

**ECONOMIC VALUATION OF IRRIGATION WATER IN BAHIR DAR ZURIA
WOREDA, ETHIOPIA: THE CASE OF CHILAL ABAY, NEGIDA AND UPPER
ANDASA IRRIGATION SCHEMES**

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This is to certify that the thesis prepared by Ayana Anteneh, entitled: *Economic Valuation of Irrigation water in Bahir Dar Zuria Woreda, Ethiopia: the case of Chilal Abay, Negida, and Upper Andasa irrigation schemes* and submitted in partial fulfillment of the requirements for the degree of Master of Science (Resource and Environmental Economics) complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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ABSTRACT

Economic Valuation of Irrigation Water in Bahir Dar Zuria Woreda, Ethiopia: The Case of Chilal Abay, Negida and Upper Andasa Irrigation Schemes

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This study attempts to determine the economic value of irrigation-water by eliciting farmers' willingness to pay (WTP) using contingent valuation method in Bahir Dar Zuria Woreda, Ethiopia. Single bounded and double bounded dichotomous choices with a follow up open ended questions were employed. Primary data obtained from 197 randomly sampled household heads was analyzed using both descriptive statistics and Econometric models. The descriptive analysis indicates that the mean annual income of the irrigators is twice more than that of non-irrigators. And out of the total respondents 95 percent of them are dissatisfied with the existing irrigation water supply.

In this study, Probit and Bivariate Probit model was used to measure WTP and to determine the factors that influence the variation in WTP. To identify the basic determinants of maximum WTP, we also used Tobit model. The result from the Probit model revealed that the bid level, farming income, education, family size, land size, having pumping motor, sex of the household heads, and dissatisfaction with the existing irrigation water supply are significant factors that affect respondents' WTP for the improvement of the current irrigation schemes. In the Tobit model households' income, family size, land size, and having pumping motor are found to positively and significantly affect households' maximum willingness to pay. In the Bivariate Probit model result, off farm income, initial bid and follow-up bid were found to have a negative and significant effect on the households' probability of accepting that bid. In this model variables such as income, land size, having pumping motor and dissatisfaction with the existing irrigation water supply have a positive effect on the households' probability of WTP.

The mean willingness to pay for the provision of improved irrigation water is found to be 674.5 and 579 Birr per year/0.25 ha from the double bounded dichotomous and open-ended questions, respectively. The estimated aggregate willingness to pay for improved irrigation water supply using the DBDC and open ended questions is found to be about birr 15,703,709 and 13,480,278

per year, respectively. Among the surveyed households, 99 percent have shown their willingness to pay if there is an improvement in existing irrigation water supply. Thus, it may be a good indicator for the concerned body to invest for expanding the current irrigation projects and introducing proper irrigation water pricing.

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List of Abbreviation

ADF - African Development Fund

AfDB -African Development Bank

ADSWE - Amhara Design & Supervision Works Enterprise

CEM – Choice Experiment Method

CVM - Contingent Valuation Method

DBDC- Double Bounded Dichotomous Choice

DRIS - Doho Rice Irrigation Scheme

ECA - Economic Commission for Africa

EUWI – European Union Water Institute

FAO – Food and Agricultural Organization

Ha – Hectare

IBRD - The International Bank for Reconstruction and Development

MoWR - Ministry of Water Resources

MWTP –Maximum Willingness To Pay

PCGP- Planning Commission Government of Pakistan

O&M - Operation and Maintenance

OLS - Ordinary Least Squares

RUM- Random Utility Model

SBDC- Single Bounded Dichotomous Choice

WMO - World Meteorology Organization

WTP- Willingness To Pay

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Chapter one: Introduction

1.1. Background of the study

Water is a precious natural resource, vital for life, development and the environment. It can be a matter of life and death, depending on how it occurs and how it is managed. When it becomes too much or too little, it can bring destruction, misery or death. Irrespective of how it occurs, if properly managed, it can be an instrument for economic growth. However, when inadequate in quantity and quality, it can be a limiting factor in poverty alleviation and economic recovery, resulting in poor health and low productivity, food insecurity, and constrained economic development. Thus what we get out of water depends largely upon what we put into it in terms of management and use (MoWR, 2002, ECA, 2001).

Utilization of water resources for consumption purposes comes under a number of categories such as: household needs; small-scale productive activities; agricultural production and industrial uses. Other non-consumptive uses include hydropower, transport, fisheries and tourism. Agriculture is by far the largest consumer, on average accounting for an estimated 88 percent of the total volume of utilized water. It is obvious that any future expansion in irrigation, particularly in water scarce or water stressed regions, will put considerable pressure on the availability of water for other uses. This calls for higher level of efficiency in water utilization not only in agriculture but in other sectors as well, including augmentation of existing water resources, wastewater recycling and reuse, and land application of wastewater (AfDB, 2000).

Described as the water tower of Africa, Ethiopia has abundant water resources, including 12 river basins and 22 natural and artificial lakes (ADF, 2005). The geographical location of Ethiopia and its favorable climate provide a relatively high amount of rainfall for the sub-Saharan African

region. Annual surface runoff, excluding groundwater, is estimated to be about 122 billion m³ of water. Groundwater resources are estimated to be around 2.6 billion m³ (MoWR, 2002). However, these ample water resources is found on the central, western and south western parts, while most of North Eastern and Eastern parts of the country are relatively dry. The distribution and availability of water is erratic both in space and time. Hence, despite abundance in some parts the country is highly water-scarce due to lack of water control infrastructure (*Awulachew et al, 2007*).

Although Ethiopia has abundant rainfall and water resources, its agricultural system does not yet fully benefit from the technologies of water management and irrigation. The majority of rural dwellers in Ethiopia are among the poorest in the country, with limited access to improved water for agriculture. Specifically, developing the irrigation sector has many potential benefits in efforts to reduce vulnerability and improve productivity. Such as increase productivity of land and labor, reduce reliance on rainfall and increase exports are among the few (*Awulachew et al, 2010*).

Irrespective of Ethiopia's endowment with potentially huge irrigable land the area of land under irrigation is very low. Even if there are several irrigation development projects under construction (including Kesem-Tendaho, Koga, Rib, Gidabo, Megech-Sereba, Kobo-Girana, Raya-Azebo, and Adea- Betcho), by the end of 2009/10 national irrigation coverage is only about 2.4 percent (MoWR, 2013). This shows that water resources have made little contribution towards the development of irrigated agricultural sector.

Given the amount of water available, even while passing through the semi-arid, arid, and desert areas, it is evident that the promotion of water development technologies, especially irrigation, can provide an opportunity to improve the productivity of land and labor and increase production volumes (*Awulachew et al, 2007*). But it could be possible if sufficient financial resources were

made available (MoWR, 2002). Along with the required finance can be generated through the implementation of well-designed water pricing.

Water pricing can potentially raise significant financial resources to pay for the sustainable management of water resources. Indeed, in some countries like France and Netherlands, it is the main source of revenue (over 90 percent) for the water sector. Revenues from water pricing are particularly important for developing countries in which funds from public budgets and from donor sources are unpredictable and may vary significantly from year to year (EUWI, 2012). Therefore, to implement water pricing, a study on the valuation of irrigation water based on users' willingness to pay is very important.

1.2. Statement of the problem

Water is becoming increasingly scarce in many parts of the world. Water scarcity originates from low availability of the resource in time and space. But, quite often, it gets to alarming levels because of intense water uses. Competition and conflicts among uses and users of water arise mostly at local and regional levels. Hence, the allocation of water among the main sector uses (i.e. domestic, industrial and agricultural) is today a critical issue for most countries in the world. (Latinopoulos, 2005). Water has been recognized as a scarce resource by the international community since the 1992 Dublin Statements which clearly stated that water resources are finite and they are “vulnerable” (WMO, 2007).

In principle water pricing policies have the potential to mitigate water scarcity. It is argued that water pricing can play a significant role in making irrigation water use more efficient. In strict economic terms water pricing is the main mechanism for cost recovery (Latinopoulos, 2005).

Indeed, fee collection rates are near zero in some projects, even when water charges are well below the cost of project operation and maintenance (IBRD, 2005).

This creates serious problems both for irrigation agencies and, in the long run, for farmers. If the fees collected do not cover the costs of an irrigation project, its sustainability, without continued government subsidies, may be at risk. Water fees are collected from farmers for two main goals. The first objective is to cover the O&M cost so that the project is financially sustainable. In many cases, fees will also need to include a charge for the cost of capital required to construct the project. This charge for capital is important for future irrigation investments (IBRD, 2005). This is because while construction of large scale irrigation project is funded by the government, its proper maintenance and up-gradation mostly remains an issue for lack of funds, especially in developing countries with meager financial resources (PCGP, 2012).

The second objective involves pricing to encourage farmers to use less water per unit of output or produce greater net economic returns per unit of water, or both. Historically, the first objective has been paramount, but as water scarcity increases, the water use efficiency objective is likely to grow in importance and be given a higher priority (IBRD, 2005). Water charges could also bring an ownership feeling to the farmers, which will ultimately lead to better use of available water and increased crop production. While free or very low charge encourages overuse, reduces the incentive for farmers to cooperate or participate in irrigation originations, and may result in low system productivity and poor conservation (Bongole, 2014).

Generally, proper water pricing is among the several demand management measures to improve water use efficiency and productivity. Although water is available naturally, ensuring reliable and sustainable supply of water needs costly infrastructure for its storage, conveyance and distribution,

besides huge management expenses. In this context, irrigation water is provided to the users at a cost, mostly paid from the general public money. Water being an essential input for agriculture is supplied at a very nominal price (water charge) to the farmers. It could be too priced (like supply of electricity, seeds, fertilizers) properly to ensure its efficient use for high value output (PCGP, 2012).

Implementing an effective water management system, however, is a complex task. One important requirement for success is sufficient knowledge about farmers' demand or willingness to pay for irrigation water. This information is important for the adequate implementation of water pricing policies, for accurate cost benefit analyses of investments in water supply or water market infrastructure, and also for determining an optimal distribution of the scarce resource between different users (Storm et al., 2010). In this regard, the Ethiopian government has a policy to *“develop the appropriate cost recovery systems and mechanisms for all irrigation schemes”*. In other words, the government has water pricing policy which is based on the willingness to pay by users of water systems. It says that *“as willingness to pay by users of water systems is a powerful impetus for financial sustainability of water resources systems, willingness to pay shall be promoted.”* (MoWR, 2001).

So far, to our knowledge, no attempt has been made in the study area to impute economic values and/or farmer' WTP for irrigation water. Thus, central aim of this study is to determine the value of irrigation water, which farmers would be willing to pay for the provision of improved irrigation water in Bahir Dar Zuria Woreda.

1.3. Objective of the study

The general objective of this study is to estimate economic value of improved irrigation water in Bahir Dar zuria Woreda of Amhara Regional State.

The specific objective of this study is

- To elicit the farmers' willingness to pay for improved irrigation water
- To identify the major socioeconomic factors that affect farmers' Willingness to Pay for the provision of improved irrigation water
- To estimate the aggregate demand for improved irrigation water supply
- To identify key challenges and suggest alternative policy options.

1.4. Significance of the study

Knowledge about farmers demand for irrigation water is an important requirement to manage the scarce resource successfully. The proper adjustment of the CVM provides a way to deliver this information to policy makers in a direct way.

Rational decision making about water management issues requires reliable estimates of the economic value of irrigation water (Molle et al., 2008; Speelman et al., 2008). Knowledge of these values are necessary when, for instance, making investment decisions concerning water resources development, policy decisions on sustainable water use and water allocations, or when the socio-economic impacts of water management decisions must be determined (Molle et al.,2008). Specifically for the agricultural sector, this knowledge is important to design fair, informed and rational pricing systems, providing incentives to irrigators to use water efficiently (Speelman et al., 2008).

Moreover, the issue that is most important for project designers and planners is how to ensure the financial sustainability of a project. This can involve predicting what users will be able and willing to pay for water in the future.

1.5. Scope and limitation of the study

The concept of economic value of irrigation water provision is a very broad concept since it should include both the demand for and supply of irrigation water. However, the scope of the study is limited to the analysis of demand side for the provision of improved irrigation water from a cross section data at a given point in time. Besides, the sample used for this study is limited in both coverage and size. The coverage of the study is limited only to three irrigation schemes in Bahir Dar zuria woreda and the sample size is limited to 200 households; So as to make the work manageable, feasible, applicable and to set it precisely.

1.6. Organization of the study

The thesis consists of five chapters. The first chapter provides an introduction of the research which includes background of the study, statement of the problem, objectives, significance, and scope of the study. In Chapter two theoretical background on water pricing, environmental valuation and the literatures on various methods of valuation techniques are presented. Then, a review of previous studies particularly empirical literatures related to the contingent valuation method is done. In chapter three, the methodological framework of the CVM, sampling technique, data collection, and survey design issues are presented. The descriptive and econometric results are presented and analyzed in chapter four. Lastly, in chapter five the main findings of the study are concluded and some policy implications are discussed.

Chapter Two: Literature Review

2.1. Theoretical literature review

2.1.1. Value of Water

Water has economic value or yield benefits whenever users would pay a price for it. Efficient market operation results in a set of market values which serve to allocate water in a manner consistent with the objectives of producers and/or consumers (Young, 2005). However, due to non-existence or imperfect water markets, it is quite difficult to determine the actual value of water for different users. In addition, value of water varies among users, sectors, locations, seasons, times, quality and reliability. Thus, unlike other economic goods, proper valuation of water is not simple due to large scale complexities involved in water sector. It is generally perceived that the actual value of water is mostly not recognized due to which majority of water management project could not be sustained. Similarly, under-valued water encourages wasteful usage. Thus, for water to be considered as an economic good, it needs to flow to the high-value end use (PCGP, 2012).

2.1.2. Water Pricing

Water pricing has been a policy issue since the Dublin International Conference on Water and the Environment in 1992 even though the issue for self-financing and recovery of operation and maintenance costs has a longer history. The Dublin Conference established the concept that water itself is an “economic good”. One of the principles agreed at the conference, suggested that full cost pricing could be a powerful instrument for water management (FAO, 2004).

Water pricing is a key element of sustainable financing (EUWI, 2012). Financially unsustainable irrigation system, where water pricing is independent of the actual water consumption by different

crops, results in wastage of water by farmers. In the absence of incentives, farmers inundate their entire fields through flood irrigation rather than irrigating the crops (PCGP, 2012).

Water pricing can be a very powerful instrument in pursuing different water policy objectives. Water pricing is often promoted by economists for its incentive effects. For instance, if the price of bulk water increases, there will be a strong incentive for an industry to invest in water-saving technologies. This will have two positive consequences: it will lead to resource efficiency (for instance, less water is used as an input to produce the same level of output) and it will also lead to allocative efficiency (for instance, water will move from activities where it represents low value to those where it represents high value). Thus, water pricing can simultaneously promote economic growth and environmental sustainability objectives. In addition, water policymakers are often attracted to water pricing for its revenue effects. The revenue raised by water pricing instruments can then be used to fund the variety of water resource management functions needed to achieve the water policy objectives (EUWI, 2012).

2.1.2.1. Efficiency versus Equity in water pricing

The trade-offs between efficiency and equity and the use of water allocations to address poverty in many areas of the world are important questions (Johansson et al, 2002). Among the primary roles of water price are: (1) the ‘economically efficient’ allocation of existing supplies; (2) the generation of adequate revenues for the operation, maintenance and expansion of the water system; and (3) the ‘equitable’ treatment of water users. A third consideration in water pricing is fairness or equity among water users. It is often asserted that raising the price of water will ‘hurt the poor’ or be unfair to them. This is a major issue in Third World countries where much of the population is at subsistence level (Howe, 2005). However, concerning equity performance, Tsur et al (2004)

argued that water pricing should be designed primarily to increase the efficiency of water use, leaving income distribution considerations to other policy tools.

2.1.2.2. Water pricing methods

Several water pricing methods are implemented throughout the world (Tsur and Dinar, 1997). There are two reasons: First Costs of supplying irrigation water vary widely, reflecting different combinations of water sources, suppliers, distribution systems, and other factors such as field proximity to water, and topography (Christian-Smith and Kaphiem, no date). Secondly, efficient water allocation can be achieved by the marginal cost pricing rule, but its implementation is a costly operation that requires metering, monitoring, fee collection and other administrative tasks. Thus, the most implemented water pricing methods are presented as follows (IBRD, 2005; Fragoso, and Marques, 2013).

- I. **Volumetric water pricing:** Water is charged by direct measurement of water volume consumption (the charge is based on the amount of water delivered). The economic optimal pricing rule requires that price should be set equal to the marginal cost of providing the water, and it requires accurate measurement of water through meters. The advantage of this pricing method is that it encourages farmers to limit their water use. Also, it is easy to understand in the sense that you pay for the quantity of water delivered to your farm. However, it has several disadvantages. First, the implementation costs can be high because meters are required, and they have to be honestly read and reported. Second, marginal cost pricing does not allow full cost recovery in the case of decreasing average costs (for example, large canal systems). Once the infrastructure is in place, the marginal project costs will be lower than average costs, thus pricing based on the marginal cost will not

achieve full cost recovery. In contrast, for the case of pump irrigation using groundwater, the marginal project costs are likely to be higher than average project costs, particularly when marginal costs include the marginal user cost. Thus, for some groundwater projects, marginal cost pricing could result in over collection as well as high water charges relative to farm income.

- II. **Output/input:** Irrigation water charged based on output produced or on input used other than water; According to FAO (2004) output pricing, where the water fee is levied on each unit of output produced by the user; and input pricing, where a farmer pays for irrigation water indirectly through higher prices for inputs purchased from the government or water agency. Both input and output pricing avoid the need to measure the volume of water diverted or consumed. However, there is no evidence found for the application of these two methods in practice; because of distortion effects on the price of crops.
- III. **Area-based pricing:** Water is charged by irrigated area and fees usually vary according to the kind and extent of irrigation crop, irrigation method, and season of the year. The disadvantage of this pricing method is that, once the irrigated area decision is made, the water charge will have no effect on farmers' water consumption, because the marginal cost of applying additional quantities of water per hectare is zero. Thus, the demand for water is usually higher than it would be under a price or charge that varied by the quantity of water used, and it is likely to lead to overuse of water by farmers near the head of the canal. The advantage is that it is simple to calculate, easy for farmers to understand, and the implementation costs are lower than for volumetric pricing because water deliveries do not have to be measured. Although it gives farmers no incentive to reduce water use per

hectare, it is one of the most widely used water pricing method around the world due to the simplicity of its implementation (Chazovachii, 2012; PCGP, 2012).

- IV. **Block-rate:** Under this pricing method, different volumetric rates vary according to certain threshold values of water consumption. Block pricing involves varying the water price when water use for a set time period exceeds a set volume (for example, 5,000 m³ per hectare per season). If high water charges are a concern, an increasing block charge can be used. The price of the first block can be set below O&M costs. The second and later blocks are raised to higher rates that cover O&M costs and reflect the marginal cost of operations.
- V. **Two-part tariff:** A two-part charge is a combination of volumetric pricing and fixed annual charge for the right to access water which can be charged by irrigation area (based on size of the area irrigated). For the block pricing methods described above, the two objectives—full cost recovery and reduced water use—are often in conflict. The advantage of a two-part charge is that it can reconcile the conflict.
- VI. **Water markets:** Their participants may trade water rights at a particular price during specific periods of time or trade water quantities at the spot price or for future delivery, and water is charged on a volumetric or flow basis. There are several kinds of water markets, from sanctioned markets for water rights in Chile (Herane and Easter, 1998 as cited in Fragoso, and Marques, 2013) to spontaneous spot markets in Brazil (Kemper and Olson, 2000 as cited in Fragoso, and Marques, 2013).

Each water pricing method is associated with different levels of welfare and net benefits, and choice depends particularly on the implementation cost, which varies from region to region due to climate issues, demography, social structure, water rights, water facilities, history and economic conditions. The preferred pricing method should be the one that achieves the highest benefit. In

the absence of implementation cost, volumetric methods are the most efficient (Fragoso, and Marques, 2013). Tsur and Dinar (1997) compared volumetric pricing and per area pricing, and conclude that the latter yield better results when implementation costs exceed 7.5 percent of water proceeds. As a result, in this study per area pricing (area based pricing) method will be employed.

2.1.3. Valuation

The basic strategy for environmental valuation is the ‘commodification’ of the services that the natural environment provides. The services are used by households and firms, and are treated as arguments in utility and production functions, respectively. The standard theories for consumer and producer behavior can then be used to derive methods for assigning values to environmental services. Most of the environmental valuation literature is about services which flow to households (Perman et al, 2003). In this regard, this thesis focuses on households in the valuation of improved irrigation water provision.

2.1.3.1. Types of valuation

The total value of an environmental asset is composed of not one, but several willingness to pay. This is because in many instances environmental assets are characterized by economic factors, but also by special attributes such as uniqueness, irreversibility and uncertainty as to future demand and supply. When any one of the above attributes is relevant, the economic value of a natural resource should include both the use and nonuse values (Hussen, 2000).

Thus, Total Economic value = Use value + Nonuse value

Use value reflects the direct use of the environmental resource. If people used one of their senses to experience the resource—sight, sound, touch, taste, or smell—then they have used the resource.

Some of these uses are called passive-use values or non-consumptive use values if the resource is not actually used up (consumed) in the process of experiencing it (Tietenberg and Lewis, 2012).

Nonuse value reflects the common observation that people are more than willing to pay for improving or preserving resources that they will never use. One type of nonuse values is a bequest value. Bequest value is the willingness to pay to ensure a resource is available for your children and grandchildren. A second type of nonuse value, a pure nonuse value, is called existence value. Existence value is measured by the willingness to pay to ensure that a resource continues to exist in the absence of any interest in future use (Tietenberg and Lewis, 2012).

In the environmental and resource economics, nonuse values are hypothesized as having three separable components, namely option, bequest and existence values or demands (Hussen, 2000).

Nonuse value = Option value + Bequest value + Existence value

Option value refers to a sort of insurance premium individuals may be willing to pay to retain the option of possible future use.

Bequest value refers to the satisfaction that people gain from the knowledge that a natural resource endowment is being preserved for future generations. Strictly speaking, bequest value is an intergenerational component of the option value. Bequest value would have considerable relevance in a situation where the natural resources under consideration are unique and irreversible, and there exists uncertainty regarding future generations' demand for and/ or the supply of these resources.

Existence value refers to the satisfaction that some people derive from the preservation of natural resources so that there remains a habitat for fish, plants, wildlife, and so on.

Since nonuse values are derived from motivations other than personal use, they are obviously less tangible than use values. Total Economic Value estimated without nonuse values, however, will

be less than the minimum amount that would be required to compensate individuals if they are deprived of this environmental asset.

2.1.3.2.Valuation Methods

Valuation methods can be separated into two broad categories: stated preference and revealed preference methods. Revealed preference methods are those that are based on actual observable choices that allow resource values to be directly inferred from those choices. These methods are “observable” because they involve actual behavior and “indirect” because they infer a value rather than estimate it directly (Tietenberg and Lewis, 2012).

Stated Preference Methods

Stated preference methods use survey techniques to elicit willingness to pay for a marginal improvement or for avoiding a marginal loss. The most direct approach, called contingent valuation, provides a means of deriving values that cannot be obtained in more traditional ways. The simplest version of this approach merely asks respondents what value they would place on an environmental change or on preserving the resource in its current state. Alternative versions ask a “yes” or “no” question such as whether or not the respondent would pay \$X to prevent the change or preserve the species. The answers reveal either an upper bound (in the case of a “no” answer) or a lower bound (in the case of a “yes” answer). This survey approach creates a hypothetical market and asks respondents to consider a willingness-to-pay question contingent on the existence of this market (Tietenberg and Lewis, 2012).

Contingent valuation

Contingent valuation (CV) evolved as a method to quantify the benefits of non-marketed environmental goods and attributes so that they could be entered directly into cost–benefit

calculations (Bateman and Willis, 2001). It is a survey-based method frequently used for placing monetary values on environmental goods and services not bought and sold in the marketplace (Carson, 2000). In other words, the contingent valuation method (CVM) is a direct method in that it involves asking a sample of the relevant population questions about their WTP or WTA. It is sometimes referred to as a stated preference method. It is called 'contingent valuation' because the valuation is contingent on the hypothetical scenario put to respondents (Perman et al, 2003).

Steps involved in CVM

The steps involved in applying the CVM can be stated as follows (Perman et al, 2003):

1. Creating a survey instrument for the elicitation of individuals' WTP/WTA. This can be broken down into three distinct, but related, components:
 - a. Designing the hypothetical scenario,
 - b. Deciding whether to ask about WTP or WTA,
 - c. Creating a scenario about the means of payment or compensation.
2. Using the survey instrument with a sample of the population of interest.
3. Analyzing the responses to the survey. This can be seen as having two components:
 - a. Using the sample data on WTP/WTA to estimate average WTP/WTA for the population,
 - b. Assessing the survey results so as to judge the accuracy of this estimate.
4. Computing total WTP/WTA for the population of interest.
5. Conducting sensitivity analysis.

Advantages of Contingent valuation

CVM has been increasingly advocated by economists and some specialists as a useful tool for gathering reasonably accurate data about how much a household can afford and is willing to pay and sanitation options presented to them (Wedgwood, and Sanson, 2003).

The primary attraction of CVM is that it can measure the economic benefits or damages of a wide assortment of beneficial or adverse effects in a way consistent with economic theory (Young, 2005). The most important part of contingent valuation methodology is creating a realistic contingent valuation scenario, which has accurately priced water supply 'options' that reflect the levels of prices that the water service provider would have to charge in order to provide the service. The respondent is asked about their preferences and is effectively asked at what price they would be willing to 'buy' the water, based on the level, quantity and quality of services (Wedgwood, and Sanson, 2003).

CVM has two advantages over indirect methods. First, it can deal with both use and non-use values, whereas the indirect methods cover only the former, and involve weak complementarity assumptions. Second, in principle, and unlike the indirect methods, CVM answers to WTP or WTA questions go directly to the theoretically correct monetary measures of utility changes. While the CVM can be used for both use and nonuse values, its actual use has mainly been in regard to the latter. Particularly, most CVM applications have concerned existence, or passive-use, values (Perman et al, 2003). Specifically, CV was seen both as an alternative method of valuation to travel-cost (TC) and hedonic pricing (HP) models and as being able to quantify some types of benefits, such as non-use or passive-use benefits, which lie outside the scope of TC and HP studies (Bateman and Willis, 2001). Given this, and the fact that indirect methods cannot address non-

use/existence values, the study shall employ the CVM in the context of trying to ascertain non-use/existence values.

Limitation of Contingent valuation

As compared with indirect methods it is seen by many economists as suffering from the problem that it asks hypothetical questions, whereas indirect methods exploit data on observed, actual, behavior (Perman et al, 2003). The major concern with the use of the contingent valuation method has been the potential for survey respondents to give biased answers. Four types of potential bias have been the focus of a large amount of research (Tietenberg and Lewis, 2012):

1. Strategic bias; it arises when the respondent provides a biased answer in order to influence a particular outcome.
2. Information bias; it may arise whenever respondents are forced to value attributes with which they have little or no experience.
3. Starting-point bias; it may arise in those survey instruments in which a respondent is asked to check off his or her answers from a predefined range of possibilities. How that range is defined by the designer of the survey may affect the resulting answers. A range of \$0–\$100 may produce a valuation by respondents different from, for example, a range of \$10–\$100, even if no bids are in the \$0–\$10 range.
4. Hypothetical bias; it can enter the picture because the respondent is being confronted by a contrived, rather than an actual, set of choices. Since he or she will not actually have to pay the estimated value, the respondent may treat the survey casually, providing ill-considered answers.

The National Oceanic and Atmospheric Administration (NOAA) convened a panel of independent economic experts to evaluate the use of contingent valuation methods for determining nonuse values. The panel made clear its conclusion that suitably designed surveys could eliminate or reduce these biases to acceptable levels and it provided specific guidelines for determining whether a particular study was suitably designed. Specifically, they suggested the use of referendum-type (yes/no) willingness to pay questions, personal interviews when possible, clear scenario descriptions, and follow-up questions (Arrow et al., 1993). All these suggestions are considered and then were implemented in this study.

Elicitation format

There are different ways to ask willingness to pay questions in contingent valuation surveys, which are known as elicitation methods (Ahmed and Gotoh, 2006). Presently five types of elicitation methods are commonly used in CVM studies. These are open-ended (OE), bidding game (BG), Payment Card (PC), single-bound dichotomous-choice (SBDC) and double-bound dichotomous-choice (DBDC) (Chanel et al., 2015).

Dichotomous choice contingent valuation questions have gained popularity over the last several years. This is due primarily to their purported advantages in avoiding many of the biases known to be inherent in other formats used in the contingent valuation method (Cameron and Quiggin, 1994).

However, all these methods of asking questions have their relative advantages and disadvantages and none is free from criticisms (Ahmed and Gotoh, 2006). A summary of the characteristics of the most commonly used elicitation methods is provided as follows (Ahmed and Gotoh, 2006; Chanel et al., 2015):

In the **bidding game** respondents face several rounds of discrete choice questions involving increasing/decreasing bids (or both) with a final question being an Open Ended WTP question. Advantages of such method are that it eases the respondents' cognitive process and encourages them to carefully consider the valuation task while the final Open Ended question provides more accurate monetary values than other formats. However, such method can be subject to higher extreme responses, to "anchoring" or "starting point" bias, and to a tendency to "yeah-saying" for avoiding answering "No".

In the **Open Ended** question, the respondent provides a monetary value that directly corresponds to a change in utility. This method can provide more accurate WTP values compared with other methods, as it is not prone to "anchoring" or "starting point" bias. Yet, it may be difficult to answer especially in cases where the purchasing decision involves unfamiliar (non-market) commodities. Besides, it may lead to a higher non-response rate, and a larger number of "Don't know" and extreme responses compared with other formats.

In the **single-bounded question**, the respondent gives a "Yes" or "No" answer to a proposed bid. Such method is easy to implement and much more familiar to the respondents because of the similarity to the market condition. Thus, it minimizes non-responses and decreases outliers. However, a large sample size may be required to get a sufficient level of accuracy in WTP estimation. Thus, increasing the cost of the survey.

The double-bounded question is an extension of the single-bounded version. Accordingly, a second bid is introduced conditional to the answer given to the first bid. Thus, in this method more statistical efficiency can be achieved than that of SBDC as additional information can be elicited on each respondent's WTP. However, similar to the single-bounded method, the double-bounded question

method may require a large sample size to reduce the risk of feeble information on the WTP distribution.

Finally, in the **Payment Card** respondents are required to choose a bid as close as possible to their true WTP in a list with several bids. The PC has become popular since it better mimics real life decisions compared to the Open Ended (setting the price). Besides, it offers a visual aid that facilitates the construction of evaluation and avoids a high rate of non-response and overestimated values. But biases due to starting values and the range and centering of the bids may arise. Thus, it requires direct individual interviews, which are costly.

2.2. Empirical literature review

There are various empirical studies undertaken in measuring the economic value of irrigation water throughout the world. Some studies that used CVM in valuation of irrigation water are presented as follows.

Shantha, and Ali (2014) attempts to determine the economic value of irrigation-water for government managed irrigation project in Sri Lanka using contingent valuation method followed by single bounded dichotomous choices. Logistic regression model was used to measure WTP and to determine the factors that influence the variation in WTP. Primary data were obtained from 367 farmer households in Nagadeepa irrigation schemes in dry zone. The Authors estimated that value of irrigation water was Rs. 5,275 (\$40) per hectare per season. They found that farm income, existing knowledge of water management, Location of paddy(a field in which rice growing) field, ownership of paddy land, Extent cultivated of paddy, Irrigation scarcity, main income source were significant variables which influence the variation of farmers' WTP. One of the most important policy implications of this study is the possibility of restructuring the existing irrigation pricing

system by taking into account the economic value of irrigation water to use irrigation resources efficiently by motivating improvement in water management practices.

Angella et al (2014) tried to estimate Willingness to pay for irrigation water and its determinants among rice farmers using data gathered from 200 rice farmers in 2012 at Doho Rice Irrigation Scheme (DRIS) in Uganda. They used contingent valuation (CV) bidding game approach and Ordinary Least Squares (OLS) methods to elicit WTP and analyze the determinants of WTP, respectively. The study findings show that while farmers are willing to pay Ush 20,000 (\$8)/acre/season on average, Ush 15,000 (\$6) acre/season is actually needed to cover maintenance costs as per the 2013/2014 work plan for DRIS. The authors recommend charging Ush 15,000/acre/season, however, which not only generates sufficient revenue to cover the maintenance costs, but also lies below the average WTP, which several farmers should be willing to pay without coercion. However, because not all farmers are willing to pay Ush 15,000, it is necessary to incentivize voluntary payment and strong enforcement of penalties against non-payment among those with low WTP. The OLS regression results suggest need for additional intervention that enhances private benefits to farmers, such as improved access to credit, markets and training in soil/water management and rice growing.

Storm et al (2010) used Contingent Valuation Method (CVM) which is adjusted to derive a demand function for irrigation water along farmers' willingness to pay for one additional unit of surface water or groundwater. An application in the Middle Drâa Valley in Morocco shows that the method provides reasonable results in an environment with limited data availability. For analyzing the censored survey data, the Least Absolute Deviation estimator was found to be a suitable alternative to the Tobit model when errors are heteroscedastic and non-normally distributed. The adjusted

CVM to derive demand functions is especially attractive for water scarce countries where water management doubtlessly plays a decisive role.

Tiwari (2005) determined the economic value of irrigation water using both direct and indirect valuation techniques. The results indicated that the opportunity cost of irrigation water was considerably greater than the maximum willingness to pay. He concluded that there is unsustainable use of irrigation water at present. Tiwari used both the open and closed-ended questions elicitation methods to identify the factors that affect respondents' WTP. From the closed ended question the result found that WTP was related to respondents' gender, agricultural income, perceived water sufficiency, education, family size and landholding. On the other hand, the WTP from open ended question was significantly varying with the farmers' attitude towards paying fee, sex, education, migrating family members, family size and access to credit.

Chandrasekaran et al (2009) also determined the economic value of tank irrigation water in South India through Contingency Valuation Method by analyzing farmers' willingness to pay for irrigation water under improved water supply conditions during wet and dry seasons of paddy cultivation. Logit model was used to describe the farmer's decision on whether or not they agreed to pay for existing supply of irrigation water as well as under improved water supply conditions. It could be seen that the family labor force, area under rice cultivation and the water requirement found to be significant factors influencing farmers WTP in the wet season. While in dry season, the variables area under rice cultivation and the water requirement are found to be significantly influencing the farmers' WTP for irrigation water. Area under rice cultivation had significant bearing on WTP by farmers. Chandrasekaran (2010) also assessed the Economic and Social Value of Irrigation Water in the same area of cultivation, India. The economic value of irrigation water was determined through Contingency Valuation Method. The author used Logit model to assess

the factors influencing farmers' WTP for irrigation water. Factors namely, area under rice and water requirement influenced the willingness to pay for water by farmers. Social values of farmers' over water were found to be high. The comparison of the economic value of water estimated using different methods strongly suggests that the present water use pattern will not lead to sustainable use in the tank command areas.

Omondi (2014) conducted a study to estimate the economic value of irrigation water in Kenya. Both Contingent Valuation Method (CVM) and Residual Value Method (RVM) were used to estimate the economic value of irrigation water while the Ordinary Least Square (OLS) was used to assess the factors influencing farmers' WTP for irrigation water. The author estimated production function to determine which factors influence rice output and whether water is a significant input in rice production. Participation in off-farm income generating activities, access to credit and satisfaction with the management of water supply positively influence farmers' WTP for irrigation water. Volume of irrigation water, Quantity of fertilizer and labor were also found to influence rice output positively. The author findings reveal that irrigation water is a significant input in rice production and Irrigation water at Ahero Irrigation Scheme should be charged at appropriate price relative to its economic value of Ksh.7.54/m³ to avoid its wasteful use.

There are also some studies on Economic valuation of irrigation water in Ethiopia. Mezgebo et al (2013) conducted a study to determine the economic value of irrigation water in Wondo Genet area by eliciting households' willingness to pay (WTP) using contingent valuation method (CVM) in the form of double bounded closed ended WTP questions with open ended follow up questions. By using 154 randomly selected households, they applied bivariate Probit and Probit models to determine the mean and factors affecting willingness to pay for irrigation water, respectively. The result of the study shows that the total willingness to pay from double bound elicitation method

was computed at 156,785.1 birr (1 US\$=17 birr) per annum for five years, while the willingness to pay from open ended elicitation method was computed at 128,264.55 birr per year. The study empirically proved that households' income, age, cultivated land, initial bids, awareness and educational level are the key determinants of demand for irrigation water.

Tesfaye (2013) applied CVM to estimate the economic value of irrigation water for sustainable use of resource in Koga Irrigation Project. He employed single bounded logit model and 383 randomly selected irrigation beneficiary households was used to estimate respondents' willingness to pay (WTP) for irrigation water to support operation and maintenance program. The mean WTP value was 86.88 ETB/timad/year. The aggregate mean WTP value was 444,999.36 ETB/timad/year. The study found out respondents' age, farm input expense, and predetermined bid price had a statistically significant negative impact on WTP while number of family labor, education level, number of oxen owned, experience in irrigated agriculture, expectation towards irrigated agriculture, per capita income, fairness of output price, type of crop grown, extension support, perception on water sufficiency, satisfaction with the management of water delivery all had a statistically significant positive impact on WTP. In contrast, the following variables do not have a statistically significant impact on WTP: sex, family size, market distance and off-farm activity.

Teshome (2010) conducted a study on Economic Valuation of Irrigation Water for Erere Woldia Irrigation Project in Harari Regional State. He employed a multi- stage purposive sampling and random sampling techniques in the selection of the study site and the respondents, respectively. A contingent valuation method was employed to elicit farmers' willingness to pay for improved irrigation water. The OLS method was used to determine the factors that affect the maximum price farmers are willing to pay. The study found Size of cultivable land, access to credit, experience

with irrigation, land fertility, perception about water scarcity and dissatisfaction with the existing project have a positive effect while age, household size and cultivating water demanding crops have a negative effect. He also employed logit model to determine the factors that affect the willingness to pay (accept) the bid price. Frequency of DA visit, experience with irrigation, income and perception about water scarcity were found to have a positive effect, while the size of cultivable land, amount of fertilizer used and dissatisfaction with the existing project have a negative effect.

Assefa (2012) valued the economic benefit of irrigation water by using contingent valuation and choice experiment methods to Ribb irrigation and drainage project in South Gonder, Ethiopia. The author employed a single bounded value elicitation format with an open ended follow up question for the CVM and four attributes were identified with three environmental attributes (irrigation water availability, fish stock abundance and productivity) and a monetary attribute (annual payment). Probit, multinomial logit and random parameter logit models were used to analyze the factors influencing households' willingness to pay and estimate measures of welfare change for farm households. The author identified important variables that determine households' WTP for irrigation water include practical irrigation experience of households, average annual income, participation in off-farm activities, and market access. Irrigation farming experience, income of the household, land size, education, number of ox have positive impact on the probability of households WTP for irrigation water supply while bid value, participating in off farm activity, households market access, female headed households, the quantity of fertilizer used in the previous crop season and age have negative impact.

Using CVM Bane (2005) attempted to obtain the valuation of peasants for nonagricultural uses of irrigation water in two peasant associations in Bure district of west Gojam, Ethiopia. He used

probit and bivariate probit models to analyze the economic values of multiple uses of irrigation water emphasizing its non-agricultural uses. He employed single-bounded and double-bounded referendum style elicitation format with open ended follow up questions. And he estimated the annual total WTP for improved irrigation water. It was birr 217,832, 204,168 and 151,716 in single bounded, double bounded and open ended questions, respectively. The study identified the following determinants of WTP: income, age, sex, family size, irrigation water management, choices of water use rights, quantity of irrigation water consumption, distance from current sources (in meters), wealth, land tenure, Peasant Associations (Sites), quality of water, location and starting point bid.

Tilahun (2009) explore the value of irrigation provided to households as an initial step towards the development of a payment for environmental services (PES) program in the Koga Watershed of the Upper Blue Nile Basin. Using CVM, he estimated households' willingness to pay (WTP) to establish PES for upland soil and water conservation measures that ultimately reduce sedimentation loading in the newly constructed reservoir. The Logit model results revealed that the aggregate expected WTP for the total of 7,000 hectares of irrigable land was 964,320 birr per year with a household utility-maximizing price of 192 birr per hectare of irrigable land per year.

Moreover, he examined the magnitude and determinants of labor supply behavior of farm households for the routine management and maintenance of irrigation infrastructure in the Upper Blue Nile basin. For the total irrigable land area it is estimated that households could contribute an estimated 468,784 person labor days per year. A logit model analysis indicated that households' willingness to contribute labor was influenced by education, age of the household head, expectations about yields in irrigated agriculture, wealth of the household, involvement in off-farm

activities, time taken to walk to the nearest market, the household's dependency ratio and randomly assigned bid working days.

As shown above in the empirical literature, many studies are conducted using CVM in the valuation of irrigation water but a few in improved irrigation water provision in Ethiopia. Hence, this study will contribute its own significance to the irrigation sector.

Chapter three: Research Methodology

3.1. Description of the study area

The study was conducted in Bahir Dar Zuria Woreda selected three irrigation schemes namely chilal abay, negida and upper andasa which covers sebatamit, yigoma huletu and bete Mariam Kebeles. The study area is located to the South of Bahir Dar via Tis Abay –Bahir Dar gravel road and it is about 10-18 km far from Bahir Dar.

Total size of the woreda (Bahir Dar Zuria Woreda) is approximately 1,283.6 km², and includes 32 kebeles, three of which are partially included in the proposed study area. The woreda is bounded in the east by south Gonder Zone, in the west by Mecha and Achefer woredas and by Lake Tana, Yelimana densa woreda in the north and south, respectively. Analyzing the topographic features of the woreda indicates that approximately 48 percent can be defined as rolling, 32 percent hilly, 13 percent mountainous, 7 percent valleys. The altitude in meters above sea level ranges from 1,750 to 2,300. And all of the woreda area can be classified within woina-dega climatic zone (MoWR, 2009).

Agriculture is the dominant economic base and it is almost the only means of living for the people of the study area. Nearly 100 percent of the population with in the area depends on this sector of the economy. However; it is subsistence, low in production and productivity and backward in its production system and cultural practices involved. In addition to this, land holding of the farmers, which is the main input of agriculture, is small and highly fragmented as a result of increasing population pressure from time to time (ADSWE, 2012).

River diversion irrigation systems are practiced in the woreda using Abay and Andasa Rivers which are the main source of water for modern irrigation system in the sampled kebeles. That is, Chilal Abay and Negida irrigation projects were constructed by diverting river Abay while river

Andasa is the source of water for the upper Andasa diversion project. According to the woreda's Agricultural development office (2015), Chilal and Negida schemes were constructed by the Amhara Water Works Construction Enterprise in 2014 and 2010, respectively. And Upper Andasa was first constructed in 1992 and then re-constructed in 2013. However, all of these diversions are not well constructed and proper canal construction is the major and severe problem in the study area.

3.2. Data type and source

The data source for this study was obtained from primary sources. It was collected from a sample of three kebeles (sebatamit, yigoma huletu and bete Mariam) by using questionnaire.

Given time and financial constraints and bearing in mind the need to minimize exposure to small sample bias, this study was obtained the data from 200 randomly selected farm households in the study area. The data sets included all the information necessary to represent all the variables to estimate the required models.

3.3. Sampling technique

The study combined a purposive sampling and random sampling techniques in the selection of the study site and the respondents respectively. In the first stage, the study site-Chila Abay, Negida, and Upper Andasa irrigation schemes- is purposively selected mainly because of the following reasons. First our knowledge or familiarity with the area, the local language and culture; Second as per to our information, no study has been conducted in the area; Third the presence of Abay and Andasa rivers in the near of fertile lands which is suitable for irrigation. And the fourth reason is the problems posed on these irrigation schemes.

After identifying the command area which includes sebatamit, yigoma huletu and bet Mariam kebeles, individual respondents were selected from each kebeles by applying the technique of random sampling. According to Bahir Dar zuria woreda agricultural development office (2015) including potential beneficiaries, there are 3,548 irrigation beneficiary household heads in the three administrative Kebeles. Among these number of households, currently 2640 are irrigation beneficiary in these kebeles. Specifically, 1040 of the irrigation beneficiaries are in sebatamit, 1499 are in yigoma huletu and the remaining 101 are in Bet Mariam. Since the remaining household have potential to benefit if there is an improvement in the existing irrigation project, the sampling frame of this study consists all the 3548 households.

Then, the total sample size (200) was distributed to the three kebeles based on the proportion of irrigation beneficiaries in each kebeles. Accordingly, 35 percent of the samples were drawn from sebatamit, 47.5 percent) and 17.5 percent from yigoma huletu and bete mariam kebeles respectively. Finally, by applying the technique of random sampling, individual respondents were selected from each kebeles.

Table 3.1: Sample size distribution

Kebele	Number of beneficiary' households	Sample size	Percent
Sebatamit	1234	69.56=70	35
Yigoma huletu	1693	95.43=95	47.5
Bet Mariam	621	35.01=35	17.5
Total	3548	200	100

Source; Bahir Dar zuria woreda agricultural development office, 2015

3.4. Value Elicitation Format

There are different elicitation methods used to estimate willingness to pay from a sample of households in contingent valuation surveys. The most commonly and widely used elicitation formats are open-ended, bidding game, payment card, single- bounded dichotomous choice, and double-bounded dichotomous choice methods. Among them especially dichotomous-choice (DC) format is the most widely used one (Ahmed and Gotoh, (2006). The NOAA panel advocated this method as the most appropriate one in most circumstances (Arrow et al., 1993).

The other three methods have been shown to suffer from incentive compatibility problems in which survey respondents can influence potential outcomes by revealing values other than their true willingness to pay. The dichotomous choice approach has become quite widely adopted, despite criticisms and doubts, in part because it appears to be incentive-compatible (Haab and McConnell, 2003). Incentive compatibility means that the properties of the value elicitation format assure that there is no advantage in answering strategically: the truthful preference revelation is an optimal (and the dominant) strategy for the respondent (chanel et al., 2015).

Moreover, SBDC method is easy to implement and much more familiar to the respondents because of the similarity to the market condition. Thus, it minimizes non-responses and decreases outliers (chanel et al., 2015). In DBDC method more statistical efficiency can be achieved than that of SBDC as additional information can be elicited on each respondent's WTP (Ahmed and Gotoh, (2006). According to Haab and McConnell (2003) it increase efficiency over single bounded dichotomous choice method in three ways. First, the answer sequences *yes-no* or *no-yes* yield clear bounds on the WTP. For the *no-no* pairs and the *yes-yes* pairs, there are also efficiency gains. Finally, the number of responses is increased, so that a give function is fitted with more.

Therefore, in this study single-bounded and double bounded dichotomous choice approach were applied. Following Ahmed and Gotoh (2006) an open-ended follow-up questions was also used to increase the precision of the estimate with dichotomous choice question.

3.5. The Questionnaire Design and survey implementation

The survey questionnaire is divided into four main parts (see Appendix 1). The first section provides general information aiming at making respondents feel comfortable with the interviewers and the questions. This followed by the second part, which contains the socio-economic characteristics of household respondents such as age, education, occupation, sex, income, and land ownership. The third section of the questionnaire seeks to generate data on households' actual experience on irrigation practice, credit access, using motor pumping, problems of the existing irrigation schemes and whether they grow cash crops or not.

The fourth section consists of CV questions of household's willingness to pay for the provision of improved irrigation water. This is based on the hypothetical market scenario that were designed. In this section, to elicit households' WTP the single bounded and double bounded dichotomous choice with open- ended follow up questions were used.

In this study, in order to generate primary data the field survey was under taken. Before the final survey was implemented, the focus group discussion and pilot survey were carried on. The focus group discussion was provide some information to make some modification in the design of the main survey questionnaire based on the responses so as to make it understandable for respondents. It was also provide important information for descriptive analysis. And the pilot survey was made to set the bids price for the contingent valuation elicitation part of the questionnaire. Between March to April 2015, data was obtained from a survey in the irrigation command areas of the Chilal, Negida, and Andasa irrigation schemes.

Where, $i = 1$ is the final state (the state or condition that prevails when the CV program is implemented), and $i = 0$ for the status quo.

Y_j is the j th respondent's income,

X_j is households' socio-economic characteristics and attributes of the choice, and

ε_{ij} is a component of preferences known to the individual respondent but not observed by the researcher.

It is obvious that something has been changed from the status quo to the final state. It could be a measurable attribute-e.g. an improvement indicator q could change from q_0 to q_1 so that utility for the status quo would be

$$U_{0j} = U_0(Y_j, X_j, \varepsilon_{0j})$$

and utility in the final state would be

$$U_{1j} = U_1(Y_j, X_j, q_1, \varepsilon_{1j}).$$

Based on this model, respondent j answers yes to a required payment of B_j if the utility with the CV program exceeds utility of the status quo

$$U_1(Y_j - B_j, X_j, \varepsilon_{1j}) > U_0(Y_j, X_j, \varepsilon_{0j}) \dots \dots \dots \dots \dots \dots 2$$

Where, B_j is the bid amount in Birr and $\varepsilon_{0j}, \varepsilon_{1j}$ are the error terms

In other words, a farm household will agree to pay for irrigation water if the condition in Equation 2 is satisfied i.e. the utility derived after paying B_j for change is greater than utility derived without the change.

However, we do not know the random part of preferences and can only make probability statements about yes and no. The probability of a yes response is the probability that the respondent thinks that he is better off in the proposed scenario, even with the required payment, so that $U_1 > U_0$. For respondent j , this probability is

$$pr(\text{yes}_j) = pr\left(U_1(Y_j - B_j, X_j, \varepsilon_{1j}) > U_0(Y_j, X_j, \varepsilon_{0j})\right) \dots \dots \dots 3$$

But this equation is too general for parametric estimation. Virtually all approaches begin by specifying the utility function as additively separable in deterministic and stochastic preferences; then we can rewrite equation 1 as follow:

$$U_i(Y_j, X_j, \varepsilon_{ij}) = U_i(Y_j, X_j) + \varepsilon_{ij} \dots \dots \dots 4$$

With the additive specification of equation 4, the probability statement for respondent j becomes

$$\begin{aligned} pr(\text{yes}_j) &= pr[U_1(Y_j - B_j, X_j) + \varepsilon_{1j} > U_0(Y_j, X_j) + \varepsilon_{0j}] \\ &= pr[U_1(Y_j - B_j, X_j) - U_0(Y_j, X_j) + \varepsilon_{1j} - \varepsilon_{0j} > 0] \\ &= pr[\Delta U + \eta > 0] \\ &= pr[\eta > -\Delta U] \end{aligned}$$

For a symmetric distribution $pr[\eta > -\Delta U] = pr[\eta \leq \Delta U]$; then

$$\begin{aligned} pr(\text{yes}_j) &= pr[\eta \leq \Delta U] \\ &= F_\eta[\Delta U] \end{aligned}$$

Where, $\Delta U = U_1 - U_0$

$$\eta = \varepsilon_{1j} - \varepsilon_{0j}$$

$F_\eta[\Delta U]$ is the cumulative distribution function of η .

Most commonly, the parameters in binary choice models are estimated by the method of maximum likelihood (Verbeek, 2004). The likelihood, or the joint probability, follows more or less directly from the formulation of the model. Let I_j be an indicator variable for observation j, with $I_j = 1$ given by

$$p[\text{yes}] = p[I_j = 1] = p[\eta_j \leq \Delta U_j] = F_\eta(\Delta U_j)$$

And $I_j = 0$ given by

$$p[No] = p[I_j = 0] = 1 - p[\eta_j \leq \Delta U_j] = 1 - F_\eta(\Delta U_j)$$

The likelihood function is then given by

$$L = \prod_{j=1}^N p[I_j = 1]p[I_j = 0] = \prod_{j=1}^N [F_\eta(\Delta U_j)]^{I_j} [1 - F_\eta(\Delta U_j)]^{1-I_j}$$

Where N is the number of observations. If we obtain the log-likelihood function

$$\log L = \sum_{j=1}^N I_j \ln F_\eta(\Delta U_j) + (1 - I_j) \ln(1 - F_\eta(\Delta U_j))$$

The Probit model takes the following form;

$$WTP_i^* = X_i^* \beta + \varepsilon_i$$

WTP^* is unobservable, it is referred to as a latent variable, that is unobservable households' willingness to pay for the provision of improved irrigation water. But we can observe the dummy variable WTP_i which is defined as:

$$WTP_i = 1 \text{ If } WTP_i^* \geq B$$

$$WTP_i = 0 \text{ If } WTP_i^* < B$$

Where, WTP_i is willingness to pay of the i^{th} household (1, if the response is "Yes" and 0, if the response is "No")

X_i is Vector of independent or explanatory variables

β is Vector of parameters of the model

B is the bid randomly offered to the respondents

ε_i is Error term where, $\varepsilon_i \sim (0, \sigma^2)$

Based on the above justification, Probit model for households' preferences for the improved irrigation water service can be specified as follows:

$$\begin{aligned}
WTP_i = & \beta_0 + \beta_1 incm + \beta_2 bid + \beta_3 edu + \beta_4 age + \beta_5 hhsiz + \beta_6 landsiz + \beta_7 exper \\
& + \beta_8 cashcrop + \beta_9 cred + \beta_{10} pumping + \beta_{11} offrinc + \beta_{12} sexhh + \beta_{13} ox \\
& + \beta_{14} dissat + \beta_{15} corr + \varepsilon_i
\end{aligned}$$

3.6.2. The Bivariate Probit Model

Bivariate Probit model is a natural extension of the Probit model which involves more than one equation, with correlated error terms, in the same way as the seemingly unrelated regressions model (Greene, 2003), This bivariate Probit model is interesting in its own right for modeling the joint determination of two variables.

According to Greene (2003), the general specification for a two-equation model is;

$$y_1^* = x'_1 \beta_1 + \varepsilon_1, y_1 = 1 \text{ if } y_1^* > 0, 0 \text{ otherwise,}$$

$$y_2^* = x'_2 \beta_2 + \varepsilon_2, y_2 = 1 \text{ if } y_2^* > 0, 0 \text{ otherwise,}$$

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

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

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

Where y_1 and y_2 are WTP responses corresponding to the initial bid and 2nd bid price.

$\rho(rho)$, is the covariance between the errors term.

The double-bounded version of discrete response CV follows up on the initial question with a second question, again involving a specific bid to which the respondent can respond with a "yes" or a "no." Let B^1 denote the amount of the first bid. The amount presented in the second bid depends on the response to first bid; if the individual answered "no" to B^1 , the second bid is some lower amount $B^0 < B^1$, while if respondent answered "yes" it is some higher amount $B^2 > B^1$. Thus,

there are four possible response sequences: (a) both answers are yes; (b) both answers are no; (c) a yes followed by a no; and (d) a no followed by a yes (Hanemann and Kanninen, 1998).

According to (Haab and McConnell, 2003) the bounds on WTP are

1. $B^1 \leq WTP < B^2$ for the yes-no responses;
2. $B^1 > WTP \geq B^2$ for the no-yes responses;
3. $B^1 < WTP \geq B^2$ for the yes-yes responses;
4. $B^1 > WTP < B^2$ for the no-no responses;

Where, B^1 be the first bid price and B^2 be the second.

Hence, the probability of the responses is given by

$$pr\{Yes/Yes\} = P^{yy} = pr(WTP_i^1 > B^1, WTP_i^2 > B^2)$$

$$pr\{No/No\} = P^{nn} = pr(WTP_i^1 < B^1, WTP_i^2 < B^2)$$

$$pr\{Yes/Yes\} = P^{yy} = pr(WTP_i^1 > B^1, WTP_i^2 > B^2)$$

$$pr\{Yes/No\} = P^{yn} = pr(WTP_i^1 > B^1, WTP_i^2 < B^2)$$

$$pr\{No/Yes\} = P^{ny} = pr(WTP_i^1 < B^1, WTP_i^2 > B^2)$$

The most general econometric model for the double-bounded data comes from the formulation

$$WTP_{ij} = \mu_i + \varepsilon_{ij}$$

Where, WTP_{ij} represents the i^{th} respondent's willingness to pay, and

$i = 1, 2$ represents the first and second answers.

The μ_1 , and μ_2 are the means for the first and second responses.

This general model incorporates the idea that, for an individual, the first and second responses to the CV questions are different, perhaps motivated by different covariates, perhaps by the same covariates but with different response vectors, and with different random terms.

To construct the likelihood function, we first derive the probability of observing each of the possible two-bid response sequences (yes-yes, yes-no, no-yes, no-no). For example, the probability that respondent j answers yes to the first bid and no to the second is given by;

$$\begin{aligned} pr(\text{yes}, \text{no}) &= pr(WTP_{1j} \geq B^1, \quad WTP_{2j} < B^2) \\ &= pr(\mu_1 + \varepsilon_{1j} \geq B^1, \mu_2 + \varepsilon_{2j} < B^2) \end{aligned}$$

The other three response sequences can be constructed analogously. The j^{th} contribution to the likelihood function becomes

$$\begin{aligned} L_j(\mu/B) &= pr(\mu_1 + \varepsilon_{1j} \geq B^1, \mu_2 + \varepsilon_{2j} \geq B^2)^{YN} * pr(\mu_1 + \varepsilon_{1j} > B^1, \mu_2 + \varepsilon_{2j} \geq B^2)^{YY} \\ &\quad * pr(\mu_1 + \varepsilon_{1j} < B^1, \mu_2 + \varepsilon_{2j} < B^2)^{NN} * pr(\mu_1 + \varepsilon_{1j} < B^1, \mu_2 + \varepsilon_{2j} > B^2)^{NY} \end{aligned}$$

Where; YY = 1 for a yes-yes answer, 0 otherwise,

NY = 1 for a no-yes answer, 0 otherwise,

YN= 1 for a yes-no answer, 0 otherwise and

NN= 1 for a no-no answer, 0 otherwise.

This formulation is referred to as the bivariate discrete choice model. If the errors are assumed to be normally distributed with means 0 and respective variances of σ_1^2 and σ_2^2 then WTP_{1j} and WTP_{2j} have a bivariate normal distribution with means μ_1 and μ_2 , variances σ_1^2 and σ_2^2 and correlation coefficient ρ .

The likelihood function for the bivariate probit model can be derived as follows. The probability of a no-no response, is

$$pr(\mu_1 + \varepsilon_{1j} < B^1, \mu_2 + \varepsilon_{2j} < B^2) = \Phi_{\varepsilon_1\varepsilon_2} \left(\frac{B^1 - \mu_1}{\sigma_1}, \frac{B^2 - \mu_2}{\sigma_2}, \rho \right)$$

Where $\Phi_{\varepsilon_1\varepsilon_2}$ is the standardized bivariate normal cumulative distribution function with zero means, unit variances and correlation coefficient ρ . Similarly, the probability of a no-yes response is

$$pr(\mu_1 + \varepsilon_{1j} < B^1, \mu_2 + \varepsilon_{2j} \geq B^2) = \Phi_{\varepsilon_1\varepsilon_2} \left(\frac{B^1 - \mu_1}{\sigma_1}, -\frac{B^2 - \mu_2}{\sigma_2}, -\rho \right)$$

The probability of a yes-no response is

$$pr(\mu_1 + \varepsilon_{1j} \geq B^1, \mu_2 + \varepsilon_{2j} < B^2) = \Phi_{\varepsilon_1\varepsilon_2} \left(-\frac{B^1 - \mu_1}{\sigma_1}, \frac{B^2 - \mu_2}{\sigma_2}, -\rho \right)$$

and the probability of a yes-yes response is

$$pr(\mu_1 + \varepsilon_{1j} \geq B^1, \mu_2 + \varepsilon_{2j} \geq B^2) = \Phi_{\varepsilon_1\varepsilon_2} \left(-\frac{B^1 - \mu_1}{\sigma_1}, \frac{B^2 - \mu_2}{\sigma_2}, \rho \right)$$

Defining $y_{1j} = 1$ if the response to the first question is yes, and 0 otherwise, $y_{2j} = 1$ if the response to the second question is yes, and 0 otherwise, $d_{1j} = 2y_{1j} - 1$, and $d_{2j} = 2y_{2j} - 1$, the j^{th} contribution to the bivariate probit likelihood function becomes

$$L_j(\mu/B) = \Phi_{\varepsilon_1\varepsilon_2} \left(d_{1j} \left(\frac{B^1 - \mu_1}{\sigma_1} \right), d_{2j} \left(\frac{B^2 - \mu_2}{\sigma_2} \right), d_{1j}d_{2j}\rho \right)$$

The bivariate probit model is a general parametric model of two-response surveys.

Maximum willingness to pay

In the Double bounded discrete choice question with follow up by an open-ended question, respondents who agreed to the given bid levels were asked to specify the maximum amount they would willingness to pay for the provision of improved irrigation water. Respondents who refused to pay the given bid were also asked to specify their maximum amount. In other words, if the answer to double bounded discrete choice was “yes-yes” the maximum WTP would be higher than

the posed bid. On the other hand, if the answer was “no-no” the maximum WTP must be lower than the assigned bid. TOBIT regression is deal these open-ended responses.

3.6.3. Tobit Model

The Tobit model is used given that there is a censoring from below at lower limit and from above at upper limit. Tobit model is appropriate for analyzing dependent variables that cannot take values below or above a particular limit. As it is clearly stated above if the dependent variable takes values below the lower limit and above the upper limit for some part of the population and positive continuous values for the rest of the population the Tobit model is appropriate. The Tobit model that we employed here is censored from below or left- censoring. Hence, the form of the Tobit model following Verbeek (2000) is:

$$\begin{aligned}
 MWTP_i^* &= X_i\beta + \varepsilon_i, \quad i = 1, 2, 3 \dots N, \\
 MWTP_i &= MWTP_i^*, \text{ if } MWTP_i^* > 0 \\
 MWTP_i &= 0, \quad \text{if } MWTP_i^* \leq 0
 \end{aligned}$$

Where, $MWTP_i$ is maximum willingness to pay of the i^{th} household

X_i is vector of independent or explanatory variables

β = Vector of Coefficients

ε_i is the error term where, $\varepsilon_i \sim (0, \delta^2)$

$MWTP_i^*$ is the latent variable which is not observed when it is less than or equal to zero but is observed if it is greater than zero.

Thus, the Tobit model can be specified as follows;

$$\begin{aligned}
 MWTP_i &= \beta_0 + \beta_1 INCM + \beta_2 BID + \beta_3 EDU + \beta_4 AGE + \beta_5 FAMSIZ + \beta_6 LANDSIZ \\
 &+ \beta_7 EXPER + \beta_8 CASHCROP + \beta_9 CRED + \beta_{10} PUMPING + \beta_{11} OFFRINC \\
 &+ \beta_{12} SEXHH + \beta_{13} OX + \beta_{14} DISSAT + \beta_{15} CORR + \varepsilon_i
 \end{aligned}$$

3.7. Welfare Measure

A plausible goal of welfare analysis is to expand the sample mean willingness to pay to the population. In such a case, it would be reasonable to calculate the welfare for each individual in the sample and then use the sample mean (Haab and McConnell, 2003).

Mean and Aggregate WTP Estimation

The ultimate goal pursued in most contingent valuation studies is to estimate willingness to pay (WTP) measures and confidence intervals. Because WTP measures are non-linear functions of estimated parameters, procedures such as the delta method are inappropriate as they yield symmetric confidence intervals (CI). Non-symmetric CI obtained using Krinsky and Robb simulations are recommended (Jeanty, 2007; Haab and McConnell, 2003).

Following Abdullah and Jeanty (2011), the mean WTP and 95 percent confidence intervals are calculated using the approach developed by Krinsky and Robb (1986), sometimes known as the parametric bootstrapping approach. This approach operates by taking a large number of draws (10,000, in this study) from a multivariate normal distribution with means given by the regression coefficients, and covariance given by the estimated covariance matrix of the coefficients (Hole, 2006). A simulated WTP distribution is produced by estimating a WTP value for each draw using the regression equation. By removing the highest and lowest 2.5 percent of the estimated values, and estimate of the 95 percent confidence interval for WTP is obtained. The confidence intervals produced in this fashion are commonly referred to as percentile intervals (Poe et al., 1997).

For the open ended contingent valuation survey responses the maximum willingness to pay figures reported by the respondents can be simply be averaged to produce an estimate of mean willingness to pay:

$$\text{Mean WTP} = \frac{\sum_i^n y_i}{n}$$

Where n is the sample size and each y is a reported willingness to pay amount by surveyed households (Haab and McConnell, 2003).

3.8. Description of variables and their expected effect

The dependent variable (willingness to pay) and independent variables which will be used to estimate the farmers' willingness to pay for improved irrigation water provision and the expected effect of these variables are discussed below.

Dependent variable

WTP: is farmers' willingness to pay for the provision of improved irrigation water. This variable is a dummy variable which takes the value of 1 if the respondent is willing to accept the offered bids and 0 otherwise.

MWTP: is the Maximum willingness to pay that respondents will be asked to state their maximum willingness to pay for improved scheme in Birr (open ended question). In this case, the dependent variable MWTP takes a continuous value and the researcher employed a censored regression model, i.e., the Tobit model.

Independent variables

BID: is the offered bid price to the respondents. In this study, the bid price is used as one of the most determinant independent variables of households' willingness to pay for the improved irrigation water supply. As economic theory states, the higher is the bid price, the less likely households would be willing to pay for the improved environmental goods/services. Thus, the expected coefficient of this variable is negative.

INCM: is annual income of the household. Households with higher income will have high willingness to pay for the improved irrigation water services. Thus the expected sign of this variable is positive.

EDU: is education level of the household head. This variable is a dummy variable which is equal to 1 if the household head is literate and 0 if the household head is illiterate. More educated people have a better understanding on the benefit of the improved irrigation water provision and are more likely to support the idea. Hence the expected sign of this variable is positive.

AGE: age of the household head in years. It is believed that older people prefer to keep tradition and therefore they are less likely to support idea of paying for irrigation water. Hence, it has a negative relationship with WTP.

FAMSIZ: is family size that will be measured as the total number of people in the farming household. In the case of irrigation farming, households with large family size will have more labor input that can utilize the increased water availability. On the other hand, large family size requires relatively large amount of money to feed the family and in such situation the household will be resistant to the idea of paying for the improved irrigation water provision. Thus, it is difficult to determine a prior sign between family size and households' WTP for improved irrigation water supply.

LANDSIZ: is the potential irrigable land size that households have the right to use for irrigation in Timad (0.25 hectare). Households with large farm land are expected to benefit more from the improved service either by cultivating or renting it. Thus, the expected sign of this variable is positive.

EXPER: is irrigation experience of the household. In this case, the more experienced households are expected to have more knowledge and awareness about the economic benefits of irrigation.

Thus, the expected sign of this coefficient is positive and irrigation practice of the household head expected to have a positive effect on the households' willingness to pay for improved irrigation water services.

CASHCROP: is the cash crop growing farmers in the last years such as chat, sugarcane, coffee and /or others. This is expected that farmers who grow cash crops will pay for the improved irrigation water supply because not only they are aware about the economic importance of cash crops but they also earn income by growing it. Hence, the expected sign of this variable is positive.

PUMPING: is households' ownership of pumping motor. If farmers have pumping motor, they may be volunteer to pay more for the improved irrigation water services since they will be saved fuel costs which incurred for pumping water to their irrigated land. Thus, the expected sign of this variable is positive.

CRED: is a dummy variable for access to credit of the respondents. It is equal to 1 if they have access to credit and 0 otherwise. Credit improves the ability to invest in improved technologies like irrigation. The coefficient is therefore expected to be positive.

SEXHH: a dummy variable for sex of the household head (1=male, 0=female). The coefficient can be positive. This is because male headed households are expected to be financially better than female headed households and they have more decision power so that they can be more willing to pay.

OX: is the number of oxen the household owned. In rural area, ox is considered as wealth and it is used as an input for farming. The higher the number of oxen the farmers possess, the more likely to accept the improved scheme given the irrigable farm land. Therefore, the expected sign of this variable is positive.

OFFRINC: is a dummy variable for off farm income. It is 1 if a household head earns off farm income and 0 otherwise. The coefficient for off farm income can be positive or negative. When off farm income supplements farm income, the coefficient is expected to be positive. When off farm income is high and the income from farming is minimal, the coefficient for off farm income is expected to be negative.

CORR: is corrugated iron sheets measured by number of corrugated iron sheets used in making the roof. It is a dummy variable to represent the presence or absence of a corrugated roof in the valuation of irrigation water supply as a proxy of wealth. Therefore, CORR may have a positive impact on household's decision to pay for provision of improved irrigation water services.

DISSAT: dissatisfaction with the existing irrigation project. It is 1 if the respondent is unsatisfied with the existing project and 0 otherwise. Households who are dissatisfied by the existing project will be paying more for the improved irrigation water provision. Thus, the expected sign of this variable is positive.

Table 3.2: Description of dependent and explanatory variables

Variables	Description	Variable Type	Measurement
bid1	Initial bid amount	Continuous	Birr
answer1	Willingness to pay when price is Bid1	Dummy	1= yes; 0=no
bid2	Follow up bid amount	Continuous	Birr
answer2	Willingness to pay when price is Bid2	Dummy	1= yes; 0=no
MWTP	Maximum willingness to pay	Continuous	Birr
INCM	Annual farming Income of the household	Continuous	Birr
EDU	Education level of the household head	Continuous	Grade
AGE	Age of the household head	Continuous	Year
FAMSIZ	Family size of the household	Continuous	Number
LANDSIZ	Potential irrigable land size	Continuous	Timad (0.25 ha)
EXPER	Length of irrigation experience	continuous	Year
CASHCRO P	Households whether Growing cash crops or not	Dummy	1=growing cash crop 0=otherwise
PUMPING	Having pumping motor	Dummy	1= having pumping motor; 0= Otherwise
CRED	Access to credit	Dummy	1= access to credit; 0= otherwise
SEXHH	Sex of the household head	Dummy	1=male; 0=female
OX	Number of oxen	Continuous	Count
OFFRINC	Off farm income	Dummy	1=earns off farm income; 0= otherwise
CORR	Number Corrugated iron sheet	Continuous	Count
DISSAT	Dissatisfaction with the existing irrigation schemes	Dummy	1=dissatisfied; 0= otherwise

Chapter four: Results and Discussion

In this chapter, data obtained in the survey is analyzed using both descriptive and econometric analysis. Accordingly, in the first part of this section households socio-economic characteristics that affects households' willingness to pay for the provision of improved irrigation water are analyzed. In addition to this, the problem of existing irrigation schemes in the woreda are also discussed. In the second part multivariate econometric analysis is made to identify the factors that determine households' willingness to pay for the provision of improved irrigation water. Finally, the aggregate economic value of improved irrigation water is estimated in this part of the analysis.

4.1. Descriptive analysis

4.1.1. Socio-economic Characteristics of the Respondents

For this study a total of 200 households were interviewed in three Kebeles of the Bahir Dar zuria Wereda; but 3 observations were eliminated as invalid responses and these are too small to create sample selection bias. Therefore, further discussions are made using the remaining 197 households who gave valid responses. The basic information obtained in the survey is presented in Table 4.1. From the total surveyed households, 187 (94.9 percent) were male headed while only 10 (5.1 percent) respondents were female headed. The average household size of the surveyed households is 5.66 persons, ranging from 2 persons to 10 persons. The average age of the sampled respondents was 42.7 years with the minimum age of 23 years and a maximum of 80 years old.

The survey results also show that the average household yearly farming income is about 41,978 birr. The income level ranges from a minimum of birr 3,500 to a maximum of birr 126,500 per year. Besides agriculture, engagement in off-farm activities by members is another source of income for the household in the survey area. Thus, about 12.7 percent of the households interviewed earned off farm income, while 41.6 percent of the farmers had access to credit in the

year 2014/15. The roofing of all sampled respondents' house is Corrugated iron sheet. The mean number of corrugated iron sheets was found to be 59.49 with a minimum of 29 and a maximum of 136 sheets.

Table 4.1: Descriptive statistics of the socioeconomic characteristics of the respondents

Variable	Mean	Std. Dev.	Min	Max
INCM	41978.1	24105.43	3500	126500
EDU	.954	1.90	0	9
AGE	42.72	11.37	23	80
FAMSIZ	5.66	1.83	2	10
LANDSIZ	4.819	2.44	1	14
EXPER	4.67	3.10	0	14
CASHCROP	.8071	.395	0	1
PUMPING	.77	.420	0	1
CRED	.416	.49	0	1
SEXHH	.949	.22	0	1
OX	1.756	.80	0	5
OFFRINC	.1269	.33	0	1
CORR	59.49	20.65	29	136
DISSAT	.9543	.20	0	1

Source; own survey, 2015

As shown in Table 4.1, 77.2 percent of the household heads have pumping motor either alone or sharing with other household heads and 80.7 percent of the respondents are growing cash crops which includes chat, sugarcane and/or coffee.

Of the total household heads about 68 percent of them did not attend any formal education (illiterate) and the remaining 32 percent household heads attended formal education or they are

literate. The average years of schooling for the household heads is 0.95 ranged from illiterate or zero years of schooling to a maximum of 9 years of schooling.

Regarding to the land ownership, the average land holding size of the sampled households is around 4.82 timad (1.21 ha), ranges from 1 to 14 Timad. Among the sampled household heads, 12.2 percent of them have no any irrigation experiences while the remaining 87.8 percent household heads have practical experiences in irrigation farming. In other words, the average number of years of practical irrigation experience was 4.67 which ranges from zero (no experience) to 14 years of experience.

4.1.2. Households’ willingness to pay for the improved irrigation water

In the questionnaire, households were asked whether they are willing to pay for the improved irrigation water supply in the command area. Consequently, among the sample household heads about 99 percent are willing to pay if there is an improvement and the remaining 1 percent of them are not willing to pay for the improved irrigation water supply in the given scenario. This indicates that the improvement of the existing irrigation schemes is supported by about 99 percent households. Those who refused to pay anything are treated as having zero WTP. They were asked to state their reasons and respond as, “We didn’t have enough money”.

Table 4.2. Households’ willing to pay

WTP	Frequency	Percentage	Cumulative
Is not WTP	2	1.015	1.015
WTP	195	98.985	100
Total	197	100	

Source; own survey, 2015

4.1.3. Households' WTP in the initial and follow up bids

In order to determine households' willingness to pay for the provision of improved irrigation water, they were asked their willingness to pay by giving them randomly assigned five initial bid values (100, 200, 300, 400, and 500) and the corresponding follow up bids. Hence, given the randomly assigned initial bids, out of the total household heads who are willing to pay, 73.8 percent of them said "yes" or they were willing to accept the initial bids. And the remaining 51 (26.2 percent) said "no" or they were not willing to accept the initial bids.

The follow up bids were doubled for those households who were willing to pay the given initial bids and halved for those households that were not willing to accept the initial bids. Thus, there are four possible response sequences in the double-bounded dichotomous choice model: these are; both answers are yes (Yes-Yes); both answers are no (No-No); a yes answer followed by a no answer (Yes-No); and a no answer followed by a yes answer (No-Yes) (Haab and McConnell, 2003).

Hence, given the randomly assigned follow up bids 146 [100+46] (74.9 percent) households said "yes" or they were willing to accept the follow-up bid and 44 (22.5 percent) household heads said "no" or they were not willing to accept the follow-up bids. The result is summarized in the Table below.

Table 4.3 distribution of yes and no responses for initial and /or follow up bid value

Bid value	Responses			Percentage		
	initial bid	initial and follow up bids		Single	Double	
1 st / 2 nd bid level	Yes	YY	YN	% Yes	%YY	%YN
	No	NY	NN	%No	%NY	%NN
100 /(200/50)	39	35	4	100	89.4	10.6
	0	0	0	0	0	0
200/(400/100)	35	27	8	89.4	69.2	20.5
	4	4	0	10.6	10.3	0
300/(600/150)	31	20	11	79.5	51.3	28.2
	8	7	1	20.5	17.9	2.6
400/(800/400)	21	9	12	53.9	23.1	30.8
	18	17	1	46.1	43.6	2.5
500/(1000/250)	18	9	9	46.2	23.1	23.1
	21	18	3	53.8	46.2	7.6
All bids	144	100	44	73.8	51.3	22.5
	51	46	5	26.2	23.6	2.6

Source; own survey, 2015

The distribution of “Yes” and “No” answers to the corresponding initial and follow up bids are given in Table 4.3. There are five randomly assigned initial bids for improved irrigation water supply for one Timad (0.25 ha) of irrigable land per year. If the respondent accepts the first bid, the initial bid would be doubled; on the other hand, if the respondent does not accept the initial bid, it would be halved.

When the initial bid was Birr 100 per Timad (0.25 ha) of irrigable land per year, all randomly offered respondents were willing to accept it. That is, 39 out of 195 respondents were randomly

offered this bid and all of them accepted the initial bid. However, when the initial bid was doubled (200 Birr) 4 respondents did not accept it.

As shown in Table 4.3, for the first initial and its follow up bids, 35 respondents answer “YY” (Yes to both the initial and the follow up bids); but no one answers “NN” (No to both the initial and the follow up bids) and “NY” (No to initial and Yes to the follow up bids). In the second initial and its follow up bid values, 27 household heads answer “YY” and 4, 8 and 0 answer for “YN”, “NY” and “NN”, respectively.

Regarding the third initial bid, which is Birr 300, majority (20 out of 39) respondents answer “YY” (yes to first bid and no to the follow up bids) and one household answers “NN” (No to first and No to the follow up bids). But, only 11 respondents answer “YN” (Yes to first and No to the follow up bids) and 7 of them answer “NY” (no to first and yes to the follow up bids). This trend is the same in the fourth and fifth initial and follow up bid levels.

Overall, as the initial and follow up bids increased, the responses to “YY” (Yes both to the initial and follow up bids) decreased whereas “NN” (No to both the initial and follow up bids) answer increased. At the 1st bid, there are 35 “YY” (89.4 percent) answer which reduced continuously up to the last bid level and reached at 9 (23.1 percent). Therefore, this result is consistent with the economic theory of demand, that is, as the price of the product itself increases the quantity demand of that product decreases, *ceteris paribus*.

The distribution of “yes” and “no” responses along the initial bid level also illustrate our argument that the probability of ‘yes’ responses decline with increased bid price. At the 1st initial bid value (100 birr), all of 39 respondents accept it. However, as the bid level rise, ‘No’ response become increased.

4.1.4. Income and income source of the sampled households

In the questionnaire households were asked to specify their source of income. Of the total respondents, 87.3 percent of them claimed that their only source of income is Agricultural activities. The remaining 12.7 percent obtained their livelihood both from agriculture and non-agricultural activities.

According to the survey results, the main non-farm activities in the study area are trade, Carpenter, and Daily laborer on construction or other non- farm activities. The mean annual income of the respondents was about 42,619 birr per household with a maximum income of 126,500 birr and with a minimum income of 5,750 Birr. From the total mean annual income of a sampled household, cash crops contributes the highest income (birr 16,250) followed by cereal crops (8,728), vegetables (7,131), dairy (5,247), income gained from sold livestock (1,863), woodlot (1,017), off-farm income (964), poultry (825), honey (342) and fruit (304), respectively.

However, these amount varies when the respondents classified into two: irrigators and non-irrigators. In the case of non-irrigating households, cash crops, vegetables, and fruits are excluded from their source of income since these items are growing by those households who have access to irrigation water. That is, unlike irrigating households, non-irrigating households depend only on rain-fed cultivation.

As a result, irrigators had more income sources. The mean annual income of irrigators was about 45,572 birr per household with a maximum income of 126,500 birr and with a minimum income of 10,500 Birr. But the mean annual income of non-irrigators was less than half of the irrigators'; that is 21,329 birr per household with a maximum income of 38,000 birr and with a minimum income of 5,750 Birr. Such differences in income between the households who have and haven't

access to irrigation supports the argument of (Awulachew et al, 2010). They argued that investment in irrigation serve as a strategy to ensure food security and for poverty alleviation.

Table 4.4. Income sources of the respondents

Income Source	N=197			Irrigators			Non-Irrigators		
				N=173			N=24		
	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min
Cereal Crops	8728	28350	0	8176	28350	0	12710	20000	3350
Sold Livestock	1863	30000	0	1962	30000	0	1150	4000	0
Dairy	5194	29200	0	5413	29200	0	3615	10000	0
Poultry	825	25000	0	755	25000	0	1333	10000	0
Honey	342	15000	0	390	15000	0	0	0	0
Vegetable*	7131	75000	0	8120	75000	0	0	0	0
Fruit****	304	5000	0	346	5000	0	0	0	0
Woodlot**	1017	15000	0	1024	15000	0	971	15000	0
Cash crop***	16250	81000	0	18504	81000	0	0	0	0
Off-farm income	964	20000	0	883	20000	0	1550	18000	0
Total income	42619	126500	5750	45572	126500	10500	21329	38000	5750

Source; own survey, 2015

* (Tomato, Potato, Pepper, Onion, Cabbage), ** (eucalyptus tree, Gesho), *** (chat, sugarcane, coffee), **** (avocado, mango, papaya)

Maize, Dagusa, and Teff were the main cereal crops grown by both irrigators and non-irrigators.

However, there is a difference in magnitude, that is, on average, irrigating households obtained about birr 8,176 income from cereal crops in the year 2014/15 whereas non-irrigating households gained birr 12,710. This difference may be due to the shift of resources (land, labor and others) to

irrigation practices by those who have access to irrigation since irrigation yields higher return than rain-fed agriculture.

There is also a difference in the magnitude of income obtained from off-farm activities between the two groups, that is, on average, off-farm activities yield birr 883 and 1,551 to irrigating and non-irrigating households, respectively. This might be due to the labor intensive nature of irrigation. The implication is that households who have access to irrigation are more occupied in their own farm and have less off-farm participation. In general, the descriptive statistics makes clear that irrigators have less off-farm employment but more cash crop income.

Overall, the total mean income of non-irrigators (rain-fed farmers) and irrigators is, on average, birr 21,329 and 45,572 respectively. Thus, the mean income for irrigators is significantly higher than that of non-irrigators.

4.1.5. Challenges and problems in the existing irrigation schemes

In the structured questionnaire, households were asked whether they are satisfied with the current irrigation water supply system. Consequently, out of total respondents 95.4 percent of them are dissatisfied with the existing irrigation water supply. After asked whether they are satisfied with the existing scheme, households were asked to specify any challenges and problems they have faced/observed in the existing irrigation schemes. Attempt has been made to rank the major constraints of irrigated schemes from the most severe problems to the least (see Figure 4.1). The following problems were listed/specified by the sampled respondents:

1. Insufficient water supply

The most frequently mentioned problem by the household heads was insufficient water supply. Among the sampled respondents, 47.7 percent of them have shortage of water which forced them

to produce partially or grow crops that are not sensitive for water shortage for short period of time like chat, mango, and avocado. In addition to this, farmers encounter a problem of water interruption due to the prevention of river Abay at its outlet of Lake Tana for the purpose of the other irrigation developments (mainly for Tana Belese). This problem was confirmed by officials of the Water Resource Development Bureau of the Amhara Region at the time of focus group discussion. From this discussion and from the respondents, we understood that water users are not advised to make necessary adjustments to their irrigation to accommodate the interruption.

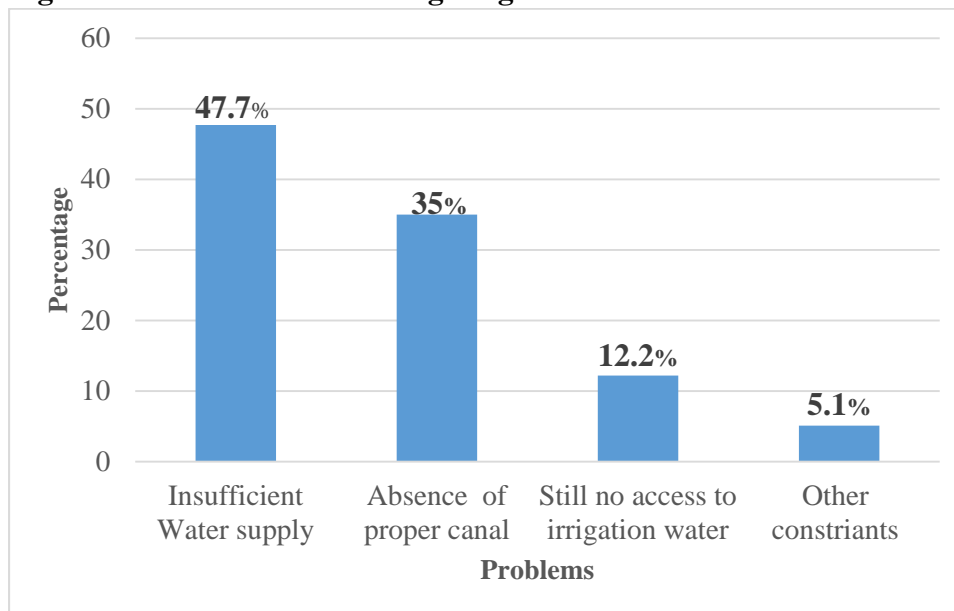
2. Canal problem

Absence of proper canal in which irrigation water flows into farm lands was another major problem mentioned by about 35 percent of respondents. In the study area, concrete canals is constructed from the diversion up to some distances. After that water is flows with the side of the road and the way that farmers directed. During the data collection it has been observed that the irrigation water sank in to the soil before it reached the irrigable land which was also been confirmed by sample survey respondents. This leads to a higher water wastage and distribution problem. That is why, most of the farmers use pumping motor to irrigate their land. This forced farmers to spend a higher fuel costs for pumping water. This problem is severe especialy in Chilal Abay irrigation project and lower in upper Andasa irrigation scheme.

3. No access to irrigation water

Out of the total sample household heads, 12.2 percent of respondents told us that they have still no access to irrigation water. Even if these respondents are found in the command area, they can't access to water due to shortage of water, and unsuitable topography.

Figure 4.1: Problems of existing irrigation schemes



Source; own survey, 2015

4. Other constraints

These include water distribution, water pollution, infrastructure, and seed constraints. Some farmers are suffered by the chemical wastages released into the main canals in which the irrigation water flows near of the outlets by the tannery factory. Moreover, the water user committee are not well organized and found to be weak to run the irrigation systems. That is, some farmers do not respect the distribution program.

4.2. Econometrics analysis

In this section, econometric method of data analysis is used to estimate the coefficients of the socio-economic variables that affect households' willingness to pay for the provision of improved irrigation water. In order to estimate the coefficients for the socio-economic variables three econometric models (Probit, Bivariate Probit and Tobit models) with maximum likelihood estimation method are employed.

Before estimating the effect of the explanatory variables on households' WTP decision to improve the existing irrigation water provision, test was made for the prevalence of multicollinearity since this problem reduces the precision of estimating the coefficient of variables. From correlation matrix (correlation coefficient analysis), it is observed that there is no multicollinearity problem among independent variables. As rule of thumb, multicollinearity is a serious problem, when a correlation coefficient between two independent variables is greater than or equal to 0.8 (Gujarati, 2004). Among other methods, the Variance Inflation Factor (VIF) method was used in this study to check for the existence of collinearity among the explanatory variables. Therefore, from correlation matrix generated using the survey data it is shown that there is no series multicollinearity problem in the study (see Appendix 3).

When we use cross-sectional data we may encounter problem of heteroscedasticity (Greene, 2008). In order to correct the heteroscedasticity problem we can estimate the robust standard errors instead of the usual standard errors (Wooldridge, 2002). Thus, the econometric models which are used in this study are corrected for heteroscedasticity problem using the robust command in Stata.

4.2.1. Results of the Probit model

As we have discussed before, Probit and Bivariate Probit models are employed in order to estimate coefficients of independent variables for the single-bounded and double-bounded dichotomous choice models, respectively. The Probit regression was estimated which can be seen from the regression results summarized in Table 4.5. In this model, the dependent variable assumes the value of 1 if a household is willing to pay the proposed bid amount and 0 otherwise.

The study tests the joint significance of explanatory variables by using Wald test. The Wald test which takes a chi-squared (χ^2) distribution with 15 degrees of freedom is about 82.42 with a p-value (Prob > chi2) 0.0000 tells us the Probit model as a whole is statistically significant, as

compared to the model with no predictors. From χ^2 distribution Table with 15 df the critical value is 5.23 at 1 percent level of significance. The null hypothesis that all the coefficients of the independent variables are simultaneously equal to zero is rejected at 1 percent level of significance. Thus, the model has some explanatory variables.

As reported in Table 4.5 in the Probit model, out of the fifteen explanatory variables, eight of them were significant variables in determining farmers' WTP for improved irrigation water supply. These are the bid level, farming income, education, family size, land size, having pumping motor, sex of the household heads, and dissatisfaction with the existing irrigation water supply. Explanatory variables such as age, irrigation experience, credit access, off farm income, number of oxen, corrugated iron sheet are insignificant. The remaining variable, growing cash crops, has unexpected sign even if it significant.

Marginal Effects After Probit

It is easy and possible to interpret the coefficients of the independent variables based on the sign and significance level of those coefficients. However, the result from the Probit model is not indicating the magnitude effect of the explanatory variables on the probability that respondents accept or reject the initial bids. According to Cameron and Trivedi (2005), in the statistics literature, a very common interpretation of the Probit model coefficients is in terms of marginal effects. Therefore, the marginal effects after Probit model are given in Table 4.5.

The estimated coefficient of the bid value (bid1), which is the most crucial explanatory variable of probability of WTP, was found to be statistically significant at 1 percent level of significance with the expected negative sign. This indicates that the probability of WTP to support for improving the existing irrigation water supply decreases (increases) as the bid price increases (decreases)

under the hypothetical market scenario. The marginal effect estimates show that when the initial bid increases by one Birr, the probability accepting the initial bid decreases by around 0.15 percent, holding other things constant.

Farming income (INCM) has a positive impact on willingness to pay as the expected and it is significant at 10 percent. The results intuitively suggest that household income has a positive effect on the probability of accepting the proposed bid price. Considering irrigation water as a normal good, this result confirms the general demand theory which says, there is a positive relationship between income and quantity demanded. Keeping other factors constant at their respective mean, a 1 birr increase in the income of the household, increase households' probability of willing to pay for the improvement of the irrigation water provision by about $4.01e^{-04}$ percent. This result is consistent with the findings of Teshome, (2010) and Assefa, (2012). They recognized the significant association between households' income and willingness to pay.

As it is shown in Table 4.5, the land ownership variable (LANDSIZ) has a positive and statistically significant effect on the households' probability of willing to pay the proposed bid level at 5 percent level of significance. As the land ownership of the household increased by one timad (0.25 ha), the amount of price that the household head is willing to pay for improved irrigation water service will increase by about 5 percent, other factors remain constant. The possible explanation of this may be due to the higher benefit derived from cultivating the land or renting it in irrigation farming since land is one of the prominent input in agricultural activities. Thus, land size is one of the major determinants of the bid price that the farmers' are willing to pay. This result is consistent with the finding of Tiwari (2005) and Mezgebo et al. (2013).

Moreover, dissatisfaction with the existing irrigation water supply system (DISSAT) positively influenced farmers' WTP for improving the existing irrigation water provision at 1 percent level

of significance. Farmers who are not satisfied with the current irrigation water supply system were found to be willing to pay more if there is an improvement as compared to those satisfied with the existing irrigation water supply. The marginal effect estimates also show that households who are not satisfied by the existing irrigation water supply are 65 percent more likely to support its improvement. This may be due to the problems which is prevailed in the existing irrigation schemes.

As expected, education (EDU) also positively influenced farmers' WTP for irrigation water. This could be due to the possibility that more educated household heads may have more knowledge and awareness about the economic benefit which results from improving the existing irrigation water supply. The marginal effect estimates show that one year increases in the education of the household head leads to an increase in the probability of saying "yes" or accepting the proposed bid price by about 3 percent, holding other factors remain constant.

The sign of family size (FAMSIZ) is positive, even if it was indeterminate as a prior. And it is significant at 5 percent. This implies that households with large family size are willing to pay a higher price than families with small size. Looking at the marginal effect, keeping other factors constant, as the family size of the household increased by one person, the amount of price that the household head is willing to pay for improved irrigation water service will increase by about 5.03 percent. This may be the fact that a higher family size has labor potential to utilize additional water supply and/or needs to more sustenance which can be comes from mainly in irrigating farming than rain fed farming. This is consistent with the findings of Mezgebo et al. (2013) and Tiwari (2005).

The dummy variable having pumping motor (PUMPING) has positive sign in line with expectation and statistically significant at 5 percent level. Thus, the marginal effect suggests that households

who have pumping motor are 40 percent more likely willing to pay for the improvement of irrigation water provision. The possible reason may be that, in the command area of the study, farmers are irrigated their land in two different ways; using canals (in direct flow) and/or using pumping motor. Households, who use pumping motor to irrigating their land, incurred costs mainly fuel costs. But households who use canals (in direct flow) are free from such costs. Therefore, having pumping motor is the major determinant for household heads' willingness to pay for the improvement of the existing irrigation water supply.

The variable sex of the household head (SEXHH) has a positive sign as it is expected and it is statistically significant at 1 percent level of significance. Thus, male headed households are 39 percent more likely to be willing to pay for improving irrigation water provision. The possible explanation is that male headed households may be financially strong than that of female headed households.

Table 4.5: Coefficient estimates of single bounded Probit model

Variables	Coef.	P>z	Marginal effect after Probit		
			dy/dx	P>z	X
bid1	-.005 (.0011)***	0.000	-.0014(.0002)	0.00	296.95
INCM	.00001 (7.6e-06)**	0.037	4.01e-06 (.00)	0.04	41978.1
EDU	.117 (.06)*	0.062	.029 (.016)	0.06	.95
AGE	-.004 (.01)	0.764	-.001 (.003)	0.76	42.72
FAMSIZ	.175 (.08)**	0.046	.043 (.02)	0.03	5.66
LANDSIZ	.207 (.08)**	0.019	.052 (.02)	0.01	4.81
EXPER	.07 (.05)	0.169	.017 (.01)	0.18	4.67
CASHCROP	-1.25 (.51)	0.014	-.21 (.06)	0.001	.80
PUMPING	1.29 (.43)***	0.003	.40 (.15)	0.01	.77
CRED	.097 (.28)	0.734	.02 (.06)	0.72	.41
SEXHH	1.15 (.43)***	0.008	.39 (.16)	0.01	.94
OX	-.22 (.18)	0.226	-.05 (.04)	0.24	1.75
OFFRINC	-.25 (.38)	0.504	-.06 (.11)	0.53	.126
CORR	.0002 (.007)	0.972	.00006 (.001)	0.97	59.49
DISSAT	1.8 (.55)***	0.001	.65 (.15)	0.00	.95
_cons	-2.70 (.97)	0.005			

Survey estimation result, 2015

***, ** &* represent statistically Significant at 1 percent, 5 percent and 10 percent level of significant, respectively

Figures in parenthesis are robust standard Errors

4.2.2. Results of the Bivariate Probit model

In the case of bivariate Probit analysis we have two binary response variables that vary jointly.

However, to estimate the coefficients needed to account for this joint distribution, first we have to check whether the correlation between the two error terms ('rho', ρ) is different from zero. If the correlation between the two error terms is different from zero, it is possible to employ the bivariate Probit model. Therefore, in this study, the bivariate Probit model is employed because, as it is

clearly shown in Table 4.8, the 'rho' (ρ), is different from zero which is about 0.35 and the Wald test shows that this correlations are statistically different from Zero at 5 percent level of significance. The overall significance test against the null hypothesis of all explanatory variables including the constant term are zero is tested by the Wald chi squared test; it is statistically significant at 1 percent level so the null hypothesis is rejected. The results of the Bivariate Probit regression was computed by STATA 13 are shown Table 4.6.

Here after by calculating the marginal effects of Bivariate Probit regression, the interpretation of coefficients and influence of covariates on the two responses are presented.

The results produced by Double Bounded Dichotomous Choice model are generally consistent with expectations; it reveals a negative relationship between the bid values presented to respondents. The first bid and second bid prices are both found to be statistically significant at 1 percent level. Holding other variables constant, a 1 birr increase/decrease in the initial and follow up bid prices, decrease/increase households' probability of willing to pay for the improvement of the irrigation water provision by about 0.12 percent and 0.08 percent, respectively.

It could be seen from Table 4.7 that farming income (INCM) of the respondent found to have positive and significant relationship with the households' WTP. It is significant at 5 and 1 percent in the first and follow up bid, respectively. This positive effect indicated that respondents with higher income were more likely to say yes to the initial bids and the follow up bids than households with lower income. Keeping the influences of other factors constant, a one birr increase in income of the respondent increases the probability of accepting the proposed bid price by about 0.001 percent.

Table 4.6: Estimated Coefficients of the Bivariate Probit model

	Coefficient [answer1]	P>Z	Coefficient [answer2]	P>Z	Marginal effect	P>Z
Bid1	-.006(.001)	0.000			-.0012(.0002)***	0.00
Bid2			-.004(.0012)	0.001	-.0008 (.0001)***	0.00
INCM	.00001 (7.64e-06)	0.035	.00003 (8.37e-06)	0.000	.00001 (.000)***	0.00
EDU	.11 (.06)	0.086	-.007 (.07)	0.925	.019 (.01)	0.26
AGE	-.004 (.01)	0.769	-.004 (.01)	0.651	-.001(.003)	0.63
FAMSIZ	.18 (.08)	0.035	.007 (.07)	0.920	.034 (.02)	0.13
LANDSIZ	.21 (.08)	0.014	.11 (.07)	0.102	.06 (.02)**	0.01
EXPER	.06 (.04)	0.163	-.05 (.04)	0.256	.002 (.01)	0.85
CASHCROP	-1.26 (.49)	0.011	.35 (.51)	0.491	-.06 (.14)	0.66
PUMPING	1.26 (.41)	0.003	.37 (.49)	0.445	.36 (.14)***	0.01
CRED	.11(.27)	0.679	-.15 (.23)	0.506	-.008 (.07)	0.9
SEXHH	1.03 (.48)	0.032	-1.52 (.66)	0.021	.22 (.16)	0.17
OX	-.22 (.18)	0.224	-.21 (.16)	0.191	-.08 (.04)	0.08
OFFRINC	-.28 (.38)	0.457	-.79 (.38)	0.039	-.23 (.12)*	0.06
CORR	.0003(.007)	0.966	.006 (.0078)	0.337	.001 (.001)	0.5
DISSAT	1.84 (.55)	0.001	.30 (.83)	0.718	.55 (.16)***	0.001
_cons	-2.43 (1.15)	0.036	1.77 (.90)	0.049		
/athrho	.37 (0.62)					
Rho	.35					
Wald test of rho = 0: chi2(1) = .238641 Prob > chi2 = 0.0252						
Log pseudolikelihood = -136.47438						
Wald chi2(30) = 164.98 Prob > chi2 = 0.0000						

Survey estimation result, 2015

***, ** &* represent statistically Significant at 1 percent, 5 percent and 10 percent level of significant, respectively

Figures in parenthesis are robust standard Errors

Off farm income (OFFRINC), even if it is indeterminate as a prior, has a negative and a statistically significance impact on WTP in the case of follow up bids. The marginal effect shows that, other factors remain constant, households who have off farm income are 23 percent less likely to willing to pay for the improved irrigation water supply. The possible explanation of this may be due to households' expectation that engagement in off-farm activities have higher benefit than the benefit of irrigation farming.

Land holding size of the household is statistically significant at a conventional level. It is expected that as the land ownership of a household in timad increases, the opportunity of high income from crop production using irrigation water will be rise; this would lead to higher demand for improved irrigation water. Other factors remained constant, if land holding increases by one percent, the probability of accepting the bids increase by about 0.6 percent.

Having pumping motor is statistically significant at 1 percent level in the first equation. Although it is no statistically significant in the second equation, the marginal effect for full model shows that it is statistically significant at 5 percent. The effect of the variable on willingness to pay in the full model is positive. The marginal effect (from Table 4.6) shows that household heads who have pumping motor are 55 percent more likely to say yes for the proposed bids than those who have not. The rationale behind this result is that these farmers incur costs to irrigate their land using motor pump and also they are pumping water in a far distance from the main canal and/or river Abay/ Andasa. Thus, they support more the improvement of the existing irrigation scheme.

4.2.3. Results of the Tobit model

As discussed before in the methodology part, Tobit model is used to estimate the coefficients of explanatory variables for the open-ended questions to analyze factors that affect households'

maximum willingness to pay for improved irrigation water supply. The result of Tobit model is presented in as follows.

Table 4.7: the Tobit model results of the maximum willingness to pay

MWTP	Coef.	T	[95percent Conf.	Interval]
INCM	.008 (.001)***	6.12	.006	.011
EDU	9.27 (14.99)	0.62	-20.30	38.85
AGE	-2.35 (2.87)	-0.82	-8.022	3.31
FAMSIZ	33.86 (17.16)**	1.97	-.0005	67.73
LANDSIZ	39.31 (14.43)***	2.72	10.83	67.79
EXPER	8.18 (11.54)	0.71	-14.59	30.97
CASHCROP	-170.16 (99.44)	-1.71	-366.37	26.04
PUMPING	210.93 (85.54)***	2.47	42.15	379.71
CRED	59.80 (56.55)	1.06	-51.78	171.39
SEXHH	-10.739 (140.40)	-0.08	-287.75	266.28
OX	-74.62 (39.16)	-1.91	-151.89	2.65
OFFRINC	-49.49 (88.16)	-0.56	-223.44	124.45
CORR	1.42 (1.67)	0.85	-1.87	4.73
DISSAT	135.75 (146.24)	0.93	-152.77	424.29
_cons	-245.78 (203.35)	-1.21	-646.99	155.43
/sigma	375.04 (19.02)		412.57	

Survey estimation result, 2015

***, ** & * represent statistically Significant at 1 percent, 5 percent and 10 percent level of significant, respectively

Figures in parenthesis are robust standard Errors

In the Tobit model as shown in Table 4.7 income, family size, land size, and having pumping motor are statistically significant variables and the major determinant of maximum WTP for the improved irrigation water supply while the remaining variables are either insignificant or unexpected sign.

As expected, farming income has a positive impact on the household heads' maximum willingness to pay and it is statistically significant at 1 percent level of significance. This result is the same as the result obtained in the Probit and bivariate Probit models. Thus, annual income of the households is one of the major determinant of respondents' maximum willingness to pay for the improvement of existing irrigation water. Besides, family size and land size are significant at 5 and 1 percent level, respectively. They have also a positive impact on respondents' MWTP for the provision of improved irrigation water.

Finally, the variable having pumping motor is found to be significant at 5 percent level of significance. Its positive sign shows that, households who have pumping motor are more likely to support the improvement. That is, this variable also one of the determinant of MWTP for the improvement of the existing irrigation schemes.

4.3. Comparison of Single-Bounded and Double-Bounded Model Estimates

The referendum double bounded format (Hanemann et al., 1991) has emerged a means to improve efficiency in contingent valuation applications. Following Hanemann et al. (1991) Statistical efficiency of single bounded and double bounded model can be compared from three perspectives. First the precision of the estimates of constant and bid coefficients, which is measured using estimated standard errors; second the goodness of fit of the estimated WTP model; and third the precision of the estimates of welfare measures derived from the underlying coefficient estimates.

Table 4.8: Comparison of SBDC and DBDC model estimates of households' WTP

Answer1	Probit model				Bivariate Probit model			
	Coef	Std. Err.	Z	P>z	Coef	Std. Err.	Z	P>z
Bid1	-.005	.00112	-5.26	0.00	-.006	.00117	-5.40	0.00
Constant	-2.70	.97	-2.78	0.00	-2.43	1.15	-2.10	0.03
Number of obs = 197					Number of obs = 197			
Wald chi2(15) = 82.42					Wald chi2(30) = 164.98			
Prob > chi2 = 0.0000					Prob > chi2 = 0.0000			
Pseudo R ² = 0.4471								

Source; own survey, 2015

The coefficients of the bid and the constant terms are statistically significant for the two types of dichotomous-choice surveys, and standard errors of these coefficients of bids and constant terms are approximately the same for both double-bounded and single-bounded models. Besides, the two models have almost approximately the same value of z- statistics which is a measure of goodness of fit that does not much differing in the two models (Table 4.8).

This indicates that the use of double-bounded instead of single-bounded does not increase statistical efficiency. However, According to Jeanty, (2007) SBDC approach yields inefficient welfare measures due to limited information obtained from each respondent. When we compare the welfare amount which is calculated by using the mean WTP, DBDC gives higher value than SBDC model. Therefore, the bivariate Probit model estimates (DBDC model) was used to obtain the aggregate economic value of improved irrigation water supply.

4.4. Estimation of Mean WTP

The mean WTP estimation was made using the two bid price answers. It was conducted in two steps. The first step was estimation of the bivariate Probit model; then finding the mean WTP using `wtpciker` command in Stata 13. To estimate the mean WTP the study resort to simulating confidence intervals with the Krinsky Robb procedure. The Krinsky Robb method uses random draws from assumed multivariate normal distribution to generate new parameter vectors. Table 4.9 presents a summary of the WTP estimates produced by selected valuation models used in this study.

Table 4. 9: Summary of WTP and its Aggregate values

Elicitation format	Model	Mean WTP	Aggregate WTP for about 3,548 beneficiary households and 5820.5 ha. Land
Single bounded	Probit	454 Birr	10,570,028 Birr
Double bounded	Bivariate Probit	674.5 Birr	15,703,709 Birr
Open ended		579 Birr	13,480,278 Birr

Source; own survey, 2015

As the above Table shows the mean willingness to pay is higher in double-bounded dichotomous choice format than that of single-bounded and open-ended CVM. That is, when the mean willingness to pay from the DBDC and the open-ended questions are compared, the mean WTP of the DBDC, which is 674.5 Birr per year per 0.25 ha, is greater than that of the mean WTP of open-ended questions, which is 579 Birr per year per 0.25 ha. This result is consistent with the findings of Mezgeb et al (2013) who suggested a possible reason that respondents may want a free service from the government or become free riding in the open ended questions.

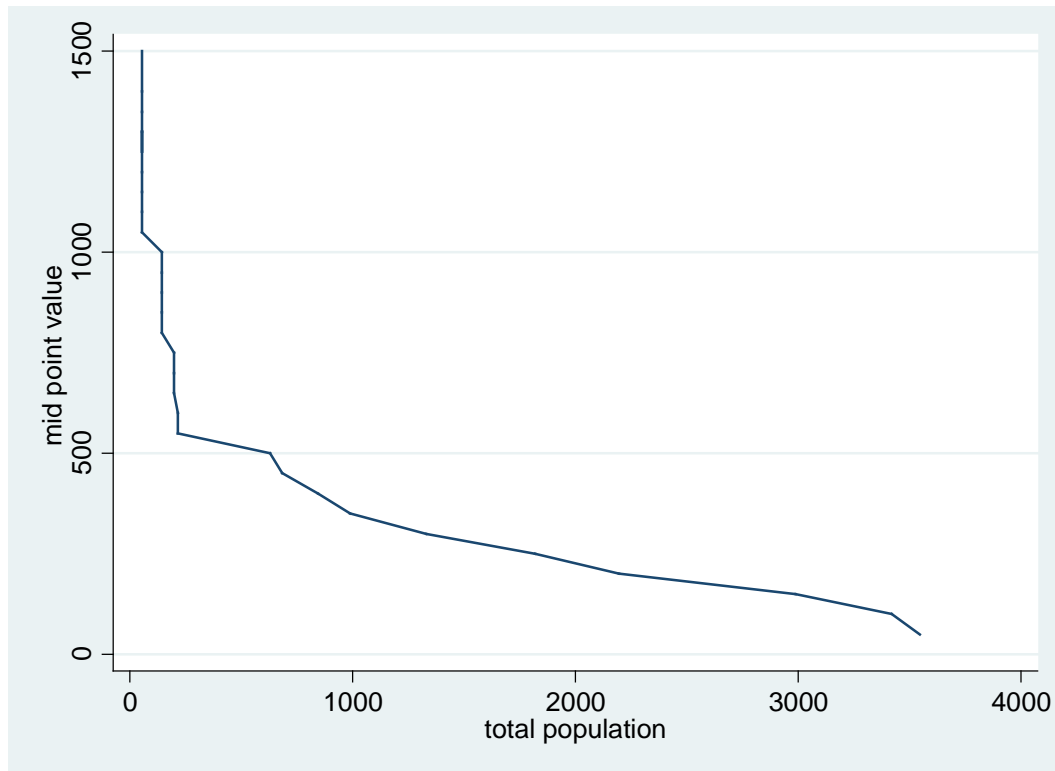
4.5. Estimating Aggregate Willingness to Pay (Aggregate Economic value)

The aggregate willingness to pay for improved irrigation water supply can be estimated by taking the total number of beneficiary households in the command area. According to the Bahir Dar zuria woeda Agricultural development office, (2015) the total number of irrigation beneficiary households is estimated about 3,548 and the total irrigable area is about 5820.5 ha. Based on this figures the expected aggregate willingness to pay for improved irrigation water supply using the DBDC and open ended question is estimated birr 15,703,709 and 13,480,278 per year, respectively.

4.6. Aggregate demand for the improved irrigation water

The demand for the improved irrigation water supply at different price level is shown diagrammatically in figure 4.2 below. The demand curve is derived with midpoint value of the maximum willingness to pay on the vertical axis and number of households in the command area on the horizontal axis.

Figure 4.2: Aggregate demand curve for the improved irrigation water provision



Source; own survey, 2015

Therefore, as it is shown in figure 4.2 the demand curve for the improved irrigation water is downward sloping and convex to the origin; it is in line with the economic theory of demand. This implies an increase in the price of the improved irrigation water decreases the quantity demand for the improved irrigation water, other things remain constant.

Chapter Five: Conclusion and Recommendation

5.1. Conclusion

Water is a finite and vulnerable resource which plays a vital role in economic development. Consequently, the development of water pricing mechanisms receives high priority among various tools for efficient water management. Pricing of water resources, therefore, require valuing of water. Irrigation water is generally regarded as non-market good. Thus, in this study Contingent Valuation Method (CVM) is used to estimate the value households are willing to pay for any attempt to improve the existing irrigation water provision in Bahir Dar zuria woreda, Ethiopia.

Data obtained from 197 sampled household heads were analyzed using both descriptive statistics and Econometric models. The descriptive analysis indicates that, out of the total respondents, 87.3 percent respondents claimed that their source of income is Agricultural activities. The remaining 12.7 percent obtained their livelihood both from agriculture and non-agricultural activities. The mean annual income of the respondents was about 42,619 birr per household. From the total mean annual income of a sampled household, cash crops contributes the highest income (birr 16,250) followed by cereal crops (8,728). However, these figures are significantly vary between irrigator and non-irrigator households. Unlike, irrigating households, non-irrigating households depend only on rain-fed cultivation.

As a result, irrigators had more income sources. The mean annual income of irrigators was about 45,572 birr per household. But the mean annual income of non-irrigators was less than half of the irrigators'; that is 21,329 birr per household. Such income differentials between irrigator and non-irrigator households are generally found to support the argument about the role of investment in irrigation as ensuring food security and a poverty reduction strategy.

Among the sample respondents 95.4 percent of them are dissatisfied with the existing irrigation water supply. This may be due to the problems found on the existing irrigation schemes. Attempt has been made to rank the major constraints of irrigated schemes from the most severe problems to the least ones specified by the sampled respondents. These are insufficient water supply (47.7 percent), absence of proper canals (35 percent), irrigation water access problem (12.2 percent), and other constraints (5.1 percent). That is why about 99 percent of the respondents are willing to pay for the improvement of the existing irrigation water supply.

In this study, three econometric models were employed; Probit, Bivariate Probit and Tobit. The result from the Probit model revealed that eight variables were significant in determining farmers' WTP for improved irrigation water supply. These are the bid level, farming income, education, family size, land size, having pumping motor, sex of the household heads, and dissatisfaction with the existing irrigation water supply. Explanatory variables such as age, irrigation experience, credit access, off farm income, number of oxen, corrugated iron sheet are insignificant. The remaining variable, having cash crops, has unexpected sign even if significant. In the Tobit model households' income, family size, land size, and having pumping motor are found to positively and significantly affect households' maximum willingness to pay for the improvement of the existing irrigation schemes.

Finally, in the Bivariate Probit model result, initial bid (Bid1), and follow-up bid (Bid2) and off farm income were found to have a negative and significant effect on the households' probability of accepting that bid. In this model, variables such as income, land size, having pumping motor and dissatisfaction with the existing irrigation water supply have a positive effect on the households' probability of WTP for the provision of improved irrigation water.

In this study, the mean willingness to pay from the dichotomous choice questions were computed using the Krinsky Robb method. Therefore, the mean willingness to pay for the provision of improved irrigation water from the double bounded dichotomous question was Birr 674.5 per year/0.25 ha. On the other hand, the mean willingness to pay from open-ended questions was Birr 579 per year/0.25 ha. Thus, in this study, the mean willingness to pay from open-ended questions is lower than the dichotomous choice questions.

The last but very crucial result of the study revealed that the expected aggregate willingness to pay for irrigation water supply using the DBDC and open ended question is estimated about birr 15,703,709 and 13,480,278 per year, respectively. This showed that the value of irrigation water from open ended format was underestimated.

5.2. Policy Implication

From the survey response of the sampled households, the current irrigation water supply system of the command area is not reliable and cannot satisfy the existing demand and thus farmers are eager to have reliable and improved irrigation water supply. Based on the findings of this study we can draw the following policy implications.

- The irrigation in the study area is contributing a lot to the wellbeing of the society. It provides smooth livelihood to many households and also guarantees a steady income for irrigators in terms of revenue. Average annual income of irrigators is twice more than that of non-irrigators. Therefore, it is really important to pay serious attention to expand the potential area under irrigation so as to bring a substantial contribution to the attainment of food self-sufficiency and to alleviate poverty.
- In the study area, there is a problem of proper water distribution canal especially in Chila and Negida irrigation schemes. Irrigation water sank in to the soil before it reached the irrigable

land. This leads to a higher water wastage and distribution problem. Moreover, this forced farmers to spend a higher fuel costs since they use pumping motor to irrigate their land. Therefore, concerned body should give attention for proper canal construction and improvement in a better way to maximize the optimal utilization of irrigation and to enhance proper water utilization.

- The empirical findings of the study revealed that several socio-economic variables are key factors influencing respondents' WTP. Therefore, understanding of socio-economic characteristics that influenced households' WTP significantly is a necessary and first step, for the concerned body, to achieve improved irrigation water and then to implement irrigation water pricing.

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APPENDIXES

Appendix 1: Questionnaire

ADDIS ABABA UNIVERSITY

ECONOMICS DEPARTMENT

This questionnaire is prepared to undertake a study on Economic Valuation of Irrigation

Water in Chilal Abay, Negida and upper Andasa Irrigation schemes

Farmer's (household's) name: _____

Questionnaire no.

Place of Interview (Kebele): _____

Enumerator: _____

Date of interview: _____

Length of interview in Minutes: _____

Part I: Introduction

Hello, how are you. I am _____. This interview is used for the research of Mr. Ayana Anteneh who is currently studying at Addis Ababa University. This research is a partial fulfillment for the awarded of MSc in economics. He is conducting a survey which focuses on valuation of Chilal, Negida, Andasa Irrigation schemes and their improvement. Now you are randomly selected and asked to give information about your socio economic characteristics, your experience in irrigation, and others as well as your support (willingness to pay) for the improvement of these irrigation projects. The result of this study will help different stakeholders and policy makers to make appropriate measures on irrigation development in the future. Whatever information you

provide will be kept strictly confidential. Therefore, you are kindly requested to provide genuine responses.

Thank you in advance for giving time for this interview

Part II: Socio- economic characteristics of the household

1. Sex of the household head _____ 1= Male 0 = Female
2. Age of the household head _____
3. Education of the household head _____
4. Total family numbers of the household _____
5. Occupation: 1. Farmer 2. Student 3. Trade 4. civil servant Other _____
6. Number of oxen _____
7. The roofing of your house is basically _____
 1. Grass
 2. Corrugated iron sheet
8. If it is corrugated iron sheet, how many sheets have you used in making the roof? _____
9. Do you have any land with holding rights? 1= Yes 0= No
10. If yes, how many timad / (0.25 hectare) of irrigable land do you have? _____
11. How many timad of Land did you cultivate (own and rent) in 2006/07? _____
12. Farm income _____ (use the following four consecutive Tables).
 - 12.1.** Income from crop production and vegetable, fruit and others harvesting during last year (use the following two Tables).

Household Crop production and Sales

NO	Type of Crops	Plot Size (Timad)	Total production (quintal,	Consumed at home (quintal, Kg)	Sold	
					Amount (quintal, kg)	Value (ETB)
1	Teff					
2	Maize					
3	Wheat					
4	Barely					
5	Sorghum					
6	Millet					
7	Dagusa					
8	Beans					
9	Pea					
10	Chickpea					
12	Lentil					
13	Noug					
16	Linseed					
17	Garlic					
19	Other crops					

Vegetable, Fruit, cash crops and woodlot production						
No	Type of Crop grown	Plot Size (Timade)	Total production (quintal, Kg)	Consumed at home (quintal, Kg)	Sold	
					Amount (quintal, kg)	Value (birr)
Vegetable						
1	Tomato					
2	Potato					
3	Pepper					
4	Onion					
5	Cabbage					
6	Kosta					
7	Others					
Fruit						
1	Avocado					
2	Papaya					
3	Mango					
4	Lemon					
5	Others					
Woodlots						
1	Eucalyptus					
2	Gesho					
Cash crops						
1.	Chat					
2.	Sugarcane					
3.	Coffee					
4.	Others					

12.2. Income from livestock sales and livestock by products during the last year (use the following two Tables).

Livestock Production					
No.	Type of animal	No of animals	Total owned	If there is any sold animal	
				Sold	Income gained
1	Cow				
2	Bull				
3	Heifer				
4	Calf				
5	Ox				
6	Mules				
7	Horse				
8	Donkey				
9	Goat				
10	Sheep				
11	Poultry				
12	Bee colony				
	Other				

Livestock output				
No.	Commodity type	Amount produced (liter, Kg, no)	Consumed (liter, Kg, no)	Sold (Birr)
1.	Dairy output			
	1.1 fluid milk			
	1.2 Butter			
	1.3 Yoghurt			
	1.4 Cheese			
2.	Poultry			
	2.1 Egg			
	2.2 Chicken			
3.	Honey bee			
	3.1 Honey			
	3.2 Bees wax			
	3.3 Bee colony			
4.	Animal by-products			
	Hide and skin			
	Manure/Dung			

13. Off farm income _____

Do any member of your family has involved last year on off farm activities? 0 = No 1 = Yes,
if the answer is yes, in which one from the next Table.

No	Off-Farm activities	How many weeks per month did you work	How many hours a week did you work	wage/ income per day (Birr) (If in kind, convert in to Birr using local price)	Income per month (Birr) (If in kind, convert in to Birr using local price)
1	Working on other' farm (manual work)				
3	Daily laborer on construction or other non- farm activities				
4	Self-employment in manufacturing e.g. Artisan (blacksmith, weaving, pottery, Tannery)				
5	Sales of fuel wood (or Charcoal)				
6	Sales of local drink and food (tela, teji, arekie, injera and bread)				
7	Driver (mini bus, Bajaj, chart or others)				
8	Carpenter				
9	Tailor				
10	Remittance				
11	Trade				
12	Aid				
13	Others				

Part III: Households' Experience

14. Do you have irrigation experience? 1. Yes 0. No

15. If the answer is yes, how long have you been in irrigation farming? _____ Year/s.

16. Are you growing cash crops using irrigation water? 1. Yes 0. No

17. If yes to Q # 16, which cash crop you are growing?

1. Sugarcane 2. Chat 3. Coffee 4. Other (specify) _____.

18. Do you have motor pumps which uses to irrigate your land?

1. Yes 0. No

19. If no to Q # 18 and yes to Q # 14 how did/ do you get irrigation water?

1. Renting pumping motor 2. Diverting from the main canal or river Abay/Andasa

3. Other _____

20. Do/did you need credit for the production of your agricultural products?

1. Yes 0. No

21. If yes, do/did you have any access to credit for the production of the Commodities?

1. Yes 0. No

22. What is the source of your Credit?

1 = Friends/relatives 2 = Traders 3 = Banks 4 = Microfinance

23. Are you dissatisfied with the current irrigation water supply system?

1. Yes 0. No

24. If Yes for Q #24, what kind of challenges and problems you have faced/observed in the existing irrigation schemes? Specify all bellow

1. _____ 2. _____

3. _____ 3. _____

25. What are the major types of crops you produce or grow under irrigated?

1 _____ 2 _____ 3 _____ 4 _____

26. Why you prefer to produce the crops you mentioned above as your major choice?

27. Which type of crop you produce is high source of your income? _____

28. Do you get enough water for your irrigational and livelihood activities from this irrigation project?

1. Yes 0. No

29. If you had shortage of irrigation water, what do you do?

1. Uses only part of the irrigation,
2. Planted crops that require less water
3. Producing partially

Part IV: Contingent Valuation survey

Willingness to pay questions

Background

As you know that the Chilal Abay, Negida, and upper Andasa irrigation schemes are found in your vicinity. The source of water for the irrigation are the River Abay and Andasa, respectively. They have enough amount of discharge in the rainy season. However, the rivers seem to decrease their flow in the dry season in large amount. None of these irrigation schemes have water storage capacity since water is comes out to the command area from the rivers by diversion. This will creates a problem at the time of dry season at which more water for irrigation is needed. Hence in order to improve the existing water supply of these irrigation projects, the water capacity of the Rivers should be enhanced through developing water storage capacity. To do so dam construction is a prerequisite to reserve/ store water which enables farmers to get sufficient water flow throughout the year.

Suppose the dam is constructed in your community. The dam and resulting reservoir will provide numerous benefits. Once the dam has been built, people will be able to irrigate their land throughout the year, swimming, boating, and fishing in the reservoir. The dam is also expected to provide flood control benefits for downstream residents. However, the high cost of construction of a dam make it difficult to implement proper provision of improved irrigation water without people paying for it. Moreover, the sustainability of irrigation projects depends on taking into consideration of environmental effects as well as on the availability of funds for the maintenance

of the implemented schemes. Negative environmental impacts could have a serious effect on the investments in the irrigation sector. Adequate maintenance funds should be provided to the implementing project to carry out both regular and emergency maintenance.

Irrigation systems need yearly maintenance and repair. Without this irrigation scheme will become dysfunctional within a few years. Farmers are expected to pay water fees to cover the operation and maintenance costs of irrigation schemes. Therefore, an effective and sustainable provision of improved irrigation water will be implemented if the households in the community pay a sufficient amount of money.

Based on this clue, now you will be asked some questions regarding an improved irrigation water provision that may be implemented in your community.

1. Are you willing to participate in this program to get year round water supply?

1. Yes 0. No

If your answer No, please respond to question #2; otherwise answer question #3.

2. If no, what is your reason?

- A. Irrigation Water should be freely provided
- B. I am satisfied with the existing source
- C. It is the responsibility of the government to provide
- D. I don't have enough money
- E. Other reasons _____

3. Are you (would you be) willing to pay _____ birr per Timad (0.25 ha) of irrigable land per year?

1. Yes 0. No

If the answer for this question is yes, proceed for question 4 and otherwise go to question 5.

4. Are you willing to pay _____ (**2B**) birr per Timad (0.25 ha) of irrigable land per year?

1. Yes 0. No

5. Are you willing to pay _____ (**0.5B**) birr per Timad (0.25 ha) of irrigable land per year?

1. Yes 0. No

6. What is the maximum amount that you are willing to pay for one Timad (0.25 ha) of irrigable land per year? _____ Birr.

7. If yes in 3 and yes in 4 and If the respondent maximum willingness to pay in Q.4 is greater than in Q.6, then ask, You said that you are willing to pay -----ETB (in Q.4) but when I ask you your maximum willingness to pay you said----- ETB (inQ.6) which is less than the amount you already agreed to pay previously Why? _____

8. If yes in 3 and no in 4 and If the respondent maximum willingness to pay Q.3 is greater than in Q.6, then ask, You said that you are willing to pay _____ birr (in Q.3) but when I ask you your maximum willingness to pay you said _____ birr (in Q.6) which is less than the amount you already agreed to pay previously Why? _____

9. If no in 3 and yes in 5 and If the respondent maximum willingness to pay Q.5 is greater than in Q.6, then ask You said that you are willing to pay _____ birr (in Q.5) but when I ask you your maximum willingness to pay you said _____ birr (in Q.6) which is less than the amount you already agreed to pay previously Why? _____

THANK YOU FOR YOUR COOPERATION!!!

Appendix 2: Correlation Matrix of the explanatory variables

corr bid1 answer1 bid2 answer2 MWTP INCM EDU AGE FAMSIZ LANDSIZ EXPER

CASHCROP PUMPING CRED SEXHH OX OFFRINC CORR DISSAT (obs=197)

	INCM	EDU	AGE	FAMSIZ	LANDSIZ	EXPER	CASHCROP
INCM	1.0000						
EDU	0.2022	1.0000					
AGE	0.0244	-0.1153	1.0000				
FAMSIZ	0.2799	-0.0248	0.2761	1.0000			
LANDSIZ	0.2577	-0.0001	0.5004	0.3584	1.0000		
EXPER	0.4644	0.2264	-0.0557	0.2189	0.1144	1.0000	
CASHCROP	0.3860	0.1237	-0.0948	0.1354	0.0825	0.5716	1.0000
PUMPING	0.3016	0.0378	-0.0485	0.1382	0.1010	0.3875	0.6227
CRED	-0.1339	0.0474	-0.0790	-0.1268	-0.1064	-0.1662	-0.0309
SEXHH	0.1333	0.0675	-0.0709	0.0714	-0.0549	0.1622	0.1800
OX	0.2951	0.0461	0.0227	0.2872	0.3189	0.1745	0.2047
OFFRINC	-0.1675	0.0975	0.1263	0.0448	0.1686	-0.0579	-0.0455
CORR	0.5253	0.1238	0.1083	0.3924	0.2290	0.3651	0.3046
DISSAT	0.1164	0.0203	-0.0739	0.0264	0.0187	0.1260	0.1395

	PUMPING	CRED	SEXHH	OX	OFFRINC	CORR	DISSAT
PUMPING	1.0000						
CRED	0.0179	1.0000					
SEXHH	0.2598	0.0076	1.0000				
OX	0.1968	-0.1417	0.1607	1.0000			
OFFRINC	-0.0832	0.0802	-0.1897	-0.1316	1.0000		
CORR	0.3030	-0.1317	0.1706	0.3757	-0.0706	1.0000	
DISSAT	0.0547	-0.0125	0.3924	0.1156	-0.2087	0.0985	1.0000

Appendix 3: Multicollinearity test

Variable	VIF	1/VIF
CASHCROP	2.14	0.466487
PUMPING	1.79	0.558556
EXPER	1.79	0.559842
INCM	1.75	0.572469
LANDSIZ	1.73	0.576456
CORR	1.67	0.598947
AGE	1.48	0.674970
OX	1.38	0.726775
FAMSIZ	1.37	0.727813
SEXHH	1.32	0.756705
DISSAT	1.25	0.798289
OFFRINC	1.20	0.830981
EDU	1.14	0.880870
CRED	1.08	0.922174
Mean VIF	1.51	

Appendix 4: Heteroskedasticity test

hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

Ho: Constant variance

Variables: fitted values of MWTP

chi2(1) = 120.50

Prob > chi2 = 0.0000

Cameron & Trivedi's decomposition of IM-test

Source	chi2	Df	p
Heteroskedasticity	104.25	101	0.3925
Skewness	19.24	14	0.1558
Kurtosis	3.69	1	0.0547
Total	127.18	116	0.2251

Appendix 5: Probit regression

probit answer1 bid1 INCM EDU AGE FAMSIZ LANDSIZ EXPER CASHCROP PUMPING

CRED SEXHH OX OFFRINC CORR DISSAT, robust

Iteration 0: log pseudolikelihood = -114.71255

Iteration 1: log pseudolikelihood = -65.625983

Iteration 2: log pseudolikelihood = -63.435439

Iteration 3: log pseudolikelihood = -63.422777

Iteration 4: log pseudolikelihood = -63.42277

Iteration 5: log pseudolikelihood = -63.42277

Probit regression

Number of obs = 197

Wald chi2(15) = 82.42

Prob > chi2 = 0.0000

Log pseudolikelihood = -63.42277

Pseudo R2 = 0.4471

answer1	Coef.	Robust Std. Err.	z	P>z	[95percent Conf.	Interval]
bid1	-.0059298	.0011281	-5.26	0.000	-.0081408	-.0037187
INCM	.000016	7.69e-06	2.08	0.037	9.26e-07	.0000311
EDU	.1179415	.0631551	1.87	0.062	-.0058403	.2417232
AGE	-.0040895	.0136217	-0.30	0.764	-.0307876	.0226086
FAMSIZ	.1754475	.0879131	2.00	0.046	.003141	.347754
LANDSIZ	.2078805	.0888509	2.34	0.019	.033736	.382025
EXPER	.07046	.0512233	1.38	0.169	-.0299357	.1708557
CASHCROP	-1.254272	.5120006	-2.45	0.014	-2.257774	-.2507689
PUMPING	1.294549	.4344592	2.98	0.003	.4430249	2.146074
CRED	.0975743	.2869535	0.34	0.734	-.4648442	.6599929
SEXHH	1.151871	.4351419	2.65	0.008	.299009	2.004734
OX	-.2291319	.1892216	-1.21	0.226	-.5999996	.1417357
OFFRINC	-.2560114	.3831321	-0.67	0.504	-1.006937	.4949138
CORR	.0002751	.007812	0.04	0.972	-.0150362	.0155863
DISSAT	1.883261	.555536	3.39	0.001	.7944306	2.972092
_cons	-2.70831	.9730019	-2.78	0.005	-4.615359	-.8012614

Appendix 6: Marginal effects after Probit regression

$$y = \text{Pr}(\text{answer1}) (\text{predict})$$

$$= .83263907$$

variable	dy/dx	Std. Err.	z	P>z	[95percent	C.I.]	X
bid1	-.0014855	.00025	-6.04	0.000	-.001968	-.001003	296.954
INCM	4.01e-06	.00000	2.04	0.041	1.6e-07	7.9e-06	41978.1
EDU	.0295469	.01625	1.82	0.069	-.002306	.061399	.954315
AGE	-.0010245	.00339	-0.30	0.763	-.007674	.005625	42.7208
FAMSIZ	.0439534	.0206	2.13	0.033	.003581	.084326	5.66497
LANDSIZ	.0520786	.02089	2.49	0.013	.011144	.093013	4.8198
EXPER	.0176518	.01325	1.33	0.183	-.008319	.043622	4.67005
CASHCROP*	-.2109082	.06446	-3.27	0.001	-.337245	-.084571	.807107
PUMPING*	.409868	.15816	2.59	0.010	.09988	.719856	.771574
CRED*	.0242512	.0699	0.35	0.729	-.112758	.161261	.416244
SEXHH*	.3980977	.1686	2.36	0.018	.067653	.728542	.949239
OX	-.0574025	.0493	-1.16	0.244	-.154028	.039223	1.75635
OFFRINC*	-.0699597	.11213	-0.62	0.533	-.289725	.149805	.126904
CORR	.0000689	.00196	0.04	0.972	-.003767	.003904	59.4924
DISSAT*	.6507565	.15459	4.21	0.000	.347773	.95374	.954315

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

Appendix 7: Bivariate Probit regression

```
biprobit ( answer1= bid1 INCM EDU AGE FAMSIZ LANDSIZ EXPER CASHCROP PUMPING  
CRED SEXHH OX OFFRINC CORR DISSAT) ( answer2 = bid2 INCM EDU AGE FAMSIZ  
LANDSIZ EXPER CASHCROP PUMPING CRED SEXHH OX OFFRINC CORR DISSAT),  
robust
```

Fitting comparison equation 1:

Iteration 0: log pseudolikelihood = -114.71255

Iteration 1: log pseudolikelihood = -65.625983

Iteration 2: log pseudolikelihood = -63.435439

Iteration 3: log pseudolikelihood = -63.422777

Iteration 4: log pseudolikelihood = -63.42277

Iteration 5: log pseudolikelihood = -63.42277

Fitting comparison equation 2:

Iteration 0: log pseudolikelihood = -112.66146

Iteration 1: log pseudolikelihood = -75.337762

Iteration 2: log pseudolikelihood = -73.509848

Iteration 3: log pseudolikelihood = -73.487738

Iteration 4: log pseudolikelihood = -73.487725

Iteration 5: log pseudolikelihood = -73.487725

Comparison: log pseudolikelihood = -136.9105

Fitting full model:

Iteration 0: log pseudolikelihood = -136.9105

Iteration 1: log pseudolikelihood = -136.48569

Iteration 2: log pseudolikelihood = -136.4744

Iteration 3: log pseudolikelihood = -136.47438

Iteration 4: log pseudolikelihood = -136.47438

Seemingly unrelated bivariate probit	Number of obs =	197
	Wald chi2(30) =	164.98
Log pseudolikelihood = -136.47438	Prob > chi2 =	0.0000

Coef.	Robust Std. Err.	Z	P>z		[95percent Conf. Interval]	
answer1						
bid1	-.0063343	.0011735	-5.40	0.000	-.0086342	-.0040343
INCM	.0000161	7.64e-06	2.10	0.035	1.10e-06	.000031
EDU	.1105495	.0643466	1.72	0.086	-.0155675	.2366664
AGE	-.0040083	.0136563	-0.29	0.769	-.030774	.0227575
FAMSIZ	.1813368	.0861607	2.10	0.035	.0124649	.3502087
LANDSIZ	.2131344	.0864648	2.46	0.014	.0436666	.3826022
EXPER	.0690632	.0494971	1.40	0.163	-.0279493	.1660757
CASHCROP	-1.265957	.4972178	-2.55	0.011	-2.240486	-.2914279
PUMPING	1.260831	.4185621	3.01	0.003	.440464	2.081197
CRED	.1152403	.2782001	0.41	0.679	-.4300219	.6605025
SEXHH	1.035036	.4832382	2.14	0.032	.0879064	1.982165
OX	-.2281285	.18771	-1.22	0.224	-.5960333	.1397762
OFFRINC	-.283022	.3808162	-0.74	0.457	-1.029408	.463364
CORR	.0003377	.007866	0.04	0.966	-.0150793	.0157548
DISSAT	1.841093	.559212	3.29	0.001	.7450576	2.937129
_cons	-2.43173	1.15869	-2.10	0.036	-4.70272	-.1607401
answer2						
bid2	-.0041922	.0012512	-3.35	0.001	-.0066446	-.0017398
INCM	.0000392	8.37e-06	4.68	0.000	.0000228	.0000556
EDU	-.0073967	.0790174	-0.09	0.925	-.1622679	.1474746
AGE	-.0049676	.0109732	-0.45	0.651	-.0264747	.0165394
FAMSIZ	.0079041	.0786146	0.10	0.920	-.1461776	.1619858
LANDSIZ	.1170102	.0714737	1.64	0.102	-.0230756	.257096
EXPER	-.0558359	.0491146	-1.14	0.256	-.1520987	.0404269
CASHCROP	.3529752	.512782	0.69	0.491	-.6520591	1.35801
PUMPING	.3790494	.4963162	0.76	0.445	-.5937124	1.351811
CRED	-.1565594	.2354464	-0.66	0.506	-.6180259	.3049072

SEXHH	-1.529776	.6608439	-2.31	0.021	-2.825006	-.2345455
OX	-.2109719	.1614057	-1.31	0.191	-.5273213	.1053776
OFFRINC	-.7945554	.385001	-2.06	0.039	-1.549143	-.0399673
CORR	.0067258	.0070058	0.96	0.337	-.0070054	.020457
DISSAT	.3024902	.8373899	0.36	0.718	-1.338764	1.943744
_cons	1.777269	.9016004	1.97	0.049	.0101645	3.544373
/athrho	.3713785	.7602279	0.49	0.625	-1.118641	1.861398
Rho	.3551969	.6643138		-.8070956	.9528078	

Wald test of rho=0: chi2(1) = .238641 Prob > chi2 = 0.0252

Appendix 8: Marginal effects after biprobit regression

$y = \text{Pr}(\text{answer1}=1, \text{answer2}=1) (\text{predict})$

= .732513

variable	dy/dx	Std. Err.	z	P>z	[95percent	C.I.]	X
bid1	-.0011665	.00027	-4.33	0.000	-.001694	-.000639	296.954
INCM	.0000101	.00000	3.62	0.000	4.6e-06	.000016	41978.1
EDU	.0190185	.01703	1.12	0.264	-.014357	.052394	.954315
AGE	-.001638	.0034	-0.48	0.630	-.008297	.005021	42.7208
FAMSIZ	.0348261	.02352	1.48	0.139	-.011269	.080921	5.66497
LANDSIZ	.060446	.02396	2.52	0.012	.013486	.107406	4.8198
EXPER	.002604	.01428	0.18	0.855	-.025379	.030587	4.67005
CASHCROP*	-.0629639	.14731	-0.43	0.669	-.351682	.225754	.807107
PUMPING*	.3615842	.14242	2.54	0.011	.082444	.640725	.771574
CRED*	-.0080631	.0709	-0.11	0.909	-.147031	.130905	.416244
SEXHH*	.222976	.16561	1.35	0.178	-.101622	.547574	.949239
OX	-.080228	.04665	-1.72	0.085	-.171655	.011199	1.75635
OFFRINC*	-.2327839	.12478	-1.87	0.062	-.477344	.011776	.126904
CORR	.0012805	.00194	0.66	0.510	-.002531	.005092	59.4924
DISSAT*	.550194	.16238	3.39	0.001	.231935	.868454	.954315
bid2	-.0007594	.00013	-5.83	0.000	-.001015	-.000504	434.772

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

Appendix 9: Tobit regression

tobit MWTP INCM EDU AGE FAMSIZ LANDSIZ EXPER CASHCROP PUMPING CRED
SEXHH OX OFFRINC CORR DISSAT, ll(0)

Tobit regression

Number of obs = 197

LR chi2(14) = 101.33

Prob > chi2 = 0.0000

Log likelihood = -1434.4215

Pseudo R2 = 0.0341

MWTP	Coef.	Std. Err.	T	P>t	[95percent Conf.	Interval]
INCM	.0089937	.0014697	6.12	0.000	.006094	.0118935
EDU	9.274009	14.99182	0.62	0.537	-20.30504	38.85306
AGE	-2.355498	2.872093	-0.82	0.413	-8.022173	3.311176
FAMSIZ	33.8691	17.16647	1.97	0.050	-.0005453	67.73875
LANDSIZ	39.31544	14.43265	2.72	0.007	10.83964	67.79124
EXPER	8.188285	11.54945	0.71	0.479	-14.59891	30.97548
CASHCROP	-170.1666	99.44756	-1.71	0.089	-366.3778	26.04461
PUMPING	210.9343	85.54377	2.47	0.015	42.1554	379.7132
CRED	59.80508	56.55742	1.06	0.292	-51.78339	171.3935
SEXHH	-10.73064	140.4047	-0.08	0.939	-287.7508	266.2896
OX	-74.62162	39.16742	-1.91	0.058	-151.8994	2.656171
OFFRINC	-49.49428	88.16269	-0.56	0.575	-223.4403	124.4518
CORR	1.428935	1.676268	0.85	0.395	-1.878363	4.736232
DISSAT	135.7573	146.2411	0.93	0.354	-152.7782	424.2927
_cons	-245.7822	203.3514	-1.21	0.228	-646.997	155.4325
/sigma	375.0454	19.02065		337.5174	412.5733	

Obs. summary: 2 left-censored observations at MWTP<=0
195 uncensored observations
0 right-censored observations