses to the proposed scenario.

The indirect utility function for the jth respondent can be specified as follows:

$$U_{ij}=U_i\ (Y_j,\ X_j,\ \varepsilon_{ij})$$

Where Y_j= j^{th} respondent's income

i=1 denotes the final state and i=0 the status quo (or the initial state)

X_j= vector of household characteristics and attributes of a given choice

ε_{ij}= random component of the given indirect utility

If a payment (also called the initial bid, β_i*) is introduced due to changes in measurable attributes like quality or quantity of environmental goods, the consumer accepts the proposed bid only if

$$u_{1j}(y_j - \beta_i^*, x_j, \varepsilon_{1j}) > u_{0j}(y_j, x_j, \varepsilon_{0j})$$

For the researcher, however, the random components of preferences cannot be known and s/he can only make probability statement of 'yes' or 'no' responses. Thus, the probability that the respondent says' yes' is the probability that s/he thinks that s/he is better off in the proposed program. For individual j, the probability is:

$$P\ (yes) = P\ [u_{1j}(y_j - \beta_i^*, x_j, \varepsilon_{1j}) > u_{0j}(y_j, x_j, \varepsilon_{0j})]$$

This probability statement provides an intuitive basis to analyze binary responses. Assuming the utility function is additively separable in deterministic and stochastic preferences:

$U_i(y_j, x_j, \varepsilon_{ij}) + \varepsilon_{ij}$. Given the additive specification of the utility function the probability statement for respondent j becomes:

$$P\ (yes) = P\ [u_{1j}(y_j - \beta_i^*, x_j) + \varepsilon_{1j} > Uoj\ (y_j, x_j) + \varepsilon_{0j}]$$

This probability statement is the point of departure for the linear utility function in income and covariates, which is assumed by the empirical models.

The Probit model can be defined as

$$Ti = \beta' X_i + \varepsilon_i$$

Where

- β' is vector of parameters of the model
- Xi is vector of explanatory variables
- εi (the error term) and is assumed to have random normal distribution with mean zero and common variance δ2 (Greene, 1993).
- Ti=unobservable households' actual WTP for improved water supply service. Ti is simply a latent variable. What we observe is a dummy variable WTPi, which is defined as:

  $WTP_i = 1$ if $T_i \geq \beta_i^*$

  $WTP_i = 0$ if $T_i < \beta_i^*$

In the single bounded elicitation format, the jth respondent is asked if s/he would be willing to pay the initial "bid", (β_i*), to get, say, a given improvement in environmental quality, quantity or

both. The probability of a "yes" response, or a "no" response, $p^{Y \text{ or } N}(\beta_i^*)$ can be cast in terms of random utility maximization chosen by the respondent. It is clear from the random utility framework that the individual's WTP is a random variable from the point of view of the researcher. Thus, while the individual knows his/her own maximum WTP, T_i to the observer is a random variable with a given cumulative distribution function (cdf) denoted by $G(T_i;\Theta)$ where Θ represents the parameters of this distribution, which are to be estimated on the basis of the responses to the CV survey. Then, following the work of Hanemann (1984), the response probabilities related to the underlying WTP distribution are:

$$P^Y \equiv p\{\text{yes to } \beta_i^*\} \equiv p\{\beta_i^* \leq Ti\} = G(\beta_i^*;\Theta)$$

$$P^N \equiv p\{\text{no to } \beta_i^*\} \equiv p\{\beta_i^* < Ti\} = 1-G(\beta_i^*;\Theta)$$

The resulting log-likelihood function for the responses to a CV survey using the single –bounded format is

$$\ln L(\Theta) = \sum\{ d_i^Y \ln G(\beta_i^*;\Theta) + d_i^N \ln[1- G(\beta_i^*;\Theta)] \}$$

where d_i^Y =1 if the ith response is yes and 0 otherwise, while d_i^N =1 if the ith response is no and 0 otherwise

One of the main objectives of estimating empirical WTP model based on the CV survey response is to derive central value (or mean) of the WTP distribution (Hanemann, Loomis and Kanninen, 1991). Therefore, the mean WTP (μ) using the model for the single –bounded probit model format can be defined as follows:

$$= -\beta_0/\beta$$

Where, = the constant (or intercept) term

β= the coefficient of the bid posed to the respondent

3.7.2 The Tobit Model

An alternative method to OLS when the dependent variable response is less or equal to zero for a significant fraction of the observation is the so-called Tobit model. Tobit econometric model is used to analyze the determinants of WTP and the maximum amount of money that individuals are willing to pay. This model has an advantage over other discrete choice models (Linear probability model, Probit, and logistic) in that, it reveals both the probability of willingness to

pay and the maximum WTP of the respondents. Following Jhonston and Dindaro (1997) and Maddala (1997), the Tobit model can be specified as:

$$MWTP_i = \beta_0 + \beta_i X_i + \varepsilon_i$$

$$MWTP = MWTP_i \text{ if } MWTP_i > 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$= 0, \text{ if } MWTP_i \leq 0$$

where MWTP is a vector of willingness to pay which is censored at 0; X is a matrix of explanatory variables that are hypothesized to influence willingness to pay; β_i is vector of unknown parameters to be estimated corresponding to the matrices of explanatory variables X; ε_i is a disturbance term which is independently and normally distributed with mean zero and common variance δ^2 With $\varepsilon_i \sim N(0, \delta^2)$ and; $MWTP_i$ is a latent variable corresponding to MWTP. Remember that a value of MWTP is observed when it is greater than zero.

Then, the estimable model with censored data at 0 is:

$$MWTP_i = \beta_0 + \beta_1 RESX + \beta_2 REYS + \beta_3 IB + \beta_4 REAG + \beta_5 REIN + \beta_6 HOUSE + \beta_7 REFS$$
$$+\beta_8 WBD + \beta_9 REMS + \beta_{10} RESF + \beta_{11} REED + \beta_{12} SORC + \beta_{13} HHHD$$
$$+ \beta_{14} REOC + \beta_{15} LSAT + \beta_{16} VOLM + \beta_{17} QLTY + \beta_{18} RLTY + \varepsilon \text{ if } MWTPi > 0$$
$$= 0 \text{ otherwise (if } MWTP_i \leq 0) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

3.8 Description of Explanatory Variables and Hypothesis

RESX: **The sex of the respondent**. It is assumed that women would express more preference for improved water services and would be more willing to pay than men for the reason that women are often around the house with a higher burden of fetching water for domestic uses. A dummy variable for sex will be specified as 1 for female and 0 for male with a positive expected sign.

REED: **The education level of the respondent**. It is expected that, households with higher educational level are more aware of the different benefits that could be gained from an improved water services thus a positive relationship is expected. A dummy variable 1 is specified for formal education (primary, secondary and tertiary) and 0 otherwise.

REAG: **Age of the respondent**. This is a continuous variable with a negative expected sign. This is because older people, who used to live with freer water supply and less prices, may be reluctant to prefer new improved and less willing to pay for it.

REOC: **Respondents occupational status**. This is a dummy variable taking 1 if the respondent works in the formal sector for salary; 0 otherwise. There is no prior expectation in this case and it is included to test its effect.

REIN: **Monthly income of the househol**d. This continuous variable is a sum of the head's income and the income of other members of the family. The available literature suggests that there is a positive relationship between income and improved water service. Theory also supports this intuition that income and quantity demanded are positively related in the case of normal goods. As a result a positive sign is expected on the variables of income.

HOUSE: Ownership of house. This variable is taken as proxy for wealth. It is a dummy variable 1 if the respondent has house, 0 otherwise. The expected sign of the coefficient of this variable is positive since richer individuals demand for the improved water service is high because they are less resource constrained.

REMS: **Respondents Marital Status**. This is a dummy variable taking 1 if the respondent is married; 0 otherwise. This variable is expected to have a positive sign since married people are more cautious of the health and other risk involved in poor water supply service due to family responsibility in the future than the single ones.

HHHD:-Whether the respondent is head of his/her household-it is also a dummy variable, taking 1 if the respondent is the head of his/her household, 0 otherwise. The coefficient has positive expected sign for the reason that if he/she is the head he/she is responsible for the health status of his/her family and thus the demand for improved water service is high indicating higher willingness to pay for the proposed scheme.

REFS: **Respondents family size**. There are two different views concerning the impact of family size on willingness to pay. One study has shown that as the number of family size increases, willingness-to-pay for improved water services will also increase. The rationale given is that, as the number of members increases in a given household, households will be more aware of the risk involved with poor water supply provision. Thus crave for a better service by giving high willingness-to-pay. But in our case with limited job opportunities in Mekelle, increase in family

size will also increase the number of unemployed members in the family. Thus it will increase household's expenditure and a growing need to match with one's income. Thus a negative relationship is expected in the second case.

REYS: **Respondents years of stay in the area**. It is hypothesized that the more households stay in a particular area, the more they would be willing to pay for the proposed improvements since they will know more about the benefits. In addition, there will be sentimental attachments to that area. A positive relationship is thus expected.

IB: **Initial bid**. This variable will help to see whether household's responses are affected by the initial bid. In the closed ended dichotomous choice format it has a negative expected sign since higher offers are more likely to be rejected by respondents. However the coefficient of this variable is difficult to determine a priori in the open-ended format since it is determined by respondents.

WBD: **Respondents or members of the household who suffer from water born diseases** are expected to be more willing to pay in order to improve piped water service in the city. A positive relationship is thus expected.

RESF: **Respondents sanitation facility**. Based on Mekelle water supply and sewerage services data, three sanitation facilities (flush toilet, pit latrine, and public toilet) were selected, which are believed to represent the sanitation facilities available in the city (Mekelle). A dummy variable one is given to flush toilet and, 0 otherwise. A positive sign is expected because flush toilet requires the use of water for its function as compared to other sanitation facilities and hence makes households to be more willing to pay for the improved water service.

SORC: Main source of water being used. It is a dummy variable, taking 1 if the household has private connection; 0 otherwise. Since a household with private connection is expected to be less interested, it is expected to be less likely to pay for the improved service than others who use public taps and others. The expected sign of this variable's coefficient is, therefore, negative.

LSAT: Respondents level of satisfaction with the existing service. It is a dummy variable which is 1 if the household is satisfied with the existing water service; 0 otherwise. A negative relationship is expected between willingness to pay and this variable as households that are satisfied with the existing water services are expected to have less willingness to pay for improved services.

RLTY: Reliability of the existing source being used. This is a dummy variable taking 1 if the existing source is reliable; 0 otherwise. The expected sign of the variable's coefficient is negative since households WTP for improved water service will be lower if the existing source is reliable.

VOLM: Volume of water used by household. Households whose water usage is high are expected to have less likelihood to support the improved water service scheme since they spend more to get water from the improved services. On the other hand households whose water usage is low would be more likely to pay for this improved water service. Therefore it is difficult to determine the coefficient's sign a priori.

QLTY: Respondents' perception level of quality of the existing supply. Without any theoretical a priori, if households perceive a good quality then there will be no incentive for them to prefer the improved system and vice versa. A dummy variable 1 will be specified for households who perceive high quality and zero otherwise.\

Chapter Four

Analysis of the Surveyed Data

This chapter deals with the empirical findings and discusses the results obtained. The data from the **contingent valuation survey** is analyzed in two ways. The first part used descriptive analysis with the help of summary statistics. Besides, an overview of the households' attitude towards the existing water supply in the city is discussed. In the second part, Probit and Tobit models are used to analyze the surveyed data econometrically. In the Probit model we have analyzed and discussed factors that affect households' probability of accepting the initial bid posed to them and the mean WTP from the closed-ended questions has been also estimated while using the Tobit model we have analyzed and discussed the factors that affect the maximum amount of money that households are willing to pay.

4.1 Descriptive Analysis

4.1.1 Socioeconomic and Demographic Characteristics of Households

As previously stated a total of 215 households were interviewed from three different Kebeles of Mekelle city. Of all the sample population, 13 responses were dropped because some of them lacked the required information and others gave unreliable and inconsistent answers. Hence, only 202 questionnaires were used for this analysis. The basic information on sampled households is displayed in Table 2. Of the surveyed households, 106 (52.48%) were female respondents while 96 (48.52%) were male respondents. From the total of 202 sampled households 128 (63.37%) were head of their households and the rest 74 (36.63%) were just members of the households. The later sets of respondents were only interviewed in the absence of their household heads. According to the survey findings, 75.25% of the respondents are married. The data about the respondents' age shows that the average is about 39 years which ranges from 16 to 75 years of old. The average family size of the households is about 5 individuals with a minimum of 1 person in the house to a maximum of 11 household members.

The education figure reveals that 82.67% of the respondents have attended their formal education (primary, secondary, and tertiary) and the rest are either illiterate or have religious education.

Concerning the employment structure of the respondents, 62 (30.69%) respondents were employed in the formal sector for salary, 21.45% run their own businesses, 19.31% were housewives and students, and the rest of the respondents were unemployed, retired and self employed. The survey result also shows that 144 (71.29%) households were living in their own house; moreover the surveyed households have been living for 20.75 years on average in the city starting from a minimum of 6 months to a maximum of 70 years.

The most difficulty was the query on the level of income the household earns. Most of the respondents were not eager to state their earnings and others don't really know their average monthly income. But appropriate emphasis was given in the training session to this part and the enumerators were able to come up with a fair estimate of households' average monthly paycheck, taking average monthly expenditure as a cross checking mechanism. Therefore, the average monthly income of the sample households is about birr 2990. The income level ranges from a minimum of birr 200 to a maximum of birr 15,000 per month. In line with this, the average monthly expenditure of the sampled households is about 2456 birr. Among different expenditures of the household; like food, electricity, water, transport, medical, etc., food expenditure takes the lion's share.

Table 2: Characteristics and water use profiles of surveyed households

Variable	Description	Mean	Std.Dev	Min.	Max.
RESX	**Gender, dummy variable 1 if male,0 other wise**	**.4752475**	**.5006277**	**0**	**1**
REMS	**Marital status, dummy variable 1if married, 0 otherwise**	**.7524752**	**.4326464**	**0**	**1**
HHHD	**Household head, dummy variable 1 if head, o otherwise**	**.6336634**	**.483**	**0**	**1**
REAG	**Age of the respondents in years**	**38.78713**	**15.32985**	**16**	**75**
REIN	**Households' average monthly income in birr**	**2990.153**	**2378.433**	**200**	**15000**
REFS	**Family size of the respondent in number**	**4.945545**	**2.049634**	**1**	**11**
HOUSE	**House, a proxy for wealth, dummy variable 1 if the respondents have their own house,0 otherwise**	**.7128713**	**.4535462**	**0**	**1**
REYS	**Respondents years of stay in the city in years**	**20.74505**	**14.49792**	**0.5**	**70**
REED	**Education level of the respondent, dummy variable 1 if formal education, 0 otherwise**	**.8267327**	**.3794185**	**0**	**1**
REOC	**Respondents occupation, dummy variable 1 if the respondents work in formal sector for salary, 0 otherwise**	**.3069307**	**.4623663**	**0**	**1**
VOLM	**Volume of water used by household in jerry can (20 liter container) per day**	**4.235149**	**2.894566**	**0.5**	**20**
QLTY	**Quality of water being used, dummy variable 1 if good, 0 otherwise**	**.2821782**	**.4511778**	**0**	**1**
RLTY	**Reliability of the existing source, dummy variable if reliable, 0 otherwise**	**.2772277**	**.4808536**	**0**	**1**
LSAT	**Level of satisfaction with the existing service dummy variable 1 if satisfied,0 otherwise**	**.2574257**	**.4383021**	**0**	**1**
SORC	**Households' main water source, dummy variable 1 if piped, 0 other wise**	**.8960396**	**.3059674**	**0**	**1**
RESF	**Respondents sanitation facility, a dummy variable 1 flush toilet, 0 otherwise**	**.5544554**	**.4982606**	**0**	**1**
PURIF	**Purification of water ,dummy variable 1 if households are purifying water before drinking, 0 otherwise**	**.1980198**	**.3994972**	**0**	**1**
WBD	**Water born diseases, dummy variable 1 if yes,0 otherwise**	**.1138614**	**.318432**	**0**	**1**
RESP	**Responsible organ for provision of improved water, dummy variable 1 if government, 0 otherwise**	**.7524752**	**.4326464**	**0**	**1**
IB	**Initial bid offered to the respondent**	**29.60396**	**7.716467**	**20**	**40**
YES/NO	**Households' WTP for initial bid, dummy variable 1 if yes, 0 otherwise**	**.8366337**	**.3706181**	**0**	**1**
MWTP	**Households maximum willingness to pay**	**51.5099**	**27.65859**	**0**	**200**

Source: computed from surveyed data, 2013

Note: The description of each variable is given in section 3.8

Note that the mean estimates of dummy variables should be interpreted as percentage. For example, the mean of the respondents' gender is 0.4752475. This means that 47.52% of the respondents are male.

4.1.2 Existing water supply condition of the sampled households

Most of the surveyed households, 95.6%, use piped water. Of the total surveyed households about 81% of the households have private connections, 11.24% use yard connections, 7.76% use public tabs and private venders. Only nine persons or (4.4%) of the total respondents use none piped water mainly dug well. The survey results also show that sampled households, on the average consume 4.24 jerry can or 84.8 liters of water per day.

As to the standards of the existing services delivery only, 25.74% of the respondents satisfied with the status quo level. One hundred fifty respondents (74.26) revealed their dissatisfaction with the existing systems. When these respondents asked to tell the main causes of their dissatisfaction, about 47% of them said unreliability, 33.5% of them condemned quality, the rest said low quantity, higher volume charge, and far away from home.

Of the total surveyed households, only 27.72% of them said the existing source is reliable and available as the time it is needed. About one hundred forty five respondents (71.77%) of the total respondents complained that the existing water quality is poor. But most of the respondents do not use any kind of purification method to treat the water they use. When they asked why they don't treat before drink, 53.7% of them said the water is not clean but treating is costly and time consuming, 33.36% of them replied the water is not clean but has no side effect on health, and the rest reasoned out that the water is clean for drinking. Only 19.80% of them reported purification sometimes before drinking either by boiling or adding chemicals. The other findings of the study shows that out of the total respondents, 23 (11.39%) of them indicated that the member of their households were suffered from water born diseases such as diarrhea, typhoid, cholera, and vomiting due to deficient water quality.

Regarding the responsibility in the provision of improved water supply for the city 75.25% of the respondents claimed that the government should take the responsibility to provide the improved water services. Twenty eight (13.86 %) respondents said government and community should provide the improved services. Twenty two (10.89%) said private sectors should provide the improved water services for the city.

4.1.3 Households' Willingness to Pay for Improved Water Services

As briefly explained in the methodology part, in the final survey, three starting prices for the corresponding valuation question were used for the close-ended dichotomous choice format together with the open-ended question to inquire them their possible maximum willingness to pay for one jerry can or 20 liter of water they get from the hypothetical improved services.

In the close-ended question, from the total of 202 respondents, 169 (83.66%) have said 'Yes' to pay an average initial bid amount of 29.60 cents per Jerry can (20 liter of water) which ranges from a minimum of 20 cents to a maximum of 40 cents and the rest 33 (16.34%) have refused to pay this initial bid amount. Furthermore the surveyed result indicated that in the open-ended questions, 199 (98.51%) of them bestowed positive amounts as they are willing to pay for improved water services for 20 liter of water in cents and the rest 3 (1.49%) were having zero WTP. The following table summarizes households' maximum willingness to pay for improved water services during the survey period.

Table 3: Summary of Maximum Willingness to Pay Reported by Surveyed Households

Maximum WTP Reported	Number of surveyed households	Valid percentage	Cumulative Percentage
0-30	**47**	**23.28**	**23.28**
31-60	**110**	**54.46**	**77.74**
61-90	**31**	**15.34**	**93.08**
91-200	**14**	**6.92**	**100**

Source: own survey result, 2013

As we can see from the table, 47 (23.28%) of households have been willing to pay within the range of 0 and 30 cents which is 15 cents on average, 110 (54.46%) said that they are willing to pay an approximate average of 45.5 cents, 31 (15.34%) of them have been willing to pay an average of 75.5 cents, the rest 14 (6.92%) have been willing to pay an average of 145.5 cents per 20 liter of improved water. In addition to this, the survey result shows that the mean willingness to pay for the whole sampled households is 51.51 cents per 20 liter of water which ranges from a minimum of 0 cents to a maximum of 200 cents from the open- ended question and 29.60 cents from the close-ended dichotomous choice format per 20 liter of water and these amounts are

surprisingly higher than the current water tariff structure of the city which are 8 cents for the consumption of 0.1-5m^3, 10 cents for the consumption of 5.1-10 m^3, 16 cents for the consumption of 10.1 -20 m^3, 20 cents for the consumption of 20.1-50 m^3, 24 cents for the consumption of 501-100 m^3, and 30 for the consumption of above 100 m^3 per 20 liter of water at private connections and 8 cents per 20 liter of water at the public taps (from table 2.1). This shows that the surveyed households were willing to pay more than the current water tariff rate for the improved water services. Therefore, if the improved system is introduced in addition to addressing the water needs of the city, the city's utility management can also collect more funds from water sale which can be used for water expansion projects.

4.2 Empirical Analysis

As we have pointed out earlier, in addition to the descriptive analysis, deterministic analysis puts us in a broader framework, as to which factors are responsible for the willingness to pay for improved water services. The WTP question for private connection is presented for all respondents (for both who have a private access to the existing pipe system and those who have not). The general approach of this technique is to estimate a valuation function that relates the hypothesized determinants with the WTP responses. The variables to be included in the models were mainly based on the degree of theoretical importance and their significant impact on WTP.

Data exploration is an important preliminary step before estimation is done. The precision of estimating the coefficients of variables is reduced by the existence of multicolliniarity between variables that is if the explanatory variables are highly correlated it is difficult to distinguish the effects of one single explanatory variable on the dependent variable (Maddala, 1992, pp. 269-270). Gujarati has established a rule of thumb which says that multicoliniarity is a serious problem when a pair wise correlation coefficient between two regressors is greater than or equal to 0.8 (Gujarati, 1998, p. 229). Accordingly, the correlation matrix generated using the data shows that multicolliniarity is not a serious problem (See Annex-1)

Econometric theory tells us that we are likely to encounter heteroscedastcity frequently in econometric data, particularly with cross-sectional data. Before passing in to the analysis of the result of the estimation of the models, test on the possible existence of heteroscedastcity is

important for this study. The violation of the homoscedaticity assumption in the general linear model, OLS estimates are consistent but inefficient. However the problem for non-linear models such as Tobit is more sever, i.e. the resulting estimates are not even consistent (Maddala 1983). Since our data is cross sectional by its nature we are likely to encounter with the problem of heteroscedastcity. One of the important methods used to test the existence of heteroscedastcity in Tobit model is the log–likelihood ratio (LR) test (see Annex 2). This test shows that the null hypothesis of homoscedaticity is rejected, i.e. heteroscedastcity is a problem for the model.
Because of this we cannot use a simple Tobit model for this study rather we use heteroscedastic Tobit model. To correct this heteroscedastcity problem robust standard errors can be estimated for the Probit model.

4.2.1 Results and discussions of the Probit Model

The Probit estimation results obtained using STATA version 11.0 is given in Table 4. The coefficients of the Probit model only give the significance and the direction of the effects of each explanatory variable on WTP. The marginal effects indicate that the probability that respondents accept or reject the offered bid due to a unit change in continuous explanatory variables and a change of dummy variables from 0 to1, for discrete variables (Greene, 1993). Both the coefficients and marginal effects of the Probit model are given in Table 4.

Table 4: Maximum likelihood estimates of the probit model

Variable	Coef.	Robust Std. Err.	Z-value	Marginal Effects(dy/dx)
RESX	-.7745432	.3834256	-2.02**	-.0880859
REAG	-.0132842	.0136629	-0.97	-.0014103
REMS	.6414984	.3820293	1.68*	.0891616
HHHD	.2915	.4116347	0.71	.0292045
REIN	.0001789	.0000937	1.91*	.000019
REFS	-.0748643	.068072	-1.10	-.0079476
HOUSE	.161947	.3355376	0.48	-.016276
REYS	.0068416	.0114457	0.60	.0007263
REED	.6495563	.3692761	1.76*	.0968647
REOC	.7869971	.325262	2.42**	.0680255
SORC	.4063998	.4537035	0.90	.0557726
VOLM	-.0432142	.0420681	-1.03	-.0045876
QLTY	-.448714	.2259504	-1.99**	.023197
RLTY	-.4637406	.2423187	-1.91*	-.0492308
LSAT	-.620733	.3375085	-1.84*	-.0847871
WBD	.5507	.5271017	1.04	.0416449
RESF	.2357092	.3038367	0.78	.0245993
IB	-.0831483	.0199541	-4.17***	-.008827
_cons	3.812686	.7480502	5.10	
Number of obs		*202*		
Wald chi2(18)		*53.05*		
Prob > chi2		*0.0000*		
Pseudo R2		*0.3919*		

*** - Significant at 1% level of significance

**- Significant at 5% level of significance

*- Significant at 10% level of significance

-(dy/dx) is for discrete change of dummy variable from 0 to 1

The dummy variable, gender of the respondent, has a negative sign as expected and it is also statistically significant at 5%, suggesting that female respondents are willing to pay more than their male counterparts. This may be true because females are usually responsible for water supply management in the house. Therefore, the marginal effect of this variable implies that females have 8.81% more probability than males to accept any initial bid offered, ceteris paribus.

Marital status of the respondent is another dummy variable significant at 10%, implying that married individuals are more cautious about the health status of their family members; thus, their probability of accepting any starting bid posed is 8.92% more likely than their single counterparts, ceteris paribus.

Income of the household, which is significant at 10% level, suggests that a one birr increase in the income of the household increases the probability of accepting an offered bid by 0.0019%, other things being equal.

Education level of the respondent is another important dummy variable significant at 10% which implies that the probability of accepting the initial bid posed is 9.69% more for respondents who have formal education (primary, secondary, and tertiary) than those who have not, ceteris paribus

The respondents' occupation has a positive sign as expected and it is significant at 5% significance level which implies that the probability of accepting any initial bid offered is 6.8% more for employees working in the formal sector for salary than those in other sectors, keeping effects other regressors constant.

As expected, the dummy variable representing reliability of the existing water source has a negative sign and is significant at 10% significance level. This suggests that if households feel the existence source is reliable then they are less willing to pay for the improved service of water, vice versa.

The coefficient of the dummy variable representing the level of satisfaction with the existing service has the expected negative sign and it is statistically significant at 10%. This shows that respondents who reported satisfaction from the existing source are less willing to pay for the improved water services than those who did not, other things constant..

The dummy variable quality of water being used has a negative sign as expected and is statistically significant at 5% level of significance. This suggests that households for whom water

quality from the existing source is good are less likely to pay for improved water services, ceteris paribus.

Initial bid offered to the respondents has a negative effect on the probability of accepting the bid and is significant at 1% significance level. This suggests that a one percent increase in the initial bid will reduce the likelihood that respondents are paying for improved water services by 0.88%, ceteris paribus.

Main source of water used by a household, a dummy variable either piped or otherwise, is the only variable with an unexpected positive sign which implies that a household with a piped source is more willing to pay for the improved service than the household without it. This may be due to the difference in taste and preference of respondents for piped water and the less awareness for the advantage of piped water for those who used to live in free and less improved water sources. This variable is also statistically insignificant and taken as less important for this study.

Ownership of the house, being household head, water born diseases, respondents years of stay in the city, and respondents' sanitation facility are the other variables in the model with a positive sign as expected but statistically insignificant to explain the model and thus considered as less important regressors for this study.

The age of the respondent, respondents' family size, and volume of water used per household per day are also independent variables used in this model with a negative sign as hypothesized before but with statistical insignificance, hence we consider them as less important for this study.

As described in the methodology part, for the Probit model the mean WTP for dichotomous choice contingent valuation survey responses can be calculated by dividing the negative of the regression constant (intercept) by the bid coefficient.

Therefore Mean WTP $=\mu=-\beta_0/\beta=-3.812686/-0.0831483=45.854$. Thus, we conclude that the mean WTP obtained from the closed-ended format is 45.9 cents for the proposed improved water services per 20 liters of water.

4.2.2 Results and Discussions of the Tobit Model

The Tobit results using STATA version of 11.0 are given in Table 5. The result for the variable income is consistent with a priori expectation as it has a positive influence on the amount of money that households are willing to pay and is highly significant at 1% level. The regression result confirms the economic theory which says that income and quantity demanded for a particular commodity are positively related for the case of normal goods.

Like in the Probit model, sex of the respondent is significant at 5% level with negative sign as expected in the Tobit model which articulates that females are more willing to pay for the improved water services than males, other things being constant.

Higher level of education leads to higher amount of money that households are willing to pay suggesting that educated people are more aware and know the value of improved water services. Thus, as expected the respondents' education as a dummy variable is affecting positively the households' maximum willingness to pay and also significant at 5% level.

The dummy variable level of satisfaction of the existing service has also the expected negative sign and is significant at 5% level. This suggests that households who are satisfied with the existing service are not willing to pay more for the proposed water improvement scheme than those who claimed that they are not satisfied, ceteris paribus. Its significance level indicates that it is one of the strongest factors affecting the amount of money that households are willing to pay for this improvement scheme.

Water born diseases is a dummy variable if a household member is suffered or not, which significantly affects, at 5%, the maximum amount a household pays for improved water services in the Tobit model unlike in the Probit model even if the sign is positive in both models as expected..

Respondent's sanitation facility is another dummy variable significant at 5% in the Tobit model, which implies that respondents who have flush toilets are more willing to pay than those who do not have (those using pit latrines and off-site options), other things being constant.

The other regressors, in the Tobit model, are statistically insignificant and their signs are in line with the researcher's prior expectations and parallel with what most literatures states except the dummy variable main source of water being used by households which has also a positive sign here in this model like in the Probit model above.

Mean WTP $=\mu=\Sigma Ti/n$, where 'Ti' is the reported maximum WTP amount by surveyed households and 'n' is the sample size.

Mean WTP $=\mu=10405/202=51.5099$

Thus, we conclude that the mean WTP obtained from the open-ended format is 51.51 cents for the proposed improved water services per 20 liters of water.

Table 5: Maximum Likelihood Estimates of the Tobit model

Variable	Coef.	Std. Err.	t	Marginal Effects(dy/dx)	Mean
RESX	-10.39111	3.966021	-2.62**	-10.39111	.475248
REAG	-.0313492	.1608721	-0.19	-.0313492	38.7871
REMS	.9943504	4.208562	0.24	.9943504	.752475
HHHD	6.414532	4.380275	1.46	6.414532	.633663
REIN	.0033948	.000832	4.08***	.0033948	2990.15
REFS	-.4700089	.915346	-0.51	-.4700089	4.94554
HOUSE	4.157664	3.968209	1.05	4.157664	.712871
REYS	.0540881	.1483813	0.36	.0540881	20.745
REED	11.88203	4.928432	2.41**	11.88203	.826733
REOC	2.665614	3.873758	0.69	2.665614	.306931
SORC	5.970171	5.977733	1.00	5.970171	.89604
VOLM	-.7490928	.634931	-1.18	-.7490928	4.23515
QLTY	-.3092477	4.165796	-0.07	-.3092477	.282178
RLTY	-1.721539	3.855907	-0.45	-1.721539	.277228
LSAT	-10.55708	4.496778	-2.35**	-10.55708	.257426
WBD	14.35117	5.546537	2.59**	14.35117	.113861
RESF	9.059149	3.757659	2.41**	9.059149	.554455
IB	.1608665	.2239788	0.72	.1608665	29.604
_cons	35.45866	10.16488	3.49		
Number of obs		*202*			
LR chi2(18)		*81.88*			
Prob > chi2		*0.0000*			
Pseudo R2		*0.0431*			

***** - Significant at 1% level of significance**

****- Significant at 5% level of significance**

***- Significant at 10% level of significance**

-(dy/dx) is for discrete change of dummy variable from 0 to 1

From the overall results of the valuation, the results indicate that the mean willingness to pay for the improved water services from the closed-ended dichotomous choice questions is 29.60 cents, while it has a value of 51.51 cents from the open-ended question surveys per jerry can (20 liters of water) putting the range of households' willingness to pay between 29.60 and 51.51 cents per 20 liters of water for the proposed improved water service.

4.2.3 Total Willingness to Pay and Total Revenue

In the previous sections we have seen the factors that are influential for willingness to pay if there is improvement in water supply service. So theoretically, what comes next is aggregation, which is the last part of the CV survey. Based on the willingness to pay derived from the open-ended surveys the total willingness to pay and total revenue at different prices that households are willing to pay is calculated and the demand curve for the improved water service has also been derived.

The total population of Mekelle city as explained in chapter three is about 257, 290 constituting 51, 458 households which is approximately the same as dividing the total population by our survey results of average family size of 4.9 (FDRE PCC, 2008).

The class boundaries for the maximum willingness to pay amount reported by households are used to make the aggregation of total WTP, total revenue and deriving the demand curve for the proposed improved water scheme.

Table 6: Aggregate WTP and Aggregate Revenue (in cents) from improved water services

Maximum WTP Reported	Mid(class mark) for WTP	Number of surveyed HHs		Total number of HHs.	Sample HHs willing to pay at least that amount(cumulativ)		Total HHs willing to pay at least that amount (cumulative)	Total revenue (in cents)
		Count	percentage		Count	percentage		
0-30	15	47	23.28	12,224	202	100	52,508	787620
31-60	45.5	110	54.46	28,596	155	76.7	40,284	1812780
61-90	75.5	31	15.34	8,117	45	22.3	11,750	887125
91-200	145.5	14	6.92	3633	14	7	3,633	528601

As noted earlier, in addition to reducing the water problem of the city, the proposed water improvement scheme can increase the revenue of the water utility management in the city.

In terms of total number of households and their associated maximum WTP, this study also used the survey to derive the demand curve for the proposed improved water services of the city. The aggregate demand curve is derived using the mid WTP amount along the vertical axis and the

number of households willing to pay at least that mid amount per jerry can (20 liters of water) along the horizontal axis. Therefore, the demand curve for the improved water service at different price levels is shown graphically as follows.

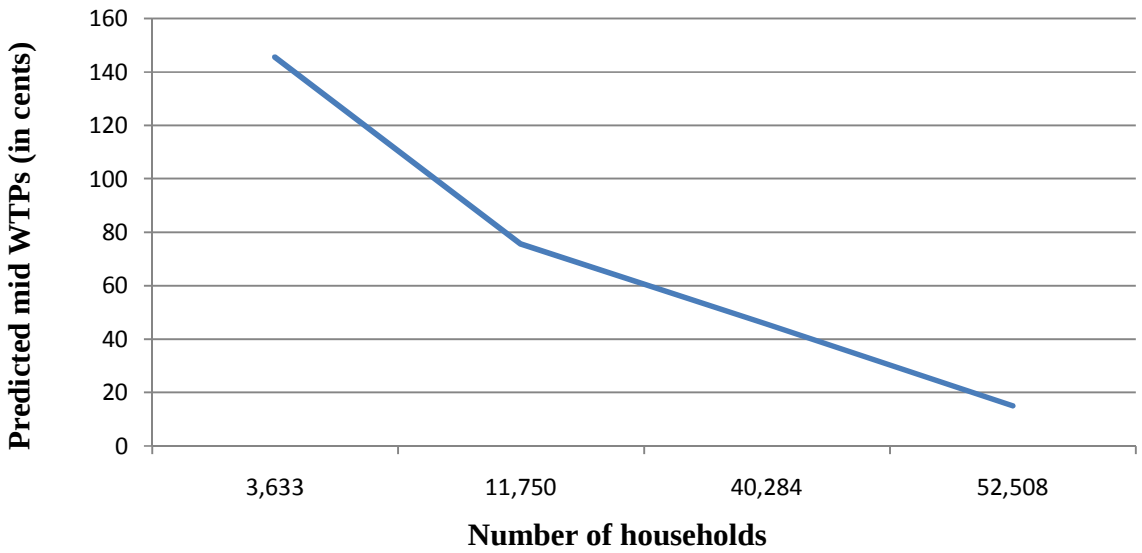

Figure 1 : Aggregate Demand curve of improved water services

We note from the above fig. that the demand curve is negatively sloped indicating that, like most economic goods, the demand for improved water services will decrease with increasing water use charges, keeping all other things constant.

Chapter five

Conclusions and Policy Implications

5.1 Conclusions

Urban water supplies provided by public utilities are facing an acute crisis in many developing countries. As such, the urban and industrial centers of Ethiopia are also characterized by poor water supply services. Mekelle city is one of the areas faced with unreliable and inadequate supply of water. As noted above, one of the main reasons for this acute shortage of water is population increment which creates incompatibility between the supply and demand of improved water services which in turn creates a greater burden on the supplier due to financial constraint.

This study, therefore, attempted to analyze the demand side of improved water supply services with the aspire of looking into the possibility of cost sharing by the residents for the improved water services by eliciting their WTP. The study mainly used cross-sectional primary data while it is also supplemented by secondary data from different relevant sources.

The Contingent Valuation Method (CVM) is used based on face-to-face interview with 215 randomly selected sampled households. The single-bounded dichotomous choice with an open-ended follow up elicitation format was used for the valuation part. Further the sampled households were also asked questions related to demographic and socioeconomic characteristics, problems with the existing water services, their water use practices and some other general questions.

We used the Probit model to analyze the determinants of households' to accept or reject the initial bid posed to them and to calculate the mean WTP of these sampled households while the Tobit model was used to analyze the factors affecting maximum amount of money that households are willing to pay for the proposed improved water scheme. The results obtained from the CV survey were analyzed using the econometric software STATA version 11.0.
The descriptive analysis showed that out of the total 202 usable response, 95.6% of respondents confirmed that piped water is the main source of water for their households.74.26% of them were

not satisfied with the existing water service due to factors that include poor quality, low quantity, unreliability, higher volume charge, and distance from the source. The survey result also showed that the mean consumption of water per household per day was 4.24 jerry can (84.8 liters of water).

98.51% of the usable responses had positive willingness to pay for improved water services with a mean WTP of 51.51 cents per jerry can in the open-ended and 29.6 cents within the closed-ended format, which are much higher than the current water tariff of the city which is 8 cents per jerry can for those who consume up to 5m3. This shows that if the city's utility management will implement the proposed water improvement scheme, in addition to solving the severe water problem of the city, the water service office can collect more revenue from the sale of improved water by charging higher price than the current tariff.

The Probit model shows that quality of water being used dummy (1 if good), reliability of the existing water source dummy (reliable=1), level of satisfaction for the existing source, respondents' education, income of the household, respondents' occupation, sex of the respondents, respondents' marital status, and initial bid offered were significant factors that affect households' probability of saying 'Yes' to initial bid. The remaining variables are statistically insignificant.

The output from the Tobit model shows that the following variables had a positive and statistically significant effect on the maximum amount of money that households are willing to pay for improved water services: monthly income of the household, respondents' education, water born diseases, and sanitation facility of the household. The variables, sex of the respondent and level of satisfaction (1 if satisfied) have the expected negative sign with a statistically significant influence on the maximum willingness to pay of households. The rest variables are statistically insignificant.

Therefore, sex of the respondents, income, education, and level of satisfaction for the existing service are significant variables that affect WTP in both of the two models.

5.2 Policy Implications

Based on our findings, we can draw the following important policy implications.

- ✓ Project planners should take in to consideration the poor quality and unreliability problems in designing the water system of the city to provide good quality and reliable water supply services since these two variables are found to be the sources of greater dissatisfaction of the existing service.
- ✓ Policy makers need to consider that supplying improved water services can further empower females because they are found more willing to pay than their male counterparts in both elicitation formats.
- ✓ Consider the effect of awareness, income and education in water development programs and design mechanisms to address them appropriately.
- ✓ Consider the demand side of the market for water as opposed to the supply side in service providing development programs.
- ✓ Since the mean WTP of the sampled households is far above the city's current water tariff, the utility management can implement the proposed water improvement scheme to satisfy the water needs of the community while at the same time collecting more revenue from the sale of this improved water at a higher price.

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Annex 1**: Correlation Matrix for Explanatory Variables**

	sex	age	rems	areuhe~h	rein	refs	house	reys	dummye~c	dumocc~n	mainso~e
sex	1.0000										
age	0.2991	1.0000									
rems	0.1783	0.3663	1.0000								
areuheadofhh	0.4973	0.4443	0.2305	1.0000							
rein	0.0100	-0.0099	0.1798	-0.0383	1.0000						
refs	-0.1056	0.2015	0.1530	-0.0353	0.3475	1.0000					
house	0.0124	0.2395	0.1938	-0.0510	0.1611	0.2667	1.0000				
reys	0.0034	0.5662	0.1743	0.1493	0.0759	0.2729	0.2865	1.0000			
dummyeduc	0.0166	-0.2767	-0.0201	-0.1309	0.2296	0.0390	-0.0014	-0.0881	1.0000		
dumoccupat~n	0.1405	-0.0420	0.1578	0.1273	-0.0042	-0.0715	-0.0284	-0.1849	0.2196	1.0000	
mainsource	0.0643	0.0090	0.1053	-0.0233	0.2092	0.0941	-0.0011	0.0366	0.1441	0.2267	1.0000
volume	-0.0003	0.2282	0.1142	0.0192	0.2997	0.2864	0.1862	0.3099	0.0486	-0.0802	0.1317
quality	-0.1341	0.1353	-0.0227	-0.0484	-0.1534	0.0328	0.0089	0.1232	-0.1198	-0.1072	0.1054
reliability	0.0286	0.0674	0.0206	0.1610	-0.0852	0.0709	0.0018	-0.0216	-0.0081	-0.0266	-0.0060
satisfaction	0.0972	0.1185	-0.0296	0.0952	-0.1743	-0.0175	0.0483	-0.0088	-0.2091	0.0010	0.2006
wbd	0.1270	0.1232	0.0611	0.1755	0.0002	0.1010	0.1241	0.0149	0.0406	0.0656	-0.1332
sanitation~e	0.0952	0.1640	0.0167	0.0626	-0.2782	-0.0531	-0.0846	0.0551	-0.2525	-0.0513	0.0863
ibperjerican	0.1005	0.0195	0.0301	0.0543	0.1899	0.0332	0.0384	0.0273	0.0784	-0.0076	0.1721

	volume	quality	reliab~y	satisf~n	wbd	sanita~e	ibperj~n
volume	1.0000						
quality	0.1318	1.0000					
reliability	0.1084	0.2797	1.0000				
satisfaction	-0.0127	0.3604	0.3443	1.0000			
wbd	-0.0859	-0.1555	-0.1747	-0.1041	1.0000		
sanitation~e	0.0075	0.2965	0.2066	0.3228	-0.0550	1.0000	
ibperjerican	0.1033	0.0751	0.0566	0.1480	-0.1638	-0.1108	1.0000

Annex 2: Test for Heteroscedastcity and Goodness of Fit

The LR statistics of testing the null hypothesis of homoscedaticity assumption is obtained by

λ_{LR}=2[Log Lu-LogLr]

Where log Lu is the value of unrestricted log-likelihood function and LogLr is the value of restricted log –likelihood function

λ_{LR} has a $X^2(n)$ distribution with n degrees of freedom where n is the number of independent restrictions. If the data do not support the null hypothesis (homoscedaticity assumption), then the value of the test-statistic became large and null hypothesis is rejected $\lambda_{LR} \geq X^2(n)$. The result of the test for the model is shown below

λ_{LR} =2[Log Lu-LogLr]

=2[-853.3735 – (-934.4304)]

=2[81.0569]

=162.1138

The critical value of the chi-square at 18 degrees of freedom is 63.36 at 95% level. Comparison of the results (test statistics) with critical table value shows that all of the test statistics (computed values) are found to be larger than the critical table value.

1.2 Test for Goodness of fit

Equivalent to R2 in a conventional OLS regression model the likelihood ratio index is used to measure the goodness of fit for probit model. It is computed using the formula

LRI = 1-lnLr/lnLo

Where lnLr is the value of unrestricted log-likelihood function and lnLo is the value of loglikehood function. Its value lies between 0 and 1. If it is one implies" perfect" fit. According to Green (1993) values between zero and one have no natural interpretation but as LRI approaches one it shows improvement in goodness of fit

- ✓ Then the computed value of LRI for our probit model is:

LRI =1- (-79.87260 /-159.7614) =0.3919

The computed ratio shows that the model seems adequate it explains 39.19%of the variation, which is common for cross-sectional data.

The computed value of LRI for the Tobit model is

LRI =1- (-853.3735/-934.4304) =0.0431. The LRI is 0.0431 this means that the model explains about 4.3% of the variation in explained.

Annex-3: Contingent valuation survey- household questionnaire on Water supply service

Interviewer Name_____

Place of interview_____ (write kebele №)

Date of Interview_____

Length of Interview_____ (minutes)

Household Code _____

Supervisor _____

INTRODUCTION TO THE RESPONDENT

How are you, I am _____. I am assisting an ongoing research by **Saleamlak Fentaw** for the partial fulfillment of his MSc. in economics at Mekelle University. The questionnaire is designed to obtain information on the current situation of water supply in Mekelle city, and resident's willingness to pay for improved water supply services by taking some selected households in the city. So your view could be used as an important input to officials and policy makers in their attempt to improve the water supply system of the city. Further your opinion and perception will help us to understand the attitude of the residents towards drinking water quality improvement program and their involvement. The interview will take a few minutes and the answer will be completely confidential and strictly for academic purpose only. Your name will never be associated with your answers. There are no correct or wrong answers. Thus please answer the questions honestly and as truthfully as you can.

THANK YOU IN ADVANCE!

SECTION I: EXISTING WATER USE PRACTICES AND PROBLEMS

1. What is the main source of water for the members of this household?

   1. Piped water 2. Other source

   If piped water **GO TO Question 2**

   If other source **GO TO Question29**

2. If piped, what kinds of piped do you use?

1. Tap inside the house **(GO TO Questions 4)**
2. Tap in the compound, shared with neighbors **(GO TO Question3)**
3. Tap in the compound, private **(GO TO Question 4)**
4. Public Taps **(GO TO Question 15)**

3. How many households use the shared tap in the compound? _____ Households.

4. How much water does your household consume per day? _____Jerican (**Note that one Jerican is assumed to be a 20 liters container).**

5. For what purpose(s) is the water from this source mainly used by your household?

IDENTIFY AND RANK STARTING BY WRITING (1) IN THE BLANK SPACE FOR THE MOST IMPORTANT PURPOSE.

A. _____drinking B. ___ washing clothes C. ____ housekeeping (cleaning house, gardening, etc) D. ____ watering livestock E. _____others (specify)

6. How much, on average, do you pay for your water consumption per month from this source? _____ Birr per month.

7. In relation to its quality, amount and reliability, how would you rank the existing water service from this source?

A. Quality: 1-good 2-average 3-poor

B. Quantity: 1-good 2-average 3-poor

C. Reliability: 1-reliable 2-unreliable

8. During what time you often face water shortage?

1. During day time 2 .Morning 3.At Noon 4.Afternoon 5. During Night time

9. From your experience how often do you get piped water within 24 hours? _____Hours.

10. Is there any time where piped water is completely absent?

1. Yes 2. No

11. If your response to 10 is “yes” specify the time during which water is completely absent?

1. During day time 2.Morning 3.At Noon 4.Afternoon 5. During Night time

12. In general are you satisfied with the existing piped water service?

1. Yes 2. No

13. If “No” what are the main causes of your dissatisfaction? (**Multiple answers possible**)

1. Poor quality 2.Low quality 3.Unreliabilty 4. Higher volume charge

5. Far away from home 6 .Other reason specifies.

14. How do you judge the existing water tariffs of the town's water service office?

1. Fair and affordable 2.Too cheap 3.Too expensive 4. It is difficult to judge

Go to Question 39

15. If public tap, how many persons from the household go at a time to fetch water from this source? _____ Persons.

16. If public taps how much time, on average, do you spend to reach from your house to these other sources to fetch water? _____ Minutes.

17. If public taps how much time, on average, do you spend for waiting to fetch water at a time? _____ Minutes.

18 if public taps how many times, on average, do you go per day for fetching water? _____times.

19. If public tap who often go to the public tap to fetch water? (**Multiple answers possible**)

1. Boys 2. Girls 3. Women 4. Men 5. 2 and 3 6. All

20. When do you prefer the public tap to be open?

1. Early in the morning 2. Afternoon 3. Evening 4. All the day

21. What is the present status of public tap service?

A. Quality: 1. Good 2.Average 3. Poor

B. Quantity: 1. Good 2.Average 3. Poor

C. Convenience of service hours: 1. Good 2.Average 3. Poor

22. For what major purpose(s) do you use water collected from public tap? **IDENTIFY AND RANK STARTING BY WRITING (1) IN THE BLANK SPACE FOR THE MOST IMPORTANT PURPOSE.**

A. _____ drinking B. _____washing clothes C. _____house keeping
D. _____ watering livestock E. _____ others, specify

23. Had there been any interruption of water supply from the public tap?

1. Yes 2. No

24. If "Yes" on average how frequent was this interruption?

1. Daily 2.Weekly 3.Bi-weekly 4. Monthly 5. If other time, specify.

25. Are you satisfied with this source of water?

1. Yes 2. No

26. If “No” why are you dissatisfied? **IDENTIFY AND RANK STARTING BY WRITING (1) IN TNE BLANK SPACE FOR THE MOST SERIOUS PROBLEM**.

A. ____ Poor quality B. _____ Low quantity C. ____ Unreliability

D. _____ higher volume charge E. _____ Far away from home F. ____ others, specify

27. Why don’t you have your own or yard connection, if your current source of water is public tap?

1. The house is not mine but rented 2. High connection cost 3. Shortage of water

4. I don’t want to have yard or private connection 5. Other reason, specify.

28. How do judge the existing water tariffs of the city’s water service office?

1. Fair and affordable 2.Too cheap 3.Too expensive 4. It is difficult to judge

Go to Question 39

29. If “others “to Question 1, what other source do you often use for water collection?

1. River 2. Well 3.Spring 4. Others, specify

30. How much water do you collect on average per day? _____ Jerican.

31. How much do you pay per Jeri can? _____ cents.

32. How many times on average per day do you go to fetch water from this other source? _____ Times.

33. How much time, on average, do you spend to reach from your house to these other sources to fetch water? _____ Minutes

34. How much time, on average, do you spend for waiting to fetch water at a time? _____ Minutes

35. How many members of the household go to fetch water at a time? _____ Person(s).

36. Who often goes to fetch water from this source? **(Multiple answers possible)**

1. Girls 2. Boys 3.Women 4. Men 5.1 and 3 6. All

37. Are you satisfied with this source of water? 1. Yes 2.No

38. If “No” why are you dissatisfied? **IDENTIFY AND RANK STARTING BY WRITING (1) IN THE BLANK SPACE FOR THE MOST SERIOUS PROBLEM.**

A. _____ poor quality B. _____low quantity C. _____unreliability

D. _____high volume charge E. _____ far away from home
F. _____availability problem G. _____others, specify.

39. Do you treat your piped/ public tap/other source water to make it safe to drink?
1. Yes 2. No

40. If "No" what are your reasons for not treating your piped/public tap/other source water?
1. The water is clean for drinking 2. The water is not clean but treating is costly and time consuming 3. The water is not clean but has no side effect on health.

41. If "yes" what is the mechanism used to make your pipe public tap/other source water safe to drink?
1. Boiling 2. Add chemicals 3. Use water filter 4. Other, specify.

42. If "yes" how much you pay to treat your piped/public tap/other source water to make it safe to drink? _____ Birr per month.

43. Have any of your household members suffered from diseases caused by deficient water quality? 1. Yes 2. No

44. If yes what were the diseases? **(Multiple answers possible)**
1. Diarrhea 2.Typhoid 3.Cholera 4.Vomiting 5. Other water born diseases

SECTION II: - HOUSEHOLDS WILLINGNESS TO PAY FOR IMPROVED WATER SUPPLY SERVICES AND SANITATION FACILITIES

BACKGROUND INFORMATION

In the next section of the questionnaire, I would like to ask you how much value you are prepared to pay for an improved water service provision. That is it concerns on how much the provision of improved water service is worth to you in monetary terms.

INTERVIEWER: READ THE FOLLOWING INTRODUCTION

Now a day there is a big difference between the supply and the demand for clean potable drinking water in Mekelle city. The reason for excess demand over its supply that is shortage of city's water supply are:-high population growth, there are low water pressure problems and limited number of boreholes which are not enough to supply the current water supply of the present population.

The provision of improved water service among other things requires the construction of additional boreholes, additional water pumps for the new water boreholes to be operational,

additional water reservoirs, the construction of pipelines from the boreholes or other water sources to the public taps to have public taps at different places of the city. Thus to practice all this, in addition to investment costs it is also necessary to pay for operational and maintenance costs and thus it is costly to implement the improvement program. Therefore, residents are requested to share the cost of the project. The proposed water improvement program goes ahead if the community agrees to share the cost and sufficient funds were generated. The provision of improved water services to the city's community means provision of good quality water which is safe for health, availability of good quality of water for 24 hours per day and 7 days a week throughout the year, and also the family need not have to spend its time and effort in fetching water from distant sources.

However, all household of the city, including yours, who have an option to have private connection to such an improved piped water supply scheme, would have to pay initial investment and running costs which will be added to your water bill, but you may not be required to pay initially the costs of connection to the new scheme, instead it will be distributed for the next 20 years in your monthly bills.

QUESTIONS ON WILLINGNESS TO PAY FOR IMPROVED WATER SERVICES

(Note that this part is asked to the whole respondent)

45. Are you willing to participate in this water improvement program?

1. Yes 2. No

46. If "Yes" suppose that the town's water service office made the improved water service available, would you be willing to pay ____ cents per Jerican or(for 20 liters container)?

1. Yes 2. No

47. If the answer to Q.46 is 'Yes', **ask the following question**. If the price of water per Jerican from the improved water service is increased to (2X), _____ cents per Jerican (or for 20 liters container), would you be willing to pay?

1. Yes 2. No

48. If the answer to Q.46 is 'No' **ask the following question.** If the price of water per Jerican from the improved water service is decreased to (0.5X), _____ cents per Jerican (or for 20 liters container), would you be willing to pay?

1. Yes 2.No

49. What is the maximum you could pay for one Jerican of water from this improved water scheme? _____Cents per Jerican

50. **(To Interviewer)-**If the maximum amount that they would like to pay for the improved water service they will get from the improved scheme is 'zero', ask them why they do not want to pay?

1. Water should be provided free of charge
2. I satisfied with the existing source
3. I do not have enough money
4. I know that money will not be used properly 5. Other reason specify

QUESTIONS ON WILLINGNESS TO PAY FOR IMPROVED PRIVATE PIPE CONNECTION (Note that this part is asked to respondents who use public taps and other sources)

Les us assume that you have private pipe connection together with the improved water supply scheme ,but you may not be required to pay initially the cost of connection to the new scheme for the reason that it will be distributed for the next 20 years in your monthly bills.

51. Are you willing to pay any amount to have private pipe connection with the improved water provision?

1. Yes 2. No

52. If "Yes" and if the price from the improved water service with private pipe connection is_____ cents per Jerican, are you willing to pay?

1. Yes 2. No

53. If the answer to Q.52 is 'Yes' **ask the following question**. If the price from the improved water services with private pipe connection is increased to (2X), _____ cents per Jerican (or for 20 liters container), would you be willing to pay?

1. Yes 2.No

54. If the answer to Q.52 is 'No' **ask the following question**. If the price from the improved water service with private pipe connection is decreased to (0.5X), _____cents per Jeri Can (or for 20 liters container), would you be willing to pay?

1. Yes 2.No

55. What is the maximum amount you want to pay for one Jeri can of water for this improved pipe water scheme? _____ Cents per Jerican.

56. **(To Interviewer)-**If the maximum amount that they would like to pay for the improved water service they will get from the improved scheme is 'zero' ask them why they do not want to pay?

1. Water should be provided free of charge
2. I satisfied with the existing source
3. I do not have enough money
4. I know that money will not be used properly 5. Other reason, specify

QUESTIONS ON WILLINGNESS TO PAY FOR IMPROVED PUBLIC TAPS PROVISION (Note that this part is asked to respondents who use public taps and other sources)

If the improved water service scheme benefited households that does not have access to individual piping but using public taps and other sources of water,

57. Are you interested to participate in this improvement scheme?

1. Yes 2. No

If "Yes" and suppose that a new scheme of improved water system will be provided using a public tap as near as possible to your home and with this public taps you get quality water that does not require boiling to drink at any time of the day.

58. If the price of water from the improved service is _____ cents per Jerican or (20 liters container), are you willing to pay?

1. Yes 2. No

59. If the answer to Q.58 is 'Yes' **ask the following question.** If the price of water from the improved service is increased to (2X), _____ cents per Jerican (or for 20 liters container), would you be willing to pay?

1. Yes 2.No

60. If the answer to Q.58 is 'No' **ask the following question**. If the price of water from this improved service is decreased to (0.5X), _____ cents per Jerican (or for 20 liters container), would you be willing to pay?

1. Yes 2.No

61. What is the maximum you could pay for one Jerican of water from this improved water scheme? _____ Cents per Jerican

62**. (To Interviewer)-**If the maximum amount that they would like to pay for the improved water service they will get from the improved scheme is 'zero' ask them why they do not want to pay?

1. Water should be provided free of charge
2. I satisfied with the existing source
3. I do not have enough money
4. I know that money will not be used properly 5. Other reason, specify

THE EXISTING SANITATION PRACTICE

63. What type of sanitation system does this household use?

a. Facility in house

1. Pit latrine 3. Other (specify)
2. Flush toilet

b. No facility in house

1. Use public latrine 3. Streets
2. Bush 4. Other (specify)

ONLY FOR THE HOUSEHOLD USING PIT LATRINE AND FLUSH TOILET

64. Do you share the pit latrine/flush toilet with other in the house?

1 .Yes 2. No

65. If yes, how many households use the pit latrine/flush toilet?

_____ number of households.

66. How satisfied are you with the pit latrine/ flush toilet you have?

1. Very satisfied
2. Satisfied
3. Not satisfied at all

67. How would you describe the relationship between the use of pit latrine and availability of water?

1 Very related
2 Related
3 Not related at all

ONLY FOR HOUSEHOLDS USING PUBLIC TOILET

68. How far is the public latrine from your home?

_____ KMs (Meters).

69. Is the public latrine usually on service?

1 Yes 2 No

70. How satisfied are you with the public latrine you use?

1. Very satisfied

2. Satisfied

3. Not satisfied at all

71. How would you describe the relationship between the use of public toilet and availability of water?

1. Very related
2. Related
3. Not related at all

SECTION III:-QUESTIONS ON DEMOGRAPHIC AND SOCIO-ECONOMIC CHARACTERSTICS

To remind you, the question here is for background purposes only and thus the answers are very important. Besides your personal information is strictly for academic purposes and confidential.

72. Gender (observation):-

1. Male 2. Female

73. Marital status of the respondent

1. Married 2. Otherwise

74. Are you the head of household?

1. Yes 2. No

75. How old are you? _____Years of old.

76. Education level _____

77. Occupation:-

1. Government employee 4. Private business 7. Self employee
2. House wife 5. Unemployed 8. Retired
3. Student 6. Other, specify

78. How much is your own gross income per (month) excluding your family's income? _____Birr.

79. Would you please telling me your household members' income per (month) excluding your own income?

1. Person1_____birr 3. Person 3_____ birr 5. Person 5 _____ birr

2. Person2_____birr 4. Person4_____ birr 6. Person 6_____ birr

80. How many are you in your household including yourself? _____ (No of people)

No of adults _____, ≥15 years old

No of children _____, <15 years old

81. Do you have your own house?

1. Yes 2. No

82. For how many years have you lived in the town? _____Years.

83. Do you have_____ in your house? (Multiple answers possible)

1. Refrigerator 2.Telephone 3.Tape 4.Radio 5. Television

84. How much do you spend per month for_____ in birr?

1. Food_____ 4.Water_____ 6. Telephone_____

2. Schooling_____ 5.Electricity_____7. Transport_____ 8. Medical_____

3. Community service (Eder, ekub, etc.)_____

85. Is your household aware about water born diseases?

1. Yes 2. No

86. Who do you think is responsible for water supply?

1. Government 2.Community 3.Private 4. Others, specify

87. What do you recommend regarding the proposed improved water supply for the city?

1. Very good 2. Good 3.Satisfactory 4. Others, specify