90

# VALUING NON-AGRICULTURAL USES OF IRRIGATION WATER: EMPIRICAL EVIDENCE FROM THE BLUE NILE RIVER-BASIN OF THE AMHARA REGIONAL STATE, ETHIOPIA

**By**

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A thesis submitted to the School of Graduate Studies of Addis Ababa University in partial fulfillment of the requirements for the Degree of Master of Science in Economics (Resource and Environmental Economics)

June, 2005

Addis Ababa

90

**ADDIS ABABA UNIVERSITY**
**SCHOOL OF GRADUATE STUDIES**

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## Acknowledgments

It is my honor to glorify Jesus Christ whose love and mercy is abundant towards my life.

My special thank goes to my advisor Dr. Alemu Mekonnen for his professional guidance and constructive comments without which the paper could not achieve its goals.

I am indebted to the Department of Economics of Addis Ababa University, Sida/SAREC, National Centre of Competence in Research North-South and African Economic Research Consortium for the financial support through out the study and during the research work.

Dr. Eline Boelee from the International Water Management Institute deserves my special thank for her material support and valuable comments on the proposal and field survey questionnaires of the research.

I express my heartfelt thank to friends Ato Abebe Taddesse, Ato Anteneh Kebede, Ato Kassahun Taddesse and Ato Zakarias Mamma for material and moral supports. I also appreciate Bure District Rural Development and Agricultural Bureau, development workers and my enumerators for all their dedications during the field survey.

Jonse Bane

## Table of Contents

Page

# List of Tables

**Tables** **Description**

**Page**

## List of Figures

**Figures** **Description**

**page**

## List of Annexes

**Annexes** **Description** **Page**

## *Abstract*

*Using the contingent valuation method (CVM), the study sets out to analyze determinants of households' WTP, estimate total WTP of and derive aggregate demand for non-crop uses of irrigation water. The study used cross-sectional data collected from 260 households in the Blue Nile River Basin of the Amhara Regional State of Ethiopia through double-bounded value elicitation format with open-ended follow up questions under detailed descriptions of two different scenarios, namely, existing and improved irrigation water supply for domestic uses. The empirical models adopted by this study are probit and bivariate probit models.*

*Results of the study reveal that respondents' WTP is affected by a number of explanatory variables including institution-related variables such as water users associations (WUAs), water father and community-based water management and choices of these institutions, and socio-economic variables like income, wealth, ownership of ox, age, education and family size of respondents. Although females are responsible to fetch water for domestic uses, being a female has no significant effect on the probability of accepting the proposed bid. Specific location of users, site, quantity and quality of irrigation water for domestic uses are other explanatory variables that affect consumers' WTP for non-crop uses of irrigation water. The study also finds that using double-bounded value elicitation techniques does not improve statistical efficiency over single-bounded format.*

*Total WTP for gardening and domestic use of irrigation water is estimated based on open-ended and single-bounded value elicitation formats and our scenarios. Assuming existing irrigation water quality, total WTP for these uses of irrigation water is Birr 291,776 and 363,063.6 per year using open-ended and single-bounded mean WTP, respectively. After proposing quality improvement for domestic uses of irrigation water but with existing quality for gardening, the respective total WTP increases to Birr 361,336 and 409,441.6 per annum.*

*The following policy implications are derived from the study. First, facilitating establishment and strengthening capacity of WUAs through decentralization could improve efficient and equitable uses of irrigation water. Second, since households are willing to pay for multiple uses of irrigation water, introducing pricing in irrigation water uses may be promising. Finally, considering multiple uses of irrigation water in developing and implementing irrigation water projects ensures sustainability and reduces conflicts among uses and users of irrigation water.*

**Key words**: *non-agricultural uses, irrigation water, CVM, WTP, Blue Nile, Ethiopia*

# Chapter One

# Introduction

## 1.1. Background

Water, which constitutes about 75% of the earth's surface and about 75% of human body, is a special economic good that has some basic characteristics. Individually, these characteristics may not be restrictive, but in combination they show that water has to be dealt with in a very special way. These basic characteristics include, firstly, water is essential in the sense that there is no life, no economic production, no environment and no human activities without it. This may make water special, but not unique. The same can be said about air, land, fuel and food. Secondly, water is scarce. That is, in many parts of the world, increasing demands for water for irrigation, domestic, industrial and environmental uses have created more scarcity and competition for this vital resource. Thirdly, water is fugitive, i.e., it is gone if not captured and flows if not stored. Fourthly, since water is too bulky, it is not traded over long distances. Fifthly, water is a resource with a system where several processes (infiltration, surface runoff, recharge, seepage, re-infiltration and moisture recycling) are interconnected and interdependent with only one direction of flow: downstream. Sixthly, water is without substitutes. Although other economic goods have alternatives, water has none (Savenije, 2001).

Globally, approximately 47,000$m^3$ renewable water has been generated per year from oceans through evaporation of which about 41,000$m^3$ (87%) are potentially exploitable per year. Of the fresh water available for human consumption, we are using about 40-60% (Johansson, 2000). Irrigation accounts for about 70 per cent of all global fresh water use, while industry and domestic uses consume 23 per cent and 8 per cent, respectively (Matsuno et al., 2002 and Jensen et al., 1998). This implies that available fresh water is used for agricultural and non-agricultural purposes.

Although primary purposes of irrigation systems are supplying water at the appropriate time and quantity to the agricultural sector in order to ensure food security particularly in rural areas of low-income countries, these systems also provide water for a wide variety of less documented non-agricultural* uses. According to Meinzen-Dick and Jackson (1997), non-agricultural uses of irrigation water can be seen as consumptive purposes such as gardening, drinking water, livestock watering, fodder production and construction, and non-consumptive uses including washing, bathing, fishing, and religious and recreational uses. The pressure on irrigation water for non-crop purposes is higher in situations where it is difficult, expensive or even impossible to develop new water supply systems for domestic uses. In arid and semiarid parts of the world, especially the developing countries, water from irrigation systems is the sole source for domestic uses such as drinking, washing and other related purposes (Boelee and Laamrani, 2004).

## 1.2. Statement of the Problem

Ethiopia is the water tower of north-eastern Africa with surface annual run-off of 122 billion $m^3$. The three largest rivers, namely, Abbay, Baro-Akobo and Omo-Gibe account for about 76% of this total surface annual run-off. The country has also an estimated ground water potential of 2.6 billion $m^3$. Land suitable for irrigation is estimated to be 10 million ha, of which only 500,000 ha (5% of the potential) is currently utilized, which accounts for only 3% of country's total food production. The country's hydropower potential, which is 650TWH per year, stands second in Africa next to Democratic Republic of Congo (DRC) (MoWR, 2002 and FDRE, 2002a).

However, by the degree of water withdrawal in relation to water availability, water is economically more scarce than many other resources in Ethiopia as it has only made use of about 3% of its available water resources, especially in the area of agriculture (irrigation). The limited water withdrawal has created a significant social, economic, environmental and political crisis in the country mainly due to absence of infrastructure, organizational set up, policies and legislations that provide different services of water for different users at the required quality, quantity, time and location. Some of the problems are, on average, 6 million people are exposed

* In this paper the terms non-agricultural and non-crop uses of irrigation water are used interchangeably.

to recurrent drought annually including the surplus producing areas and vulnerability of agricultural sector to drought. For instance, the 1984/85 depression, where real value-added in the sector declined by 20% and real GDP fell by over 9% (the worst during the last four decades) is mainly due to shortage of rainfall. Similarly, in 1997/98 and 2002/03, agricultural growth per year declined by 11.2% and 12.2%, respectively, as a result of drought (MoFED and NBE data base); diseases caused by water related problems account for 70% of the diseases in the country; 25% of the livestock of the country are lost due to drought each year; 40% and 75% of the urban and rural population does not have access to clean drinking water, respectively, and 90% of the population does not have access to electricity (FDRE, 2002a and MoWR, 2002).

Thus, one of the paradoxical facts of Ethiopia is that on the one hand the country is the water tower of north-eastern Africa and on the other hand it is one of the most food insecure and drought affected countries on the planet. This situation is not only due to high dependence on nature particularly rain-fed agriculture (i.e., lack of investment in irrigated agriculture) but also lack of appropriate technology and water institutional regimes that ensure efficient and equitable allocation of water among users and use systems in a sustainable manner.

By realizing this fact, the country has developed a 15-year water development plan, which aims to narrow the current 'gap' between demand and supply by increasing supply. The intention of the plan is to address most of the gaps with-in 15 years time (2002 – 2016) through increasing the number of large, medium and small scale new water supply infrastructures, maintenance of the existing structures and introducing efficient water supply technologies. Among the water sectors, agriculture (irrigation) has got due attention because of the national development strategy (Agricultural Development Led Industrialization, ADLI) (MoWR, 2002). Sustainable Development and Poverty Reduction Program (SDPRP) of the country also stressed the importance of safe drinking water supply, sanitation, irrigation, hydropower, etc. (FDRE, 2002a). Similarly, the Nile Basin Initiative introduced in 1999 emphasized efficient uses of irrigation water for agricultural sector (Nile Initiative Secretariat, 2001). But both national and regional water development plans have marginalized the multiple uses of irrigation water. The IFAD special country program phase-II, which was implemented in 1999 also primarily deals with small scale irrigation in different regions of the country including Amhara, Oromiya, and

Tigray (FDRE, 2002b). The program also basically ignored non-agricultural uses of irrigation water among small scale farmers where other sources of water for non-crop uses are limited. Hence policy makers/practitioners cannot make comprehensive water resource utilization plans and management as non-agricultural uses have been excluded or ignored from both national and regional water development programs.

The quantity of water used for non-agricultural purposes is small relative to total quantity of water diverted for irrigated agriculture, but the former use values of irrigation water are higher in terms of household income, nutrition and health in rural areas (Meinzen-Dick and Bakker, 2001). Thus, the implication here is that estimating economic values of irrigation water based on irrigation output (or crop per drop) essentially leads to underestimation of the total value of irrigation water. Moreover, failure to take into account non-agricultural uses of irrigation water has implications for irrigation water management and assigning water rights, especially as increasing scarcity challenges existing water allocation mechanisms.

### 1.3. Objectives of the Study

The general objective of this study is to analyze the economic values of multiple uses of irrigation water emphasizing its non-agricultural purposes using data from the Abbay (or Blue Nile) River Basin of the Amhara Regional State of Ethiopia. The specific objectives of the study are to:

- Elicit consumers' willingness-to-pay (WTP) for non-crop uses of irrigation water and identify major socio-economic determinants of their WTP for such uses of irrigation water;
- Examine the impact of institutional setup (or property rights regimes) related to irrigation water uses and land tenure security on the respondents' WTP for non-agricultural uses of irrigation water;
- Identify whether women are more willing to pay for non-agricultural uses of irrigation water compared to men;
- Estimate total WTP of and the demand for non-agricultural uses of irrigation water;

- Draw concluding remarks and policy recommendations relevant to the existing situations of the country

## 1.4. Research Questions

- What are the key socio-economic determinants of households' WTP for non-agricultural uses of irrigation water?
- Do irrigation water institutional regimes and land tenure security have any impact on the respondents' WTP?
- What would be the non-agricultural use values of irrigation water?
- Are women willing to pay more for non-crop uses of irrigation water compared to men?

## 1.5. Significance of the study

Currently, there are a number of problems bested rural Ethiopia that include chronic food insecurity, lack of access to safe drinking water, water born communicable diseases, low agricultural productivity and low utilization of electricity, which are challenging for the government and the people. One of the causes of these and related problems is lack of appropriate and comprehensive water use policies and institutional setup that ensure multiple uses of this vital resource (particularly irrigation water) among various uses and users. In this regard, identifying and promoting multiple uses of irrigation water and accordingly valuing its economic uses partly improve its allocation among various uses and users that in turn contributes to the millennium development goals. Since non-agricultural uses of irrigation water has important implications on health, income and nutritional status of rural households, enhancing multiple uses of irrigation water improves welfare of these users in all aspects (food, health, cash income, better nutrition, etc.). Establishing and strengthening capacity of appropriate water institutions like WUAs help to avoid conflicts among irrigation water uses and users. It also has significant role in enhancing efficient and equitable irrigation water allocation. The area requires vigorous studies to make policy implications relevant to the particular situation of the country. In this regard, the findings of the study contribute a lot.

### 1.6. Organization of the Study

The rest of the paper is organized as follows. The second chapter deals with literature survey followed by the third chapter, which is devoted to the data and empirical models. The fourth chapter provides descriptive analysis, estimation results and discussion. Finally, the study provides concluding remarks and policy recommendations relevant to the existing situation of the country.

### 1.7. Limitations of the Study

Despite its originality, the study has some limitations. Firstly, the sample size is limited and hence it may not be representative. Secondly, time and finance limit us to a specific area in the Blue Nile River Basin. Lastly, the study basically emphasized the benefit side of irrigation water. That is, it did not consider the cost side of irrigation water projects as information on costs is not available[1].

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[1] But even if costs are available, the study is look at part of the total value of irrigation water (only non-crop use values) and hence it is difficult to compare the total costs with the total benefits.

# Chapter Two

# Literature Survey

## 2.1. Theoretical Framework

### 2.1.1. Economic Theory and Environmental Valuation

The theoretical basis of environmental valuation techniques is basically derived from welfare economics, which is built on the utilitarian moral philosophies. Utilitarian moral philosophy was developed by philosophers like David Hume (1711-1776), Jeremy Bentham (1748-1832) and John Stuart Mill (1806-1873). The most completed version of the moral philosophy was in the Utilitarianism (1863) work of Mill. The central axiom of this philosophy is that utility is comparable over time and over individuals. Thus, social welfare is a weighted average of utilities enjoyed by all individuals in the relevant society (Perman et al., 1999).

The change in utility due to change in prices, quantities or both leads to a change in welfare of the society. Then, by converting changes in utilities into monetary values, it is possible to calculate welfare changes due to the above reasons.

The starting point is the conventional utility maximization theory, which argues that an individual maximizes utility from consumption of marketed goods and non-marketed environmental goods subject to income level or the budget constraint. That is,

Max. $U^j = U(X_i, Z)$

Subject to: $\sum_{i=1}^{n} X_i P_i = Y_j$ ..............................................(1)

Where:

$U^j$ =utility of individual j (j=1, 2, 3,…, m)

$X_i$=vector of marketed commodities (i=1, 2, 3, …, n)

Z= vector of non-marketed environmental goods

$P_i$= market price of the $i^{th}$ commodity

$Y_j$= income level of individual j in monetary value

Then Lagrangean function of this utility maximization problem may be written as:

$$L = U(X_i, Z) - \lambda(Y_j - \sum_{i=1}^{n} X_i P_i) \qquad \text{.............................(2)}$$

Where: $\lambda$ = the Lagrangean multiplier

Then, the first-order necessary conditions of the Lagrangean function (assuming interior solutions) become:

$$\frac{\partial L}{\partial X_i} = \frac{\partial U(X_i, Z)}{\partial X_i} - \lambda P_i = 0$$

$$\frac{\partial L}{\partial \lambda} = \sum_{i=1}^{n} X_i P_i - Y_j = 0 \qquad \text{.................................(3)}$$

Solving equation (3) for $X_i$ gives us what is known as the Marshallian (or ordinary) demand function, which depends on market price ($P_i$), money income ($Y_j$) and environmental goods (Z). That is,

$$X_i = X(P_i, Y_j, Z) \qquad \text{..........................................(4)}$$

For the Marshallian demand function, the welfare changes due to price changes is given by the area between two price lines bounded by the Marshallian demand curve. This is basically equal to the consumers' surplus (CS), which is defined as:

$$CS = \int_{p_0}^{p_1} X_i(p_i, Z, Y)dP_i \quad \text{.........................(5)}$$

Now, substituting (4) into $U^j = U(X_i, Z)$ yields the indirect utility function given as follows:

$$V = (P, Y, Z) = U(X(P_i, Y, Z), Z) \quad \text{........................(6)}$$

The indirect utility function depends on market prices of commodity (X), money income (Y) and environmental commodities (Z).

However, both direct and indirect utilities are unobservable and hence it is impossible to measure welfare change due to price changes based on the utility concepts. Fortunately, there are two basic concepts, namely, the compensation variation (CV) and equivalent variation (EV) to measure welfare change due to price changes. That is, CV and EV are the conventional welfare measures (for the price changes) corresponding to the maximum amount of money an individual would be willing to pay (WTP) to secure the change or the minimum amount he/she would be willing to accept (WTA) to forgo the change (Hanemann, 1991).

Suppose the price of a marketed commodity declines from $P^0$ to $P^1$. In terms of indirect utility function, the CV and EV measures for this change become:

$$V(P^0, Z, Y) = V(P^1, Z, Y - CV) \quad \text{........................(7)}$$

$$V(P^0, Z, Y + EV) = V(P^1, Z, Y) \quad \text{........................(8)}$$

The dual problem of the utility maximization in (1) is expenditure minimization.

That is,

$$\text{Min} \sum X_i P_i$$

Subject to: $U(X_i, Z) = U$ ..............................................(9)

Where: U= a given minimum utility level

Solving the first-order necessary conditions of the Lagrangean function of the expenditure minimization problem yields the demand function known as Hicksian (or compensated) demand function, which may take the form:

$$h_i = h(P, Z, U) \quad \text{..............................................(10)}$$

And expenditure function of the form:

$$e(P, Z, U) = \sum_{i=1}^{n} P_i h(P, Z, U) \quad \text{.........................(11)}$$

Then, in terms of the expenditure function, the CV and EV can be defined as:

$$CV = e(P^0, Z, U^0) - e(P^1, Z, U^0) \quad \text{..............(12)}$$

$$EV = e(P^0, Z, U^1) - e(P^1, Z, U^1) \quad \text{...............(13)}$$

Welfare measures can also be defined for changes in quantities of environmental goods. The quantity-constrained nature of the problems implies that consumers cannot adjust for quantity changes to satisfy the conventional optimizing conditions of equality of marginal rate of substitution and price ratios. Thus, in such a case the appropriate measures of welfare change are compensating surplus (CS) and equivalent surplus (ES) (Freeman, 1993).

By differentiating the indirect utility function in (6) with respect to the environmental goods (Z), it is possible to indicate welfare change due to changes in environmental commodities. That is,

$$\frac{\partial V(P,U,Z)}{\partial Z} = \frac{\partial U(X(P,Y,Z),Z)}{\partial Z} \quad \text{.............................(14)}$$

$$\Delta U^{j} = V(P,Y,Z^{1}) - V(P,Y,Z^{0}) \quad \text{......................(15)}$$

Equation (15) implies changes in welfare of single individual for changes in Z from $Z^0$ and $Z^1$ while price and income remain constant at P and Y. For all individuals in the relevant society the welfare changes become:

$$\sum_{j=1}^{m} \Delta U^{j} = \sum_{j=1}^{m} \{V(P,Y,Z^{1}) - V(P,Y,Z^{0})\} \quad \text{....................(16)}$$

This implies that the welfare impact of changes in environmental goods is equal to the sum of the individual marginal valuation of that good between $Z^0$ and $Z^1$.

Ceteris paribus, change in Z from $Z^0$ to $Z^1$ ($Z^1 > Z^0$) leads to change in the indirect utility function from $V^0 = V(P, Z^0, Y)$ to $V^1 = V(P, Z^1, Y)$ ($V^1 > V^0$). Then, the compensating surplus (CS) and equivalent surplus (ES) measures for this change are defined, respectively, as:

$$V(P,Z^{1},Y - CS) = V(P,Z^{0},Y) \quad \text{..........................(17)}$$

$$V(P,Z^{1},Y) = V(P,Z^{0},Y + ES) \quad \text{..........................(18)}$$

It is also possible to define the CS and ES in terms of the expenditure function as:

$$CS = e(P, Z^0, U^0) - e(P, Z^1, U^0) \quad \text{.....................(19)}$$

$$ES = e(P, Z^0, U^1) - e(P, Z^1, U^1) \quad \text{.....................(20)}$$

Therefore, CS due to change in environmental goods (Z) measures the maximum amount of money that individuals are willing to pay to secure any positive change in Z while ES measures the minimum amount of money individuals are willing to accept in compensation for any reduction in environmental quantities, qualities, or both.

### 2.1.2. Methods of Environmental Valuation: Direct and Indirect Approaches

Over the past few decades, several valuation methods have been developed to analyze the types of economic values associated with environmental and natural resources (Hanemann, 1994). These valuation methods can generally be classified into two groups, namely, direct and indirect methods.

#### 2.1.2.1. Direct Methods of Environmental Valuation

The direct approach (or stated or expressed preference method) refers to the direct expression of individuals' willingness to pay or willingness to accept in compensation for any change in environmental quantities, qualities, or both. That is, direct valuation method involves direct estimation of environmental value based on the responses of individuals to the hypothetical valuation questions and hence it does not depend on market information (Freeman, 1993). A typical example of direct valuation method is the contingent valuation method (CVM).

The CVM involves the use of sample surveys (questionnaires) in order to elicit the willingness of respondents to pay (generally) for hypothetical projects or programs. The name of the method refers to the fact that the values stated by respondents are contingent upon the constructed (or hypothetical) market presented to respondents (Portney, 1994). Mitchell and Carson (1989) also defined the CVM as a survey technique that attempts to elicit information about individual preferences for a good or service by directly asking individuals questions on how much they value the good or service.

In the contingent valuation method, respondents are asked various questions on the basic issues such as the maximum amount they are willing to pay (WTP) to access and enjoy any welfare gain due to an improvement in environmental quantities, qualities or both or the minimum amount they are willing to accept (WTA) in compensation for welfare loss due to deterioration in environmental quantities or qualities or both. The basic idea of the contingent valuation method is that in the hypothetical market it provides a means of deriving values when they are not observed in the real market i.e., when values cannot be obtained in more traditional ways (Tietenberg, 2003).

The history of the CVM can be traced back to 1940s when Ciriacy-Wantrup (1947) wrote about benefits obtained from preventing soil erosion, conserving some biodiversity and reducing siltation of streams by directly asking individuals for their maximum WTP. Unfortunately, he did not attempt to use it. Almost after two decades it was Davis (1963) who is said to have applied the contingent valuation method in academic research for the first time where he tried to estimate the value to hunters and wilderness lovers of a particular recreational site. Since then particularly in the 1970s researchers in natural resource and environmental economics have made increasing uses of the CVM in order to value non-marketable natural resources. In the mid 1990s a bibliography lists 1,600 studies and papers using the CVM from over 40 countries on several topics including sanitation, health, environment, transportation and education (Hanemann, 1994 and Portney, 1994). However, studies using the CVM formed a sort of academic industry and it is only in the late 1980s that contingent valuation studies began to receive the kind of scrutiny normally devoted to the evidence in high-stake legal proceedings (Portney, 1994).

CV surveys entail three operations, namely, designing a survey questionnaire, conducting a survey, and analyzing the survey results (Kaliba et al., 2003). Although there is no standard approach in designing contingent valuation surveys, the following basic components must be there. Firstly, the surveys must contain a detailed description of the situations respondents are being asked to value. Secondly, the surveys must have mechanisms for eliciting value from the respondent. These mechanisms can take several forms including open-ended questions, bidding games, payment card and single bounded and double bounded referendum formats. Thirdly, contingent valuation surveys usually elicit information on the socio-economic characteristics of the respondents such as age, sex, income level, education, marital status, and family size (Christe and Schuwab, 1995 and Portney, 1994).

Since the 1970s many researchers have employed the CVM due to its basic advantages over other methods of valuation. Firstly, it captures both use values and non-use values and hence it is more comprehensive. Secondly, the CVM yields compensated or equivalent income consumer surplus from the Hicksian (or compensated) demand functions.

Although a number of researchers have employed the CVM, using such survey method has some basic problems in the sense that survey respondents could give biased information. Four major potential biases in contingent valuation surveys are: strategic bias, starting point bias, hypothetical bias and information bias (Tietenberg, 2003).

The basic idea of strategic bias is that a respondent or groups of respondents may give biased information (answer) to influence a particular outcome. Such information may not reflect the actual value of the resource being valued.

The concept of starting point bias refers to survey instruments in which respondents are asked to check of their answers from a predefined range of possibilities. The problem here is that how the survey questionnaire is designed may affect the resulting answers. For instance, a survey questionnaire with a range of \$0-\$100 may produce different result compared to a survey questionnaire with arrange of \$50-\$100.

As the name indicates, in hypothetical survey questionnaires, respondents are confronted by an artificial set of alternatives rather than actual choices. Since the respondents are not actually expected to pay the estimated values, the respondents may treat the survey as providing illconsidered answers. Studies in the literature tried to compare WTP estimated based on hypothetical survey with actual expenditure and some reported that estimated value from the hypothetical WTP survey results are higher than the actual expenditure while majority of the studies found that the differences are not statistically significant (Hanemann, 1994).

The problem of information bias may arise in the situation where respondents are asked to value attributes with which they have no or little experience. Thus, if respondents have no experience about attributes of resources they are asked to value, the valuation will be based on an entirely false perception.

Choice experiment (CE) is also another stated preference method in which individuals are given a hypothetical setting and asked to choose their preferred alternative among several alternatives in a choice set, and they are usually asked to perform a sequence of such choices. Each alternative is described by a number of attributes or characteristics (Alpízar et al., 2001). However, CE is not popular and ease compared to the CVM and hence the study employs the CVM as it is simpler for estimation of the total value of non-agricultural uses of irrigation water (using CVM) as opposed to the values of particular characteristics/attributes of a certain non-agricultural use (using CE).

#### 2.2.1.2. Indirect Method of Environmental Valuation

The indirect approach (or revealed preference method) involves inferring about the unobservable demand for and hence value of the environmental goods and services based on the observable demands for the related marketable goods and services. That is, using information on market transactions for related private goods and services, economists try to infer the demand for environmental goods and services (Freeman, 1993 and Tietenberg, 2003). The indirect methods include travel cost method (TCM), hedonic pricing method (HPM) and averting expenditures.

The basic idea of TCM is that it infers the value of a recreational site (such as parks and lakes) using information on the amount of money and time individuals spent to enjoy that site. Thus, it measures value of environmental resources based on actual (or observed) preferences. However, a main drawback of this method is that it ignores non-use values of environmental resources (Tietenberg, 2003).

Hedonic pricing (HP) derives from characteristics theory of value and it has been mostly applied to estimate the value of air quality using information about the price of houses and characteristics of housing such as age, size and number of rooms and neighborhood characteristics like crime rate and availability of public goods (e.g. roads) and level of air quality (Palmquist, 1984). In recent years, the HPM is applied to wider areas such as agricultural land, land rents, effects of climatic conditions on agriculture, urban land, etc. (Kolstad, 2000).

However, there are a number of problems that beset the HPM. Firstly, if consumers are not well informed about attributes of the good being valued, HP estimates are of little relevance. Secondly, it imposes strong assumptions concerning separability of consumers' utility functions. Thirdly, it suffers from econometric pitfalls such as identification problems, endogeneity problems, non-linearity and functional form (Palmquist, 1984).

In this study we employ the CVM to elicit consumers' WTP for non-agricultural uses of irrigation water. The main reason is that the market does not exist for non-crop uses of irrigation water. Thus, it is impossible to get such use values based on market information. Besides, indirect methods are inappropriate as they need existence of markets for related goods to infer values of environmental goods.

## 2.2. Empirical Review

### 2.2.1. Multiple Uses of Irrigation Water: Country Experience

In developing countries, irrigated agriculture has consumed the largest share of fresh water, accounting over 80% of water withdrawals (Boelee, Laamrani and Van der Hoek, 2000). The primary purpose of irrigation systems is to produce field crops (i.e., water for agricultural uses).

However, in low-income countries where modern sources of water supply is limited, irrigation systems supply water for a large number of non-crop production uses including drinking water, livestock watering, gardening, fishing, construction, washing, religious ceremonies, recreational uses and maintaining biodiversity. Sometimes in semiarid areas of developing countries irrigation systems may be the only possible source of water to fulfill the domestic water needs of households (Bakker et al., 1999, Boelee et al., 2000, Meinzen-Dick and Bakker, 2001, Van der Hoek et al., 2001, Renwick, 2001, Van der Hoek et al., 2002, Van der Hoek, Boelee and Konradsen, 2002, and Boelee and Laamrani, 2004).

Modern water supply systems, which are implemented with the help of water and sanitation experts and aimed at providing pure drinking water of limited amount (about 25-50 liters per capita per day) also, provide water for productive activities like small-scale enterprises. This may lead to the over-use of water from such systems and hence often leads to the breakdown of the systems (Penning de Vries et al., 2003). This implies that water systems (irrigation or modern drinking water systems) have multiple purposes (i.e., have uses outside the domain of their primary purposes). This multiple use of water is recognized by indigenous water supply systems.

An estimate indicates that in developing economies the demand for non-agricultural uses of water has been increasing faster (even 100%) between 1995-2025 due to population growth, urbanization, and economic expansion (Southeast Asian countries) in the face of growing water scarcity, which has been worsened by severe constraints on the supply side. The constraints include: limited sources particularly in dry areas of North Africa, West Asia and northwest India and economic constraints that slow development of new water supply systems (Rostgrunt, 2000).

Although the amount of irrigation water used for non-agricultural purposes is small compared to the amount used for field crops, use values are high in terms of household income, nutrition and health in rural areas (Meinzen–Dick and Bakker, 2001). Therefore, non-agricultural uses of irrigation water have important implications in irrigation water management and assigning water rights particularly in face of growing scarcity of water resources. However, non-agricultural uses and users of irrigation water are ignored in developing water resource policies. That is, multiple needs of irrigation water have rarely been taken as a starting point in designing irrigation water systems. One manifestation of this is that most agents dealing with water resources have only sectoral policies (i.e., either irrigation water or drinking water or water for environmental uses) separately. Thus, there are no policies that carefully promote multiple uses of irrigation water. In other words, although a government has overall water development policies and strategies, the implementing bodies have neither the mandate nor the incentive to balance water resources among various uses and users (Meinzen–Dick and Bakker, 2001, Yoder, 1983). Empirical evidence on multiple uses of irrigation water from different African, Latin American and Asian countries is briefly summarized below.

#### 2.2.1.1. The African Experience

An estimate indicates that all African countries will be physically or economically water scarce by the year 2025. South and North African countries are among the nations that will face physical water scarcity and hence they may not meet their projected water needs in 2025. For instance, in Egypt during 1997 water requirement and availability was $59X10^9$ $m^3$ and $60X10^9m^3$, respectively, but during 2025 the projection indicates that water requirement will rise to $81X10^9$ $m^3$ while availability will remain at $60X10^9$ $m^3$ implying a deficit of $21X10^9m^3$ (Gad, 2000).

Economically water scarce countries have high potential of water resources but they are not in a position to make additional investment in water sector development due to shortage of capital and do not encourage institutional set up that leads to efficient and equitable water allocation among various uses and users (Inocencio et al., 2003).

In Africa where the majority of its citizens are food insecure, priority is given to production of enough food at national and household levels using both rain-fed and irrigated agriculture. Thus, most African countries including Ethiopia have emphasized irrigation water for agricultural purposes in their programs of food self-sufficiency. This implies that multiple uses of irrigation water particularly its non-agricultural uses have not been given enough attention or at times have been ignored by the concerned bodies. But it is clear that in dry areas of African countries agricultural water has been used for non-agricultural purposes such as domestic uses and livestock watering.

A case study in semi-arid Zaio in northeast Morocco where average annual rainfall is 230mm reveals that in addition to its primary purposes of crop production, irrigation water plays a crucial role in fulfilling basic human needs for water including drinking, bathing and cooking, watering livestock and making bricks. In this area agriculture and livestock (particularly sheep and goats) are the major sources of income. Thus, since irrigation systems provide water for livestock, which are the main sources of income, the multiple uses of irrigation water have significantly contributed to income and nutrition of Zaio region (Boelee and Laamrani, 2004).

Macgregor et al. (2000) attempted to estimate agricultural uses of water in the Stampriet area in Namibia using the residual imputation model developed by Young (1996). The country gets its water supplies from three major sources, namely, ground water (about 50% of country's water supply), the perennial border rivers and the internal ephemeral rivers. The authors estimated economic value of water for agricultural uses, which has consumed about 65% of total water supply of the county and reported an economic water value of 0.64 Namibian dollars per cubic meter. The study did not consider economic value of non-agricultural use of irrigation water, which has consumed the remaining 35% of water supply. Therefore, economic value of water reported in this study seriously underestimates total economic value from the water supply systems in Stampriet area.

Tanzania with a population of 34 million (80% of whom depend on agriculture) has abundant physical water resources particularly on its coastal and highland areas, which have received over 1,0000mm rainfall per year. However, the country is economically water scarce to overcome extreme temporal and spatial variability in rainfall. The country has utilized small portions of its irrigation potential particularly in the Rufiji and Pangani basins. Irrigation water from these basins is not only used for crop production but also used for non-crop production such as domestic uses, hydropower supply, livestock watering and fishing (Koppen et al., 2004).

#### 2.2.1.2. The Latin American Experience

In the case of the Maipo River Basin in Chile, Rosegrant et al. (2000) introduced an integrated economic hydrologic modeling framework that accounts for the interactions between water allocations, farmer input choice, agricultural productivity, non-agricultural water demand, and resource degradation in order to estimate the social and economic gains from improvement in the allocation and efficiency of water use. The authors reported that of the total water withdrawal from the basin, agriculture accounted for 64%, domestic uses for 25%, and industry for the remaining 11%. Competition among the different water users and uses, in particular, agriculture and domestic and industrial water uses is increasing rapidly.

The authors pointed out that although the quantity of irrigation water diverted to the agricultural sector is large, its value is small. The authors further argued that introducing trading with water will create incentives to move water from lower valued agricultural products to higher valued agricultural outputs and non-agricultural uses. The idea here is that farmers can gain more benefits if they sell their water rights (assuming that water rights are well-defined) to municipal and industrial uses during months of little or no crop production. The basic implications are that irrigation water has multiple-uses and urban dwellers (like the rural societies) are willing to pay for domestic uses of irrigation water. Introducing pricing in water uses may also lead to efficient allocation of this vital resource.

#### 2.2.1.3. The Asian Experience

In the dry zone of Sri Lanka with tropical climate where temperature is almost constant ($26^0$c - $28^0$c) across the year and mean annual rainfall is about 1,000mm, irrigation water is directly or indirectly used for domestic purposes (like drinking, cooking and bathing), gardening livestock watering, and fishing but recreational use of irrigation water is minimal (Bakker, et al., 1999 and Meinzen–Dick and Bakker, 2001).

Meinzen–Dick and Bakker (2001) analyzed a survey of 156 households stratified into old and new irrigation systems in Kirindi Oya region of Sri Lanka based on an interdisciplinary field research. The authors also interviewed concerned government officials, local politicians and representatives of different water user groups in order to derive the implications for water resource management. In this irrigation system the authors identified various uses and users of irrigation water.

Although agriculture is the most important user of water from irrigation systems in the region, irrigation water has been used for homestead gardens, which are the main sources of vegetables and fruits for home consumption and markets. Water from irrigation systems is also used for domestic uses (drinking, cooking and bathing), livestock and fishing implying that water from Kirindi Oya irrigation systems has multiple uses. Renwick (2001) also reported the multiple uses of irrigation water in the Kirindi Oya irrigation systems. The author tried to estimate economic value of irrigated paddy rice production and reservoir production. For instance, the average net economic return from fisheries (based on market information) is estimated to be $544,000 – $566,000 per year (18% of the total economic returns to water in irrigated paddy production). This result implies the importance of recognizing and assessing the value of irrigation water for non-agricultural uses.

However, water management institutions do not consider such multiple uses of irrigation water in Kirindi Oya irrigation systems. That is, although water rights for agricultural purposes are well-defined, such rights for non-agricultural uses are less recognized or sometimes not recognized particularly in the statutory law, which is also typically the case in most developing economies (Meinzen–Dick and Jackson, 1998). Non-agricultural uses of irrigation water are not only ignored by the law but also taking irrigation water for such uses particularly for homesteads is "illegal" in Kirindi Oya due to shortage of irrigation water for agricultural uses (Meinzen–Dick and Bakker, 2001).

Therefore, in designing irrigation water rights and estimating values of irrigation water, it is very important to consider multiple uses and users' rights and uses of water for non-crop purposes as ignoring these use values leads to underestimation of the total economic value of water from irrigation systems.

In the case of China, Daming et al. (2002) discussed water resource policies, institutional capacities and availability of water for agriculture and non-agricultural uses in Yunnan river basin of Yunnan Province of China. The authors reported that even if the province has rich water potential in absolute terms, drinking water for human-beings and livestock is in short supply due to lack of appropriate water infrastructure. This implies that there is a competition for water from this river basin among various uses and users within and outside the agricultural sector. Thus, as in the case of many developing countries water from Yunnan river basin provides multiple-services for the rural dwellers of the province.

Empirical evidence from northwest India revealed that since groundwater of the area is salty, irrigation canals provide water not only for agricultural purposes but also for non-agricultural uses such as domestic uses, livestock watering, recharging groundwater, wildlife, flora and fauna. When irrigation water is in short supply, animals use salty groundwater, which reduces milk products by about 50%. Since income from livestock accounts for a significant share of income of rural households, a reduction in milk products has an implication on overall income and nutritional status of the societies (Rogers et al., 1998).

In estimating economic uses of irrigation water the authors argued for consideration of non-agricultural use values as leaving out such use values could result in a serious underestimation of the total benefits of irrigation water. Total economic value of water can be divided into three, namely, value to users, which basically refers to net value of crop output per $m^3$ of water; net benefits from indirect uses (or non-agricultural) uses; and net value from return flows such as from water diverted for urban uses, agricultural and industrial uses.

Using data from irrigated agriculture in an arid zone of Haryana in India, Rogers et al. (1998) estimated agricultural and non-agricultural use values of irrigation water. Agricultural use value defined as net value of output per unit of water input (USD/$m^3$) was estimated to be \$0.019/$m^3$. Non-agricultural use value for the same area was estimated to be \$0.01/$m^3$ for additional benefits to the value of water diverted for irrigation purposes. The authors also estimated agricultural and non-agricultural use values of water from irrigation systems in the Subernarekha river basin in India and found that net value of output per unit of water input is

$0.027/m^3$, which is higher than that of Haryana zone, may be due to climatic variations. Non-agricultural use value is estimated at $0.01/m^3$ implying that estimation of only irrigation use value of water from Subernarekha river basin also underestimates use values of irrigation water.

In the case of Punjab basin in Pakistan Van der Hoek et al. (1999) identified multiple uses of irrigation water by collecting information from 360 households in 24 villages using a stratified random sampling technique. The authors reported that the most important source of water for domestic uses is the village tank (*diggi*), which is filled weekly with water from the irrigation systems. The authors concluded that water from irrigation systems is the only sources of all domestic uses either directly or indirectly. The study also claimed that all households particularly females are willing to pay for improved domestic uses of irrigation water in Punjan basin.

Van der Hoek et al. (2001) also identified multiple uses of irrigation water by emphasizing health impact of domestic uses of water from irrigation systems using 200 households in ten villages of Punjab in Pakistan over one year. The authors claimed that incidence of water born diseases particularly diarrhea is higher where there is absence of enough piped water and storage facilities, lack of toilet and low level of hygiene. Therefore, taking into account domestic uses of water from irrigation systems in managing irrigation water could yield essential health benefits for users. Van der Hoek, Feenstra and Konradsen (2002) also reported the same results, especially in the area of integrated irrigation water management, which gives priority for domestic uses of water from irrigation systems.

Matsuno et al. (2002) cited various research works on the multiple uses of irrigation water in Taiwan, China, Japan, India, Pakistan and Bangladesh. For instance, using groundwater recharge function, which depends on area of rice, soil infiltration rate and number of irrigation days, the authors analyzed non-agricultural uses of irrigation in Taiwan and reported that the total value of groundwater recharged from the rice fields was estimated at $2.2 million during 2000.

In Japan and Taiwan besides rice production, which is a staple food, paddy rice irrigation fields provide environmental services and opportunities for recreational activities (Matsuno, 2002).

### 2.2.2. Water Related CVM Empirical Studies

Since the pioneering work of Davis in 1963, a number of researchers in various fields of studies have extensively applied the CVM mainly in developed economies including sanitation, health, environment, transportation and education (Hanemann, 1994). However, using the CV survey studies in developing countries is relatively a new phenomenon. Whittington (1998) argued that during the late 1980s very rudimentary CV studies were conducted in developing economies. The conventional wisdom at that time was that posing hypothetical questions to illiterate and low income individuals were assumed to be so overwhelming and one should not even try. But today a number of CV studies are reported using data collected from respondents in developing countries. This implies that in recent years CVM has been extensively applied in both developed and developing countries to the valuation of a wide range of environmental goods and services (Venkatachalam, 2004).

#### 2.2.2.1. The Ethiopian Experience

The Ethiopian experience reveals that limited CVM studies have been conducted to investigate factors that influence households' willingness to pay for improved water supply in rural and urban areas including Addis Ababa. To our best knowledge there is only one academic research that estimated WTP for irrigation water for agricultural purposes (not for domestic uses) in Tigray Regional State of Ethiopia.

Using the CVM, Fissiha (1997) examined households' WTP for piped water supply in Meki town in Ethiopia. The study reported that more than 50% of sampled households are willing to pay almost twice the existing tariff rates for improved water services. Another CV study by Dunfa (1998) estimated respondents' WTP for improved water supply in Ada'a Liben district of central Ethiopia using data collected from 228 sampled households. The author found that households' WTP for rural water supply is related to a number of explanatory variables such as income, availability of credit, distance from existing water sources and quality of water for domestic uses.

The CVM study by Genanew (1999) that used data from 270 sampled households in Harar town tried to identify determinants of households' WTP and demand for improved water supply using both OLS and ordered probit models. The study found that WTP of households for the required purposes is affected by various factors including income, education level, sex of the respondent and quality of water. The author further reported that mean WTP is about 15 times higher than the existing charges.

Using OLS and ordered probit regression models Tsegabrihan (1999) conducted the CVM study in Tigray Ethiopia for 82 randomly sampled farmers. The study estimated WTP of small holder farmers for irrigation water particularly for small scale irrigation schemes. The survey results are for the main irrigation seasons and the whole year, which depends on the 0.25 hectares of irrigable land. The study reported that about 90% of respondents are willing to pay up to Birr 600 for the main irrigation system alone. The study further found credit availability, education, income and fertilizer supply as the major determinants of respondents' WTP. It is not clear from the study whether the question to elicit WTP for 0.25 hectares of irrigable land asks for the land itself or irrigation water or both. The study also does not consider non-crop use values of irrigation water.

However, all these studies did not consider water from irrigation systems for non-crop purposes as some of them were conducted in urban or semi-urban areas of the country where irrigation is not practiced.

#### 2.2.2.2. Other Developing Countries' Experience

One of the early CV studies carried out by Whittington et al. (1990) estimated individuals' WTP for improved water services in rural areas of southern Haiti using the ordered probit model. The study concluded that WTP of individual respondents is affected by household wealth, education level of respondents, distance of the household from the existing water sources, quality of water and sex of respondents (female). Another early CV study was conducted by Briscoe et al. (1990) in rural areas of Brazil to examine users' WTP for improved rural water supplies and it concluded that tariff for yard taps can be increased substantially (i.e., consumers are willing to pay for improved rural water supply).

Whittington et al. (1991) employed revealed preference and stated preference methods to examine demand for rural water for domestic uses in Ontisha in Nigeria. The stated preference method used CVM to estimate respondents' WTP for improved water supplies. The CV survey study results based on data collected from 235 households seemed consistent with the data obtained from private water vending. This implies that the CV study results are sufficiently accurate to be used by policy makers.

In rural areas of Punjab in Pakistan Altaf et al. (1992) conducted a CV study with the main objective of identifying determinants of households' WTP for improved rural water supply and comparing the CV study results with market-based results. The authors found that wealth and education of respondents are among the major factors that affect respondents' WTP for improved rural water services. Empirical results of the study also confirmed that the CV study results seem consistent with revealed preference results.

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

Calkins et al. (2002) estimated WTP of sixty-two households for improved drinking water delivery systems in semi-urban area of Douentza in Mali using linear regression model and a logit model. The later model helps to explain the decision to purchase water or not. The authors asserted that wealth, relative distance to the planned new sources compared to the best existing sources, land tenure security and family size are major determinants of respondents' WTP. The study reported that land tenure insecurity is positively related to WTP implying that tenure insecurity discourages construction of one's own well and hence households tend to pay more for public water sources.

Using multinomial logit model Kaliba et al. (2003) estimated WTP of households from 30 villages in two regions of Central Tanzania to improve community-based rural water utilities. The study reported that households in both regions are willing to pay the fee, which is higher than the existing tariff charges. WTP is affected by respondents' socio-economic factors like age, wealth and household size. More specifically, WTP for improved water services is negatively affected by age and wealth as older individuals are not directly involved in water fetching and wealthier households have their own water sources or they delegate others to collect water for them at lower costs. Family size is positively related to WTP as households with larger family need more water and hence they are willing to pay more.

Farrington (2003) also employed the CVM to investigate factors influencing respondents' WTP decisions for improved rural water supply in Tanzania. Findings of the study suggested that decisions to pay for improved water supply for domestic uses are affected by a vector of variables including social and economic factors, perceptions and attitudes towards water quality and personal experiences.

The CV study conducted by SANREM CRSP (2003) tried to analyze factors that affect WTP of local communities for improved performance of portal and irrigation water systems through watershed conservation by taking 80 individuals from Cotacachi area in Ecuador. Half of the sampled individuals have access to water from irrigation systems for crop production and non-crop production purposes. The study reported that local individuals in the study area are willing to pay for the improvement in quantity and quality of the drinking water from irrigation water and other sources. The study also argued that the maximum WTP of the society is positively associated with respondents' income level and family size.

In rural Bangladesh Ahmad et al. (2003) analyzed determinants of piped water supply using multinomial logit model. The authors found that the demand for improved water in the arsenic-affected area directly varies with income of the respondents but declines as charges for piped water supply increase. Education level of respondents also positively affects their WTP for improved water supply.

Using the contingent valuation method, Chen et al. (2002) investigated the extent to which farmland provides value other than crop production in Taiwan. They claimed that the majority of people in Taiwan have recognized positive externalities of the paddy rice fields and on average each individual is willing to pay about $170 per year in order to maintain water preservation and land protection functions of paddy rice irrigation water. This implies that individuals are willing to pay for non-crop production uses of irrigation water and paddy rice fields.

### 2.2.3. CVM Empirical Studies on Other Resources: the Ethiopian Experience

Alemu (2000) employed the CVM to analyze households' WTP for community forestry in Ethiopia using tobit model by correcting for sample selection bias in the empirical analysis due to invalid responses (protest zeros, outliers and missing bids). The author concluded that income, family size, sex of household head, number of trees owned by respondents and distance of homestead to plantation are the main factors that influence households' WTP for community-forestry in rural Ethiopia.

Tegegne (1999) also applied the CVM to elicit respondents' WTP for environmental protection in terms of cash requirements and time spent (or labor contribution) in Sekota district (Northern Ethiopia) for the sample size of 98 farmers. The study found that about 70% of the sampled farmers are willing to pay zero Birr for environmental protection. However, farmers are willing to spend a considerable amount of their time for environmental protection particularly during the slack period. Farmers' willingness to contribute labor for environmental protection is affected by education level, age, sex and households size of respondents.

Using the CVM study, Tekie (1998) tried to obtain ex-ante valuation of farmers for improved land tenure system in Ethiopia. The study also identified factors that trigger the choice for a positive WTP and the amount farmers are willing to pay for land tenure improvements. The study concluded that farmers are willing to pay for changes in existing tenure arrangements and probability of paying for any institutional change is affected by a number of factors like area of land owned by respondents, literacy of household head, non-farm income, number of adult members and mean distance of plots to homestead of the household.

In a nutshell, these and other CVM empirical studies in developing economies in general and Ethiopia in particular on water quality improvement and other non-marketable environmental goods and services imply that the CVM can be successfully applied to low income countries. This invalidates the conventional wisdom, which argues that the CVM could not be applied to developing countries with a majority of illiterate individuals who could not understand hypothetical CVM questions.

Our CV study has three major contributions. Firstly, to our best knowledge it is the first in applying the CVM to value non-crop uses of irrigation water (at least in Ethiopia). Secondly, it adds some empirical knowledge to the limited water related CV studies in Ethiopia. Lastly, it also witnesses the possible application of CV studies in developing countries.

# Chapter Three

## Survey Design, Data Collection and Empirical Models

### 3.1. Data Sources and Types

The primary data utilized in the descriptive and multivariate analyses of this study were collected from 260 randomly selected households in two peasant associations (PAs) in Bure district of West Gojam zone of the Amhara Regional State of Ethiopia. Survey questionnaires elicited data on demographic characteristics of respondents; socio-economic variables such as income, expenditure (on food, non-food & agriculture related activities), education level and wealth of surveyed households; water and land related information particularly on water use rights and security of each right.

Besides the survey contained double-bounded referendum style CV questions in which prices (or bids) on non-crop uses (particularly domestic uses and gardening) of irrigation water were proposed to respondents under existing and improved irrigation water supply settings. More specifically prices were proposed for gardening and domestic uses of irrigation water from a specific source without introducing any change in quality and reliability of irrigation water under existing institutional setups that govern irrigation water allocation among various uses and users. The main objective here is to know how farmers (or users) value the existing natural resources (water in this case) without proposing any change (i.e., without proposing any improvement).

Knowing values of existing irrigation water resources helps in formulating policies and strategies that contribute to sustainable and efficient uses of existing resources. Finally, prices were also proposed for domestic uses (drinking, cooking and washing household equipment and hands) after a change in quality of irrigation water is undertaken in order to know the level and determinants of users' WTP for the improvement in quality of irrigation water for domestic uses.

### 3.2. Designing Survey Questionnaires and Elicitation Format

For most environmental goods, markets fail to exist due to the public nature of environmental goods and externalities. In such cases researchers develop hypothetical markets in which they elicit from consumers or potential consumers their WTP/WTA for a change in quality, quantity or both of environmental goods.

Designing CV survey questionnaires usually includes detailed description of the good under consideration and its possible substitutes and hypothetical circumstances under which the good is made available to users; questions that elicit WTP/WTA of the respondents for a proposed change; payment vehicle and respondents' socio-economic and other relevant variables.

The CV survey questionnaire of this study has seven parts. The first two sections provide general information and detailed description of the purposes of the survey followed by the third and fourth parts that try to collect information on demographic characteristics and education level of respondents and water related data, respectively. The fifth section elicits consumers' WTP for non-crop uses of irrigation water (see Annex 8). The last two parts are devoted to pursue information on income, wealth and expenditure and land related indicators.

Generally, there are four types of value elicitation formats, namely, open-ended; bidding game; payment card and dichotomous or discrete choice formats. Each format has its own advantages and disadvantages. Double-bounded CV elicitation format can improve statistical efficiency over single-bounded through a number of ways. First, yes-no and no-yes answer to the initial bid make clear bounds on unobservable true WTP. Second, even though yes-yes or no-no answers do not bound actual WTP, additional questions will sharpen the true WTP and hence there are also efficiency gains. Finally, more questions in double-bounded elicitation format lead to large number of responses so that a given function will be fitted with greater observations (Haab and McConnell, 2002). As a result, this study employs double-bounded referendum style elicitation format.

### 3.3. CV Survey Scenarios

In our survey questionnaires, we provided respondents with detailed descriptions of the good being valued (i.e., irrigation water) in terms of its uses, possible sources (rivers, springs and rivers and springs), quality and institutional setup. The double-bounded CV questions were asked with open-ended follow up questions[1] for various non-crop uses of irrigation water under two scenarios. The first scenario assumes that existing irrigation water quality and institutional setup remain the same. In this case respondents were asked to pay the proposed initial bid for specific uses of irrigation water (domestic uses and gardening) from a particular source (river or spring or both). Respondents were also asked the open-ended questions to express their maximum WTP for each specific non-crop uses of irrigation water (see Annex 8).

Under the second scenario, respondents were asked to pay for domestic uses of irrigation water after an improvement is proposed in quality and reliability of irrigation water for domestic uses while keeping the institutional setup the same. The reference point for quality improvement is protected springs (built by cement and other materials) (see Annex 8).

The payment vehicle for specific non-crop uses of irrigation water is implemented in the form of water users' charges twice per year just after the harvest as farmers in the study area produce at least two times a year.

### 3.4. Sampling Technique

The study area, Bure district of West Gojam zone of Amhara Regional State of Ethiopia, is selected based on various criteria[2] such as location (i.e., inclusion in the Blue Nile river basin), long history of irrigation experiences and different water-related institutional arrangements (namely traditional communal-water fathers and modern communal-water users associations) that govern irrigation water allocation among users. However, time and budget limited us from

[1] During the field survey the inconsistency of responses to dichotomous choices and open-ended follow up questions was checked. We obtained small proportion of such results who said I was mistaken.
[2] Cost minimization with almost the same expected results compared to other similar locations in the basin could also be one of the criteria.

expanding our survey to other zones of the Amhara Regional State of Ethiopia, which are located in the Abbay river basin.

Once the study area is identified, two kebeles[1] (peasant associations) were selected purposively along four major rivers as peasants must be users of irrigation water for multiple purposes for our study and allocation of irrigation water for crop production is ruled by various property right regimes like water father (WF), water users associations (WUAs) and community based (or open access). These two PAs are stratified into a number of Gots[2] from which a total of 260 households were selected using simple random sampling. Number of households to be selected from each Got is determined based on the rule of proportional stratification sampling. Thus, the study combines both simple random sampling and stratified sampling techniques to select the sample households. Finally, the data were collected from the head of sampled households using CV survey questionnaire that employ face-to-face (or direct personal interview) data collection techniques.

### 3.5. Fieldwork Procedure

The field survey was undertaken in Bure district of West Gojam zone. Before the final survey was implemented the pilot survey that included 15 households was carried out. The pre-testing pilot survey was conducted after a two-day intensive training of enumerators so that they could grasp the objective of the survey and detailed questions in the survey questionnaire.

A main objective of the pilot survey was to set up the starting prices (or initial bids) to be used in the main survey. In the pilot survey, the open-ended elicitation format is employed, which takes the form "What is the maximum amount you are willing to pay for irrigation water you have used for six months for domestic uses? Gardening?" The pilot survey also elicited maximum willingness to pay for improved irrigation water for domestic uses. The maximum

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[1] The two kebeles have practiced irrigation activities and use irrigation water for multiple uses. But not all kebeles in the district are users of irrigation water. Besides, the selected kebeles are somehow unique in the sense that property right regimes like WUAs and water father govern irrigation water allocation among users are practiced in these Kebeles.

[2] Got is a unit in a kebele that constitutes approximately 20-50 households.

WTP obtained from the pilot survey varies from zero (protest zeros[1]) to Birr 80.00 for the six months for different uses. The results of the pilot survey were also used to modify the survey questionnaire in the process of finalizing it.

Then based on the pilot results five starting prices were introduced and total sampled households were divided randomly into five groups of equal size (each group with 52 households). The final survey was implemented from 20 February - 10 March 2005 where ten enumerators and one supervisor participated in the survey after necessary training was given to the participants. The field survey was successfully completed with a relatively small number of invalid responses (about 5% protest zeros).

## 3.6. Empirical Models

### 3.6.1. The Probit Model

The main objectives of estimating econometric (or parametric) models in WTP survey are to calculate mean WTP and to allow inclusion of respondents' socio-economic factors into WTP functions. Such incorporation of individuals' socio-economic variables into the CV models helps the researcher to gain information on validity and reliability of the CV results and increases confidence in application of results obtained from the CV empirical analysis (Haab and McConnell, 2002).

Hanemann (1984) developed the basic model to analyze dichotomous responses based on the random utility theory. 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.

[1] Valid zeros and protest zeros are clearly identified using the follow-up questions to the open-ended question. According to responses to the follow-up questions, all zeros are protest zeros as respondents wanted free access to irrigation water for multiple uses.

Suppose $u_{ij} = u_i(y_j, x_j, \varepsilon_{ij})$ is indirect utility function for the j[th] respondent.

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

$\varepsilon_{ij}$ =random components of the given indirect utility

Now, if a payment (also called the initial bid, $\beta_i$*) 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 can not 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:

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

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

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

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

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

For dichotomous (yes/no) responses to the initial bid ( $\beta_i^*$ ) (i.e., in the case of a dichotomous dependent variable) the probit/logit model better fits the problem at hand. The probit model can be defined as:

$$\mathbf{T_i = \beta' X_i + \varepsilon_i}$$

$\mathbf{T_i}$ = unobservable households' actual WTP for gardening and domestic uses of irrigation water. $\mathbf{T_i}$ is simply a latent variable. What we observe is a dummy variable $\mathbf{WTP_i}$, which is defined as:

$$\mathbf{WTP_i} = 1 \text{ if } \mathbf{T_i} \geq \beta_i^*$$

$$\mathbf{WTP_i} = 0 \text{ if } \mathbf{T_i} < \beta_i^*$$

In the single bounded elicitation format, the $j^{th}$ respondent is asked if s/he would be willing to pay the initial "bid", ( $\beta_i^*$ ), to get, say, a given improvement in environmental quality, quantity or both. The probability of a "yes" response, or a "no" response, $p_i^{Y \text{ or } N}(\beta_i^*)$ 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 it is a random variable with a given cumulative distribution function (cdf) denoted by $G(T_i; \boldsymbol{\theta})$ where $\boldsymbol{\theta}$ 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:

$$p^Y \equiv p\left\{yes\ to\ \beta_i^*\right\} \equiv p\left\{\beta_i^* \leq T_i\right\} = G(\beta_i^*;\theta)$$

$$p^N \equiv p\left\{no\ to\ \beta_i^*\right\} \equiv p\left\{\beta_i^* > T_i\right\} = 1 - G(\beta_i^*;\theta)$$

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

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

Where: $d_i^Y$ = 1 if the $i^{th}$ response is yes and 0 otherwise, while $d_i^N$ =1 if the $i^{th}$ response is no and 0 otherwise.

**3.6.2. The Bivariate Probit Model**

The double bounded (or bivariate) CV model was first proposed by Hanemann (1985) and applied by Hanemann, Loomis and Kanninen (1991) with the main aim to show how the statistical efficiency of single-bounded dichotomous choice pioneered by Bishop and Heberlein can be improved by asking respondents further questions with higher or lower bid based on the responses to the initial bids.

According to Greene (1997), bivariate probit model can assume the following general form:

$$T_1^* = \beta_1' x_1 + \varepsilon_1$$

$$T_2^* = \beta_2' x_2 + \varepsilon_2$$

$$E(\varepsilon_1) = E(\varepsilon_2) = 0$$

$$Var(\varepsilon_1) = Var(\varepsilon_2) = 1$$

$$Cov(\varepsilon_1, \varepsilon_2) = \rho .$$

Where: $\mathbf{T_1}^*$= $j^{th}$ respondent's actual unobservable WTP at the moment the first question is posed. WTP=1 if $\mathbf{T_1}^* \geq \beta_i^0$ (initial bid), 0 otherwise

$\mathbf{T_2}^*$= $j^{th}$ respondent's implicit underlying point estimate at the time the second bid is posed.

This implies that disturbance terms of these equations are correlated in the same spirit as the seemingly unrelated regression models.

The double bounded format starts with an initial bid, $\beta_i^0$. If the respondent answers Yes, s/he receives a follow-up bid $\beta_i^u > \beta_i^0$; if s/he answers No, s/he receives a follow-up bid $\beta_i^l < \beta_i^0$.

Thus, there are four possible outcomes: (Yes, Yes), (Yes, No), (No, Yes), and (No, No). In terms of the random utility maximizing model given above, the corresponding response probabilities are:

$$p^{YY} = p(\beta_i^u \leq T_i) \equiv G(\beta_i^u;\theta)$$
$$p^{YN} \equiv p(\beta_i^0 \leq T_i < \beta_i^u) \equiv G(\beta_i^u;\theta) - G(\beta_i^0;\theta)$$
$$p^{NY} \equiv p(\beta_i^l \leq T_i < \beta_i^0) \equiv G(\beta_i^0;\theta) - G(\beta_i^l;\theta)$$
$$p^{NN} = p(\beta_i^l > T_i) \equiv 1 - G(\beta_i^l;\theta)$$

The log-likelihood function for the responses to a CV survey using the DB format is:

$$\ln L^{DB}(\theta) = \sum \begin{Bmatrix} d_i^{YY} \ln G(\beta_i^u;\theta) + d_i^{YN} \ln\left[G(\beta_i^u;\theta) - G(\beta_i^0;\theta)\right] + \\ d_i^{NY} \ln\left[G(\beta_i^0;\theta) - G(\beta_i^l;\theta)\right] + d_i^{NN} \ln\left[1 - G(\beta_i^l;\theta)\right] \end{Bmatrix}$$

(see Hanemann et al., 2001).

Where: $d_i^{YY}$ =1 if the $i^{\text{th}}$ response is (Yes, Yes) and 0 otherwise, $d_i^{YN}$ = 1 if the $i^{\text{th}}$ response is (Yes, No) and 0 otherwise, $d_i^{NY}$ =1 if the $i^{\text{th}}$ response is (No, Yes) and 0 otherwise, $d_i^{NN}$ =1 if the $i^{\text{th}}$ response is (No, No) and 0 otherwise.

### 3.7. Description and Rationale of Explanatory Variables

In this sub-section rationale and explanations of each expected determinants of WTP included in our empirical models are briefly summarized.

#### 1. Income

As indicated in the 1999/2000 household income, consumption and expenditure survey of the Central Statistical Authority (CSA, 2001), households usually tend to underestimate their actual income level due to various reasons like fear of income tax increment. This is actually observed in this survey where average income is Birr 4,729.65 per household per year whereas average annual total expenditure per household is Birr 5,077.15 (see Table 4.1). This study utilizes expenditure as proxy for household income to solve the problem of income underestimation. It is expected that households with higher income have more ability to pay and hence respondents' income affects their WTP positively.

**2. Age**

In most rural areas of developing countries, farmers have a close touch with natural resources like land, forests and water from their childhood. This implies that age of the respondent could be used as a proxy for experience in using natural resources and as s/he gained more experiences s/he is expected to be concerned more about these resources in general and water in particular. Therefore, age of a respondent is expected to have positive impact on her/his WTP. But the positive effect has some maximum age limits and hence age-squared is expected to have a negative effect on WTP of the respondents.

**3. Sex**

Most often females are responsible to fetch water for domestic uses. Our survey results depict that fetching water for domestic uses is almost fully the responsibility of females (99%). Thus, it is expected that female-headed households are willing to pay more for domestic uses of irrigation water compared to male-headed households.

**4. Education**

Generally, education widens the horizon of an individual. Moreover, educated (or literate) individuals are expected to know relatively more about advantages of natural resources in general and irrigation water resource in particular and hence they are concerned more about these resources. Thus we expect education to positively affect respondent's WTP for non-crop uses of irrigation water.

### 5. Family size

There are two opposing views about the effects of family size on households' WTP for improved rural water supply. One view argues that households with larger family sizes have more labor available to collect water from alternative sources. A similar view, which leads to the same conclusion, claims that given limited income of rural households, families with more members have less income left to pay for improved irrigation water supply or other natural resources. Therefore, in both cases family size is expected to affect households' WTP for rural water supply negatively. The second view, which is contrary to the first, argues that households with large family size are concerned more about quality, reliability and quantity of water supply and hence they are willing to pay more.

### 6. Irrigation Water Management

Outside its primary uses irrigation water in the study area provides multiple services for the nearby farmers. Irrigation water is managed by "water father" (WF), water users associations (WUAs) and community as a whole (i.e., the open access case) particularly to regulate irrigation water allocation for irrigation purposes among users. The former two irrigation water management systems are very important in settling conflicts over this resource among users.

WUAs have relatively strong legal background and clearly defined and written rules and regulations, which could strengthen rights enforcement mechanisms and develop conflict resolving capacity. These associations teach their members and other farmers to create awareness about uses of natural resources in general and irrigation water in particular. Besides WUAs provide different services such as credit services, marketing services and modern farm tools for farmers, which contribute in boosting income level of these farmers. Thus, farmers organized under WUAs are expected to pay more for non-crop uses of irrigation water compared to farmers under the umbrella of traditional water regulating bodies (i.e., water father and open access) where problems of free riding are high and rights enforcement mechanisms are weak.

**7. Choices of Water Use Rights**

In the study area, farmers have access to irrigation water for multiple purposes under different institutional regimes (i.e., WUAs, WF and/or open access). Farmers have also choices among these institutional arrangements based on their perception towards advantages of each institutional regime, their experiences about modern farmers' associations. But regardless of the history of farmers' associations in Ethiopia, which generally did not reflect the interest of most farmers (and hence was not successful), households choosing WUAs are expected to be willing to pay more compared to those who choose WF or community based irrigation water use rights. This is probable due to advantages of WUAs mentioned above and problems related to irrigation water management under WF and open access.

**8. Quantity of Irrigation water Consumption**

Households consuming more irrigation water for non-crop uses are expected to be willing to pay more as the payment directly varies with quantity of irrigation water consumed.

**9. Distance from Current Sources (in meters)**

An inverse relationship is expected between distance to fetch water from the existing water sources and WTP for domestic uses of irrigation water. This is due to the fact that as the household is far way from water sources, time spent to fetch water is higher that increases opportunity cost of time.

**10. Wealth**

In rural areas households that have more livestock are considered wealthier. Thus, this study takes total value of livestock as wealth indicator. It could be the case that wealthier individuals are able to pay more for non-crop uses of irrigation water.

### 11. Land Tenure

Since farmers in the study area have no water well or other water sources on their own plots of land, land tenure insecurity due to village level government land redistribution may not have negative impact on their WTP for irrigation water uses.

However, reduction in the size of farm plot due to a rise in family size (i.e., household level factor) is expected to induce farmers' willingness to pay more for non-agricultural uses of irrigation water. The intuition behind such expectation is that as land size gets smaller and smaller, farmers are forced to practice intensive farming, which requires higher amount of water. This would imply that irrigation water becomes a more scarce resource that asks for higher prices to access it. Thus, respondents who are feeling reduction in farm plot are willing to pay more compared to the base group (those feeling no change in farm plot).

### 12. Peasant Associations (Sites)

Farmers in Wan Gedam, one of the peasant associations included in the sample, are exercising intensive farming activities to produce vegetables and fruits that improve their income. In addition some irrigation water users in Wan Gedam PA for irrigation purposes are organized under WUAs where leaders of the association teach users to increase their awareness about benefits of irrigation water. As a result, respondents in Wan Gedam are expected to be willing to pay more compared to the reference site (Wondegi peasant association).

### 13. Quality of water

Our CV survey questions tried to elicit consumers' WTP for domestic uses of irrigation water. The respondents were asked to provide their WTP under two scenarios. Firstly, they were asked to pay for existing water supply. In this case quality of water supply is expected to be directly related to WTP responses (i.e., consumers facing lower irrigation water quality are expected to pay less). Secondly, consumers were asked to pay for domestic uses of irrigation water after quality improvements are proposed. In this case consumers' WTP for improved water is expected to be higher for low quality of irrigation water as consumers want to pay more to get improved water.

### 14. Location of users

In this study locations of users of irrigation water for multiple purposes are divided into three. First, the upper users, who are users of irrigation water immediate to the diversion of water from a river. Second, the middle users are those users of irrigation water next to the upper users down the canal (or river). Lastly, the end (lower) users refer to irrigation water users at the lowest point. As irrigation water moves down from the upper users to the end users, its quality becomes poorer and hence the end users are expected to be willing to pay less than the upper users for existing irrigation water (without introducing changes). However, the opposite is true if improvement in quality of irrigation water is proposed for domestic uses (taking the upper users as reference group). That is, since irrigation water available for lower users is with poor quality for domestic consumption, respondents at the lowest point are expected to pay more to get improved water supply.

### 15. Starting Bid

The higher the starting bid is the lower the expected number of respondents who accept the bid and hence an inverse relationship is expected between initial bid and the yes responses to that bid.

# Chapter Four

## Descriptive Analysis, Estimation Results and Discussion

Data collected through CV questions can be analyzed in three different ways. First, the data may be discussed through descriptive analysis of socio-economic characteristics of surveyed households and other variables. Second, data can be analyzed using bivariate analysis such as cross-tabulation of households' responses to WTP questions. Finally, econometric models can be employed to examine determinants of WTP responses of sampled households for multiple uses of irrigation water.

Accordingly, this chapter is organized as follows. The first section presents descriptive statistics of the survey results. The second section provides the bivariate analysis focusing on simple correlation analyses of the responses to the CVM questions and variables that are expected to influence these responses. The third section deals with multivariate analysis of determinants of respondents' WTP for non-crop uses of irrigation water. The last section estimates mean WTP, total WTP and aggregate demand for non-crop uses of irrigation water.

### 4.1. Descriptive Analysis

#### 4.1.1. Overview of the Study Area and Characteristics of Surveyed Households

The Amhara Regional State with the total population of over 18 million and total land area 17,675,200 hectares (15% of the country's land area) is one of the nine regional states of Ethiopia. In the region about 650,700 hectares of land is irrigable. But according to 1995 (E.C*) data only 83,000 (12.7%) of the potential was actually irrigated of which 93% was cultivated through traditional ways (Plan, Agricultural and Information Department, 1995).

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* E.C. refers to the Ethiopian Calendar

Our case study area is Bure District (woreda) in west Gojam zone, which is one of the nine zones of the Amhara Regional State of Ethiopia. The District has a total number of 26 Kebeles with total population of 164,675 in which rural dwellers account for about 85.6%. In the woreda there is limited basic infrastructure: only one health center in Bure town, four state-owned clinics, 22 primary schools, one high school and one Agricultural Technical College (Bure Rural Development and Agricultural Bureau, 2004). The capital of Bure Woreda is Bure town which is located at 411 km from Addis Ababa, capital of Ethiopia on the way to Bahir Dar – the capital of Amhara region.

The district has a total number of 28,205 peasant households out of which male-headed households account for about 88%. The total number of households in the two kebeles we selected is 3,760 of which 2,139 and 1,621 households are living in Wan Gedam and Wondegi Kebele, respectively. The sample size of 260 households (about 7% of households of the two kebeles) was selected.

These Kebeles are endowed with sufficient water sources. More specifically, Wan Gedam Kebele has Cilala River, which is a tributary of Abbay River. This river is the main supplier of water for irrigation and non-irrigation purposes. The Kebele has 24 small and large springs which are used for different purposes such as irrigation, domestic uses and livestock watering. Wondegi Kebele has three major rivers, namely, Yisir, Muzuz, and Citty Rivers, which are used for irrigation and other activities. This Kebele has also different springs, which provide multiple purposes for nearby dwellers.

**Table 4.1: Descriptive Analysis of Explanatory Variables**

| Var. | Description | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| i1 | i1=1 if yes to initial bid, 0 otherwise-for domestic use of existing irrigation water | 0.512 | 0.501 | 0 | 1 |
| i1i | i1i=1 if yes to initial bid, 0 otherwise- for domestic use of improved irrigation water | 0.470 | 0.500 | 0 | 1 |
| i1g | i1g=1 if yes to initial bid, 0 otherwise- for gardening | 0.440 | 0.497 | 0 | 1 |
| ibid | Initial bid for domestic use of existing irrigation water (in Birr*) | 44.077 | 21.568 | 10 | 70 |
| ibidi | Initial bid for domestic use of improved irrigation water (in Birr) | 66.115 | 34.438 | 20 | 120 |
| Igar | Initial bid for gardening uses of irrigation water | 52.077 | 31.272 | 10 | 100 |
| exp | Annual total expenditure per household(in Birr) | 5,077.146 | 1,798.958 | 1,177 | 12,061.4 |
| inc | Annual total income per household (in Birr) | 4,729.646 | 2,083.76 | 456.5 | 12.239 |
| val | Total value of all livestock owned per household (in Birr) | 2528.10 | 1929.26 | 0 | 9930 |
| dis | Distance from current water sources (in meters) | 223.903 | 178.578 | 5 | 1000 |
| age | Age of respondents (in full years) | 45.396 | 13.226 | 18 | 82 |
| fsiz | Family size (in numbers) | 5.692 | 1.978 | 1 | 11 |
| edu | Education level of the respondent (in year of completion) | 1.461 | 2.618 | 0 | 12 |
| lsiz | Total land size (in hectares) | 1.049 | 0.475 | 0 | 3.5 |
| ox | Oxen (in numbers) | 1.431 | 0.962 | 0 | 4 |
| fem | Dummy for sex of household: fem=1 if sex is female, 0 otherwise | 0.188 | 0.392 | 0 | 1 |
| s1 | Dummy for site: s1=1 if site is Wan Gedem, 0 otherwise | 0.542 | 0.499 | 0 | 1 |

* 1USD was equivalent to 8.65 Ethiopian Birr at the time of the survey.

| | | | | | |
|---|---|---|---|---|---|
| edu1 | Dummy: edu1=1 if education of the respondent ≥ grade four, 0 otherwise | 0.203 | 0.4036 | 0 | 1 |
| loc2 | Dummy for location: loc2=1 if middle user, 0 otherwise | 0.715 | 0.452 | 0 | 1 |
| loc3 | Dummy for location: loc3=1 if lower user, 0 otherwise | 0.1384 | 0.346 | 0 | 1 |
| sour2 | Dummy for source of water: sour2=1 if respondent uses water from both river and spring, 0 otherwise (if only spring, which is the base group) | 0.519 | 0.501 | 0 | 1 |
| qaun | Quantity of water used per day (in jerry can=20-25 liters) | 3.017 | 1.124 | 0.5 | 6 |
| ten2 | Dummy for land tenure: ten2=1 if farmers anticipate reduction in farm plot due to high family size, 0 otherwise. No change in farm plot is base group | 0.592 | 0.492 | 0 | 1 |
| ten3 | Dummy for land tenure: ten3=1 if farmers anticipate land distribution, 0 otherwise | 0.119 | 0.325 | 0 | 1 |
| adm3 | Dummy for irrigation water management: adm3=1 if irrigation water is managed by water father, 0 otherwise. WUAs are reference group | 0.611 | 0.488 | 0 | 1 |
| adm4 | Dummy: adm4=1 if water is managed by community (open access), 0 otherwise | 0.096 | 0.295 | 0 | 1 |
| chr2 | Dummy for choice of water use rights: chr2=1 if respondents choose water father, 0 otherwise | 0.327 | 0.470 | 0 | 1 |
| chr5 | Dummy chr5=1 if respondents choose community based water use rights, 0 otherwise. WUAs are our base group | 0.427 | 0.496 | 0 | 1 |
| qual2 | Dummy for water quality: qual2=1 if water quality is satisfactory, 0 otherwise | 0.558 | 0.498 | 0 | 1 |
| qual3 | qual3=1 if water quality is bad, 0 otherwise .Good quality is our reference point | 0.231 | 0.422 | 0 | 1 |
| use2 | Dummy for users of irrigation water: use2=1 if farmers use for domestic purposes only ( users for both irrigation and domestic activities are reference group) | 0.188 | 0.392 | 0 | 1 |

Source: Sample survey

The data show that about 19% of sampled households are female-headed. The surveyed households have an average of 5.69 family members per household with a minimum of one member and a maximum of eleven members (see table 4.1).

According to our survey results, almost all household heads interviewed are decision makers both economically and socially and hence the CV survey responses obtained from these individuals are more reliable.

Age composition of the surveyed households depicts that age ranges from 18 to 82 years with an average age of 45.4 years (Table 4.1). Categorizing age of respondents witnesses that about 38.8 percent of respondents are 50 years old or above whereas the younger ones (age less than 35 years) account for about 21 percent of our sampled households.

Formal education of respondents varies from zero (illiterate) to grade 12 complete with an average formal school attainment of about 1.5 years which means that majority of the sampled households are mainly illiterate or primary school attendants (see Table 4.1).

### 4.1.2. Income, Expenditure and Wealth of Surveyed Households

Farmers in the study area are engaged in mixed farming activities. These activities include food crop production like 'dagusa', maize, 'teff', wheat, and barley and vegetables and fruits production including tomatoes, potatoes, onions, carrots, pepper, cabbages, beetroot, bananas, coffee, orange, and sugar cane. Farmers are also rearing domestic animals such as cows, oxen, sheep and goats, donkeys and mules.

Major sources of income in the study area are on-farm activities mainly from crops, fruits and vegetables, which accounts for the lion's share (about 90%) of average income per household. Farmers also earn income from sales of livestock and livestock by-products (like butter, skins and honey). Income from other sources such as trading crops and livestock, renting-out ox, mule and land, producing traditional alcoholic drinking and remittance from relatives are also sources of income for some farmers. Income of the surveyed households ranges from 456.5 to 12,239

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Birr with an average value of Birr 4,729.65 per annum per household (see Table 4.1). Per capita income is Birr 831.22 and 69.27 per annum and per month, respectively. The monthly per capita income from our data is higher than Birr 62.7 monthly per capita income reported by the IMF at country level (IMF, 2001).

On the expenditure side, surveyed households spent on food, non-food items (like clothing, education, health and transport), and agricultural related activities including expenditure on fertilizers, selected seeds, chemicals, and renting ox and land. Expenditure on food takes a significant share of average expenditure (about 52%). On the average household expenditure is Birr 5,077.15 with a range of Birr 1,177 to Birr 12,061.4 per annum.

Comparing average expenditure with average income of households the former is higher than the latter suggesting that households tend to underestimate their actual income. Therefore, since credit to finance expenses of sampled households is limited (about 2% of average expenditure mainly for agriculture related inputs), expenditure better indicates households' actual income and hence it is used as a proxy for income in our regression analysis.

Finding wealth indicators is difficult in rural areas of most developing countries. Sometimes corrugated iron-roofed houses can be taken as proxy for wealth. But in our study area over 91 percent of sampled households have corrugated iron-roofed houses suggesting that corrugated iron-roofed house may not be a good variable to measure wealth of respondents. Ownership of oxen can also be taken as a wealth indicator as oxen are major traction power in rural areas where most households depend on agriculture for their livelihoods. Alternatively, total number of livestock owned by a household may be taken as a proxy for wealth of the household. This wealth indicator seems better as total number of livestock includes oxen and other domestic animals as well. Thus, total monetary value of all livestock owned by a farmer is used as a proxy for wealth of the respondent.

The surveyed households have a total numbers of 372 oxen, 190 cows, 116 bulls, 125 calves, 417 goats and sheep, 8 mules, 31 donkeys and 93 beehives with the corresponding average of 1.43, 0.73, 0.45, 0.48, 1.60, 0.03, 0.12 and 0.36 per household. Cultivated (both rain-fed and irrigated) land holding per household ranges from 0 to 3.5 hectares with an average of about 1 and 0.18 hectares per household and per person, respectively (see Table 4.1).

On average, monetary value of livestock is Birr 2,528.10 per household with a range of Birr 0 to Birr 9,930 and about 8.5% of surveyed households have no livestock.

### 4.1.3. Institutional Setups, Water Quality and other Variables

As reported in Table 4.1, about 61% and 30% of the surveyed households are users of irrigation water for multiple purposes, which is governed by water fathers and WUAs, respectively. Concerning choices of irrigation water use rights by farmers, only 24% of our respondents choose irrigation water rights under the umbrella of WUAs compared to about 43% who want to use irrigation water managed by the community.

A majority of our respondents (over 59%) are anticipating reduction in farm plot due to higher family size as it is the responsibility of heads of household to give land for their male children usually after marriage. Only about 12% of the sampled households expect that there will be a decline in the size of their farm plots because of village level land redistribution by the government (see Table 4.1).

Regarding irrigation water quality, most respondents (56%) perceived the quality as satisfactory followed by respondents who considered irrigation water quality as good (23%). The remaining 21% responded that irrigation water quality for domestic uses is bad. Quantity of irrigation water collected for domestic uses varies from 0.5 - 6 jerry cans each day with an average of about 3 jerry cans per household per day (see Table 4.1). This means that water consumption per capita per day for domestic uses (like drinking and cooking) is about 0.53 jerry cans (or about 12 liters).

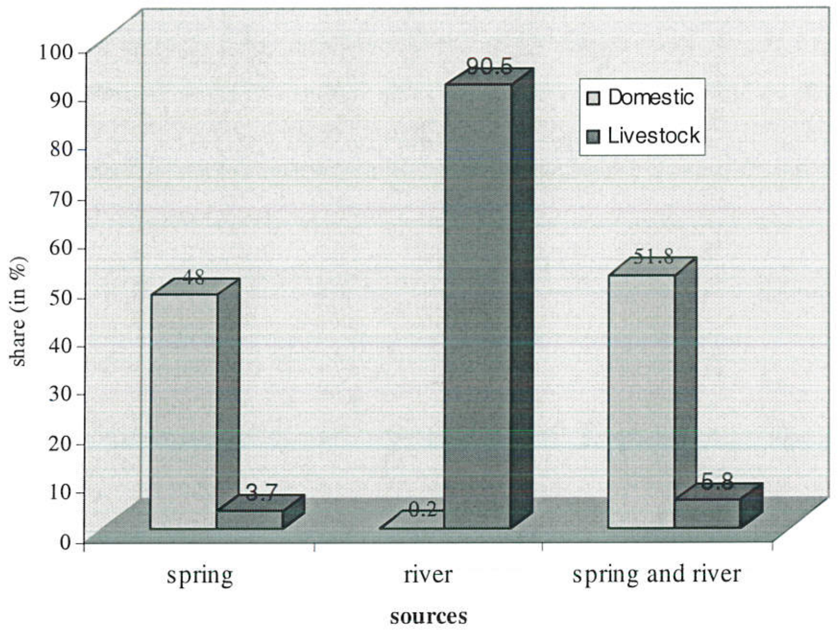
Users of irrigation water in the sampled households are divided into upper users (14%), middle users (72%) and lower users (14%) implying that households access irrigation water with different qualities and quantities for multiple purposes and partly for this reason their WTP is expected to vary with location of users.

### 4.1.4. Multiple Uses of Irrigation Water: Non-Crop Uses

In the study area, irrigation water from river and major springs is used for crop production mainly vegetables (cabbage, tomatoes and potatoes) and fruits (orange, banana and coffee). Apart from irrigating crops, irrigation water from both sources is used for domestic purpose (including drinking, cooking, washing and cleaning household equipment), livestock watering and gardening. In rural areas of Bure district where piped water supply is limited or non-existent but with relatively abundant irrigation water, most households use irrigation water for non-crop purpose such as drinking, cooking, washing and livestock watering.

In the two kebeles (Wan Gedam and Wondegi) of Bure woreda selected for this study, a large proportion of households consume water from springs and rivers that provide water for irrigation purposes. As indicated in Figure 4.1, about 52% of the households use water from both springs and rivers for domestic uses that are used by farmers for irrigation activities. About 48% collect water from springs only for domestic, which provide water for irrigation purposes directly (before flowing to the nearby river) and/or after joining the river. In the case of livestock over 90% of sampled households use irrigation water from rivers before and after diversion and from small traditional canals built on rivers.

**Fig. 4.1: Share of multiple uses of irrigation water by sources and uses**




Thus, Figure 4.1 above witnesses that almost all households in the selected kebeles used irrigation water for non-agricultural uses either from springs, rivers or both. However, in most cases when irrigation water systems have been developed, there is a tendency to focus exclusively on irrigation water in terms of irrigation water administration like modern communal (water user association) and traditional water leaders (water father), irrigation water allocation and project designing. This implies that most often multiple uses of irrigation water are ignored in designing irrigation projects, managing and allocating irrigation water. As the rural population is growing and irrigation water scarcity is felt among farmers, ignoring multiple uses of irrigation water may lead to conflicts among uses and users. On the other hand, providers of improved rural water for domestic uses rarely consider the multiple uses of water from such sources. These imply that in developing and maintaining irrigation water and provision of improved rural water supply, multiple uses of water from a given source is not considered by responsible bodies.

## 4.2. Bivariate Analysis

This sub-section provides pair-wise correlation analyses between responses to the first bids posed for non-crop uses of irrigation water and socio-economic and other variables.

The pair-wise correlation between responses to the initial bid proposed to respondents for gardening and domestic uses of existing and improved irrigation water and explanatory variables included in each probit model are reported in Table 4.2.

The correlation of discrete responses to the first bids with income, initial bid, age, age-squared, family size, education dummy, location dummy (middle user), quantity of irrigation water consumed, irrigation water management dummies and dummies for choices of these water managements and land tenure dummies is significant at 99% level of confidence for domestic uses of existing irrigation water (see Table 4.2).

In the case of improved irrigation water supply for domestic uses, the correlation exists between yes responses to the first bid and income, education, age, age-squared, quantity of water consumed, water related institutional arrangements, which fall under the umbrella of water father and community and choices of these institutions and land tenure security at less than 10% level of significance. But there is no significant pair wise correlation between yes responses to the first bid and distance from water sources, family size, sex of respondents, quality of irrigation water for domestic uses, site and location of users (see Table 4.2).

Table 4.2 reports the pair-wise correlation between positive responses to the initial bid proposed for gardening uses of irrigation water per one-fourth hectares and explanatory variables. This pair-wise correlation is significant at least at 10% level of significance between responses to the first single-bounded question and the initial bid proposed to gardening uses of irrigation water, income, family size, source of irrigation water, land tenure security, water institutional setup and ownership of oxen.

**Table 4.2: Pair-wise Correlation Analysis: gardening and domestic uses of irrigation water**

| Explanatory Variables | Dependent Variable | | |
|---|---|---|---|
| | Domestic Uses | | Gardening |
| | Existing | Improved | Existing |
| | **i1=1 if yes to the 1st bid** | **i1i=1 if yes to the 1st bid** | **i1g=1 if yes to the 1st bid** |
| Initial bid: domestic uses of existing irrigation water | -0.243*** | – | – |
| Initial bid: domestic use of improved irrigation water | – | -0.259*** | – |
| Initial bid for gardening uses of irrigation water | – | – | -0.337*** |
| Natural logarithms of income | 0.399*** | 0.348*** | 0.267*** |
| Wealth | – | 0.198*** | – |
| Distance from current water sources | -0.012 | -0.051 | – |
| Age of respondent | 0.170*** | 0.169*** | 0.107* |
| Family size of respondent | 0.051 | 0.054 | -0.012 |
| Sex dummy: female=1 | -0.049 | -0.096 | -0.089 |
| Site dummy: Wan Gedam=1, 0 otherwise | 0.018 | 0.033 | – |
| Education dummy: 1=grade 4 or more | 0.064 | 0.088 | 0.081 |
| Location dummy: middle user=1, 0 otherwise | 0.161*** | 0.089 | 0.095 |
| Location dummy: end user=1, 0 otherwise | 0.05 | 0.043 | 0.049 |
| Source dummy: 1=uses from both spring & river | 0.416*** | 0.337*** | 0.307*** |
| Age-squared of respondent | 0.143*** | 0.159* | 0.097 |
| Quantity of water consumed | 0.422*** | 0.414*** | – |
| Land tenure dummy: 1=farmers anticipate fall in farm plot due to higher family size | 0.449*** | 0.398*** | 0.354*** |
| Land tenure dummy: 1=farmers anticipate fall in farm plot due to government land redistribution | -0.158*** | -0.187*** | -0.158*** |
| Irrigation water management dummy: 1= WF, 0 otherwise | 0.323*** | 0.350*** | 0.307*** |
| Irrigation water management dummy: 1= community | -0.131** | -0.188*** | -0.052 |
| Use rights choice dummy: 1= WF | -0.343*** | -0.351*** | -0.343*** |
| Use rights choice dummy: 1= community | -0.042 | 0.023 | -0.011 |
| Irrigation water quality dummy: 1=satisfactory quality | 0.085 | 0.004 | – |
| Irrigation water quality dummy: 1=bad quality | -0.121** | -0.088 | – |
| Dummy: 1=farmers use irrigation water for domestic uses | 0.129*** | 0.102* | 0.189*** |
| Land size | – | – | 0.113** |
| Ox ownership dummy: 1= has ox/oxen, 0 otherwise | – | – | 0.235*** |

***, ** & * indicate significance level at 1%, 5% and 10%, respectively

In short, pair-wise analyses described above provide the basic relationship between variables used in our empirical models that provide further insight about relationship between left hand side variable and right hand side variables. However, one main problem of pair-wise correlation analysis is that holding other variables while we are looking at correlation between two variables is impossible. This problem can be avoided in our multivariate analysis.

The pair-wise correlation also depicts that there are correlations among explanatory variables implying existence of multicollinearity, which is not common problem in cross-sectional data compared to time series data. Although multicollinearity exists among our right hand side variables, it is not a serious problem as its magnitude is not large except between age and age-squared, which is about 0.98 (see annex 7). [0]

### 4.3. Multivariate Analysis of Determinants of Households' WTP

Econometric analysis helps in providing more insight about determinants that affect responses of households to CV survey questions. These determinants are mainly socio-economic variables and property right regimes that govern allocation of irrigation water among uses and land tenure security. In modeling determinants of non-crop uses of irrigation water we employ step-wise deletion of variables to identify explanatory variables that better explain the dependent variable (the binary response to the initial bid)[1].

#### 4.3.1. The Probit Model Estimation Results and Discussion

Estimation results of the probit model are reported based on the theoretical model that has already been developed in the preceding chapter. A statistical relationship is used to examine whether WTP responses of surveyed households are systematically related to socio-economic and other relevant variables or not. The probit model estimation results are presented on determinants of households' WTP for domestic uses of irrigation water without proposing changes in the quality of the existing water supply from irrigation systems and after some

[1] In such step-wise deletion of variables, economic theory also leads us to include some critical variables such as income even if they are statistically insignificant.

improvements are proposed concerning its quality. The estimation results are also reported on the determinants of households' WTP for gardening uses of irrigation water under existing irrigation water quality (see Annex 1, 2 and 3).

For specific use of irrigation water, Ordinary Least-Squares (OLS) estimation results are also reported in annex 4, 5 and 6. In the case of OLS empirical models the dependent variable is respondents' maximum WTP for non-crop uses of irrigation water, which was obtained from open-ended follow up questions. Statistical significances and signs of OLS model estimation results are consistent with probit model estimation results except magnitudes and statistical significance of some explanatory variables.

The measure of overall significance of the model, namely, the Wald test, which assumes the chi-square ($\chi^2$) distribution, is 78.70 for the probit model with 22 degrees of freedom (df) for domestic uses of irrigation water without proposing any change; 86.53 for the fitted probit model with 23 df after change in quality of irrigation water for domestic use is proposed and it is 69.42 for estimated probit model for gardening uses of irrigation water (see Annex 1, 2 & 3). These imply that the joint null hypothesis of coefficients of all explanatory variables included in all models are zero is rejected at less than 1% level of significance.

Another measure of goodness of fit of our models is McFadden's pseudo $R^2$, which is equivalent to coefficient of determination ($R^2$) in conventional regression model. Pseudo $R^2$ is 0.587, 0.494 and 0.381 for the probit model employed to estimate probability of accepting the initial bid for domestic use of irrigation water without any change; after an improvement is introduced and for gardening uses of irrigation water, respectively (see Annex 1, 2 & 3). This means that the model explains about 59%, 49% and 38% of the variation in explained variable for the respective probit models (i.e., the goodness of fit of the models is adequate).

The coefficients of the probit models reported in annex 1, 2 and 3 tell us only signs and significance of each explanatory variable. That is, they do not indicate the marginal effects of explanatory (right hand side) variables on the dependent (left hand side) variable. This means in the probit model only the signs (not the magnitudes) and significance of the coefficients of independent variables are important. In order to analyze the effects of each explanatory variable on the probability that respondents accept or reject the initial bid ($\beta^{*}$), the partial derivatives of discrete responses to the initial bid with respect to explanatory variables must be taken (Greene, 1997). These partial derivatives give us the marginal effect of independent variables on the dependent variable. The marginal effects of the probit model estimation results are reported below for each model (i.e., for domestic uses of irrigation water at existing quality, after improvement is proposed in irrigation water quality for domestic uses and gardening uses of irrigation water).

**Table 4.3: Marginal Effect Estimates of the Probit Model: Existing Irrigation Water for Domestic Uses**

| Dependent variable is discrete response (yes=1/no=0) to initial bid ($\beta^*$) | | | |
|---|---|---|---|
| **Explanatory variables** | **dF/dx** | **Robust Std. Err.** | **Z-Value** |
| Initial bid (in Birr) | -0.0109 | 0.0025 | -4.26*** |
| Natural logarithm of income | 0.5229 | 0.1369 | 3.67*** |
| Distance from existing water source (in meters) | 0.0004 | 0.0003 | 1.62 |
| Age of respondent (in years) | 0.0563 | 0.0207 | 2.80*** |
| Family size (in numbers) | -0.0613 | 0.0329 | -1.92* |
| Dummy for sex of household: 1 if sex is female, 0 otherwise† | 0.1116 | 0.1275 | 0.89 |
| Dummy for site: 1 if site is Wan Gedem, 0 otherwise† | 0.2889 | 0.1169 | 2.35** |
| Dummy for education: 1 if education ≥ grade four, 0 otherwise† | 0.2614 | 0.1049 | 2.46** |
| Dummy for location: 1 if middle user, 0 otherwise† | 0.0694 | 0.1413 | 0.5 |
| Dummy for location: 1 if lower user, 0 otherwise† | -0.3019 | 0.0852 | -2.58*** |
| Dummy for water source: 1 if both river and spring, 0 otherwise† | 0.5269 | 0.1351 | 3.26*** |
| Age-squared of the respondent | -0.0005 | 0.0002 | -2.54*** |
| Quantity of water used per day (in jerry can=20-25 litters) | 0.1296 | 0.0545 | 2.38** |
| Dummy:1 if farmers anticipate reduction in farm plot due to increase in family size, 0 otherwise† | 0.3661 | 0.0899 | 3.61*** |
| Dummy for land tenure: 1 if farmers anticipate land distribution, 0 otherwise† | 0.1584 | 0.1538 | 1.05 |
| Dummy: 1 if irrigation water is managed by WF, 0 otherwise† | -0.6848 | 0.1339 | -3.73*** |
| Dummy: 1 if water is managed my community, 0 otherwise† | -0.4537 | 0.0485 | -4.93*** |
| Dummy: 1 if respondents chose WF, 0 otherwise† | -0.6341 | 0.0652 | -4.93*** |
| Dummy: 1 if respondents chose community based water Use rights, 0 otherwise†. WUAs are our base group | -0.3116 | 0.1082 | -2.65*** |
| Dummy: 1 if water quality is satisfactory, 0 otherwise† | -0.2106 | 0.1139 | -1.47 |
| Dummy: 1 if water quality is bad, 0 otherwise†. | -0.2065 | 0.1000 | -2.04** |
| Dummy: 1 if farmers use for domestic purposes only† ( users for multiple uses are reference group) | 0.3744 | 0.1265 | 2.82*** |
| Number of obs = 260<br>Wald chi2(22) ($\chi^2$) = 78.70<br>Prob > chi2 ($\chi^2$) = 0.0000<br>Log likelihood = -73.585<br>Pseudo $R^2$ = 0.587 | | | |

***, ** & * indicate significance level at 1%, 5% and 10%, respectively.

† dF/dx is for discrete change of dummy variable from 0 to 1

The marginal effects of the probit model indicate the change in the probability (or likelihood occurrence) of an event due to a unit change in the continuous explanatory variables and the change of dummy variables from 0 to 1 for discrete variables.

In the case of both probit models to identify determinants of households' WTP for existing and improved irrigation water for domestic uses, the coefficient of income of the respondent is positive and statistically significant at more than 99% level of confidence interval. As Tables 4.3 and 4.4 indicate, holding other things constant, a one Birr increase in income of the respondent will pick-up the probability of accepting the first bid proposed for domestic uses of irrigation water before and after improvement is introduced by about 0.52% and 0.34%, respectively. This witnesses that a household with higher income is willing to pay more for domestic uses of irrigation water.

Table 4.4 reveals that the coefficient of the wealth of respondents is as expected and statistically significant at conventional level of significance. Other things remain the same, an increase in wealth of a respondent by one Birr leads to a 0.004% rises in the probability of accepting the proposed bid for improved irrigation water supply for domestic uses. Since the percentage increases in the probability is low, the effect of wealth of the respondent on their WTP is not strong. For existing irrigation water wealth has wrong sign but it is statistically insignificant and hence it is omitted from the probit model.

The coefficient of family size has the expected sign and statistically significant at 10% level of significance. One possible reason is that since supporting other family members is the responsibility of head of the household, respondents with larger family size are less likely to pay for domestic uses of irrigation water. As it can be seen from Tables 4.3 and 4.4, keeping other things constant, an increase in family size reduces probability of saying yes to the posed prices by 6% and 5% for existing and improved irrigation water for domestic uses, respectively.

A unit increase in age of the respondents picks up the likelihood that they are willing to pay for domestic uses of existing irrigation water by about 5.6%. The possible explanation for the significant effects of age on the WTP for existing irrigation water is that age could be taken as experience and hence older individuals know about the benefits of irrigation water better. However, as the coefficient of age-squared is negative (about -0.001 or -0.1%) there is a maximum age beyond which probability of paying for domestic uses of irrigation water falls as age increases (see Table 4.3). For these explanatory variables, coefficients are statistically significant at 99% confidence interval.

In the case of improved irrigation water supply for domestic uses, however, the influences of age of respondents on the probability of accepting the proposed initial bids is with expected sign but it is statistically insignificant even at 10% level of significance. This may be due to the fact that as age gets older and older individuals want to stick to existing irrigation water supply (see Table 4.4).

Although the coefficient of sex dummy (female=1) is as expected, it is statistically insignificant at conventional level of significance to affect probability of accepting the initial bid proposed for existing and improved irrigation water for home consumption. This result is unusual as it is the responsibility of a female to fetch water from the irrigation systems for domestic uses (see Tables 4.3 and 4.4).

The coefficient of education dummy is with expected sign and statistically significant at 10% level of significance. Holding other things constant, change in education level of the respondent from less than grade four to greater than or equal to grade four increases the probability that respondents are willing to pay the proposed bid by about 26% and 18% for domestic uses of existing and improved irrigation water, respectively (see Tables 4.3 and 4.4). One possible reason could be that relatively literate individuals are more aware about natural resources and hence they try to conserve existing environmental goods and also vote for quality improvement in such goods including irrigation water.

Contrary to our a priori expectation the coefficient of distance from existing water sources is positive but it is statistically insignificant at conventional level of significance (see Tables 4.3 and 4.4).

Irrigation water management and administration to ensure equity (i.e., minimize conflicts over irrigation water among users) and improve efficiency (avoid irrigation water misallocation) are important explanatory variables in our model. The coefficients of dummies for water father (WF) and community-based irrigation water management are with expected signs and statistically significant at less than 1% level of significance. This implies that respondents who use irrigation water managed by water father and the community itself are less willing to pay for domestic uses of existing and improved irrigation water compared to those using it under WUAs (the reference group) (see Tables 4.3 and 4.4). In the case of existing irrigation water, for instance, accessing water under water father and community itself reduces probability of accepting the initial bid by about 68% and 45%, respectively against the base group (WUAs) (see Table 4.3).

The reasons may include: firstly, individuals organized under the umbrella of WUAs have more awareness about benefits of irrigation water but those under WF and community based management systems may not have such awareness. Secondly, the problems of "free riding" are expected to be high in the case of WF and community based irrigation water management as they do not have strong legal bases and rights enforcing mechanisms. Lastly, WUAs provide various services such as fertilizers, selected seeds and marketing for their members, which could play important role in increasing income of their members.

The coefficients of dummies for respondents' choices of institutional arrangements to manage irrigation water allocation are as expected and significant. More specifically, the probability that respondents agree to pay the proposed bid for existing irrigation water for home consumption falls by about 63% and 31% for those who chose WF and community-based irrigation water managements, respectively compared to the reference group (WUAs) (see Table 4.3). In the case of improved irrigation water for domestic uses the probability declines by 63% for respondents who chose irrigation water management falls under the umbrella of WF against our base group (WUAs) (see Table 4.4).

An important policy implication here is that organizing irrigation water users under WUAs facilitates efficiency and equity in allocating irrigation water among uses and users. Since households who choose WUAs are willing to pay more for domestic uses of irrigation water, it is possible to introduce irrigation water user fees that can signal scarcity of irrigation water under WUAs institutional setup.

The coefficient of the dummy variable for end or lower users of existing irrigation water for domestic uses is negative (-0.3) and it is statistically significant at 1% level of significance. This implies that end users are less likely (by 30%) to pay for domestic uses of irrigation water compared to the upper users (our reference group) because quality of irrigation water gets poorer as it moves down the canals. The negative impact of low quality of irrigation water on the probability of paying for it for domestic uses is also supported by the coefficients of the dummy for bad quality (-0.21) and dummy for satisfactory quality (-0.21) against the reference group (irrigation water with good quality) (see table 4.3). For improved irrigation water for domestic uses, however, the probability that end users accept the initial bid increases by nearly 23% against our reference group (the upper users), which is supported by, for instance, the coefficients of the dummy for bad quality (0.24) (see Table 4.4). One of the reasons for such higher probability of accepting the initial bid is that end users are accessing low quality irrigation water and hence they are more willing to pay for improved irrigation water supply for domestic uses.

Keeping other things constant, changing the dummy variables from base group to those anticipating land size reductions due to more family size will increase probability of accepting the initial bid by about 37% and 27%, respectively, for existing and improved irrigation water for domestic uses (see Table 4.3 & 4.4). This is probably due to the fact that smaller and smaller farm plot enforces farmers to practice intensive farming activities that require more irrigation water, which in turn makes irrigation water more scarce. The scarcity of irrigation water induces farmers to pay more for multiple uses of this resource.

The coefficient of site dummy is as expected and statistically significant at 99% confidence interval implying that being in Wan Gedan kebele increases the probability of accepting the initial bid proposed for existing and improved irrigation water by about 29% and 27%, respectively, compared to the base site (Wondegi kebele) (see Tables 4.3 and 4.4). One possible reason could be that farmers in the former kebele use irrigation water intensively for vegetables and fruits and hence they are willing to pay more.

**Table 4.4: Marginal Effect Estimates of the Probit Model: Improved Irrigation Water for Domestic Uses**

| **Dependent variable is discrete response (yes=1/no=0) to initial bid ($\beta^*$)** | | | |
|---|---|---|---|
| **Explanatory variables** | **dF/dx** | **Robust Std. Err.** | **Z-Value** |
| Initial bid (in Birr) | -0.00622 | 0.00153 | -4.05*** |
| Natural logarithm of income | 0.33750 | 0.13634 | 2.48*** |
| Total value of all livestock owned by respondent | 0.00004 | 0.00002 | 1.82* |
| Distance from existing water source (in meters) | 0.00005 | 0.00027 | 0.17 |
| Age of respondent (in year) | 0.01509 | 0.02012 | 0.75 |
| Family size (in numbers) | -0.04897 | 0.03015 | -1.65* |
| Dummy for sex of household: 1 if sex is female, 0 otherwise† | 0.04980 | 0.10887 | 0.46 |
| Dummy for site: 1 if site is Wan Gedem, 0 otherwise† | 0.27246 | 0.12254 | 2.13** |
| Dummy for education: 1 if education ≥ grade four, 0 otherwise† | 0.18362 | 0.10345 | 1.77* |
| Dummy for location: 1 if middle user, 0 otherwise† | -0.05722 | 0.12069 | -0.47 |
| Dummy for location: 1 if lower user, 0 otherwise†. | -0.23466 | 0.10886 | -1.87* |
| Dummy: 1 if is both river and spring, 0 otherwise† | 0.20279 | 0.13583 | 1.46 |
| Age-squared of the respondent | -0.00008 | 0.00020 | -0.39 |
| Quantity of water used per day (in jerry can=20-25 litters) | 0.15788 | 0.05512 | 2.88*** |
| Dummy: 1 if farmers anticipate reduction in farm plot due to High family size, 0 otherwise† | 0.27005 | 0.09962 | 2.59*** |
| Dummy: 1 if farmers anticipate land distribution, 0 otherwise† | -0.14655 | 0.11658 | -1.17 |
| Dummy: 1 if irrigation water is managed by WF, 0 otherwise† | -0.33288 | 0.21503 | -1.48 |
| Dummy: 1 if water is managed my community itself, 0 otherwise† | -0.50625 | 0.05309 | -3.92*** |
| Dummy: 1 if respondents choose water father, 0 otherwise† | -0.63186 | 0.07816 | -4.29*** |
| Dummy: 1 if respondents choose community based water use rights, 0 otherwise†. WUAs are our base group | -0.07684 | 0.10964 | -0.70 |
| Dummy: 1 if water quality is satisfactory, 0 otherwise† | 0.03352 | 0.13895 | 0.24 |
| Dummy: 1 if water quality is bad, 0 otherwise†. | 0.24253 | 0.12692 | 1.87* |
| Dummy: 1 if farmers use for domestic purposes only (users for multiple uses are reference group) † | 0.29909 | 0.16314 | 1.75* |
| Number of obs = 260 | | | |
| Wald chi2(23))($\chi^2$) = 86.53 | | | |
| Log likelihood = -90.454 | | | |
| Pseudo $R^2$ = 0.494 | | | |

***, ** & * indicate significance level at 1%, 5% and 10%, respectively.

† dF/dx is for discrete change of dummy variable from 0 to 1

Although signs of income of respondents, family size, sex and land holdings under cultivation are in line with our a priori expectation, statistically they have no impact on the probability of accepting the initial bid posed to users for gardening uses of irrigation water (see Table 4.5).

The coefficients of age and age-squared of respondents are significant and as expected. Since age of respondents is considered as experience in using natural resources such as land and water, an increase in age of farmers leads to about 3.7% increase in the probability of accepting the initial bid proposed for gardening uses of irrigation water. But age-squared has a negative effect on the probability and hence there is a maximum limit for the positive influence of age on consumers' WTP for the good under consideration (see Table 4.5).

Respondents who use irrigation water managed by water father and the community itself are willing to pay less against the base group (WUAs). More specifically, being organized under water father and community itself to use irrigation water reduces probability of responding to the initial bid by about 26% and 39%, respectively. Similar results were reported for choices of irrigation water uses rights for gardening purposes (see Table 4.5)

Ownership of oxen increases probability of saying yes to the initial bid posed on farmers for gardening uses of irrigation water by 18% (see Table 4.5). A possible explanation is that respondents who have ox/oxen are widely involved in farming activities (including gardening) by renting in land and sharing crops in addition to their own land. Thus they are willing to pay more against the base group (those without ox).

Table 4.5 reveals that farmers who are expecting reduction in farm size are willing to pay more (increases the probability by about 30.4%) compared to the reference group (who are anticipating no change). The explanation is the same as given earlier.

For all models initial bids have negative effects on the probability of accepting that bid implying that an increase in the initial bid reduces the likelihood that respondents are paying the proposed bid, which is logical (see Tables 4.3-4.5).

**Table 4.5: Marginal Effect Estimates of the Probit Model: Gardening Uses of Irrigation Water**

| Dependent variable is discrete response (yes=1/no=0) to initial bid ($\beta^*$) | | | |
|---|---|---|---|
| **Explanatory variables** | **dF/dx** | **Robust Std. Err.** | **Z-Value** |
| Initial bid (in Birr) | -0.0083 | 0.0016 | -5.14*** |
| Natural logarithm of income | 0.0466 | 0.1474 | 0.32 |
| Land holding | 0.0552 | 0.0785 | 0.70 |
| Age of respondent (in year) | 0.0374 | 0.0176 | 2.13** |
| Family size (in numbers) | -0.0403 | 0.0274 | -1.48 |
| Dummy for sex of household: 1 if sex is female, 0 otherwise† | 0.0049 | 0.1075 | 0.05 |
| Dummy for education: 1 if education ≥ grade four, 0 otherwise† | 0.2331 | 0.0943 | 2.45*** |
| Dummy for location: 1 if middle user, 0 otherwise† | 0.0780 | 0.1191 | 0.66 |
| Dummy for location: 1 if lower user, 0 otherwise† | -0.1553 | 0.1094 | -1.33 |
| Dummy for water source: 1 if both river and spring, 0 otherwise† | 0.0637 | 0.1112 | 0.57 |
| Age-squared of the respondent | -0.0003 | 0.0002 | -1.98** |
| Dummy: 1 if farmers anticipate reduction in farm plot due to high family size, 0 otherwise† | 0.3039 | 0.0818 | 3.54*** |
| Dummy: 1 if farmers anticipate land distribution, 0 otherwise† | -0.0124 | 0.1087 | -0.11 |
| Dummy for irrigation water management: 1 if irrigation water is managed by WF, 0 otherwise (WUAs is reference group) † | -0.2594 | 0.1777 | -1.43 |
| Dummy: 1 if water is managed my community, 0 otherwise† | -0.3921 | 0.0897 | -2.45*** |
| Dummy for choice of water use rights: 1 if respondents choose water father, 0 otherwise† | -0.5395 | 0.0898 | -3.60*** |
| Dummy: 1 if respondents choose community based water use rights, 0 otherwise. WUAs are our base group† | -0.2462 | 0.0848 | -2.79*** |
| Dummy: 1 if respondents are owners of ox, 0 otherwise† | 0.1821 | 0.0990 | 1.70* |
| Dummy: 1 if farmers use for domestic purposes only (users for multiple uses are reference group) † | -0.4134 | 0.1367 | -2.68*** |
| Number of obs = 260<br>Wald chi2(19) = 69.42<br>Prob > chi2 = 0.0000<br>Log likelihood = -110.391<br>Pseudo R2 = 0.381 | | | |

***, ** & * indicate significance level at 1%, 5% and 10%, respectively.

† dF/dx is for discrete change of dummy variable from 0 to 1

### 4.3.2. Bivariate Probit Model Estimation Results

Unlike the conventional probit model (or single-bounded probit model), the bivariate probit model (or the double-bounded probit model) of this study is estimated using responses to the first and the second bids. Other explanatory variables such as socio-economic variables and irrigation water rights that govern irrigation water allocations are omitted from the double-bounded model as most of them are statistically insignificant in the second equation. The bivariate probit estimates of the double-bounded CV responses are summarized in tables below (Tables 4.6 - 4.8).

**4.6. The bivariate estimates for domestic uses of irrigation water (without improvement)**

| Variables | Coef. | Std. Err. | Z-Value |
|---|---|---|---|
| Dependent variable (yesno=1 if yes to the initial bid) , 0 otherwise | | | |
| Initial bid per year | 0.0191 | 0.0038 | -5.08*** |
| Constant | 0.8707 | 0.1856 | 4.69*** |
| Dependent variable (yes2=1 if yes to the second bid) , 0 otherwise | | | |
| Second bid per year | -0.0138 | 0.0072 | -1.91* |
| Constant | 0.3559 | 0.2969 | 1.20 |
| Rho (ρ) | 0.6507 | 0.0821 | |
| Number of obs = 260 | | | |
| Wald chi2(2)($\chi^2$) = 26.93 | | | |
| Prob > chi2 ($\chi^2$) = 0.0000 | | | |
| Log likelihood = -322.7881 | | | |

Likelihood ratio test of rho=0: chi2(1) = 38.3045 Prob > chi2($\chi^2$) = 0.0000
***, ** & * indicate significant level at 1%, 5% and 10%, respectively.

### 4.7. The bivariate estimates for domestic uses of irrigation water (After proposing improvements)

| Variables | Coef. | Std. Err. | Z-Value |
|---|---|---|---|
| Dependent variable (yesno=1 if yes to the initial bid) , 0 otherwise | | | |
| Initial bid per year | -0.0105 | 0.0023 | -4.52*** |
| Constant | 0.6110 | 0.1685 | 3.63*** |
| Dependent variable (yes2=1 if yes to the second bid) , 0 otherwise | | | |
| Second bid | -0.0163 | 0.00471 | -3.46*** |
| Constant | 0.6571 | 0.1718 | 3.83*** |
| Rho (ρ) | 0.7734 | 0.0670 | |
| Number of obs = 260<br>Wald chi2(2)($\chi^2$) = 22.04<br>Prob > chi2 ($\chi^2$) = 0.0000<br>Log likelihood = -317.0677 | | | |

Likelihood ratio test of rho=0: chi2(1) = 60.1422 Prob > chi2($\chi^2$) = 0.0000
***, ** & * indicate significant level at 1%, 5% and 10%, respectively.

**Table 4.8: Bivariate Probit Model Estimates for Gardening Uses of Irrigation Water**

| Variables | Coef. | Std. Err. | Z-Value |
|---|---|---|---|
| Dependent variable (yesno=1 if yes to the initial bid) , 0 otherwise | | | |
| Initial bid per year | -0.0111 | 0.0021 | -5.29*** |
| Constant | 0.55417 | 0.1545 | 3.59*** |
| Dependent variable (yes2=1 if yes to the second bid) , 0 otherwise | | | |
| Second bid | -0.0102 | 0.0028 | -2.91*** |
| Constant | 0.5210 2 | 0.15876 | 3.28*** |
| Rho (ρ) | 0.7414 | 0.0678 | |
| Number of obs = 260<br>Wald chi2(2) = 28.23<br>Log likelihood = -313.057<br>Prob > chi2 = 0.0000 | | | |

Likelihood ratio test of rho=0: chi2(1) = 58.0412 Prob > chi2 = 0.0000
***, ** & * indicate significant level at 1%, 5% and 10%, respectively.

In all the double-bounded estimates reported above the initial bid and the second bid have the expected signs and are statistically significant at less than 10% levels of significance implying that higher initial bid and second bid lead to lower probability of accepting that bid (see Tables 4.6 - 4.8).

In our fitted bivariate model Rho ($\rho$), the coefficient of correlation of error terms of the double-bounded model, is positive and statistically significant at 1% level of significance (see Tables 4.6-4.8). This basically shows that there is a positive linear relationship between the random components of the responses to the initial bid and the second bid. The fact that Rho ($\rho$) is less than unity indicates that the correlation between the random components of the responses to the initial bid and the second bid is not perfect.

### 4.3.3. Single-Bounded and Double-Bounded Model Estimates: A Comparison

In order to compare the statistical efficiency of double-bounded and single-bounded dichotomous CV questions, two models were fitted using the CV survey data of this study. The conventional single-bounded model was fitted using responses to the initial bids while the double-bounded model was estimated using responses to both the first and the second bids. The estimation results of both models are reported in Table 4.9 below.

**Table 4.9: Probit and Bivariate Probit Estimates of Households' WTP for Non-crop Uses of Irrigation Water**

| Descriptions | Single-Bounded Model | | | Double-Bounded Model | | |
|---|---|---|---|---|---|---|
| | Existing Irrigation Water | | | | | |
| | Coef. | Std. Err. | Z-Value | Coef. | Std. Err. | Z-Value |
| Initial bid (per year) | -0.0206 | 0.0039 | -5.28*** | -0.0191 | 0.0038 | -5.08*** |
| Constant | 0.9480 | 0.1920 | 4.94*** | 0.8707 | 0.1856 | 4.69*** |
| | Improved Irrigation Water | | | | | |
| | Coef. | Std. Err. | Z-Value | Coef. | Std. Err. | Z-Value |
| Initial bid (per year) | -0.0113 | 0.0024 | -4.76*** | -0.0105 | 0.0023 | -4.69*** |
| Constant | 0.6659 | 0.1751 | 3.80*** | 0.6110 | 0.1685 | 3.63*** |
| | Gardening Use of Irrigation Water | | | | | |
| | Coef. | Std. Err. | Z-Value | Coef. | Std. Err. | Z-Value |
| Initial bid (per year) | -0.0114 | .002119 | -5.38*** | -0.0111 | 0.0021 | -5.29*** |
| Constant | 0.5809 | .157815 | 3.68*** | 0.5542 | 0.1545 | 3.59*** |

***, ** & * indicate significance level at 1%, 5% and 10%, respectively.

Statistical efficiency of double-bounded model versus single-bounded model can be compared from three perspectives. First, the precision of the estimates of the intercept term and coefficient of bids, which is measured using estimated standard errors. Second, the goodness of fit of the estimated models using pseudo $R^2$. Lastly, the precision of the estimates of welfare measures derived from the underlying coefficients of bids (Hanemann, Loomis and Kanninen, 1991).

In our case, standard errors of the coefficients of bids and constant terms are approximately the same for both double-bounded and single-bounded models, which lead to the same t-statistics (see Table 4.10). Pseudo $R^2$ , which is a measure of goodness of fit, does not differ much in the two models. These facts imply that given our sample size efficiency gain from using double-bounded model over single-bounded model is not significant as such. Therefore, we use only estimates of single-bounded model to calculate central values of households' WTP for multiple uses of irrigation water.

## 4.4. Summary of Households' WTP and Estimation of Total WTP

### 4.4.1. Summary of Households' Responses to Discrete Choice Questions

Table 4.10 reports average values of the initial bid, the second bid and numbers of yes responses to the first and second bids.

**Table 4.10: Descriptive Statistics of Households' Responses to Double-Bounded Questions: Domestic Uses of Irrigation Water**

| Variables | Current Status | | Improved Status | |
|---|---|---|---|---|
| | Mean | Std. Dev. | Mean | Std. Dev. |
| Initial (first) bid | 44.0792 | 21.5678 | 66.1153 | 34.4385 |
| Second bid | 44.0692 | 21.5274 | 65.5769 | 33.9892 |
| Discrete Responses for the first bid | 0.5115 | 0.5000 | 0.4700 | 0.5000 |
| Discrete Responses for the second bid | 0.5269 | 0.5002 | 0.5461 | 0.4988 |

Source: Summary of sample survey

The average initial bid is Birr 44.08 and 66.12 for irrigation water at existing status and after some improvements are proposed, respectively. The second bid for the respective quality of irrigation water is Birr 44.08 and 65.58. The yes response for the first bid is about 51% for irrigation water without improvement and 47% after the improvement is introduced (see Table 4.10).

**Table 4.11: Descriptive Statistics of Households' Responses to Double-Bounded Questions: Gardening**

| Variables | Gardening uses of Irrigation Water | |
|---|---|---|
| | Mean | Std. Dev. |
| Initial (first) bid | 52.08 | 31.27 |
| Second bid | 50.71 | 29.23 |
| Discrete Responses to the first bid | 0.44 | 0.50 |
| Discrete Responses to the second bid | 0.54 | 0.50 |

Source: Summary of sample survey

On average, the first bid proposed for gardening uses of irrigation water is Birr 52.08 while the average value for the second bid is Birr 50.71, which is lower than the initial bid. The yes response for the initial bid is about 44%, which is 54% for the second bid (see Table 4.11).

### 4.4.2. Average Values of WTP

#### 4.4.2.1. Estimation of Mean WTP: Open-ended Question Responses

Respondents' maximum WTP to the open-ended elicitation format for various uses of irrigation water is summarized as follows:

**Table 4.12: Average WTP across Uses of Irrigation Water: Open-ended Questions Results**

| Types of Uses | Mean | Std. Dev. | Min. | Max. |
|---|---|---|---|---|
| Domestic uses (existing quality) | 35.8039 | 30.0575 | 0 | 180 |
| Domestic uses (improved quality) | 54.2808 | 42.7861 | 0 | 190 |
| Gardening | 41.7885 | 37.2785 | 0 | 200 |

Source: Summary of sample survey

Generally, respondents are willing to pay for multiple uses of irrigation water. The average WTP results obtained from the open-ended questions vary from about Birr 35.8 for domestic uses (at existing status) to Birr 54.28 for improved water for domestic uses per annum. The minimum willingness to pay is Birr zero mainly referring to protest zeros (in all cases of uses of irrigation water) with maximum WTP of Birr 200 for gardening uses of irrigation water.

Although invalid zero exists in all cases, the proportion of those with invalid zeros is the lowest for improved irrigation water supply for domestic uses (about 0.8%) followed by zeros for gardening (about 3.8%). One possible explanation for low protest zeros in the case of gardening is that farmers are paying irrigation water to uses for agriculture especially during dry seasons in the informal markets implying that farmers have already been exercising purchasing irrigation water. The policy implication is formalizing such markets could lead to efficient allocation of irrigation water.

#### 4.4.2.2. Calculating Mean WTP: Single-Bounded Model Estimation Results

One of the main objectives of estimating an empirical WTP model based on the CV survey responses is to derive a central value (or mean) of the WTP distribution (Hanemann, Loomis and Kanninen, 1991).

Mean WTP ($\mu$) using the model for the single-bounded format is defined as follows:

$$\mu = -\frac{\alpha_0}{\alpha_1}$$

Where: $\alpha_0 =$ the constant (or intercept) term

$\alpha_1 =$ the coefficient of the bid posed to the respondent

Then mean WTP ($\mu$) can be computed using this formula and the results from the single-bounded model given in Table 4.9. Thus mean WTP is Birr 45.6 & 58.2 for domestic uses of existing and improved irrigation water, respectively. The respective mean WTP is Birr 35.8 &

54.3 from responses to open-ended CV survey questions, which are lower compared to the mean values obtained from the single-bounded probit model estimates*.

For gardening uses of irrigation water, the mean WTP is Birr 50.96 using single-bounded probit model estimation results given in Table 4.9. The corresponding mean WTP obtained from open-ended question responses is Birr 41.80, which is lower compared to the mean WTP estimated using conventional probit model outputs.

Based on these mean WTP, total values of gardening and domestic uses of irrigation water are estimated in the next sub-section under existing and improved scenarios.

### 4.4.3. Estimating Total WTP: Single-Bounded and Open-Ended Results

Total WTP obtained from all households in each selected kebele can be computed using the average WTP from single-bounded and open-ended value elicitation formats. That is, in each kebele total number of households is multiplied by the mean WTP, which gives us the total WTP of the households in the respective kebele (see Table 4.13).

* The upper limits of mean WTP obtained from double-bounded estimates are nearly equal to the mean WTP results of the single-bounded probit models.

**Table 4.13: Total WTP for Domestic Uses of Irrigation Water (in birr per year)**

| Items | Households | Single-bounded | | Open-ended | |
|---|---|---|---|---|---|
| | | Mean | Total | Mean | Total |
| | | Existing Irrigation Water | | | |
| Wan Gedam | 2,139 | 45.6 | 97,538.4 | 35.8 | 76,576.2 |
| Wondegi | 1,621 | 45.6 | 73,917.6 | 35.8 | 58,031.8 |
| **Total** | **3,760** | | **171,456** | | **134,608** |
| | | Improved Irrigation Water | | | |
| Wan Gedam | 2,139 | 58.2 | 124,489.8 | 54.3 | 116,147.7 |
| Wondegi | 1,621 | 58.2 | 93,342.2 | 54.3 | 88,020.3 |
| **Total** | **3,760** | | **217,832.00** | | **204,168.00** |
| | | Gardening uses of Irrigation Water | | | |
| Wan Gedam | 2,139 | 50.96 | 109,003.44 | 41.8 | 89,410.20 |
| Wondegi | 1,621 | 50.96 | 82,606.16 | 41.8 | 67,757.80 |
| **Total** | **3,760** | | **191,609.60** | | **157,168.00** |
| | Existing Quality | | | Improved Quality | |
| | Single-Bounded | | Open-Ended | Single-Bounded | Open-Ended |
| **Grand Total** | **363,065.60** | | **291,776.00** | **409,441.60** | **361,336.00** |

As indicated in Table 4.13, the total WTP of total households in the study area could be aggregated under two scenarios. In the first scenario, which assumes existing irrigation water quality and institutional setup, total WTP is Birr 363,063.60 based on single-bounded mean WTP and Birr 291,776.00 per year using open-ended results, which is lower than that of single-bounded estimates.

In the second scenario where we proposed improvement in quality of irrigation water for domestic uses while keeping existing institutional setup, the total WTP is Birr 409,441.60 using single-bounded estimates and Birr 361,336.00 obtained from open-ended mean WTP.

Therefore, total WTP of gardening and domestic uses of irrigation water is Birr 291,776.00 using open-ended mean WTP and Birr 363,063.60 based on single-bounded probit estimates for existing irrigation water quality, which increases to Birr 361,336.00 and Birr 409,441.60 under improved irrigation water supply for domestic uses, respectively.

## 4.5. Aggregate Demand for Gardening and Domestic Uses of Irrigation Water

The aggregate demand for specific non-crop uses of irrigation water is derived using midpoint maximum WTP obtained from open-ended follow up CV questions and total number of households multiplied by a relative frequencies of a corresponding class. In drawing the aggregate demand the vertical axis represents the midpoint and the horizontal axis represents the number of households. Fig. 4.2, 4.3 and 4.4 give us aggregate demand for domestic uses of existing irrigation water, improved irrigation water and gardening uses of irrigation water, respectively.

**Fig 1: Aggregate demand for irrigation water (current quality)**

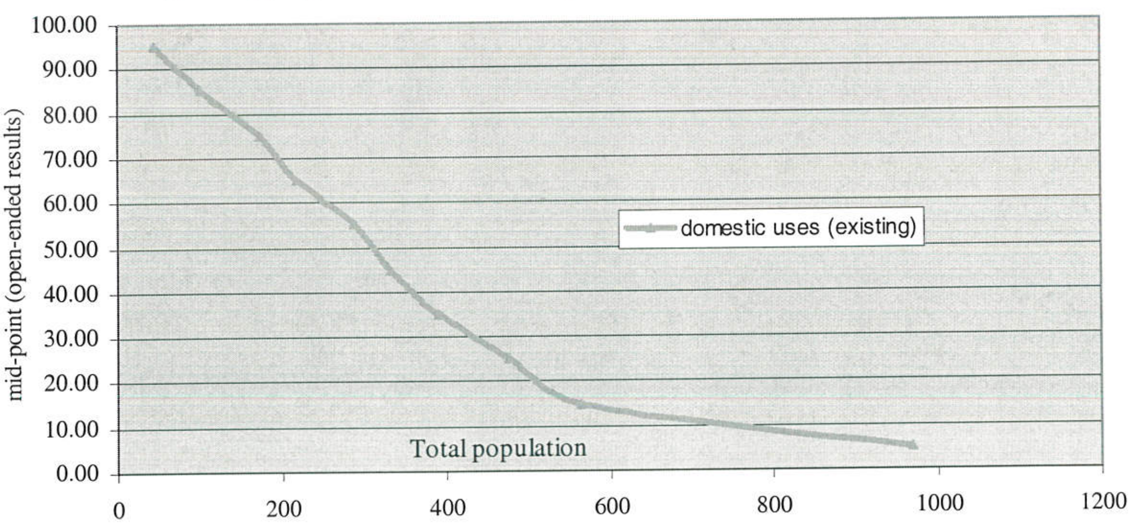


Fig. 4.2. Aggregate demand for improved domestic uses of irrigation water

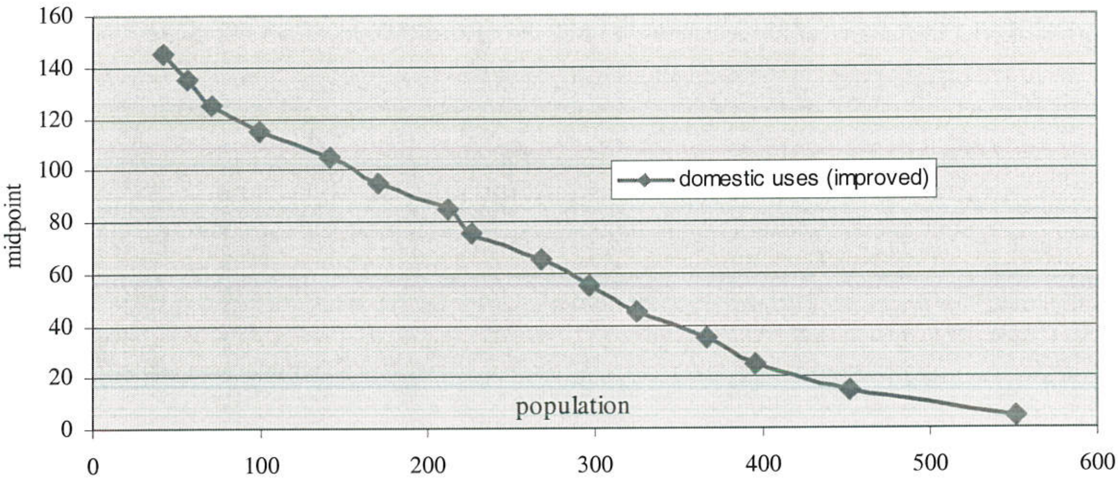
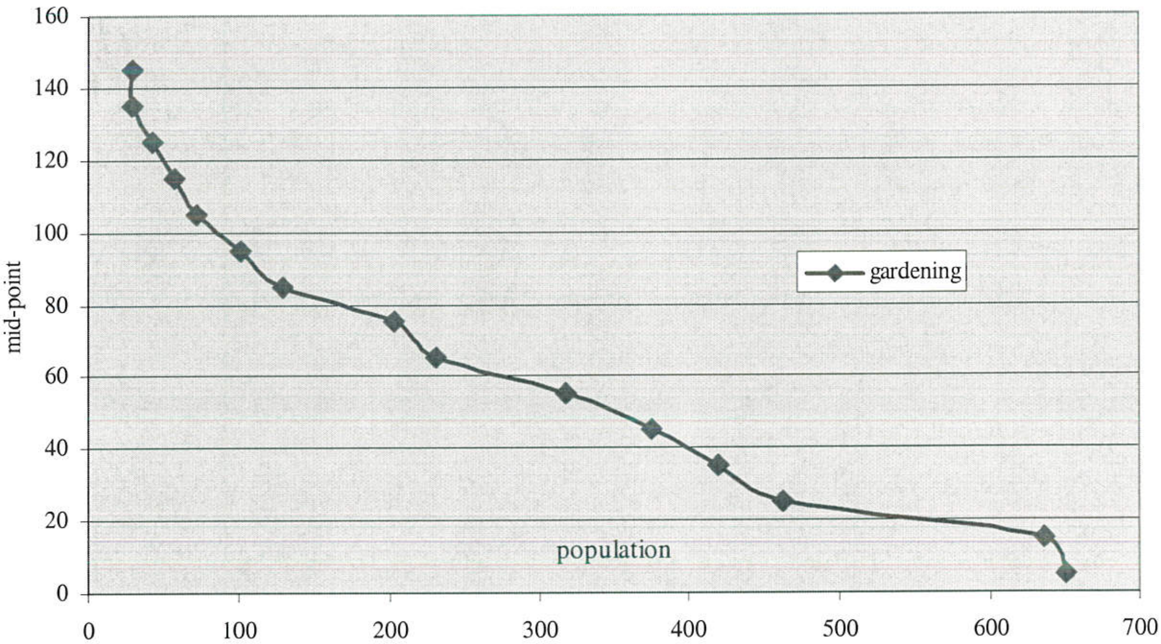



Fig. 4.3. Aggregate demand for gardening uses of irrigation water



# Chapter Five

# Conclusions and Recommendations

## 5.1. Conclusions

In most rural areas of developing countries where modern water supply is limited or non-existent but with relatively abundant irrigation water, irrigation systems provide water for multiple uses. Non-agricultural uses of irrigation water, however, are often marginalized in valuing irrigation water. Thus, using the CVM, the study aims to empirically analyze vectors of determinants of households' WTP for multiple uses of irrigation water by emphasizing its non-crop uses. The study also estimates total WTP of non-crop uses of irrigation water and derives its aggregate demand.

Double-bounded referendum style value elicitation format with open-ended follow up questions was employed to collect cross-sectional data from 260 randomly selected households in the Blue Nile River Basin of the Bure district in West Gojjam zone of the Amhara Regional State of Ethiopia. Respondents were asked the CV survey questions to express their WTP for non-crop uses of irrigation water under two different scenarios. The first scenario assumes existing irrigation water quality and quantity for domestic uses from a specific source. In the second scenario, quality improvement is proposed with reliable supply of irrigation water from a given source for domestic uses. In both scenarios institutional arrangements remain the same. The study proposed payment vehicle in the form of water users' charges twice per annum just after the harvest[1].

Descriptive statistics and multivariate analyses are used in this study. Our multivariate analyses employed single-bounded (conventional) and double-bounded (bivariate) probit models assuming a linear random utility function. Descriptive statistics and multivariate methods of data analyses were applied to examine vectors of explanatory variables that affect households'

[1] In the study area, farmers produce at least two times a year.

WTP for non-crop uses of irrigation water; estimate total WTP based on probit model and derive aggregate demand for specific non-crop uses irrigation water. The bivariate (double-bounded) model was introduced to test statistical efficiency gained from using double-bounded value elicitation format over single-bounded format. The heteroscedasticity problem is corrected using appropriate econometric software program (robust regression of the probit model).

The empirical results of the study indicate that households in the study areas are willing to pay positive amount for non-crop uses of irrigation water both before and after proposing quality improvement for domestic uses. Respondents' WTP for non-crop uses of irrigation water is affected by explanatory variables, which can be categorized into institutional arrangement related variables, socio-economic and other variables.

Institutional setups, which relate to water institution and land tenure security have significant impact on households' WTP for non-crop uses of irrigation water. More specifically, users of irrigation water managed by water father (traditional communal) and community itself (open access) are less willing to pay compared to water users associations (WUAs) (modern communal). Similarly, the probability of accepting the initial bid proposed for specific non-crop uses of irrigation water is lower for users who chose to access irrigation water under water father and community compared with WUAs. The results also suggest that land tenure insecurity due to government land redistribution at village level has no effect on the probability of accepting the first bid while expectation of farm plot reduction due to higher family size positively affects the probability.

Socio-economic variables including income, education, age and family size are among explanatory variables that influence probability of accepting the initial bid. For existing irrigation water quality for domestic uses, income, age and education level of respondents positively affect the probability of responding to the initial bid. But family size has negative effect on the probability of saying yes to the first bid. In spite of the responsibility of female to fetch water for domestic uses, being a female has no significant impact on the probability of accepting the proposed bid for both existing and improved irrigation water quality for domestic uses.

In the case of improved irrigation water for domestic uses, the probability of paying for the improvement is positively affected by respondents' income, wealth and education level whereas family size has negative impact on the probability of saying yes to the initial bid. Probability of accepting the initial bid proposed for gardening uses of irrigation water is positively affected by age and education level of respondents and ownership of ox/oxen. However, respondents' income, sex, family size and land holding under cultivation have no statistically significant effect on households' WTP for gardening uses of irrigation water.

Other explanatory variables such as location of users, site, quality and quantity of irrigation water for domestic uses and whether respondents use irrigation water for domestic uses or crop production or both have also important impacts on households' WTP. The findings of our study also show that introducing double-bounded dichotomous choice value elicitation format did not improve statistical efficiency over single-bounded format.

Mean WTP per household for existing and improved irrigation water quality for domestic and gardening uses is Birr 45.60, 58.20 and 50.96 per year, respectively, using single-bounded probit model estimates. The respective mean WTP is Birr 35.80, 54.30 and 41.80 based on responses to open-ended survey questions. In each specific non-crop use of irrigation water mean WTP obtained from probit model estimates is higher than that of open-ended results.

Based on our two different scenarios and single-bounded and open-ended mean WTP, we obtained different total WTP for gardening and domestic uses of irrigation water. Thus, assuming existing irrigation water quality total WTP for these uses of irrigation water is Birr 291,776.00 using open-ended results and Birr 363,063.60 based on single-bounded estimates per year, which picks up to Birr 361,336.00 and 409,441.60 per annum after quality improvement in irrigation water is proposed for domestic uses.

## 5.2. Recommendations

The policy recommendations derived from this study can be seen in broad and specific terms.

The broad policy recommendations include:

- Since income and probability of accepting the initial bid proposed for domestic uses of irrigation water are positively related, development policies should target to increase income per household.
- Education increases awareness of individuals concerning natural resources in general and irrigation water in particular as it is witnessed by the positive coefficient of education dummy on probability of responding to the first bid. Thus, educating rural dwellers should be emphasized.

The specific policy recommendations are:

- Water related institutional set up (particularly WUAs) has significant and positive effect on households' WTP for multiple uses of irrigation water. Therefore, facilitating establishment of WUAs and strengthening its capacity through decentralization enhances efficient and equitable uses of irrigation water. It also plays a significant role in conflict resolution as it right enforcing mechanisms are relatively stronger and it teaches users of irrigation water to develop their awareness on uses of this and other resources.
- Since irrigation systems in rural areas provide water for multiple purposes, in developing and implementing irrigation water projects its multiple uses should be taken into account. This could ensure sustainability and reduces conflicts among uses and users of irrigation water
- Our empirical results show that farmers are willing to pay for multiple uses of irrigation water. An interesting implication here is that introducing irrigation water pricing (coupled with market) may be promising.

The methodological implication of this study in accordance with water related and other CVM studies is that the CVM is successfully applied to developing countries like Ethiopia.

**We recommend future research in the following areas:**

- Developing mechanisms to undertake decentralization of water institutions to the grass-root levels through WUAs that improve water allocation efficiency and ensures equitable water distribution among uses and users. And the importance of WUAs in conflict resolution and implementing cost recovery in water related development projects.
- The area of implementing irrigation water pricing without incurring significant social and political costs.

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**Annex 1: Estimation Results of the probit model- without improvement of irrigation water**

| Dependent variable is discrete response (yes=1/no=0) to initial bid ($\beta^*$) | | | |
|---|---|---|---|
| **Explanatory variables** | **Coef.** | **Robust Std. Err.** | **Z-Value** |
| constant | 1.5814 | 0.4086 | 3.87*** |
| Initial bid (in Birr) | -0.0298 | 0.0070 | -4.26*** |
| Natural logarithm of income | 1.4286 | 0.3892 | 3.67*** |
| Distance from existing water source (in meters) | 0.0011 | 0.0007 | 1.62 |
| Age of respondent (in year) | 0.1537 | 0.0549 | 2.8*** |
| Family size (in numbers) | -0.1675 | 0.0874 | -1.92* |
| Dummy for sex of household: 1 if sex is female, 0 otherwise | 0.2956 | 0.3335 | 0.89 |
| Dummy for site: 1 if site is Wan Gedem, 0 otherwise | 0.8190 | 0.3486 | 2.35*** |
| Dummy for education: 1 if education ≥ grade four, 0 otherwise | 0.6933 | 0.2816 | 2.46*** |
| Dummy for location: 1 if middle user, 0 otherwise | 0.1850 | 0.3702 | 0.5 |
| Dummy for location: 1 if lower user, 0 otherwise. | -1.0583 | 0.4099 | - 2.58*** |
| Dummy: 1 if is both river and spring, 0 otherwise | 1.5815 | 0.4844 | 3.26*** |
| Age-squared of the respondent | -0.0014 | 0.0005 | -2.54*** |
| Quantity of water used per day (in jerry can=20-25 litters) | 0.3541 | 0.1489 | 2.38** |
| Dummy for land tenure:1 if farmers anticipate reduction in farm plot due to high family size, 0 otherwise | 1.0858 | 0.3007 | 3.61*** |
| Dummy for land tenure: 1 if farmers anticipate land distribution, 0 otherwise | 0.4132 | 0.3939 | 1.05 |
| Dummy: 1 if irrigation water is managed by wf, 0 otherwise | -2.0440 | 0.5487 | -3.73*** |
| Dummy: 1 if water is managed my community, 0 otherwise | -3.1215 | 0.6336 | -4.93*** |
| Dummy: 1 if respondents choose water father, 0 otherwise | -3.1093 | 0.6311 | -4.93*** |
| Dummy: 1 if respondents choose community based water use rights, 0 otherwise. WUAs are our base group | -0.8995 | 0.3391 | -2.65*** |
| Dummy for water quality: 1 if water quality is satisfactory, 0 otherwise | -0.6769 | 0.4590 | -1.47 |
| Dummy: 1 if water quality is bad, 0 otherwise. | -0.5631 | 0.2754 | -2.04** |
| Dummy for users of irrigation water: 1 if farmers use for domestic purposes only | 0.9816 | 0.3482 | 2.82*** |

Number of obs = 260
Wald chi2(22) ($\chi^2$) = 78.70
Prob > chi2 ($\chi^2$) = 0.0000
Log likelihood = -73.585
Pseudo $R^2$ = 0.587

**Annex 2: Estimation Results of the probit model- with improvement of irrigation water**

| Dependent variable is discrete response (yes=1/no=0) to initial bid ($\beta^*$) | | | |
|---|---|---|---|
| **Explanatory variables** | **Coef.** | **Robust Std. Err.** | **Z-Value** |
| constant | 1.0408 | 0.5112 | 2.05** |
| Initial bid (in Birr) | -0.0161 | 0.0040 | -4.05*** |
| Natural logarithm of income | 0.8731 | 0.3522 | 2.48*** |
| Total value of all livestock owned by respondent | 0.0001 | 0.0001 | 1.82* |
| Distance from existing water source (in meters) | 0.0001 | 0.0007 | 0.17 |
| Age of respondent (in year) | 0.0390 | 0.0519 | 0.75 |
| Family size (in numbers) | -0.1267 | 0.0773 | -1.64* |
| Dummy for sex of household: 1 if sex is female, 0 otherwise | 0.1277 | 0.2776 | 0.46 |
| Dummy for site: 1 if site is Wan Gedem, 0 otherwise | 0.7250 | 0.3405 | 2.13** |
| Dummy for education: 1 if education ≥ grade four, 0 otherwise | 0.4702 | 0.2652 | 1.77* |
| Dummy for location: 1 if middle user, 0 otherwise | -0.1504 | 0.3223 | -0.47 |
| Dummy for location: 1 if lower user, 0 otherwise. | -0.6744 | 0.3611 | -1.87* |
| Dummy for water source: 1 if is both river and spring, 0 otherwise | 0.5318 | 0.3648 | 1.46 |
| Age-squared of the respondent | -0.0002 | 0.0005 | -0.39 |
| Quantity of water used per day (in jerry can=20-25 litters) | 0.4084 | 0.1420 | 2.88*** |
| Dummy for land tenure: 1 if farmers anticipate reduction in farm plot due to high family size, 0 otherwise | 0.7262 | 0.2806 | 2.59*** |
| Dummy for land tenure: 1 if farmers anticipate land distribution, 0 otherwise | -0.4008 | 0.3420 | -1.17 |
| Dummy: 1 if irrigation water is managed by water father, 0 otherwise | -0.8705 | 0.5890 | -1.48 |
| Dummy: 1 if water is managed my community, 0 otherwise | -2.8386 | 0.7236 | -3.92*** |
| Dummy: 1 if respondents choose water father, 0 otherwise | -2.5500 | 0.5950 | -4.29*** |
| Dummy: 1 if respondents choose community based water use rights, 0 otherwise. WUAs are our base group | -0.1998 | 0.2863 | -0.7 |
| Dummy for water quality: 1 if water quality is satisfactory, 0 otherwise | 0.0861 | 0.3547 | 0.24 |
| Dummy: 1 if water quality is bad, 0 otherwise. | 0.6198 | 0.3309 | 1.87* |
| Dummy for users of irrigation water: 1 if farmers use for domestic purposes only | 0.7682 | 0.4389 | 1.75* |
| Number of obs = 260<br>Wald chi2(23))($\chi^2$) = 86.53<br>Prob > chi2 = 0.0000<br>Log likelihood = -90.454<br>Pseudo $R^2$ = 0.494 | | | |

**Annex 3: Estimate Results of probit model: Gardening uses of irrigation water**

| Dependent variable is discrete response (yes=1/no=0) to initial bid ($\beta^*$) | | | |
|---|---|---|---|
| **Explanatory variables** | **Coef.** | **Robust Std. Err.** | **Z-Value** |
| Constant | 1.0075 | 3.1797 | 0.32 |
| Initial bid (in Birr) | -0.0216 | 0.0038 | -5.35*** |
| Natural logarithm of income | 0.1217 | 0.3850 | 0.32 |
| Land holding | 0.1441 | 0.2054 | 0.7 |
| Age of respondent (in year) | 0.0975 | 0.0457 | 2.13** |
| Family size (in numbers) | -0.1051 | 0.0710 | -1.48 |
| Dummy for sex of household: 1 if sex is female, 0 otherwise | 0.0128 | 0.2800 | 0.05 |
| Dummy for education: 1 if education ≥ grade four, 0 otherwise | 0.6007 | 0.2452 | 2.45*** |
| Dummy for location: 1 if middle user, 0 otherwise | 0.2004 | 0.3030 | 0.66 |
| Dummy for location: 1 if lower user, 0 otherwise. | -0.4312 | 0.3254 | -1.33 |
| Dummy for water source: 1 if is both river and spring, 0 otherwise | 0.1665 | 0.2914 | 0.57 |
| Age-squared of the respondent | -0.0009 | 0.0005 | -1.98** |
| Dummy for land tenure: 1 if farmers anticipate reduction in farm plot due to high family size, 0 otherwise | 0.8331 | 0.2356 | 3.54*** |
| Dummy for land tenure: 1 if farmers anticipate land distribution, 0 otherwise | -0.0323 | 0.2857 | -0.11 |
| Dummy: 1 if irrigation water is managed by water father, 0 otherwise | -0.6766 | 0.4730 | -1.43 |
| Dummy: 1 if water is managed my community, 0 otherwise | -1.4836 | 0.6068 | -2.45*** |
| Dummy: 1 if respondents choose water father, 0 otherwise | -1.9572 | 0.5442 | -3.6*** |
| Dummy: 1 if respondents choose community based water use rights, 0 otherwise. WUAs are our base group | -0.6624 | 0.2372 | -2.79*** |
| Dummy: 1 if respondents are owners of ox, 0 otherwise | 0.5056 | 0.2971 | 1.7* |
| Dummy for users of irrigation water: 1 if farmers use for domestic purposes only | -1.0893 | 0.4067 | -2.68*** |

| | | |
|---|---|---|
| Number of obs | = | 260 |
| Wald chi2(19) | = | 69.42 |
| Prob > chi2 | = | 0.0000 |
| Log likelihood | = | -110.391 |
| Pseudo R2 | = | 0.381 |

## Annex 4: OLS Estimation Results of Domestic uses of existing irrigation water

| **Dependent variable is MWTP to open-ended questions** | | | |
|---|---|---|---|
| **Explanatory variables** | **Coef.** | **Std. Err.** | **t-Value** |
| Constant | -59.684 | 36.043 | -1.66* |
| Initial bid (in Birr) | 0.484 | 0.058 | 8.31*** |
| Natural logarithm of income | 2.789 | 4.412 | 0.63 |
| Distance from existing water source (in meters) | 0.002 | 0.008 | 0.23 |
| Age of respondent (in year) | 1.662 | 0.657 | 2.53*** |
| Family size (in numbers) | -1.402 | 0.885 | -1.58 |
| Dummy for sex of household: 1 if sex is female, 0 otherwise | 3.479 | 3.567 | 0.98 |
| Dummy for site: 1 if site is Wan Gedem, 0 otherwise | 21.330 | 3.608 | 5.91*** |
| Dummy for education: 1 if education ≥ grade four, 0 otherwise | 7.530 | 3.114 | 2.42** |
| Dummy for location: 1 if middle user, 0 otherwise | 1.136 | 4.186 | 0.27 |
| Dummy for location: 1 if lower user, 0 otherwise. | -8.705 | 4.275 | -2.04** |
| Dummy for water source: 1 if is both river and spring, 0 otherwise | 11.258 | 4.593 | 2.45*** |
| Age-squared of the respondent | -0.016 | 0.007 | -2.41*** |
| Quantity of water used per day (in jerry can=20-25 litters) | 5.676 | 1.558 | 3.64*** |
| Dummy:1 if farmers anticipate reduction in farm plot due to high family size, 0 otherwise | 12.631 | 3.389 | 3.73*** |
| Dummy: 1 if farmers anticipate land distribution, 0 otherwise | -0.386 | 4.470 | -0.09 |
| Dummy: 1 if irrigation water is managed by WF, 0 otherwise | -15.373 | 7.041 | -2.18** |
| Dummy: 1 if water is managed my community, 0 otherwise | -21.983 | 7.508 | -2.93*** |
| Dummy: 1 if respondents choose water father, 0 otherwise | -41.375 | 6.763 | -6.12*** |
| Dummy: 1 if respondents choose community based water use rights, 0 otherwise. WUAs are our base group | -6.926 | 3.413 | -2.03** |
| Dummy for water quality: 1 if water quality is satisfactory, 0 otherwise | -5.771 | 3.139 | -1.84* |
| Dummy: 1 if water quality is bad, 0 otherwise. | -11.735 | 4.707 | -2.49*** |
| Dummy for users of irrigation water: 1 if farmers use for domestic purposes only ( multiple uses is base group) | 11.223 | 4.091 | 2.74*** |

| | |
|---|---|
| Number of obs | = 260 |
| F( 22, 237) | = 17.83 |
| Prob > F | = 0.0000 |
| R-squared | = 0.6234 |
| Adj R-squared | = 0.5884 |
| Root MSE | =19.517 |

## Annex 5: OLS Estimation Results of Domestic uses of improved irrigation water

| **Dependent variable is MWTP to open-ended questions** | | | |
|---|---|---|---|
| **Explanatory variables** | **Coef.** | **Std. Err.** | **t-Value** |
| Constant | -84.198 | 60.1269 | -1.4 |
| Initial bid (in Birr) | 0.4555 | 0.0532 | 8.56*** |
| Natural logarithm of income | 5.2187 | 7.4088 | 0.7 |
| Total value of all livestock owned by respondent | 0.0003 | 0.0012 | 0.24 |
| Distance from existing water source (in meters) | 0.0015 | 0.0116 | 0.13 |
| Age of respondent (in year) | 1.6670 | 0.9590 | 1.74* |
| Family size (in numbers) | -1.9313 | 1.2909 | -1.5 |
| Dummy for sex of household: 1 if sex is female, 0 otherwise | 6.7438 | 5.1972 | 1.3 |
| Dummy for site: 1 if site is Wan Gedem, 0 otherwise | 29.196 | 5.6416 | 5.18*** |
| Dummy for education: 1 if education ≥ grade four, 0 otherwise | 9.4723 | 4.5450 | 2.08** |
| Dummy for location: 1 if middle user, 0 otherwise | 0.0042 | 6.1383 | 0 |
| Dummy for location: 1 if lower user, 0 otherwise. | -5.9373 | 6.2775 | -0.95 |
| Dummy: 1 if is both river and spring, 0 otherwise | 3.4444 | 6.9062 | 0.5 |
| Age-squared of the respondent | -0.0158 | 0.0097 | -1.63* |
| Quantity of water used per day (in jerry can=20-25 litters) | 7.4785 | 2.3298 | 3.21*** |
| Dummy: 1 if farmers anticipate reduction in farm plot due to high family size, 0 otherwise | 20.276 | 4.9518 | 4.09*** |
| Dummy: 1 if farmers anticipate land distribution, 0 otherwise | 0.3958 | 6.5234 | 0.06 |
| Dummy: 1 if irrigation water is managed by WF, 0 otherwise | -9.0148 | 10.1925 | -0.88 |
| Dummy: 1 if water is managed my community, 0 otherwise | -25.811 | 10.9473 | -2.36*** |
| Dummy: 1 if respondents choose water father, 0 otherwise | -56.629 | 9.7849 | -5.79*** |
| Dummy: 1 if respondents choose community based water use rights, 0 otherwise. WUAs are our base group | -5.7287 | 5.0815 | -1.13 |
| Dummy for water quality: 1 if water quality is satisfactory, 0 otherwise | 1.5608 | 6.9649 | 0.22 |
| Dummy: 1 if water quality is bad, 0 otherwise. | 3.5069 | 5.3272 | 0.66 |
| Dummy: 1 if farmers use for domestic purposes only ( users for both irrigation and domestic activities are reference group) | 7.9828 | 6.0509 | 1.32 |
| Number of obs = 260<br>F( 23, 236) = 15.21<br>Prob > F = 0.0000<br>R-squared = 0.5971<br>Adj R-squared = 0.5579<br>Root MSE = 28.449 | | | |

## Annex 6: OLS Estimation Results of gardening uses of existing irrigation water

| Dependent variable is discrete response (yes=1/no=0) to initial bid ($\beta^*$) | | | |
|---|---|---|---|
| **Explanatory variables** | **Coef.** | **Std. Err.** | **t-Value** |
| Constant | -37.821 | 55.039 | -0.69 |
| Initial bid (in Birr) | 0.504 | 0.056 | 9.03*** |
| Natural logarithm of income | 6.525 | 6.832 | 0.96 |
| Land holding | 1.483 | 4.352 | 0.34 |
| Age of respondent (in year) | 1.793 | 0.905 | 1.98** |
| Family size (in numbers) | -1.307 | 1.184 | -1.1 |
| Dummy for sex of household: 1 if sex is female, 0 otherwise | 0.812 | 5.049 | 0.16 |
| Dummy for education: 1 if education ≥ grade four, 0 otherwise | 8.259 | 4.296 | 1.92* |
| Dummy for location: 1 if middle user, 0 otherwise | 3.903 | 5.868 | 0.67 |
| Dummy for location: 1 if lower user, 0 otherwise. | -2.694 | 5.981 | -0.45 |
| Dummy for water source: 1 if is both river and spring, 0 otherwise | 6.333 | 5.732 | 1.1 |
| Age-squared of the respondent | -0.017 | 0.009 | -1.9* |
| Dummy for land tenure: 1 if farmers anticipate reduction in farm plot due to high family size, 0 otherwise | 19.427 | 4.523 | 4.3*** |
| Dummy for land tenure: 1 if farmers anticipate land distribution, 0 otherwise | 1.868 | 6.141 | 0.3 |
| Dummy: 1 if irrigation water is managed by water father, 0 otherwise | -26.590 | 8.782 | -3.03*** |
| Dummy: 1 if water is managed my community (open access), 0 otherwise | -37.194 | 10.070 | -3.69*** |
| Dummy: 1 if respondents choose water father, 0 otherwise | -50.641 | 9.222 | -5.49*** |
| Dummy: 1 if respondents choose community based water use rights, 0 otherwise. WUAs are our base group | -16.587 | 4.445 | -3.73*** |
| Dummy: 1 if respondents are owners of ox, 0 otherwise | 0.412 | 5.502 | 0.07 |
| Dummy for users of irrigation water: 1 if farmers use for domestic purposes only | -20.333 | 5.496 | -3.7*** |

Number of obs = 260
F( 19, 240) = 12.65
Prob > F = 0.0000
R-squared = 0.5004
Adj R-squared = 0.4608
Root MSE = 27.373

**Annex 7: Pair-wise Correlation for Non-crop uses of irrigation water♣**

| | i1 | ibidy | lexp | dis | age | fsiz | fem | edu1 | loc2 | loc3 | sour2 | agesq | qaun | ten2 | ten3 | adm3 | adm4 | chr3 | chr5 | qaul2 | qaul3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| i1 | 1.00 | | | | | | | | | | | | | | | | | | | | |
| ibidy | -0.24 | 1.00 | | | | | | | | | | | | | | | | | | | |
| lexp | 0.40 | 0.02 | 1.00 | | | | | | | | | | | | | | | | | | |
| dis | -0.01 | -0.01 | 0.15 | 1.00 | | | | | | | | | | | | | | | | | |
| age | 0.17 | -0.12 | 0.26 | 0.07 | 1.00 | | | | | | | | | | | | | | | | |
| fsiz | 0.05 | 0.08 | 0.44 | -0.03 | 0.11 | 1.00 | | | | | | | | | | | | | | | |
| fem | -0.05 | 0.00 | -0.23 | -0.03 | 0.00 | -0.33 | 1.00 | | | | | | | | | | | | | | |
| edu1 | 0.06 | 0.04 | 0.01 | 0.09 | -0.35 | -0.07 | -0.21 | 1.00 | | | | | | | | | | | | | |
| loc2 | 0.16 | 0.11 | 0.08 | -0.02 | -0.08 | -0.11 | 0.02 | -0.03 | 1.00 | | | | | | | | | | | | |
| loc3 | 0.05 | 0.05 | 0.11 | -0.01 | -0.03 | -0.04 | 0.01 | -0.09 | -0.17 | 1.00 | | | | | | | | | | | |
| sour2 | 0.42 | 0.00 | 0.21 | -0.07 | -0.04 | -0.09 | 0.01 | -0.11 | 0.38 | 0.39 | 1.00 | | | | | | | | | | |
| agesq | 0.14 | -0.12 | 0.21 | 0.09 | 0.99 | 0.03 | 0.00 | -0.31 | -0.09 | -0.05 | -0.05 | 1.00 | | | | | | | | | |
| qaun | 0.42 | 0.04 | 0.41 | -0.20 | 0.13 | 0.42 | -0.18 | 0.03 | 0.09 | 0.09 | 0.34 | 0.08 | 1.00 | | | | | | | | |
| ten2 | 0.45 | 0.02 | 0.43 | 0.06 | 0.23 | 0.18 | -0.10 | -0.07 | 0.08 | 0.17 | 0.33 | 0.19 | 0.27 | 1.00 | | | | | | | |
| ten3 | -0.16 | 0.00 | -0.31 | -0.13 | -0.09 | -0.12 | 0.10 | 0.02 | -0.12 | -0.04 | -0.10 | -0.07 | -0.12 | -0.44 | 1.00 | | | | | | |
| adm3 | 0.32 | -0.03 | 0.28 | -0.07 | 0.03 | 0.05 | -0.14 | -0.06 | 0.26 | 0.21 | 0.65 | 0.01 | 0.22 | 0.22 | -0.19 | 1.00 | | | | | |
| adm4 | -0.13 | 0.07 | -0.02 | 0.32 | -0.06 | -0.21 | 0.14 | 0.07 | -0.06 | 0.06 | -0.08 | -0.04 | -0.20 | 0.06 | 0.00 | -0.41 | 1.00 | | | | |
| chr3 | -0.34 | -0.01 | -0.30 | -0.14 | 0.02 | 0.06 | 0.07 | 0.00 | -0.21 | -0.23 | -0.58 | 0.03 | -0.13 | -0.25 | 0.18 | -0.72 | -0.16 | 1.00 | | | |
| chr5 | -0.04 | 0.08 | 0.11 | 0.29 | -0.01 | -0.10 | 0.08 | 0.06 | 0.13 | 0.01 | 0.10 | 0.00 | -0.08 | 0.00 | -0.08 | 0.11 | 0.33 | -0.49 | 1.00 | | |
| qaul2 | 0.08 | -0.05 | 0.11 | -0.21 | 0.05 | 0.11 | -0.11 | -0.01 | 0.11 | 0.02 | 0.20 | 0.04 | 0.28 | -0.05 | -0.13 | 0.37 | -0.26 | -0.16 | -0.01 | 1.00 | |
| qaul3 | -0.12 | 0.03 | -0.05 | 0.11 | -0.05 | -0.06 | -0.05 | -0.03 | 0.02 | -0.01 | -0.04 | -0.05 | -0.11 | -0.09 | 0.05 | 0.01 | 0.08 | -0.12 | 0.07 | -0.36 | 1.00 |

♣ Description of each variable is given in table 4.1

## Annex 8: Part-V: Willingness to pay Survey Questions

### Background Information

Water from irrigation systems in your village is used not only for crop production but also for non-crop production purposes such as domestic uses (drinking, cooking, washing and hygiene), livestock watering, gardening and fishing. These and other non-agricultural uses of irrigation water are very essential for your household in terms of generating income, improving nutritional status and health of members of your family.

Suppose water from irrigation sources for non-agricultural uses is available to you without any change in quality, quantity and reliability under existing institutional setup. That is, the current status in water supply from irrigation systems for non-crop uses continues to prevail. Suppose also that the government or water fathers or WUAs or any other concerned body introduces "water user fees/charges" on water users from irrigation sources based on the amount of irrigation water consumed per six months. Also note that money that is paid for non-crop uses of irrigation water is not available for other purposes. Given this information:

**A. Respondent's WTP for Domestic Uses of irrigation water from ………… scheme**

| | Yes | No |
|---|---|---|
| 1. Are you willing to pay……Birr per jerry can of irrigation water for domestic uses? | 1 | 0 |
| 2. If **YES to Q.1**, what about……..Birr per jerry can? | 1 | 0 |
| 3. If **NO to Q.1**, what about……..Birr per jerry can? | 1 | 0 |

4. What is the largest amount of money you are willing to pay per jerry can for domestic uses from this scheme?...........................(Birr)
5. If respondent's maximum WTP (Q. 4 above) for domestic uses of irrigation water is zero, ask reasons for not paying like:
   i) Has no income to pay (i.e., cannot afford).

ii) Irrigation water for domestic purposes should be free.

iii) Others, please specify......................................

6. If respondent's maximum WTP given in Q. 4 is less than the amount s/he agreed to pay under either Q. 1, Q. 2 or Q. 3, then ask

You agreed to pay Birr.....but when I ask you the maximum amount you are willing to pay you gave lower amount than what you agreed. Why?

.............................................................................................................

.............................................................................................................

**B. Respondent's WTP for irrigation water for gardening from........................ scheme**

| | Yes | No |
|---|---|---|
| 1. Are you willing to pay......Birr per 0.25 hectare per hour for cash crops? | 1 | 0 |
| 2. If **YES to Q.1**, what about........Birr per 0.25 hectare per hour for cash crops? | 1 | 0 |
| 3. If **NO to Q.1**, what about........Birr per 0.25 hectare per hour for cash crops? | 1 | 0 |

4. The largest amount of money you are willing to pay per 0.25 hectare per hour uses is .........Birr from this scheme.

5. If respondent's maximum WTP (Q. 4 above) gardening from irrigation water is zero, ask reasons for not paying like:

i) Has no income to pay (i.e., can not afford).

ii) Irrigation water for livestock should be free.

iii) Others, please specify.......................................

6. If respondent's maximum WTP given in Q. 4 is less than the amount s/he agreed to pay under either Q. 1, Q.2 or Q.3, then ask

You agreed to pay Birr.....but when I ask you the maximum amount you are willing to pay you gave lower amount than what you agreed. Why?

.......................................................................................................

**C. Irrigation Water Improvement for Domestic Uses from ......................... scheme**

1. Do you think that improvement is required in terms of quality, quantity, and reliability of water supply from irrigation sources for domestic uses? Yes 1 No 0

2. If **YES to Q.1**, what kind of improvement do you propose? ..........................................

.................................................................................................................

Now, suppose the government or NGOs or private individuals or local community have exerted efforts to improve water supply from irrigation sources so that you could get better quality water, which is safe for health of your family. Moreover, water supply is convenient, reliable and enough for domestic uses, livestock and gardening throughout the year at all time in your village. The improvements include developing springs with cement and connect pipes to the developed springs and diverting rivers and supply pure water through the same mechanisms as described above. Given this improved water supply:

1. Are you willing to pay......Birr per jerry to get improved water for domestic uses?

Yes 1 No 0

2. If **YES to Q.1**, what about........Birr per jerry can? Yes 1 No 0

3. If **NO to Q.1**, what about........Birr per jerry can? Yes 1 No 0

4. What is the largest amount of money you are willing to pay per jerry can for improved water supply for domestic uses?................(Birr)

5. If the maximum WTP of the respondent is less than what he/she agreed to pay under Q. 1, Q. 2 or Q. 3, ask the reasons for such inconsistency..........................................................

6. If respondent's maximum WTP (Q. 4 above) for such improved water for domestic uses is zero, ask for reasons not to pay like:

a) Has no income to pay (i.e., can not afford).

b) The government should pay

c) Non-governmental Organizations (NGOs) should pay

d) Others, please specify........................................

# DECLARATION

I, the undersigned, declare that this thesis is my original work, has never been presented for a degree in any other university and that all source of materials used for this thesis have been dully acknowledged.

**Declared by**:

Jonse Bane

Signature ____________

Date: June 28, 2005

**Confirmed by:**

Dr. Alemu Mekonnen
Advisor

Signature ____________

Date: June 28, 2005

Place and date of submission: Addis Ababa University, June 28, 2005