

**FARMERS' WILLINGNESS TO PAY FOR IMPROVED IRRIGATION
WATER USE: THE CASE OF WOLISO DISTRICT, SOUTH WEST
SHOA ZONE, OROMIA NATIONAL REGIONAL STATE, ETHIOPIA**

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**Farmers' Willingness to Pay for Improved Irrigation Water Use: The
Case of Woliso District, South West Shoa Zone, Oromia National
Regional State, Ethiopia**

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MASTER OF SCIENCE IN AGRICULTURE (AGRICULTURAL
ECONOMICS)**

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DEDICATION

This manuscript is dedicated to my sister Zenebech Tolera who worked hard to educate me and always very eager to see my success. Furthermore, this work is dedicated in memory of all my brothers and sisters who had sacrificed and lost their lives on October 2, 2016 on Ayyaana Irreecha at Hora-Harsadee, and may their gentle and loving souls rest in peace.

STATEMENT OF THE AUTHOR

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ACRONOMYS AND ABBREVIATIONS

ADF	African Development Fund
ATP	Ability to pay
CSA	Central Statistical Agency of Ethiopia
CV	Contingent Valuation
CVM	Contingent Valuation Method
ETB	Ethiopian Birr
FAO	Food and Agriculture Organization
GTP	Growth and Transformation Plan
HPM	Hedonic Pricing Method
Mha	Million hectares
MoA	Ministry of Agriculture
MWTP	Maximum Willingness to Pay
NPC	National Planning Commission
OLS	Ordinary Least Squares
TCM	Travel Cost Method
WTA	Willingness to Accept
WTP	Willingness to Pay
WWAdO	Woliso Woreda Administrative Office
WWIDAO	Woliso Woreda Irrigation Development Authority Office

TABLE OF CONTENTS

Contents	Page
BIOGRAPHIC SKETCH	v
ACKNOWLEDGEMENTS	vi
ACRONOMYS AND ABBREVIATIONS	vii
LIST OF TABLES	x
LIST OF FIGURES	xi
LIST OF TABLES IN THE APPENDIX	xii
ABSTRACT	xiii
1. INTRODUCTION	1
1.1. Background of the study	1
1.2. Statement of the Problem	3
1.3. Research Questions	5
1.4. Objectives of the Study	5
1.5. Significance of the Study	5
1.6. Scope and Limitations of the Study	6
1.7. Organization of the Study	6
2. REVIEW OF LITERATURE	7
2.1. General Overview of Irrigation	7
2.2. Economic Importance of Irrigation Development	8
2.3. Irrigation Potential and Development in Ethiopia	10
2.4. Methodological Framework	11
2.4.1. Review of valuation approaches and methods	11
2.4.1.1. The revealed preference methods	12
2.4.1.2. Stated preference methods	13
2.4.2. Valuation of natural resources	17
2.4.3. Economic valuation of irrigation water	18
2.5. Theoretical Framework	19
2.6. Conceptual Framework	20
2.7. Empirical Literature Review	21
3. RESEARCH METHODOLOGY	27

TABLE OF CONTENTS (CONTINUED...)

3.1. Description of the Study Area	27
3.2. Data type, Sources and Methods of Data Collection	29
3.3. Sampling Technique and Sample Size	29
3.4. Methods of Data Analysis	31
3.4.1. Descriptive and inferential statistics	31
3.4.2. Econometric model specification	31
3.5. Description of Variables and Working Hypothesis	36
3.5.1. Dependent variables	36
3.5.2. Independent variables	37
4. RESULTS AND DISCUSSIONS	42
4.1. Descriptive Analysis	42
4.1.1. Households' characteristics	42
4.1.2. Institutional characteristics of sample households	44
4.1.3. Farm characteristics and resource ownership of sample households	44
4.1.4. Households' willingness to pay for the improved irrigation water	47
4.2. Econometric Analysis Results	49
4.2.1. Users' mean willingness to pay for improved irrigation water	49
4.2.2. Estimating aggregate willingness to pay	51
4.2.3. Estimated demand for the improved irrigation water	52
4.2.4. Determinants of willingness to pay for improved irrigation water use	52
5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS	59
5.1. Summary and Conclusion	59
5.2. Recommendations	60
6. REFERENCES	64
7. APPENDICES	76

LIST OF TABLES

Table	Page
1. Distribution of sample households drawn from each kebele	30
2. Descriptions and expected signs of the explanatory variables	41
3. Summary of households' characteristics according to their willingness to pay for improved irrigation water use	43
4. Summary of institutional characteristics of sample households	44
5. Summary of farm characteristics and resource ownership of sample households	46
6. Distribution of sample households who are willing and non-willing to pay for improved irrigation water use	48
7. Frequency of sample households' discrete response	48
8. The estimated mean WTP	51
9. The Tobit model results of the maximum willingness to pay	56
10. Marginal effects of explanatory variables on the amount of willingness to pay	57

LIST OF FIGURES

Figure	Page
Figure 1: Conceptual framework for estimating economic value of irrigation water	21
Figure 2: Physical Map of the Study Area	28
Figure 3: Estimated demand curve for improved irrigation water use	52

LIST OF TABLES IN THE APPENDIX

Appendix Table	Page
1. Correlation matrix of the explanatory variables	77
2. Parameter estimates of Seemingly Unrelated Bivariate Probit model	78
3. Summary of Discrete Responses to the Double- Bounded Questions	78
4. Conversion for adult equivalent	78
5. Summary of survey questionnaire	79

Farmers' Willingness to Pay for Improved Irrigation Water Use: The Case of Woliso District, South West Shoa Zone, Oromia National Regional State, Ethiopia

ABSTRACT

As scarcity of irrigation water is rising, pricing of agricultural water and cost recovery can play a significant role in promoting water use efficiency. Hence, the main objective of this study was to analyze farmers' willingness to pay for improved irrigation water use, and identify its determinants using the contingent valuation method. Both primary and secondary data were used to achieve the objective. Cross sectional data were collected from 251 households using a two-stage sampling technique (purposive and random sampling techniques) from four kebeles of Woliso District through a semi-structured questionnaire. The result of the study showed that 92.43% of the households were willing to pay for improved irrigation water use and only 7.57% were not willing to pay. The mean willingness to pay for the use of improved irrigation water from the double bounded dichotomous question of Seemingly Unrelated Bivariate Probit model was Birr 575.23 per year per timad (0.25 ha). On the other hand, the mean willingness to pay from open-ended questions was Birr 562.25 per year per timad (0.25 ha). The result from the Tobit model revealed that education level of the household head, family size, irrigable land size, number of oxen owned, total annual income, experience in irrigated farming, dissatisfaction with existing irrigation use, credit utilization and cash crops growing are important variables that significantly and positively affect farm households' WTP for the improvement of the existing irrigation use whereas initial bid was found to have a negative and significant effect on the households' probability of accepting offered bid. Since these variables are identified as major determinants of willingness to pay for improved irrigation water use, policy makers and government should take into account these socio-economic and demographic characteristics in designing the improved irrigation water supply system for the users.

Keywords: Contingent Valuation; Willingness to Pay; Irrigation; Seemingly Unrelated Bivariate Probit; Tobit Model; Woliso.

1. INTRODUCTION

1.1. Background of the study

Water is a finite and vulnerable resource for which irrigation water is generally regarded as non-market good, plays a vital role in economic development (Ayana, 2016). However, the future use and quality of water resources is affected by the effective use, financing and management of water in addition to the most important factor of population size. As a result, one of the determining factors of water availability will be water users and, their willingness to pay for the financing of systems and the sustainable management of water resources (Aydogdu, 2012).

In many parts of the world including developed world, irrigation farming has been necessitated by the growing land shortage and the need to maximize on the limited land available to grow food (Moyo *et al.*, 2015). Irrigation, being one of ameliorating measures, is certainly most successful way of fighting against drought because it controls soil water balance, which creates favorable conditions for high, stable and economically justified plant production (Kljajic *et al.*, 2013). This also benefits the poor through higher production, higher yields, lower risk of crop failure, and higher and year-round farm and non-farm employment. Irrigation enables smallholders to adopt more diversified cropping patterns, and to switch from low value staple production to high-value market-oriented production. Increased production makes food available and affordable for the poor (Kinfu *et al.*, 2011).

Majority of sub-Saharan Africa depend solely on rainfall for food production. This result in low productivity and famine, especially during the dry season when there is low or no rainfall. Albeit, sub-Saharan Africa has rich water endowment and irrigable land, only 13% of its potential is developed. In added to this, the annual growth of irrigation systems in sub-Saharan Africa is the slowest due to access to insecure land and water, ineffective institutions and favorable policies, and high cost of development (Ofosu *et al.*, 2014). Thus, given this untapped potential of distributed irrigation systems, it is opportunity for international donor groups and African governments and institutions to make it an explicit priority investment which would help a shift in production. As a result of scaling up the use of these small-holder irrigation systems should rise to the top of African development

priorities. Therefore, with this targeted investments and policies to expand decentralized irrigation, the future for Africa's smallholder farmers could be bright which without it would be hunger, poverty and humanitarian crises persist (Burney *et al.*, 2013).

Irrigation is believed as a key for food security and poverty reduction in Ethiopia. As a result, developments in the Ethiopian irrigation system have shown great advancements so as to assure Ethiopian livelihoods especially in the rural areas. Consequently, the government and peoples of Ethiopia believes that irrigation can play a significant role for food security enhancement and economic growth. This indicates more investments on the area have paramount importance for the development of the country. However, the contribution of irrigation to the national economy as compared to its potentials is non-negligible (Gebremedhin and Asfaw, 2015). The finding of Adugna (2014) similarly revealed that although Ethiopia is considered as a water tower of Africa, only 5% irrigation potential is developed up to recent. Therefore, as agriculture will remain the main driver of the rapid and inclusive economic growth and development of the country, GTP II now aims to enhance the uses of the country's water resources. In this line, primarily focus is at attaining food security, generating foreign exchange and supplying raw-materials to industries with developing and expanding of efficient, sustainable and indigenous-technology based medium and large scale irrigation farming. As a result, irrigation based agriculture development is promoted (NPC, 2016).

Albeit, irrigation water has critical merits in supporting the livelihood of Woliso District, the supplied irrigation services have decreased over years both in quantity and quality. Problems associated with inadequate irrigation water supply service in the district contribute to damages of crop production, livestock, and cause conflicts among the farmers. Such problems also impose higher costs on the users of the district. Hence, the irrigation water supply of the district should be improved through meeting the prevailing demand of the users (WWIDAO, 2016).

Because there is nonuse value attached to irrigation water, in practice, it is difficult to determine the monetary value of irrigation water using market price. Thus, user participation throughout the entire irrigation management process appears to be an important method to achieve better irrigation water management (Tang *et al.*, 2013). Accordingly, water pricing can potentially raise an ownership feeling to the farmers, which

will ultimately lead to better use of available water and increased crop production (Bongole, 2014). However, 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. Therefore, more attention should be given by government and other stakeholders for the implementation of irrigation water management practices in order to supply reliable irrigation water to the farmers. Furthermore, government and policy makers should consider the significant variables which have an impact in determining households' WTP (Tesfahun, 2014).

Currently, the government of the country is focused on the planning and measures of different activities in order to improve the irrigation system via concentrating on the supply side and seems to neglect the effective demand of the majority of irrigation water users. However, Hudu *et al.* (2014) revealed that the implementation of these measures requires that farmers are willing to assist in recovering the cost of the management, maintenance and operation of the irrigation system that will result from the improvement. As a result, implementation of such policy decisions should also focus on the demand as opposed to supply side there by adjusting pricing mechanisms and considering the willingness to pay of the irrigation water users. Therefore, the need of examining farmers' WTP of improved irrigation water use is timely research, assuming the irrigation system is improved.

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1.2. Statement of the Problem

Water is used as an input in most production hence important for economic development. Globally, among all economic sectors, agriculture is the biggest consumer of fresh water, and a sector characterized with intense water use with low efficiency. As a result, water scarcity is on the rise with increased demand of households for water in agriculture. Underpricing of water and lack of cost recovery leads to undesirable outcomes such as excessive use, pollution, resource misallocation and non-sustainable water supply service. When water charges are low, people tend to use water carelessly. Therefore, better water allocation could be achieved if the economic value of water is known by use, region and season (Omondi, 2014).

Nevertheless irrigation farming has been embraced and supported by many developing world to counter the effects of climate change and erratic rainfall, governments and

nongovernmental organizations to varying extents with varying successes let alone failures. Moreover, productivity in irrigation schemes has also been found to vary from country to country and from scheme to scheme in the same country (Moyo *et al.*, 2015).

Irrigation development in Ethiopia is in its infancy stage (Adugna, 2014). There are some constraints regarding the development of irrigation systems in Ethiopia. The major constraints hindering irrigation developments are predominantly primitive nature of the overall existing production system, shortage of adequate agricultural inputs and limited improved irrigation technologies, limited trained human power, inadequate extension services, and heavy capital requirement (MoA, 2011a). Besides, lack of regular maintenance and rehabilitation hampered proper implementation of the irrigation project and as a consequence, discouraged smallholder farmers in the country (Tesfahun, 2014). Ethiopia has yet developed not more than 5% of the irrigation potential. Much of this is owned and poorly managed by small holder farmers (Adugna *et al.*, 2014). Similarly, Bacha *et al.* (2011) reported that irrigated agriculture comprises only 3% of the total national food production. That is why; irrigated agriculture is far from satisfactory despite of public interest, and strategic support of the government.

Looking at the area of interest, namely Woliso District, there is a water source from Walga River which is suitable to develop and maintain irrigation project scheme, and resolve the dependency on rainfed agriculture. However, there is no a well-constructed irrigation scheme and regulation to use the resource. Yet the irrigation provisions around the River have no water storage capacity since water comes out to the command area from the rivers through traditional means. This will create a problem at the time of dry season at which more water for irrigation is needed by huge number of users. Moreover, there is no lined canal, and the water wastage is a serious problem of the area. Hence, in order to improve the existing irrigation water supply, the water storage capacity should be enhanced. To do so, dam construction is a prerequisite to reserve water which enables farmers to get sufficient water flow throughout the year (WWIDAO, 2016).

Previously, a number of studies were conducted using CVM in the valuation of irrigation water improvement from single bounded and others choice format to identify only the probability of households' WTP (Nega, 2012; Alhassan *et al.*, 2013; Angella *et al.*, 2014), but a few in estimation of improved irrigation water use from double bounded dichotomous

format with an open-ended follow-up questions to analyze both the probability of WTP and amount of money the households could pay as a whole and particularly in Ethiopia. Moreover, as irrigation water is an important input in Woliso District of Ethiopia, yet no estimation of its economic value has been done. Thus, information on the amount of money the irrigation users are willing to pay for the improved service is essential for irrigable water development projects. Hence, this study will contribute its own significance to the estimation of irrigation water in this regard.

1.3. Research Questions

The present study made an attempt to answer the following key research questions:

1. How much the farm households are willing to pay for improved irrigation water use?
2. What are the determinants of households' willingness to pay for improved irrigation water use?

1.4. Objectives of the Study

The general objective of the study was to explore the size and determinants of households' willingness to pay for the improved irrigation water use in the study area.

The specific objectives of the study were:

1. To elicit households' willingness to pay for improved irrigation water use in Woliso District, and
2. To analyze the determinants of households' willingness to pay for improved irrigation water use in Woliso District.

1.5. Significance of the Study

The provision of an improved irrigation water supply is neither cost free nor sustainable unless the costs are recovered due to high investment, operation and maintenance costs. As a result, in this study the amount of money the irrigation users of Woliso District are willing to pay for water services they get from the improved system and factors that determine their willingness to pay has been assessed. These provide basic information for

government officials and different stakeholders by providing information for guiding policy in relation to irrigation water pricing, the environmental issues and the significance of the improved project in particular. The outcomes of this study are expected to be used by the governmental and nongovernmental organizations to carry out irrigation related projects. It is also expected to be used by extension agents to extend irrigation related activities and apply other mechanism in the study area. Moreover, by quantifying the valuation of improved irrigation water use in the study area, the study generated pertinent information for the farming community who provided the information. Thus, findings of this study do provide the basis for further empirical study in this area or serve as a spring board for further study for researchers.

1.6. Scope and Limitations of the Study

This study is limited to the evaluation of improved irrigation water in Woliso District based on the information obtained from sample households. Besides, because of the time and financial constraint, the sample used for this study is limited in both coverage and size. The coverage of the study is limited only to four purposively selected *kebeles*, namely Badessa-Koricha, Gute-Godeti, Ciracha-Wanberi and Gurura-Baka, due to availability of water resource for irrigation, and the sample size is limited to 251 households due to financial and time constraints. While CVM is widely applied and is very relevant for this study, like other valuation techniques this method has its own limitations such as use of cross-sectional data (that it does not allow to explore the inter-temporal variations) and failure to use alternative econometric models, e.g. recursive. Therefore, data generated in the survey were used with much care to minimize the small sample bias.

1.7. Organization of the Study

The thesis consists of five chapters including this chapter, which provides general information in its introduction. Chapter two is a review both the literature (empirical and theoretical). Chapter three presents the methodology used in this study while the fourth chapter is about the result and discussion of survey data. The last chapter, chapter five, presents the summary, conclusion and recommendations drawn from the result.

2. REVIEW OF LITERATURE

2.1. General Overview of Irrigation

Irrigation is the action of applying water in addition to natural precipitation, to land in order to supply crops and other plants with necessary water. In general, there are many methods of applying water to the field. However, in irrigation practice there are three basic methods namely: Surface irrigation (ancient irrigation type which includes basin irrigation, furrow irrigation and border irrigation), Sprinkler irrigation and Drip irrigation. The last two types are modernized irrigation systems that are mostly used which works based on the pressurized energy system. Irrigation water is applied to ensure that the water available in the soil is sufficient to meet crop water needs. The role of irrigation is to improve production and the effectiveness of other inputs. Irrigated agriculture is driving much of the competition from other water use sectors and represents a threat to the environment. On the other hand, increased food production will have to come from existing and irrigated lands. As a result, future agricultural development strategies of most of the countries depend on the possibility to maintain, improve and expand irrigated agriculture (Findi, 2012).

Globally, irrigation has been found to be the largest consumer of water, accounting for about 70% of the total diverted water. Irrigated land recently accounts for about 20% of the world's farmed area and takes care for 55% of global food production. Consequently, today's agriculture sector faces in fact a complex series of challenges: to produce more food of better quality while using less water per unit of output, to produce sustainable diets and to reduce malnutrition, to apply clean technologies that ensure environmental sustainability, to cope with possible impacts of climate change and to contribute in a productive way to the local and national economy, from producer to consumer. Thus, improving water management practices in agriculture is crucial for maintaining global food security and alleviating rural poverty. Reducing irrigation water use by increasing irrigation water productivity is crucial to meet the ever increasing water demand for agriculture (Yenesew, 2015). In addition to this, in order to ensure the sustainability of the irrigation systems, water fees should be paid. As a result, farmers' attitude towards affecting payment that mainly covers the operation, maintenance and management costs is the dominant factor (Aydogdu, 2016).

Irrigation development in Ethiopia that is common is classified based on the size of the command area, in three types. The first one is small-scale irrigation systems (SSIs), (<200 hectares (ha)), which is often community-based and traditional methods'. Examples of SSIs include household-based rain water harvesting (RWH), hand-dug wells, flooding (spate), shallow wells, individual household-based river diversions and other traditional methods. The other one is medium-scale irrigation systems (MSIs), (200-3,000 ha), which is community based or publicly sponsored. Examples: Hare irrigation scheme in Southern Region Nations and Nationalities Region. The last but not least is large-scale irrigation systems (LSIs), (>3,000 ha), which is typically commercially or publicly sponsored. Examples of LSIs include the Wonji-shoa, Methara, Nura Hera, and Fincha irrigation schemes. In recent years, however, smallholder-owned large-scale farms are emerging. Typical examples are the Fentale irrigation scheme in Oromia Region and the Koga irrigation scheme in Amhara Region (Tesfaye and Seleshi, 2014).

2.2. Economic Importance of Irrigation Development

The dependence on the unreliable rainfall is limiting factor for agricultural productivity. Therefore, transformation of the agricultural sector and thereby the economy, irrigation is among the priority areas of intervention (Hordofa *et al.*, 2011). Irrigation has a multi-faceted role in contributing towards food security, self sufficiency, food production and export (Yenesew, 2015). Irrigation can bring about increased agricultural production thereby improve the economic and social wellbeing of the farmers. For meeting the growing demand for food in the short run and long run food security, small scale irrigation has immense contribution in achieving the objective. It is one of the options which increase yield, facilitate diversification, reduce rainfall risk, and create employment opportunities. In addition, the role of irrigation development is increasing food sufficiency level of households (helps to produce sufficient amount of food consumption), increasing income level, asset building such as house construction for rent, saving account and creation of employment opportunity. Thus, it is an important indicator of economic development and brings sustainable agriculture development (Tesfa, 2011).

Molden (2007) described that in countries and regions that rely on agriculture for a large part of their Gross Domestic Product (GDP) (such as most of Sub Saharan Africa), raising agricultural productivity may require large water storage facilities, further irrigation

development, and changes in the operation of existing schemes. Therefore, this is the most possible option for reducing poverty, to keep up with global demand for agricultural products and adapt to changing food preferences and public demands, to adapt to the effect of urbanization in many developing countries shifting demand from staple crops to fruits, vegetables, and livestock products, and to respond to climate change. Belay and Bewket (2013) explained that irrigation water is critical to poverty alleviation through increased production in rural areas so as to improve food security and rural livelihoods. Smallholder irrigation has also received significant focus from local governments to enable farmers to cultivate crops twice or more per year. Bacha *et al.* (2011) in the study of the impact of small-scale irrigation on household poverty in central Ethiopia, reported that land productivity, asset ownership, credit utilization, extension support, resilience to poverty, mean off-farm income, and mean food consumption and expenditure on food and non-food assets were significantly higher for irrigators than non-irrigators.

Irrigation improves household income and contributes to poverty reduction. Irrigation user households are in a better position when compared to those that are non users. For example, users have high crop income, higher level of education of the household head, large size of livestock holding, better labor man-day equivalent and all these contributed significantly to high total income for users than non-users. As a result, access to irrigation increases the opportunity for crop intensity and diversification which increase cropping income. Therefore, access to irrigation has got a significant and positive contribution to income (Hamda, 2014). Thus, enhancing the capacity of water user associations through provision of training, market linkage and finance are a necessary step to improve irrigation performance towards poverty reduction. Irrigation use has a positive impact on households earning from crop, and livestock. And, remunerative off farm income sources like cart and trade were the results of irrigated agriculture whereas inferior livelihood activities like fire wood and charcoal selling, and casual work were dominated by non irrigators (Adugna *et al.*, 2013).

Despite both irrigated and rain-fed agriculture are important in the Ethiopian economy, the use of irrigation technology, although currently not widespread, can reduce risk and improve production. The country receives significant rainfall, although distribution and intensity vary, generally decreasing from southwest to northeast. If well managed, Ethiopia's surface water and groundwater systems are sufficient to meet most domestic and

irrigation purposes. But the lack of installed water infrastructure provides a serious constraint to irrigation development. Thus, Ethiopia offers ample scope for growth in agricultural production through irrigation development as the country is endowed with a substantial amount of water resources (FAO and IFC, 2015).

2.3. Irrigation Potential and Development in Ethiopia

Ethiopia is endowed with ample water resources including more than 10 river basins and 22 natural and artificial lakes, hence known as the water tower of Africa (ADF, 2005; Adugna, 2014). Besides, the country has an annual runoff volume of 122 billion m³ of surface water and an estimated 2.6 billion m³ of ground water potential, which makes an average of water available 1557.5 m³ per person per year. This is a relatively large volume of water. The largest four river basins of the country namely Abay, Baro-Akobo, Tekeze and Omo-Ghibe account for 80%-90% of the country's water resource. Moreover, Even if the potential and actual irrigated area is not precisely investigated (Belay and Bewket, 2013), estimates of irrigable land in Ethiopia vary between 1.5 and 4.3 Million hectares (Mha), averaged about 3.5 Mha (Seleshi *et al.*, 2005; Makombe *et al.*, 2011). On the other hand, differences in irrigation potentials and actually irrigated lands, for example 3.7 Million ha and 197,000 ha according to Seleshi *et al.* (2007) and 3.5 Million ha and 626,116 ha as reported by Fitsum *et al.* (2009) respectively, are indicated differences in this regard. MoA (2011a) also reported that about 10 - 12% of the total irrigable potential is used in traditional and modern irrigation schemes.

Irrigation development is vital to the sustainable and reliable agricultural developments in Ethiopia (MoA, 2011b). Similarly, make use of irrigated agriculture development is going to be a means for increased agricultural production to meet the growing food demands of rapid population growth. Irrigation development in Ethiopia can be considered as a cornerstone of food security and poverty reduction tool as it has a power to stimulate economic growth and rural developments (Fitsum *et al.*, 2009). As a result, irrigation infrastructures are increasing year after year, which show country wide positive development implications and experiences in small and large scale irrigation schemes. In Ethiopia, farm size per household is 0.5ha and the irrigated land per households' ranges from 0.25 ha - 0.5 ha in the Ethiopian context. As a result, individual land holdings per households are too small to feed the household. With this limited landholdings, increasing

food demands of the population depends on either one or a combination of increasing agricultural yield, increasing the area of arable land, and increasing cropping intensity by growing two or three crops per year using irrigation (MoA, 2011a).

Generally, regarding to the irrigation development in Ethiopia, different literatures reports differently regarding the amount irrigation water resources as irrigation potentials, area irrigated. This implies that irrigation water resource potentials in Ethiopia are not well-studied and documented (Gebremedhin, 2015). However, as a result of irrigation development in Ethiopia is in its infancy stage (Adugna, 2014), and its contribution to the national economy as compared to its potential is limited (MoA, 2011a), recently the Ethiopian government is therefore pursuing plans and programs to develop irrigation in an effort to substantially reduce poverty and create an atmosphere for social change (NPC, 2016).

2.4. Methodological Framework

2.4.1. Review of Valuation Approaches and Methods

Economic valuation of environmental resources is very critical before making any decision for determining the uses of environmental and natural resources. Otherwise, there is a real danger that if no economic measure of the value of environmental resources is available, then it could be perceived that they have little or no value to society and can therefore be exploited (Yeshimebet, 2015). The basic strategy for environmental valuation is the ‘commoditization’ of the services that the natural environment provides. 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.

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). 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. 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). 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 is the willingness to pay to ensure a resource is available for your children and grandchildren. 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 (Hussen, 2004).

2.4.1.1. The 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 (Mendelsohn and Olmstead, 2009). 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). The revealed preference (indirect approach) methods infer the value of environmental goods by studying their actual or revealed behaviors in closely related markets through the application of some model of relationships between marketable goods and environmental services (Bockstael *et al.*, 2005). Some of the revealed preference methods that are in use in relation with water resource valuation are hedonic pricing method (HPM) and the travel cost method (TCM).

A. Hedonic pricing method

The hedonic pricing method is the most commonly used revealed preference valuation technique. It is derived from the characteristics theory of value and seeks to explain the value of commodities as a bundle of valuable characteristics (Young, 2005). HPM relies on

market evidence related to property values to determine the value that people assign to improvements in access to public and quasi-public goods (e.g., police and fire protection, local parks) and environmental quality. It is assumed that individuals choose the amount of public goods and environmental quality they want by the choices they make concerning residential purchases. People choose to live in areas that have cleaner air or less crime, they choose to live near airports or along highways, and they choose to live on quiet or on busy streets. The choice is determined by what they are willing and able to pay for housing. HPM exploits these choices by estimating implicit prices for house characteristics that differentiate closely related housing classes (Van Kooten, 2016).

B. Travel cost method

The travel cost approach is used to estimate the value of recreational benefits generated by ecosystems or the environment. It takes the costs of travel that are incurred by individuals in visits (the costs of transport plus the value of time) made to recreational sites as implicit prices to value of the service provided and changes in its quality. TCM measure only the use value of sites and are usually limited to recreational use values. This approach theoretically takes into account for time spent in travel, assigning a value to it is somewhat arbitrary (Qureshi *et al.*, 2010).

2.4.1.2. 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). Among the frequently used methods of stated preferences, the Choice Modeling (CM) and Contingent Valuation Method (CVM) are commonly used.

A. Choice modelling

Choice modeling has its origin in conjoint analysis, information integration theory in psychology and discrete choice theory in economics and econometrics (Louviere, 1988). The contingent ranking and rating methods are variant techniques widely used in marketing known as conjoint analysis. A common feature of this type of approach is the requirement that survey respondents consider alternatives which are described in terms of their component characteristics or 'alternatives'. The alternatives are constructed by combining attributes at different 'levels' (Bennett and Blamey, 2001).

B. Contingent valuation

The CVM is a recognized and widely used non-market valuation technique (Adem, 2011). In developing countries, contingent valuation surveys were originally applied in water supply and other environmental benefits estimation, and are much easier and very straight forward to conduct because the respondents take it more serious than in the industrialized countries (Alhassan, 2012). CVM is a demand-side approach with hypothetical markets that allows individuals to state their willingness to pay for changes in the quantity or quality of environmental goods and services (Jeuland *et al.*, 2010). The objective of CVM is to measure consumer surplus for the environmental attributes (Ellingson and Seidl, 2007). There are two advantages of this method. First, CVM is able to assess an individual's WTP in the present conditions and also values their WTP with hypothetical changes. Second, CVM is able to value trips with multi destinations by asking hypothetical questions for each specified destination (Lee and Han, 2002). Specifically, CVM was seen both as an alternative method of valuation TCM and HPM and as being able to quantify some types of benefits, such as non-use or passive-use benefits, which lie outside the scope of TCM and HPM studies (Bateman and Willis, 2001). Given this, and the fact that indirect methods cannot address non- use/existence values, the study employed the CVM in the context of trying to ascertain non-use/existence values.

Following Perman *et al.* (2003) the steps involved in applying the CVM can be stated as follows. The first step is the creating of a survey instrument for the elicitation of individuals' WTP/WTAs. This can be broken down into designing the hypothetical scenario, deciding whether to ask about WTP or WTA, and creating a scenario about the

means of payment or compensation. The second step is using the survey instrument with a sample of the population of interest. This step is followed by the analyzing of the responses to the survey that can be seen as using the sample data on WTP/WTa to estimate average WTP/WTa for the population and assessing the survey results so as to judge the accuracy of this estimate. Fourthly, computing total WTP/WTa for the population of interest is followed. The last, but not least step in CVM is conducting sensitivity analysis.

According to Rahim (2008), the CVM has certain advantages which are, it can produce reliable estimates based in economic utility theory, most biases can be eliminated by careful survey design and implementation, the only method available to measure important non-use values associated with natural resources, used successfully in a variety of situations, and is being constantly improved to make the methodology more reliable. On the other hand, the major concern with the use of the contingent valuation method has been the potential for survey respondents to give biased answers (Adem, 2011). As a result, four types of potential bias have been the focus of a large amount of research. These are strategic bias that arises when the respondents believe that their bids will be collected for a referendum, and have the effect that they might understate their WTP or overstate their WTa because environmental goods are typically non-excludable in consumption. The other is information bias which may arise whenever respondents are forced to value attributes with which they have little or no experience. The third bias of CVM is starting-point bias. This bias can influence the final bid that a respondent makes, especially if the respondent has no prior experience of trading with the environmental good. Finally, hypothetical bias is that when valuations for a hypothetical market are asked for, the answers given by respondents differ systematically from the true values (Tietenberg and Lewis, 2012).

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, 2007). There are five types of elicitation methods that 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). All these methods of asking questions have their relative advantages and disadvantages and none is free from

criticisms. Hence, each particular CV format must depend on the situation and the location, so that proper and successful estimated value of the environmental amenity can be attained (Dey, 2013).

Following to Ahmed and Gotoh (2007) and Chanel *et al.* (2015), a summary of the characteristics of the most commonly used elicitation methods is provided as follows. The bidding game elicitation method proceeds like an auction where respondents' answers on several different discrete choice questions where the last one is an open ended willingness to pay 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".

An open ended question, does not have a specified value, the respondent is simply asked to specify their maximum willingness to pay or willingness to accept. 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, increases the cost of the survey.

The double-bounded question is an extension of the single-bounded version that asks respondents a yes or no question on two different values. 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 single bounded dichotomous choice 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 consumers are provided with visual aid which contains a large range of potential WTP amount ranging from 0 to a large amount. Consumers are then asked to declare which amount on the card they are willing to pay. The payment card has become popular since it better mimics real life decisions compared to the open ended.

2.4.2. Valuation of Natural Resources

Economic valuation is the attempt to assign quantitative values to the goods and services provided by environmental resources, whether or not market prices are available to assist us (Perman et al., 1999). Valuation of natural resources is well thought-out as a complex process because most of the services and benefits are non-marketed and thus placing a monetary value on them represents a challenge (Adem, 2011). The failure to account adequately for the non-market environmental values in development decisions is often the major reason for excessive depletion and conversion of the environmental and natural resources. Depletion of environmental and natural resources is an economic crisis because important values are lost, some perhaps irreversibly once it is degraded. Therefore, the decision as to what use to follow for a given environmental and natural resource, and eventually whether current rates of resource loss are extreme can only be made if these gains and losses are properly analyzed and evaluated. Accordingly, policy makers should use economic valuation as a way to quantify the trade-off in a policy choice in environmental decision- making (Yeshimebet, 2015).

The following are the main reasons. Firstly, to get a monetary value of goods in the absence of perfect markets, in order to use these resources more efficiently. Secondly, for successful sustainable management and address market failure of goods and services. Thirdly, uncertainty is involved about the demand and supply of natural resources and/or it is difficult to estimate, especially in the future due to the non rival and excludability nature of such resources. This is in the sense that, most economic markets capture, at best, the preferences of the buyers and sellers. Fourthly, governments may like to use the valuation as to pursuing efficient policies and investing in efficient projects and programs. Fifthly, in order to arrive at natural resource accounting, for methods such as Net Present Value methods, or for cost-benefit analyses, valuation is a necessity. Finally, for most natural

resources, it is essential to understand and appreciate its alternative uses apart from its direct value of the resources such as existence and indirect values (Perman *et al.* 1999).

2.4.3. Economic Valuation of Irrigation Water

Water is a limited resource that needs sustainable management, which aims to develop and protect it (Hosni *et al.*, 2014). Despite the fact that water pricing facilitated efficient utilization and also the ability to adjust consumption to resource availability and existing economic and market situations (Alarcon *et al.*, 2011), valuation of irrigation water is not easy since competitive markets for irrigation water do not exist (Lange and Hassan, 2006). Economic valuation of irrigation water cannot be undertaken as a straight forward process because this type of water is a non-marketed resource (Birol *et al.*, 2006; Jaghdani *et al.*, 2009). Nevertheless, there is a variety of methods developed by economists for estimation of the economic value of water. Water valuation techniques are based upon either revealed (indirect) or stated (direct) preferences approaches.

Generally, the effectiveness of the financial and economic roles of water pricing policies depends on the pricing method and its objective. Hence, according to FAO (2004), the existing irrigation water pricing methods are area-based, crop-based, volumetric and tradable water rights. Area base water pricing can be a fixed rate per hectare of farm, where the charge is not related to the area irrigated, the crop grown or the volume of water received, and a fixed rate per hectare irrigated that is the charge is not related to farm size, type of crop grown or actual volume of water received (except that a larger irrigated area implies a greater volume of irrigation water). The crop-based irrigation pricing is variable rate per irrigated hectare of crop, i.e. different charges for different crops, where the charge is not related to the actual volume of water received, although the type of crop and area irrigated serve as proxies for the volume of water received. On the other hand, volumetric pricing includes a fixed rate per unit water received, where the charge is related directly to, and proportional to, the volume of water received and a variable rate per unit of water received, where the service charge is related directly to the quantity of water received, but not proportionately. Finally, tradable water rights is pricing method in which entitlements of users in an irrigation project, or more widely, other users, are specified in accordance with the available water supply.

Fragoso and Marques (2013) reported that 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. However, because of problems related with volumetric pricing coupled with the country's prevailing policy, area based pricing method is advisable for Ethiopia. As a result, in this study per area pricing (area based pricing) method is employed.

2.5. Theoretical Framework

CVM is frequently applied to discrete survey responses to elicit options on various matters (Alem *et al.*, 2013; Ayana, 2016; Meseret and Endrias, 2016). The theoretical foundations of CVM are in the random utility theory (Kanyoka *et al.*, 2008). The respondent households are initially asked whether or not they would be willing to pay a specific amount for improved irrigation water supply service. When a respondent is asked one dichotomous choice question, the response is usually “yes” or “no”, depending on the individual's WTP the proposed bid value. It is assumed that respondents know which choice maximizes their utility.

The utility that individual i will realize after choosing an alternative j can be expressed as follows:

$$U_{ij} = V_{ij} + e_{ij} \quad (1)$$

Where U_{ij} and V_{ij} represent the indirect and deterministic utility individual i receives on choosing alternative j respectively, and e_{ij} is random component of utility function. The random component is assumed to be identically, independently distributed with zero mean. The marginal utility of payment depends on an expected improvement in irrigation water supply.

Let P_i be a specific amount that a respondent is willing to pay to get the improved irrigation water supply k . That is, an individual will choose alternative k over alternative j if utility from k is greater than from j (Akter, 2007). That is;

$$U_{ik} \left[\frac{(Y-P_i)}{X_i} \right] > U_{ij} \left(\frac{Y}{X_i} \right) \quad (2)$$

Where Y income and X_i is represents a vector of socio-economic characteristics of individual i . An individual will be willing to pay an amount of P_i , if the utility gained from the situation with improved irrigation water supply is larger than the utility with the current irrigation water supply system, taking into account the change in income.

2.6. Conceptual Framework

The conceptual framework for economic valuation of irrigation water is presented in Figure 2 below. The factor that may affect WTP may include household income, education level, credit utilization, experience in irrigated farming, dissatisfaction, irrigable land size, family size, sex, number of oxen, distance from the market center, perceived trend in rain-fed agricultural crop productivity, labor shortage, distance from water source, cash crops growing and age. As Omondi (2014) reported, the payments made by the irrigation water users will be used to manage the water demand. This makes again to increase the efficiency of use and productivity.

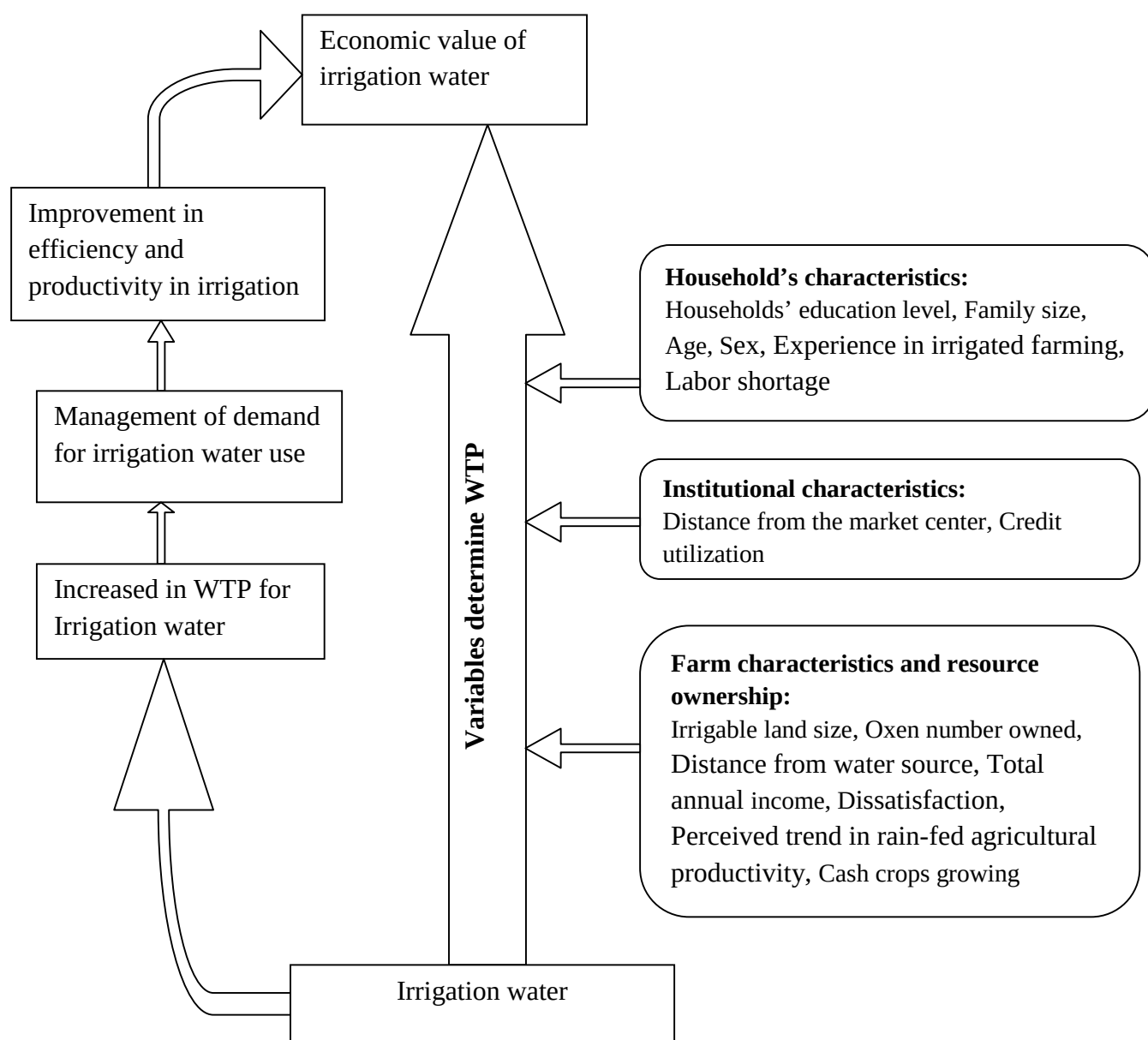


Figure 1: Conceptual framework for estimating economic value of irrigation water

Source: Own design, 2016.

2.7. 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.

The findings of Alhassan *et al.* (2013) determined how much farmers under the Bontanga Irrigation Scheme would be willing to pay for the improvement of the project in Ghana using payment card. From the results, the median WTP was calculated as US\$ 7.29 per ha per year and the mean WTP was calculated as US\$ 8.50 per ha per year. The median WTP value represents the amount 50% of the farmers will be willing to pay and at the same time it represents the amount 50% of the farmers will not be willing to pay. The mean represents the average amount an individual farmer will be willing to pay for the improvement of the project. The aggregate benefits per year for the improvement of the project assuming each farmer is expected to pay the mean WTP amount can be calculated as US\$ 4845.00 which is obtained by multiplying the mean WTP US\$ 8.50 per ha per year by the irrigated land area (570 ha). The significant and most influencing factors that were identified by OLS to affect WTP of farmers are location of the farm, ownership, and land lease prices.

Shantha and Ali (2014) made an attempt 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 choice. Logistic regression model was used to measure WTP and to determine the factors that influence the variation in WTP. The Authors estimated that value of irrigation water was \$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.

The study conducted by Njoko (2014) sought to determine farmers' willingness to pay (WTP), and ability to pay (ATP), for improved irrigation in rural areas of KwaZulu-Natal, South Africa, using the farm gross margins and also to identify factors affecting farmers' WTP and ATP. The binary and ordered probit models were used to investigate factors affecting WTP, which was generated through the contingent valuation method. Empirical results indicate that factors such as extension services, training, use of motorized pumps (diesel), and farmer perceptions of scheme management, duration of the farmer in the scheme, livestock ownership and road conditions positively influence WTP. In contrast,

factors such as conflicts, household size and total land holdings influence WTP negatively. An Ordinary Least Squares regression was used to investigate factors affecting ability to pay. Factors such as labor, training, household assets and road conditions were found to have a positive influence on ATP. The study concluded that farmers are willing and able to pay for improved irrigation water supply. A further conclusion was that support services and institutions could be manipulated through policy, to enhance both WTP and ATP. They, therefore, recommended that if government had to formally introduce water charges, it could start with a charge of Rand 50 per month per plot and then increase the charge gradually, over time.

Angella *et al.* (2014) tried to estimate willingness to pay for irrigation water and its determinants among rice farmers at Doho Rice Irrigation Scheme 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 \$8/acre/season on average, \$6 acre/season is actually needed to cover maintenance costs as per the 2013/2014 work plan for the scheme. 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.

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 to avoid its wasteful use.

Aydogdu (2016) attempted to evaluate the willingness to pay (WTP) for irrigation in Turkey and explore the potential factors that contribute to it. The study was one of the first of its type in Turkey. Based on the collected survey data, econometric model for the contingent valuation and double bond maximum likelihood methods were used for analysis by limited dependent package program. Results indicate that farmers are willing to pay 71.69% more than the existing price under certain conditions, but are paying 98 Turkish Liras/ha less. Accordingly, the yearly annual income loss of the water user associations is \$9,748,011. Explanatory factors, such as price of irrigation water, education, location, irrigation type (gravity or pumping), and attitudes toward associations, significantly explained WTP. The study determines the primary factors influencing farmers' WTP for the irrigation water for optimal management of associations and water resources.

There are also some studies on economic valuation of irrigation water in Ethiopia. They are presented as follows. Accordingly, Nega (2012) estimated 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 study identified important variables that determine households' WTP for irrigation water. Accordingly, 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. An important policy implication drawn from the study is that farm households are willing to pay for irrigation water supply. Therefore, if government designs and implements a proper charge of irrigation water, it will avoid or at least reduce inefficient water use practices and there would be a more sustainable utilization of environmental resources.

Alem *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. The study 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. From this it can be simply observed that the total annual WTP for irrigation water from double bound elicitation method was greater than from open ended elicitation method. Hence, policy makers should target double bounded elicitation method than open ended elicitation method to eliciting the willingness to pay for irrigation water. The study also shows that households' income, age, cultivated land, initial bids, awareness and educational level are the key determinants of demand for irrigation water. Therefore, these important variables should also be considered while designing irrigation water related projects at household level.

Mekonen *et al.* (2015) has also applied CVM to estimate irrigation water pricing in Awash River Basin in Ethiopia for evaluation of its impact on scheme level irrigation performances and willingness to pay by using logit and probit models to identify determinants of willingness to pay and calculate average willingness to pay, respectively. He employed logit model on two different bidding games, and identified the determinants of respondents' willingness to pay improved irrigation water. Accordingly, the study found out that respondents' income level, off-farm income, experience in irrigated agriculture, access to credit, and predetermined bid level had a statistically significant positive impact on WTP. In contrast, the following variables had a negative statistical significant impact on WTP: educational level, household size, land size, land slope and distance to the market. The average WTP value was 88 ETB/hectare/year and 3.50 ETB per 1000 m³ per year. This study also revealed that the pricing system in the basin has been serving two purposes. First, serving as source of revenue for the basin authority to exist and operate. Second, it used in covering maintenance costs of primary canals which most often are limited to removal of silt. Thus improvement in irrigation water management requires strengthening of irrigation research and extension services, building the capacity of irrigators, and improving the irrigation system operation and maintenance services.

In general, the above reviewed CVM studies revealed that, irrigation pricing system is an important tool for the use of irrigation resources more efficiently. This is also a best mechanism of irrigation water demand management practices. However, few of them have tried to study the valuation of irrigation water using the double bounded elicitation format with open ended follow up question. This choice format, however, provide more total WTP than other formats at household level. Therefore, more studies have to focus and consider this format while determining WTP of the households. As a result this study attempts to have a look at the determinants of household willingness to pay for improved irrigation water services and its mean willingness to pay by using the double bounded elicitation format with an open ended follow up question.

3. RESEARCH METHODOLOGY

3.1. Description of the Study Area

The study was undertaken in Woliso District of South West Shoa Zone of Oromia National Regional State. Woliso District is located at a latitude and longitude of 8° 32' 23.0" N and 37° 58' 16.3" E in the Southern West part of the country along Finfinne to Jimma main road, extending from 90-140 km from the capital city of the country, Finfinne. It has an area of 1,511.501 km², and 37 rural *kebeles* and three urban centers including Woliso town. The district is bordered in South by the Regional State of Southern Peoples' Nations and Nationalities and Goro district, in the North by Dendi district of West Shoa and Dawo district, in North East by Becho district, in West by Amaya district, in North West by Wonchi district, in East by Saden Sodo of South West Shoa Zone. Topographically, it is characterized by plateaus, mountains, hills and plains. Altitude wise, the district lies between 1600 and 2880 meter above sea level. Simela, Karfele and Rogda are the major mountains found in the district. Several perennial rivers (Walga, Rebu, Kono, Menisa, Dedebo, etc.), intermittent streams (Gute, Osole, Boye, Dergu, Atabela. etc.) and springs (Kora, Lencho, Boye, etc.) are found in the district. Agro-ecologically, it is classified into *weinadega* (70%) and *dega* (30%) zones. Chromic and Vertisol are the dominant soil types found in the district. The largest river in the district, Walga River that located at 8 km from Woliso town is a major source of irrigation water of the farmer (WWAdO, 2016).

The population of the district is projected at about 171,150 persons in 2014, of which 85,175 are male and 85,975 females. From the total population 3,622 are urban dwellers whereas 167,528 are rural people (CSA, 2013). Average family sizes for rural and urban areas are 4.9 and 4.8 persons respectively. The crude population density of the district is estimated at 176 persons per km². It is the most densely populated district of the zone (WWAdO, 2016).

About 71%, 20.2% and 7.2% of the district's total area is estimated to be arable (51.6% under cultivation), grazing, and forest (including shrubs and bushes) land respectively, while the remaining 1.6% is occupied by swampy and marshland, degraded and residential areas. Average farmland and oxen holding sizes per household are 2.4 hectares and a single ox respectively. *Teff*, maize, sorghum, barley, wheat, fababean, field pea, *noug*, *enset*, *khat*,

chickpea and grass pea are the most widely cultivated crops. The district has a long history of traditional irrigation practices and indigenous knowledge. Hence, it is possible to grab the opportunities and capitalize on. Accordingly, the households of the district are used to produce mostly different crops. However, there is a low institutional support for both irrigation users and non-users (Desta, 2004).

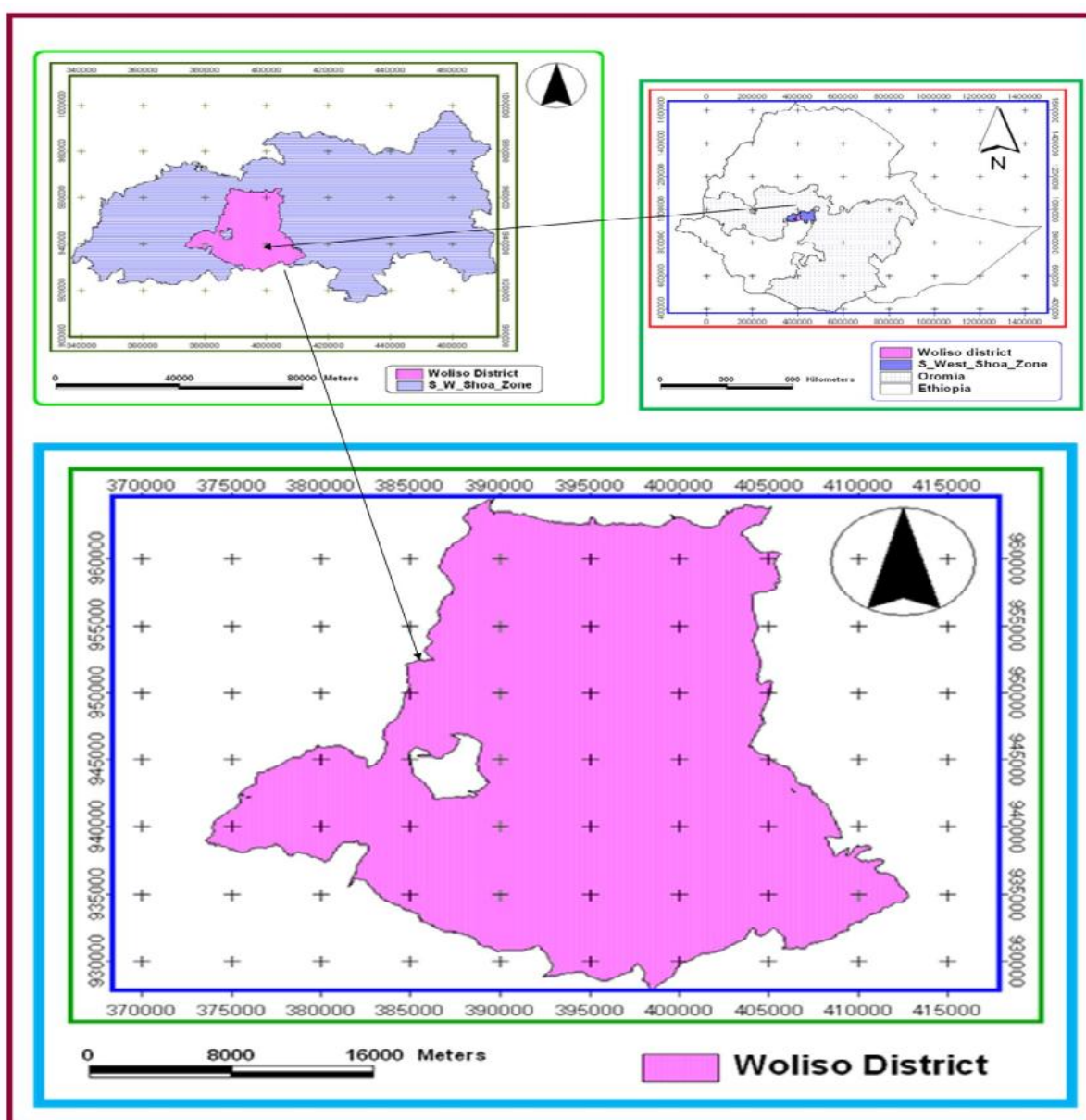


Figure 2: Physical Map of the Study Area

Source: Own design, 2017.

3.2. Data type, Sources and Methods of Data Collection

For this study, both primary and secondary data were used. The primary data were collected from sample households in the study area through semi-structured questionnaire using face to face interview. Besides, the data were generated by interview of the District Irrigation Development Authority Offices workers and supplemented by Focus Group Discussion (FGD) to generate qualitative information on the pre-test. The information from the Focus Group Discussion was also used to refine the questionnaire. The data were collected by experienced and competent enumerators and the researcher. Secondary data were also collected from the District Irrigation Development Authority Office and other relevant sources.

A pre-test of the draft questionnaire was done on 25 households in order to determine sets of bids, and to select appropriate wording and ordering of questions. However, the responses of these households were not included in the analysis in order to avoid the bias. After making the necessary adjustments to the draft questionnaire and setting bid prices, the final questionnaire was developed. Accordingly, the most frequently stated values were then selected as a starting value (price) for the double bounded dichotomous choice format. Household heads were then presented with the willingness to pay question that has any of the five different starting bid amounts determined: 200, 300, 400, 600, and 700 Birr. The starting points and iteration ranges were pre-tested to determine if the starting point range covered the expected range of willingness to pay. Follow-up open ended bid amounts were based on the households' responses. Following Mitchel and Carson (1989), household heads were randomly assigned to one of the five starting bid levels, as to minimize starting point bias. As Cameron and Quiggin (1994) stated, sets of bids were determined for double bounded dichotomous choice format by making twice the initial bid if the first response is "Yes" and half of it if the response is "No". Accordingly, the sets of bids in this study are (200, 100, 400), (300, 150, and 600), (400, 200, 800), (600, 300, 1200), and (700, 350, 1400).

3.3. Sampling Technique and Sample Size

The study used a two-stage sampling technique (both a purposive and random sampling techniques) in the selection of the study site and the sample households, respectively. In

the first stage, four *kebeles* (namely Badessa-Koricha, Gute-Godeti, Ciracha-Wanberi, and Gurura-Baka) were purposively selected from 37 rural *kebeles* of Woliso District based on representativeness to the major irrigation users of the Woliso District, proximity to the source of water i.e. their irrigable farm land is close to the river that used as the major irrigation source, and personal experience in irrigated farm in the area. In second stage, irrigation water user farm households were selected randomly from each sample *kebele* using probability proportional to sample size.

In this study, a simplified formula provided by Yamane (1967) is used to determine the required sample size at 95% confidence level, 0.5 degree of variability and 6% level of precision.

$$n = \frac{N}{1+N(e)^2} \quad (3)$$

Where n is the sample size, N is the population size (total irrigation water user households), and e is the level of precision. The district has a total of 2,701 irrigation water user households (WWIDAO, 2016). Hence, the desired sample size is equal to:

$$\frac{2701}{1 + 2701(0.06)^2} = 251$$

Table 1: Distribution of sample households drawn from each *kebele*

<i>Kebele</i>	Number of irrigation user households	Number of selected irrigation user households	Percent
Badessa-Koricha	529	48	19
Gute-Godeti	562	53	21
Ciracha-Wanberi	1393	130	52
Gurura-Baka	217	20	8
Total	2701	251	100

Source: Own computation, 2016.

3.4. Methods of Data Analysis

3.4.1. Descriptive and Inferential Statistics

Descriptive statistics such as mean, percentages, minimum and maximum were computed to explain different socio-economic characteristics of the sample households. In addition, inferential statistics such as t-test for continuous variables and chi-square test for dummy variables were employed to test statistical significance among the willing and non willing households.

3.4.2. Econometric Model Specification

Using CVM, the value of irrigation water to a user is taken as the maximum amount that the user will be willing to pay for the use of this resource. Accordingly, a household head was asked how much he/she is willing to pay (WTP) for the improved irrigation water use. Therefore, in order to quantify the households willingness to pay and the relationship between the individual characteristics and the probability of households' willingness to pay for an improved irrigation water use the Seemingly Unrelated Bivariate Probit model and Tobit model were respectively employed for this study.

Seemingly Unrelated Bivariate Probit Regression Model

Seemingly Unrelated Bivariate Probit Regression (SUBPR) is used to examine whether the dependent variables are correlated or not. This model takes two independent binary Probit models into account and estimates them together. However, the Univariate Standard Probit Regression model would produce unbiased, but inefficient estimators for exogenous variables because it assumes the error terms are not correlated with each other, also it ignores the unobservable heterogeneity between the two equations. Hence, an alternative approach to control for unobservable heterogeneity is to consider a Seemingly Unrelated Bivariate Probit model, as it provides a way of dealing with two separate binary dependent variables (Greene, 2008). Therefore, in this study a Seemingly Unrelated Bivariate Probit model was employed to estimate household's mean WTP from the double bounded elicitation method.

Following Haab and McConnell (2002), the econometric modeling for the formulation of double-bounded data is given as:

$$WTP_{ij} = \mu_i + \varepsilon_{ij} \quad (4)$$

Where:

WTP_{ij} = Is the j^{th} respondent's WTP and $i=1, 2$ represents first and second answers;

μ_1, μ_2 = Is the mean value for first and second response, and

ε_{ij} = Unobservable random component.

Setting $\mu_{ij} = X_{ij}\beta$ allows the mean to be dependent upon the characteristics of the households.

To construct the likelihood function, the probability of observing each of the possible two-bid response sequences (yes-yes, yes-no, no-yes, no-no) are given as follows. The probability that the respondent i answers to the first bid and to the second bid is given by (Haab and McConnell, 2002):

$$\Pr(\text{yes, no}) = (WTP_{1i} \geq t^1, WTP_{2i} < t^2) \quad (5)$$

$$= \Pr(\mu_1 + \varepsilon_{1i} \geq t^1, \mu_2 + \varepsilon_{2i} < t^2)$$

$$\Pr(\text{yes, yes}) = (WTP_{1i} > t^1, WTP_{2i} \geq t^2)$$

$$= \Pr(\mu_1 + \varepsilon_{1i} > t^1, \mu_2 + \varepsilon_{2i} \geq t^2)$$

$$\Pr(\text{no, no}) = (WTP_{1i} < t^1, WTP_{2i} < t^2)$$

$$= \Pr(\mu_1 + \varepsilon_{1i} < t^1, \mu_2 + \varepsilon_{2i} < t^2)$$

$$\Pr(\text{no, yes}) = (WTP_{1i} < t^1, WTP_{2i} \geq t^2)$$

$$= \Pr(\mu_1 + \varepsilon_{1i} < t^1, \mu_2 + \varepsilon_{2i} \geq t^2)$$

The i^{th} contribution to likelihood function becomes;

$$L_i \left(\frac{\mu}{t} \right) = \Pr(\mu_1 + \varepsilon_{1i} \geq t^1, \mu_2 + \varepsilon_{2i} < t^2)^{YN} \quad (6)$$

$$* \Pr(\mu_1 + \varepsilon_{1i} > t^1, \mu_2 + \varepsilon_{2i} \geq t^2)^{YY}$$

$$* \Pr(\mu_1 + \varepsilon_{1i} < t^1, \mu_2 + \varepsilon_{2i} < t^2)^{NN}$$

$$* \Pr(\mu_1 + \varepsilon_{1i} < t^1, \mu_2 + \varepsilon_{2i} \geq t^2)^{NY}$$

Where:

t^1 = First bid price, t^2 =Second bid price

YN= 1 for yes-no answer, 0 otherwise;

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

NN= 1 for no-no answer, 0 otherwise;

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

This formulation is referred to as the Bivariate Discrete Choice Model. Assuming normally distributed error terms with mean 0 and respective variances 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 . Given the dichotomous responses to each question, the normally distributed model is represented as bivariate probit model.

The i^{th} contribution to the bivariate probit likelihood function is given as:

$$L\left(\frac{\mu}{t}\right) = \Phi_{\varepsilon_1 \varepsilon_2} \left(d_{1i} (t^1 - \mu) / \sigma_1 \right), \left(d_{2i} (t^2 - \mu) / \sigma_2 \right), d_{1i} d_{2i} \rho \quad (7)$$

Where:

$\Phi_{\varepsilon_1 \varepsilon_2}$ = The bivariate normal cumulative distribution function with zero means, $d_{1i} = 2y_{1i} - 1$ and $d_{2i} = 2y_{2i} - 1$

$y_{1i} = 1$ if the response to the first question is yes, and 0 otherwise

$y_{2i} = 1$ if the response to the second question is yes, and 0 otherwise

ρ = Correlation coefficient

σ = standard deviation of the error.

After running regression of dependent variable (yes/no indicator), on a constant and on independent variables consisting of the bid levels, the mean WTP value is determined following Jeanty (2007). Accordingly, the mean WTP and 95% confidence intervals are calculated using the approach developed by Krinsky and Robb (1986), sometimes known as the parametric bootstrapping approach. Therefore, the mean WTP value of improved irrigation water can be calculated as follows.

$$\text{Mean WTP} = \frac{\bar{X}\beta'}{\beta_o} \quad (8)$$

Where $\bar{X}$ = Row vector of sample mean including 1 for the constant term,

$\beta'_{(k-1 \times 1)}$ = Column vector of estimated coefficients,

β_o = Coefficient on the bid variable, and in constant-only models, $\bar{X}=1$ and β' is the coefficient on the constant term.

Following to Habb and McConnell (2002), the mean WTP from the open ended contingent valuation responses can be estimated as:

$$\text{Mean WTP} = \sum_{i=0}^n \frac{y_i}{n} \quad (9)$$

Where n is the sample size and y_i is maximum amount of willingness to pay reported by households.

Tobit model

The Tobit model is used to handle data sets where outcome variables have natural limitations of definition. Tobit is an extension of Probit model and it is really one approach dealing with problem of censored data (Johnston and Dindaro, 1997). As a result, it is a limited variable model because of the restriction part of the regressand. Despite, the Tobit model is better than discrete regression model in valuing the amount WTP; still it measures between 0 and continuous (Gujarati, 1995).

Tobit model was used in this study for analyzing the determinants of WTP and the maximum amount of money that respondents are willing to pay for improved irrigation water use. This model has an advantage over other discrete models in that, it reveals both the probability of WTP and its maximum WTP for the households, simultaneously. From an empirical standpoint Logit and Probit typically yield similar estimates of the relevant derivatives for only between 0 and 1. The cumulative distribution functions for the two models differ slightly only in the tails of their respective distributions. This makes the choice of the model arbitrary, though Logit has advantage of simplicity and ease of interpretation. However, the Tobit model uses all of the information, including information

on censoring, and provides consistent and efficient estimates than other discrete models, logit and probit (Patnaik and Sharma, 2013).

Following Maddala (1992) and Johnston and Dindaro (1997), the Tobit model can be defined as:

$$MWTP_i^* = X_i\beta + \varepsilon_i \quad i = 1, 2, 3, \dots, N \quad (10)$$

$$MWTP_i = MWTP_i^*, \text{ if } MWTP_i^* > 0$$

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

Where, $MWTP_i$ = the observed dependent variable, in this case maximum willingness to pay of each household (i^{th} household).

$MWTP_i^*$ = is a latent variable which is not observed when it is less than or equal to 0, but is observed if it is greater than 0.

X_i = Vector of factors affecting WTP

β = Vector of unknown parameters

ε_i = Error terms that are independently and normally distributed with mean zero and common variance σ^2

The model parameters are estimated by maximizing the tobit likelihood function of the following form (Maddala, 1997 and Amamiya, 1985).

$$L = \prod_{MWTP_i^* > 0} \frac{1}{\sigma} f\left(\frac{MWTP_i - \beta'X_i}{\sigma}\right) \prod_{MWTP_i^* \leq 0} F\left(\frac{-\beta'X_i}{\sigma}\right) \quad (11)$$

Where: f and F are the density function and cumulative distribution function of Y_i^* , respectively. $\prod_{MWTP_i^* \leq 0}$ Means the product over those i for which $MWTP_i^* \leq 0$ and $\prod_{MWTP_i^* > 0}$ Means the product over those i for which $MWTP_i^* > 0$.

It may not be sensible to interpret coefficient of a Tobit in the same way as one interprets coefficients in a non censored linear model (Johnston and Dinardo, 1997). Hence, one has to compute the derivatives of the estimated Tobit model to predict the effects of changes in the exogenous variables.

$$\frac{\partial E(MWTP_i)}{\partial X_i} = f(t)\beta' \quad (12)$$

Where, $\frac{\beta' X_i}{\sigma}$ is denoted by t .

Following Maddala (1997), the change in the probability of WTP as independent variable changes is:

$$\frac{\partial F(t)}{\partial X_i} = f(t) \frac{\beta'}{\sigma} \quad (13)$$

The change in the amount of WTP with respect to a change in explanatory variable among individuals who are willing to pay is:

$$\partial E \left(MWTP_i / MWTP_i^* \neq 0 \right) = \beta' \left[1 - t \frac{f(t)}{F(t)} - \left(\frac{f(t)}{F(t)} \right)^2 \right] \quad (14)$$

Where, $F(t)$ is the cumulative normal distribution of T , $f(t)$ is the value of derivative of the normal curve at a given point (i.e., unit normal density), t is the T score for the area under normal curve, β' is the vector of tobit maximum likelihood estimate and $\pm$ is the standard error of the error term.

3.5. Description of Variables and Working Hypothesis

The dependent variables and independent variables which were used to estimate the households' willingness to pay for improved irrigation water use and the expected effect of these variables are discussed below.

3.5.1. Dependent Variables

WTP: It is households' willingness to pay for the use of improved irrigation water. It is a dummy variable which takes the value of 1 if the household is willing to accept the offered bids and 0 otherwise.

MWTP: It is the maximum willingness to pay that households will be asked to state their maximum willingness to pay for improved irrigation water in Birr. In this case, the dependent variable MWTP takes a continuous value and the Tobit model was employed.

3.5.2. Independent Variables

Initial Bid Value (IBID): It is a continuous variable, and indicates the offered bid price to the households (in hundred Birr). This is the bid amount provided for the improved irrigation water use to the households per *timad* (0.25 hectare) of irrigable land per year in order to estimate the WTP. The higher the bid price is the less likely households would be willing to pay for the irrigation water use (Aydogdu, 2016). Thus, the expected coefficient of this variable was negative.

Sex of the Household Head (SEX): It is a dummy variable taking a value of 1 if the household is male and 0 otherwise. Female headed households have less resources possession endowment as well as some cultural constraints than male headed households (Meseret and Endrias, 2016). As a result, their ability to pay may be less than male headed households. Therefore, it was hypothesized that male households are more willing to pay for irrigation water use than female headed households.

Age of the Household Head (AGE): It is a continuous variable that represents the age of the household 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. An increase in the age of the household decreases his/her WTP (Alem *et al.* 2013). Hence, it was expected to have a negative relationship with WTP for improved irrigation.

Education Level of the Household Head (EDUC): This is a continuous variable which measure the number of class year the household attended. It is assumed that educated households are more able to obtain and utilize information. A study done by Angella *et al.* (2014) found that education level of the household has a positive relationship with his/her WTP decision. Thus, it was hypothesized that this variable affects WTP for improved irrigation water positively.

Experience in Irrigated Farming (EXPER): This is a continuous variable which indicates the number of years of irrigated farming experience of the household. Households with long irrigated farming experience are more willing to pay for irrigation water than those with relatively shorter experience (Syaukat *et al.* 2014). Farmers who have an experience in irrigated farming knew the importance of irrigation and willing to pay for it

(Mekonen *et al.*, 2015). Thus, this study hypothesized that irrigation experience will have a positive effect on the WTP for improved irrigation.

Family Size (FAMSIZ): It is a continuous variable which refers to number of family member in the household that is measured by an adult equivalent. In the case of irrigation farming, households with large family size will have more labor input that can utilize the increased water availability (Tesfahun, 2014). Thus, it is hypothesis that there will be a positive relationship between family size in adult equivalent and households' WTP for improved irrigation water use.

Credit Utilization (CREDIT): It is a continuous variable which refers to the amount of credit that household obtained and utilize. Credit improves the ability to invest in improved technologies like irrigation and enhance farm production. So that it lead to pay for irrigation water use (Omondi *et al.*, 2014). Hence, credit utilization would positively affect WTP for improved irrigation water use.

Irrigable Land Size (LANDSIZ): It is the irrigable land size that households have the right to use for irrigation in *timad* (0.25 hectare). Households with large irrigable land are expected to benefit more from the improved service either by cultivating or renting it (Alem *et al.*, 2013). Thus, the expected sign of this variable is positive.

Cash crops growing (CASHCRP): It is a dummy variable which refers to whether the farmer households are growing cash crops (such as *khat*, coffee, sugarcane, and others) or not. It takes 1 if the household grows cash crops and 0, otherwise. In Ethiopia it is obvious that the largest share of export value comes from cash crops, which contributes 47 percent to agricultural GDP and 85 percent of farm cash income (FAO, 2014). Accordingly, it revealed that households who grow cash crops will pay for the improved irrigation water use 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 was positive.

Dissatisfaction (DISSAT): It is a dummy variable which takes 1 if the household head is unsatisfied with the existing irrigation water use and 0 otherwise. This variable refers to a dissatisfaction of households with the existing irrigation water use. Households who are dissatisfied by the existing irrigation use will be willing to pay more for the improved

irrigation water use than those satisfied with it (Ayana, 2016). Thus, the expected sign of this variable is positive.

Distance from Market Center (DMARKT): This is a continuous variable that measures the distance of the residence of the household in hours walk on foot to the nearest market center. If the market place is located far away from the farm and/or from the home, the commodity may perish, especially for perishable commodities, before reaching the market. Thus, the farther the market center is the lesser the income from the sale of farm produce, and less willing to pay for the improved irrigation water use. Angella *et al.* (2014) came up with a negative relationship between WTP for environmental protection and distance to market center. Following this empirical result, here too, it was expected that this variable has negative effect on WTP for irrigation water use.

Total Annual Income (INCOM): It is a continuous variable and indicates an annual total income of the household which is measured in (thousand) Birr. An increase in total annual income of the household will increase his/her financial position and affect the willingness to pay for irrigation positively. Tang *et al.* (2013) found that income affected WTP for irrigation positively. In the empirical study, it is also expected that income will affect WTP positively.

Perceived Trend in Rain-fed Crop Productivity (PTREND): This is a dummy variable that takes 1 if the household believes that there has been decrease in crop yields per hectare of land during the past four years and 0 otherwise. The decline in productivity related to rainfall during the past four years of crop season make the farmers to value irrigation water use more (Meseret and Endrias, 2016). Thus, it is expected that this variable will affect households' WTP for improved irrigation use positively.

Number of Oxen Owned (OXEN): It is a continuous variable that is measured by the number of oxen the household owned. In rural area, oxen ownership is considered as wealth and it is used as an input for farming, because ox serves for plowing. The higher the number of oxen the household possess, the more likely to accept (participate for) the improved irrigation technology given the irrigable farm land (Mensah and Adebayo, 2015). Therefore, the expected sign of this variable is positive.

Labor Shortage (LABR): This is a dummy variable referring to availability of labor in household. It takes a value of 1 if there is shortage of labor in the household and 0, otherwise. Participation in irrigation requires more labor force (Abraham *et al.*, 2015) specially, in constructing distribution structures within the farm, watering the plants and related activities require labor. Therefore, it is hypothesized that availability of labor shortage will be associated negatively with farmers WTP for improved irrigation water.

Distance from irrigation water source (DSRCE): It is a continuous variable that represents distance of the residence of the household measured in hours walk on foot from nearest water source for irrigation use. This could show that households who are far from the water source would be less willing to pay for improved irrigation water use than those located near to it (Milton, 2015). It is hypothesized that, if the water source is far from the farm, it brings a negative relationship with WTP.

Table 2: Descriptions and expected signs of the explanatory variables

Variables	Description of variables	Type of variable	Measurement	Sign
DSRCE	Distance from irrigation water source	Continuous	Hour	-
DMARKT	Distance from market center	Continuous	Hour	-
EDUC	Education level of the household head	Continuous	Class year	+
FAMSIZ	Family size	Continuous	Adult equivalent	+
LANDSIZ	Irrigable land size	Continuous	<i>Timad</i> (0.25ha)	+
OXEN	Number of oxen	Continuous	Count	+
INCOM	Total annual income of the household head	Continuous	Birr	+
IBID	Initial offered bid	Continuous	Birr	-
AGE	Age of the household head	Continuous	Year	-
EXPER	Experience of the household head in Irrigated Farming	Continuous	Year	+
SEX	Sex of the household head	Dummy	1 if male, 0 otherwise	+
PTREND	Perceived trend in rain-fed agricultural productivity	Dummy	1 if decreases, 0 otherwise	+
DISSAT	Dissatisfaction with the existing irrigation water use	Dummy	1 if dissatisfied, 0 otherwise	+
CREDIT	Credit utilization	Continuous	Birr	+
CASHCRP	Cash crops growing	Dummy	1if growing cash crops, 0 otherwise	+
LABR	Labor shortage	Dummy	1 if shortage,0 otherwise	-

Source: Own computation, 2016.

4. RESULTS AND DISCUSSIONS

This chapter presents results obtained from the survey. The first section presents the descriptive analysis followed by Econometrics analysis results.

4.1. Descriptive Analysis

In this analysis, summaries of descriptive statistics of the sample households for household characteristics, institutional characteristics, farm characteristics and resource ownership of the household are presented in Tables 3, 4 and 5, respectively.

4.1.1. Households' Characteristics

The survey results in Table 3 show that the average educational attainment of household was 6 class years with the minimum educational achievement of no attendance, and the maximum achievement was 12 class years. The group comparison in terms of educational level between the households in the study area shows the mean educational attainment for willing and non willing households is 6 class years and 1 class year respectively. The student's t-test shows that there is a statistically significance difference in the mean class year between willing and non-willing households. This may be because of the reason that the more educated households are more likely willing to participate in irrigation use.

In the study area, the households are varying according to the size of their family. Accordingly, the mean family size was 3.6 adult equivalents which vary between a minimum of 2 and a maximum of 7.4 adult equivalents. The mean family size for willing and non willing households is 3.7 and 2.47 adult equivalents, respectively. In the study area, the mean family size was significantly and statistically different among the willing and non-willing households. This shows that there is a strong relationship between family size and willingness to pay in the study area as irrigation requires intensive labor force.

Table 3: Summary of households' characteristics according to their willingness to pay for improved irrigation water use

Variable	Min	Max	Total		Willing		Non willing		t-value
			n	Mean	n	Mean	n	Mean	
Education (Class year)	0	12	251	5.65	232	6	19	1.3	-6.16***
Family size (Adult Eq.)	2	7.4	251	3.6	232	3.7	19	2.47	-5.05***
Age(Year)	24	75	251	43.39	232	43.33	19	44.26	0.36
Experience(Year)	4	33	251	15.52	232	16.18	19	7.58	-4.8***

Variable	Total		Willing		Non willing		$\chi^2 - test$
	n	%	N	%	N	%	
Sex							
Female	32	12.75	23	9.91	9	47.37	22.15***
Male	219	87.25	209	90.09	10	52.63	
Labor shortage							
Yes	103	41.04	92	39.66	11	57.89	2.41
No	148	58.96	140	60.34	8	42.11	

*** Statistically significant at 1% significance level; n: number

Source: Own computation- result based on the 2017 survey data.

The mean experience of farm household in irrigation practice was 15.52 years which range from a minimum of 4 to a maximum of 33 years. Practical irrigation farming experience significantly varies between willing and non willing households, with average years of experience of 16.18 and 7.58, respectively. Given that willing households have larger irrigated farm experience than the non willing households, one can suggest that irrigated farm experience contributes to households' willingness to pay for the supply of improved irrigation water.

It can be observed from Table 3 that of the total number of household respondents, only about 12.75% were female headed while the remaining 87.25% were male headed households. From the total 232 willing households, 90.09% were male headed households and 9.91% were female headed households. On the other hand, from 19 non-willing households, 52.63% were male headed, while female headed households were 47.37%. The chi-square value shows that there is a statistically significant difference between male and female headed households with regards to their willingness to pay, showing that sex difference is systematically related to the status of willingness to pay for improved irrigation use in the study area.

4.1.2. Institutional Characteristics of Sample Households

The mean credit households obtained from different sources and utilized is about 2069.6 Birr which ranges from 0 to 6000 Birr in the last year crop season. The significant respective mean difference for both willing and non willing households is found to be 2228.8 and 124.6 Birr, respectively. About 72.11% of the credit was from micro financial institutions. The rest 26.09% of the credit has been received from friends and relatives, and only about 1.8% comes from *idir*. The purpose of the credit received by respondents was to purchase fertilizer, to buy oxen, to buy seed, for livestock rearing, to purchase irrigation facilities, for petty trade, for home consumption and house building, in descending. The t-test of credit utilization indicates that there is statistical significant difference between the willing and non-willing households, showing that amount of credit utilized is an important component in determining WTP for improved irrigation water, since this credit is also used to pay for irrigation water use.

Table 4: Summary of institutional characteristics of sample households

Variable	Min	Max	Total		Willing		Non willing		t-value
			n	Mean	n	Mean	n	Mean	
Distance from market (Hr)	0.5	2.5	251	1.43	232	1.42	19	1.5	0.67
Credit utilization (Birr)	0	6000	251	2069.6	232	2228.8	19	124.6	-7.35***

*** Statistically significant at 1% significance level; n: number

Source: Own computation- result based on the 2017 survey data.

4.1.3. Farm Characteristics and Resource Ownership of Sample Households

The irrigable land holding is the most important input of production for households of the study area. The mean irrigable land holding of sample households is 3.99 *timad* (0.99 ha). The land holding ranges from a minimum of 0.5 *timad* (0.125 ha) to a maximum of 10 *timad* (2.5 ha). The survey result also indicated that a mean irrigable land ownership for the willing and non-willing households is 4.11 *timad* (1.03 ha) and 2.55 *timad* (0.64 ha) respectively, that was found to be statistically significant. This indicates that households with higher irrigable land often rich and have access to more resources as potential irrigable land increases the production of agriculture activities, and they were more willing to pay than households with small irrigable land size.

Oxen are the sole draft power used for plowing, and used for other function such as threshing, in the study area. Hence, it is much needed by farm households to cultivate their land on time in crop season. The average number of oxen owned by farm households was 4 with a minimum of 0 and maximum of 8 oxen. The average number of oxen possessed was about 4 and 1 for willing and non willing households, respectively and the difference is statistically significant. This means that households who do not own oxen either acquire the much needed pair of oxen at a cost or rent out/lease-out their land, which means a substantial reduction in income, and non-willing for the improved irrigation water use. However, those with large number of oxen have more income obtained from increased agricultural productivity, and more willing to pay for improved irrigation water use.

The observed average annual household income is about Birr 66,631.4. The income level ranges from a minimum of Birr 1700 to a maximum of Birr 160,223 per year. The mean income difference between willing and non-willing household is 69,939 and 26,243.79 Birr, respectively that is found to be statistically significant. This shows that higher annual income of farm household from different sources encourage households' willingness to pay for improved irrigation water use. Thus, the mean income for willing households is significantly higher than that of non-willing. From the total mean annual income of sample households, vegetable and perennial crops contribute the highest income followed by, income from livestock and its products, off/non-farm income, annual crop respectively.

Table 5 shows that the mean distance of the household walk on foot from the water source of irrigation was 1.3 hours with the range of 0.3 to 2 hours. The distance from the water source discourages households to pay, while nearness to irrigation water source may motivates farm households to pay for improved irrigation water use.

Table 5: Summary of farm characteristics and resource ownership of sample households

Variable	Min	Max	Total		Willing		Non willing		t-value
			N	Mean	n	Mean	n	Mean	
Land size (<i>timad</i>)	0.5	10	251	3.99	232	4.11	19	2.55	-3.5***
Oxen owned (Count)	0	8	251	4.15	232	4.44	19	.63	-7.67***
Income (Birr)	1700	160223	251	66631.4	232	69939	19	26243.8	-5.95***
Distance from water source (Hour)	0.3	2	251	1.3	232	1.27	19	1.57	2.49***

Variable	Total		Willing		Non willing		$\chi^2 - test$
	N	%	n	%	N	%	
Perceived trend of productivity							
Increasing	62	24.7	49	21.12	13	68.42	21.12***
Decreasing	189	75.3	183	78.88	6	31.58	
Dissatisfaction							
Yes	246	98.01	230	99.14	16	84.21	20.04***
No	5	1.99	2	0.86	3	15.79	
Cash crops growing							
Yes	241	96.02	230	99.14	11	57.89	78.1***
No	10	3.98	2	0.86	8	42.11	

*** Statistically significant at 1% significance level; n: number

Source: Own computation- result based on the 2017 survey data.

From table 5 it can be observed that of all sample households included in the study about 75.3% responded that rainfed agricultural crop productivity decreased and the remaining 24.7% of the households responded that there was no decrease in rainfed agricultural crop productivity. From the households who perceived rainfed agricultural crop productivity is declining, about 78.88% were willing to pay for improved irrigation water. Regarding the perceived rainfed crop productivity trend, there is statistical significant difference between the willing and non-willing groups. As it was indicated by the majority of household heads, the variability in rainfall pattern, intensity and amount is the major cause for the decrease in productivity. As a result, those households who believe that rainfed agricultural crop productivity is decreasing are more willing to pay for an improvement in the irrigation water supply.

The survey results in Table 5 show that about 98.01% of households are dissatisfied with the existing irrigation water use while only the remaining 1.99% households are satisfied

with the existing irrigation water supply. Out of those households, who are dissatisfied with existing irrigation use, about 99.14% were willing and 84.21% were non-willing to pay for the improved irrigation water use. The group difference was found to be statistically significant between those willing and non willing households. This may be because of seasonality of irrigation water, imbalance between existing demand and supply, distance from water source, absence of canal, and conflict among them made to be dissatisfied with the existing water use.

Table 5 also shows that of the total households surveyed, 96.02% were growing cash crops (such as *khat*, coffee, sugarcane) and 3.98% were not growing cash crops. In addition, out of the total households growing cash crops, 99.14% were willing and 57.89% were not willing to pay for irrigation water use. Furthermore, there is also a statistically significant relationship between willing and non willing household heads showing that, growing cash crops does systematically and significantly relate with WTP status. This is mostly because those households growing cash crops have the capacity to accept the offered bid, because they are in a good financial position than those households who were not growing cash crops. In the study area most households grow cash crops on the major portion of their irrigable land, and they always worry about such crops whether or not to get the optimum amount of water supply for them. It is learned that a reduction in cash crop, major source of income, leads to a substantial decline in income and reduced ability to pay, and in turn their willingness to pay.

4.1.4. Households' Willingness to Pay for the Improved Irrigation Water

In the final survey, five (200, 100, 400), (300, 150, 600), (400, 200, 800), (600, 300, 1200), (700, 350, 1400) set bid prices for the corresponding valuation question were given. These were set following what we have obtained from the pilot survey. Starting from heads of households who were asked for willingness to pay for the improved irrigation system, the data revealed that 92.43% were willing to pay for improved irrigation water use and only the rest 7.57% were not willing to pay for the improved irrigation water use (Table 6). The amount of money that a consumer is willing to pay in order to consume a particular unit of goods is the state of their willingness to pay (Tesfaye, 2014). Hence, the stated price is value that the users are willing to pay for the use of improved irrigation water use in this case.

Table 6: Distribution of sample households who are willing and non-willing to pay for improved irrigation water use

Responses to WTP	Frequency	Percent
No	19	7.57
Yes	232	92.43
Total	251	100

Source: Own computation- result based on the 2017 survey data.

To identify whether these responses are protest zero responses or not, a follow-up question was raised to the interviews. The reason for zero willingness to pay was purely an economic reason. For instance, one interviewee said the following: ‘I cannot afford the payment, as I do not have sufficient amount of money’. According to Tesfaye (2014), if the respondent thinks that he or she should not pay for the good, purely not for poverty reasons, resulting to a zero WTP, it must be treated as a protest vote and should be deleted from the calculation of the mean WTP. But, since these people are only for economic reasons we could not consider as protest votes and we cannot omit from the calculation of mean willingness to pay. Hence, none of them were considered as protest answers.

As indicated in Table 7, one can understand from the joint frequencies of discrete responses, 40.64% responded "Yes-Yes" for both the first and second bids, 23.50% responded "Yes-No", 23.11% responded "No-Yes", and the remaining 12.75% responded "No-No" for both bids. Furthermore, the households’ responses for the offered bids in double bounded questions are presented in the Appendix Table 3.

Table 7: Frequency of sample households’ discrete response

Joint response	Frequency	Percent
NN	32	12.75
NY	58	23.11
YN	59	23.50
YY	102	40.64
Total	251	100.00

Note: YY: Yes-Yes; YN: Yes-No; NY: No-Yes; NN: No-No

Source: Own computation- result based on the 2017 survey data.

4.2. Econometric Analysis Results

As mentioned earlier, this study used double-bounded dichotomous choice models and analyzed using a Seemingly Unrelated Bivariate Probit Regression model to estimate the mean WTP, and Tobit model to identify its determinants for a designed plan to improved irrigation water use, respectively. Before estimating the effect of the explanatory variables on households' WTP decision to improve the existing irrigation water provision and use, data exploration is an important step. Hence, so as to measure the strength of relationship between two or more variables, coefficients of correlation were used. Gujarati establishes a rule of thumb, which says that multicollinearity is a serious problem, when a pair wise correlation coefficient between the two regressors is greater than or equal to 0.8 (Gujarati, 2004). The correlation matrix generated using survey data shows that multicollinearity is not a serious problem (Appendix Table 1). In most econometric data, particularly in cross-sectional data, we are also more likely to encounter heteroscedasticity problem (Greene, 2008). Following to Wooldridge (2002), to solve such problem robust standard errors were used and estimated in this study.

4.2.1. Users' Mean Willingness to Pay for Improved Irrigation Water

One of the main objective of the double bounded dichotomous choice format as we discussed in the methodology part, was to estimate WTP of the households after the estimation of the Seemingly Unrelated Bivariate Probit Model (see Appendix Table 2), which is the mean WTP of the sample households for the improved irrigation water use in the study area. Before presenting the regression results from the Bivariate Probit model, first testing of whether Bivariate Probit is a better fit than Univariate Probit model by performing a Wald test by considering whether the correlation coefficient (ρ) between the two error terms is zero, or not is made.

The results of the estimated correlation coefficient between the two error terms, and test statistic from the bivariate probit model are reported in the Appendix Table 2. The Wald test suggests that, the estimate correlation coefficient is statistically and significantly different from zero at 1% level of significance. This indicating that the null hypothesis that two equations are independent is rejected at 1% level of significance for both equations. The estimated correlations coefficient is 0.98, it means that the two variables are

essentially positively correlated that means unobservable determinants together. As such, the two variables (errors) are correlated and the probability of one variable will be dependent on the probability of the other. The test used to confirm the validity of the estimation was the Wald test. Accordingly, Wald $\chi^2(2) = 215.67$ at 1% level of significance indicating that goodness-of-fit under the null hypothesis that all parameters are zero can be rejected. Hence, our data fits the bivariate probit model very well. The regression output (Appendix Table 2) also revealed that the coefficients of both the initial and follow-up (second-bid values) are negatively and significant at 1% probability level. The implication of this negative relationship indicates that, as the value of the initial and second price increases, households' WTP for the improved irrigation water use decreases.

Therefore, all results show that the bivariate probit model is superior to either independent or interval models. Since if these models are used instead, the results generated will be biased. Hence, we estimated the regression equations jointly using a seemingly unrelated bivariate probit model.

The mean WTP estimation was made based on first and second willingness to pay for offered price answers from double bounded choice format. The parametric WTP estimates are used to estimate the mean WTP and the respective confidence intervals and standard errors, and employ the method introduced by Krinsky and Robb (1986), which was found to be robust, particularly for small to medium sample sizes (Claudy *et al.*, 2011). The Krinsky-Robb method uses random draws from assumed multivariate normal distribution to generate new parameter vectors to estimate the mean WTP the study resort to simulating confidence intervals with the Krinsky-Robb procedure. It also draws a number of times from the asymptotic normal distribution of the parameter estimates and calculates the welfare measure for each of these draws. WTP is then calculated for each of these parameter estimates and they are used to construct the WTP distribution for the complete set of replications. The estimated mean WTP and the confidence intervals from both equations are presented in Table 8.

Table 8: The estimated mean WTP

Measures	WTP	LB	UB	AS	CI/Mean	Difference
Mean for Equation 1	575.23	531.16	625.72	0.0000	0.16	94.56
Mean for Equation 2	718.78	660.48	775.43	0.0000	0.16	114.95

Where: Achieved Significance Level for testing H0: WTP $\leq$ 0 vs. H1: WTP $>$ 0

LB: Lower bound; UB: Upper bound

Source: Own computation- result based on the 2017 survey data.

As shown in Table 8, the result indicates that the point estimate of the mean willingness to pay for the improved irrigation water use for equation one and two are Birr 575.23 and Birr 718.78 per year per *timad*, respectively. This value is highly significant at 1% significance level.

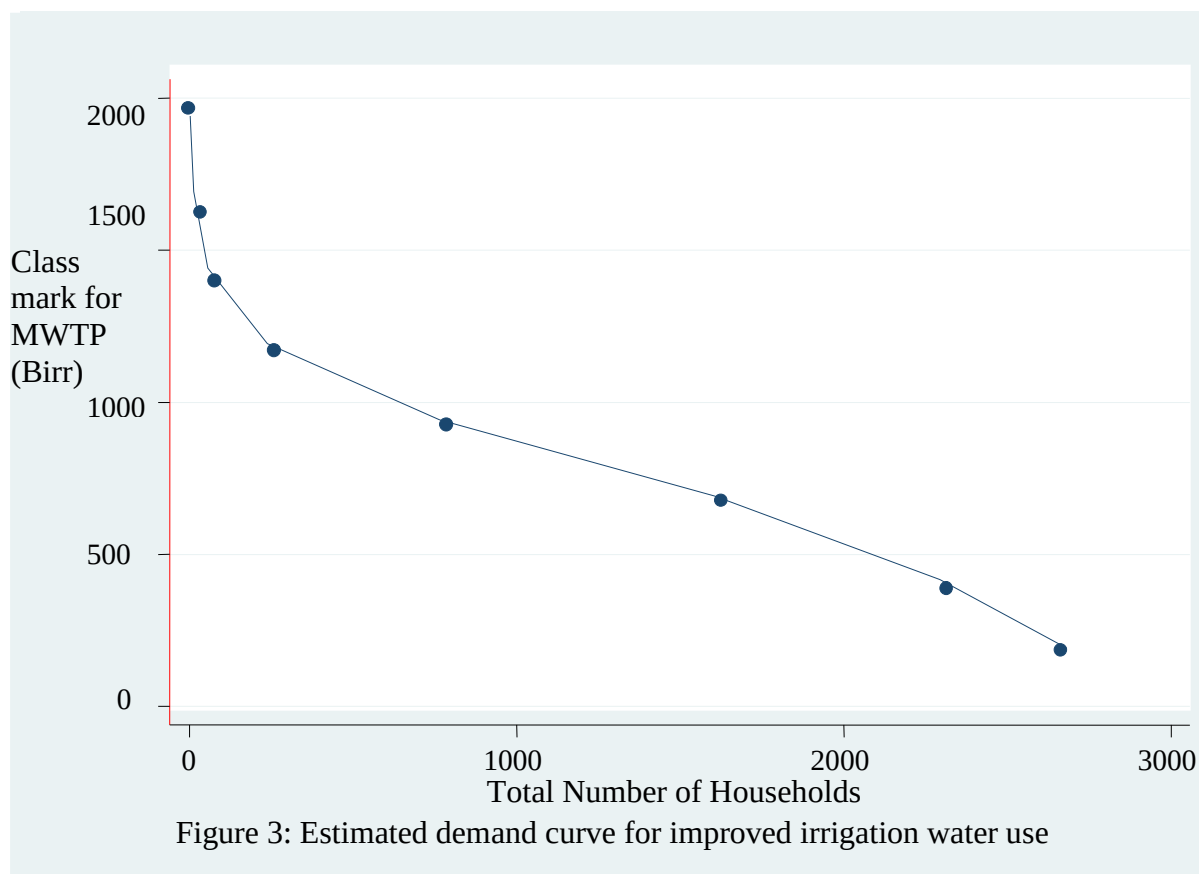
Tesfahun (2014) reported comparable reasons and mentioned the fact that the second equation parameters are likely to contain more noise in terms of anchoring bias as the respondent is assumed to take the clue from the first bid while forming his/her WTP for the second question, and estimates from the first equation are generally used in computing mean WTP. Thus, 575.23 Birr per year per *timad* (0.25 ha) estimated from the first equation was used in this study to estimate the mean WTP, if the scenario of improving irrigation use is implemented in the study area. On the other hand, the mean WTP from open ended question is estimated to be 562.25 Birr per year per 0.25 ha. As a matter of fact that households become free riders in the open ended questions, the mean willingness to pay in double-bounded dichotomous choice format is higher than that of open-ended CVM when their means are compared. This is in agreement with the finding of Ayana (2016).

4.2.2. Estimating Aggregate Willingness to Pay

The aggregate willingness to pay for year round supply of improved irrigation water can be estimated by taking the total number of beneficiary households in the command area. According to WWIDAO (2016), the total number of beneficiary households is estimated at about 2701 and the total irrigable area is about 10,777 ha. Based on these figures, the expected aggregate willingness to pay for irrigation water supply using the double bounded and open ended question is Birr 24,797,015 and 24,237,473, respectively.

4.2.3. Estimated Demand for the Improved Irrigation Water

As the payment increases, the number of households who are willing to pay that amount declines. This relationship can be more easily observed by deriving a demand curve for the improved irrigation water use. To this end, one should measure the midpoint of maximum WTP along the vertical axis and the number of households who are willing to pay per *timad* per year along the horizontal axis.



Source: Own design, 2017.

As shown in figure 4 the demand curve has a negative slope like most economic goods under normal conditions. This implies that increasing the price has a disincentive effect on the demand for improved irrigation water use, *ceteris paribus*.

4.2.4. Determinants of Willingness to Pay for Improved Irrigation Water Use

This section represents the results of the Tobit model showing the different determinants of farmers' willingness to pay for improved irrigation water use in the study area. The results of the model show that farmers' willingness to pay is influenced by 10 variables that found

to be statistically significant out of 16 explanatory variables included in the model, those are: education level of the household head, family size, irrigable land size, number of oxen, total annual income, experience in irrigated farming, dissatisfaction, credit utilization, cash crops growing, and initial bid. The results of the Tobit model and its marginal effects are presented in Table 9 and 10, respectively

Education Level of the Household Head (EDUC): Educational level, as expected was positively related to WTP and significant at 5% probability level. Keeping other factors constant, the marginal effect of the variable indicates that a class year increase in education level of the household increases the probability of WTP for improved irrigation water use by 0.024%. In the similar way, as the education level of household increased by a class year, the amount of cash a household is willing to pay for improved irrigation water use could increase by 10.87 Birr, *ceteris paribus*. That is, households with more class years are more willing to pay for improved irrigation water. One possible reason could be that more literate individuals are more concerned about water resource as education provides knowledge and makes the household get information, and the information creates awareness about the benefits obtained from improved irrigation water than less educated or illiterate ones. This was consistent with the findings of Mekonen *et al.* (2015), and Meseret and Endrias (2016).

Family size (FAMSIZ): In agreement with a prior expectation, family size was found to be statistically significant at the 10% level with positive sign. This indicates that the probability of WTP to support the improved irrigation water use practices increases as the family size increases. Keeping the influence of other factors constant, an increase in the total family size by a single adult equivalent increases the probability of being willing to pay for improved irrigation water use by 0.024%. Similarly, when the family size of the household increases by one adult equivalent, the amount of cash a household is willing to pay for improved irrigation water use may increase by 10.94 Birr, keeping other factors constant. This may be because irrigation practices are labor intensive to utilize available water; hence households with large family size are willing to invest more in irrigation. Irrigation water can also support the large family households through increasing the production and ensuring the supply of enough food to them. This is consistent with the findings of Alem *et al.* (2013) and Tesfahun (2014).

Irrigable Land Size (LANDSIZ): Irrigable land size of the household is statistically significant at 1% and related positively to WTP for improved irrigation water use. Other factors remaining constant, if irrigable land size of a household increases by one *timad* (0.25ha), the probability of WTP for improved irrigation water use increases by about 0.05%. In another way, when irrigable land size of the household increases by one *timad* (0.25 ha), the amount of cash that the household could pay for improved irrigation water use increases by 22.67 Birr, holding other factors constant. It has been expected that as the irrigable land size of a household in *timad* increases, the opportunity of high income from crop production using irrigation water will be surge; which means those households who cultivated more area of land could be in a better position than those who cultivated less (Beyan, 2016). Therefore, this would lead to a higher demand for improved irrigation water. The findings of Syaukat *et al.* (2014), Urujeni and Ngabitsinze (2015) and Ayana (2016) are in agreement with what has been found in the present study.

Number of Oxen Owned (OXEN): Total number of oxen has been found to relate to the probability of willingness to pay for improved irrigation water use positively and significantly at 1% significance level. The calculated marginal effect shows that for each additional increment of the number of oxen, the probability of households' willingness to pay for the improved irrigation water use will increase by 0.075%, keeping the other explanatory variables constant. Similarly, when the number of oxen owned by a household increases by one head, the amount of cash a household is willing to pay for improved irrigation water use may increase by 34.37 Birr, *ceteris paribus*. Number of oxen could have a lion's share in rising income and wealth of rural households for its direct role in agricultural productivity. Subsequently, it helps households to stabilize consumption by absorbing income shocks that might arise from crop failures triggered by natural disasters. As in most of the developing countries, in the study area, oxen are the sole draught power sources and hence lack of oxen, besides its negative effect on land productivity, signifies a lower economic status of farm households. This creates shortage of power and burden on the family labor. However, households with larger number of oxen are likely to participate in irrigation practice (Abraham *et al.*, 2015), and also raise farm income for they can use other farm inputs more efficiently by bringing additional land into cultivation through either cash rent or share cropping basis (Kinfu, 2012). When this holds true, the willingness to pay for improved irrigation will also increase.

Total Annual Income (INCOM): Households' total yearly income has a positive sign and it is statistically significant at 1% level of significance. The marginal effect shows that an increase in the total annual income of the household by a thousand Birr increases the likelihood of households' WTP for improved irrigation water supply by 0.0068%, keeping other factors constant. In similar way, when an income of a household increases by one thousand Birr, the amount of cash a household could pay for improved irrigation water use increases by 3.1 Birr, holding other factors constant. Higher income increases the ability of household to pay and contribute to the allocation of available water to the households. Besides, those households with higher income are willing to pay more for improved irrigation water than their counterparts with lower income. This result is consistent report of Nega (2012) and Tang *et al.* (2031).

Experience in Irrigated Farming (EXPER): The irrigation farming experience is found to be statistically significant at 1% level of significance with the expected positive sign. The results suggest that a one year increase in irrigation farming experience of a household head increases the probability of households' WTP for improved irrigation water use by 0.018%, holding other factors constant. When irrigated farming experience of a household increases by one year, the amount of cash that the households could pay for improved irrigation water use would increase by 8.1 Birr, *ceteris paribus*. A possible explanation is that households with longer irrigation farming experience can easily realize the benefit from it and hence are more likely to attach high value for irrigation water than those shorter years of irrigation farming experience. This result is consistent with the findings of Nega (2012) and Mekonen *et al.* (2015).

Dissatisfaction (DISSAT): Dissatisfaction with the existing irrigation water supply system is found to be positively influencing households' WTP for improved irrigation water use at 1% level of significance. The marginal effect estimate shows that households who are not satisfied by the existing irrigation water use are 16.1% more likely to support its improvement than those households reported their satisfaction with the existing irrigation water use. Similarly, households who are dissatisfied with the existing irrigation water use would pay Birr 326.54 more than those expressed their satisfaction with the existing use. Comparing to other variables, this variable has more an immense effect on determining the WTP of the household for improved irrigation water use in the study area. Households who are dissatisfied with the existing irrigation water supply system are found to be willing to

pay more if there is an improvement as compared to those who are currently satisfied with the existing irrigation water supply. This may be due to the prevailing problems with the existing irrigation water use such as water scarcity, poor distribution of water, imbalance between the supply and demand, and conflict among users. This result is consistent with the findings of Ayana (2016).

Table 9: The Tobit model results of the maximum willingness to pay

Variables	Coefficients	Robust Std. Err.	t- values
Distance from water source (Hour)	-4.883297	3.371691	-1.45
Distance from the market (Hour)	-23.03829	30.28418	-0.76
Education (Class Year)	10.99667**	4.766136	2.31
Family size (Adult Equivalent)	11.07262*	5.970248	1.85
Land size (<i>timad</i>)	22.9416***	8.3019	2.76
Oxen (Count)	34.78387***	6.57817	5.29
Income (Birr)	3.13863***	.523806	5.99
Age (Year)	-1.947455	1.364906	-1.43
Experience (Year)	8.166546***	2.086936	3.91
Sex (1=Male)	10.38187	35.49004	0.29
Trend(1=Decrease)	13.48568	28.93801	0.47
Dissatisfaction (1= Yes)	378.7321***	138.5536	2.73
Credit utilization (Birr)	51.29487*	27.23905	1.88
Cash crop growing(1=Grow)	190.7497**	84.03015	2.27
Labor shortage (1=Yes)	27.23397	24.11122	1.13
Initial bid (Birr)	-25.92072***	6.866233	-3.78
Constant	-488.9225	175.9271	-2.78

N_o. of observation: 251; Log likelihood = -1546.23; F (16, 235) = 27.15; Pro > F = 0.000;

Pseudo R² = 0.0987; Threshold value for the model: Lower = 0.0000 Upper = + infinity

***, **, *: significant at 1%, 5% and 10% significance level, respectively.

Source: Own computation- result based on the 2017 survey data

Table 10: Marginal effects of explanatory variables on the amount of willingness to pay

Variable	Change in the probability	Change among the water users(Birr)	Overall change
Distance from water source (Hour)	-0.0001052	-4.825382	-4.877585
Distance from the market (Hour)	-0.0004963	-22.76505	-23.01134
Education (Class Year)	0.0002369	10.86625	10.98381
Family size (Adult Equivalent)	0.0002385	10.9413	11.05967
Land size (<i>timad</i>)	0.0004942	22.66951	22.91476
Oxen (Count)	0.0007493	34.37134	34.74318
Income (Birr)	0.0000676	3.101407	3.134959
Age (Year)	-0.000042	-1.924358	-1.945177
Experience (Year)	0.0001759	8.069691	8.156993
Sex (1=Male)	0.0002389	10.25126	10.36881
Trend(1=Decrease)	0.0003082	13.31708	13.46884
Dissatisfaction (1= Yes)	0.1609477	326.5385	363.3554
Credit utilization (Birr)	0.0012903	50.59861	51.22353
Cash crop growing(1=Grow)	0.0202417	181.9665	189.3812
Labor shortage (1=Yes)	0.000616	26.8969	27.20034
Initial bid (Birr)	-0.0005584	-25.6133	-25.8904

Source: Own computation- result based on the 2017 survey data.

Credit Utilization (CREDIT): The variable credit utilization has a positive sign as expected and significant at 10% significance level. This indicates that utilization of cash credit has a positive influence on the price farmers' are willing to pay for the improved of irrigation water use. The result indicates that, keeping other factors constant, a one Birr increase in the households' credit utilization increases the probability of the households' willingness to pay for improved irrigation water use by 0.13%. Similarly, when the credit utilization of households increases by one Birr the amount of cash that the household could pay for improved irrigation water use also increases by Birr 50.6, holding the effect of factors constant. The better credit farmers utilize, the higher is the price that they are willing to pay, because credit enables cash constrained farmers to invest in complementary inputs to irrigation, thereby enhancing their output and income. Thus, credit utilization is one of the major determinants of the maximum amount of price that the households' are

willing to pay. This result is supported by the findings of Omondi *et al.* (2014) and Angella *et al.* (2014).

Cash crops growing (CASHCRP): Growing cash crops are found to influence the willingness of the households to pay for improved irrigation water use positively at 5% significance level. The marginal effect of the variable indicates that, keeping other factors constant, farmers who grow cash crops had 2.02% more probability of paying for improved irrigation water use than those farmers who do not grow cash crops. Farmers who grow cash crops would also pay Birr 181.96 for improved irrigation water more than those who do not grow cash crops. This is because of the economic importance of cash crops, which means households' growing such crops earn significant amount of income, which in turn enable the household to purchase productive inputs on time, and access technologies. In the study area, there are some households who obtain the highest annual income from sales of cash crops specially, *khat*. Therefore, in the study area households are willing to increase the area under cash crops. The increase in the area under cash crops can help in increasing the household income levels (Ali, 2013). Accordingly, they need more improved irrigation water to sustain their source of income, and they are also more willing to pay for an improved provision of improved irrigation water.

Initial Bid (IBID): The coefficient of initial bid has the negative sign as expected, and significant at 1% level of significance, indicating that the higher the amount the lesser the probability of accepting the offered amount which is consistent with the economic theory (Biswas and Venkatachalam, 2015). This suggests that a one hundred Birr increase in the offered initial bid will decrease the probability of the household's willingness to pay for improved irrigation water use in the study area by 0.056%, other factors held constant. In similar way, when the initial bid price increases by one hundred Birr, the amount of cash the farmer could pay for improved irrigation water use decrease by 25.61 Birr, *ceteris paribus*. Comparable effects have been reported by Tang *et al.* (2013) and Tesfahun (2014).

5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1. Summary and Conclusion

Water is an economic resource which is necessary in the development of irrigation and plays a vital role in economic development. As scarcity of irrigation water is rising, pricing of agricultural water and cost recovery can play a significant role in promoting water use efficiency. Hence, the main objective of this study was to analyze farmers' willingness to pay for improved irrigation water use, and identifying its determinants using the contingent valuation method in Woliso District.

The study used both primary and secondary data. The survey responses of 251 households selected in a two-stage sampling technique (purposive and random sampling techniques) through a semi-structure questionnaire from the four *kebeles* of Woliso District were analyzed using both descriptive statistics and Econometric models in the study. The elicitation method used was double bounded format with an open-ended follow up question to elicit farmers' willingness to pay for the improved irrigation water use, and the researcher administered the survey using an in-person interview. Five choice sets, (200, 100, 400), (300, 150, 600), (400, 200, 800), (600, 300, 1200) and (700, 350, 1400) were also provided to each respondent for the choice experiment part to determine their WTP for improved irrigation water use.

In this study, Seemingly Unrelated Bivariate Probit model was used to estimate the mean WTP of farmers for improved irrigation water use. Then, 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 575.23 per year per *timad* (0.25 ha). On the other hand, the mean willingness to pay from open-ended questions was Birr 562.25 per year per *timad* (0.25 ha). Thus, in this study, the mean willingness to pay from dichotomous choice questions is greater than open-ended questions. The aggregate welfare gain from improved irrigation water use in the study area from the double bounded dichotomous choice format and open ended format was calculated to be 24797015 and 24237473 per year, respectively. The study found that the value of improved irrigation water use from open ended format was relatively underestimated as compared to the double bounded format.

This indicates free riding and lack of base for answering WTP questions under open ended format. Thus, in estimating the value of environmental resource like irrigation water at farm household level, it is important to use CVM in the form of double bounded elicitation format than other elicitation method. On the other hand, the estimated aggregate demand for improved irrigation water is similar to the demand of the household to most economic goods under normal conditions which indicates as the payment increases, the number of households willing to pay that amount declines.

The contingent valuation method used a Tobit model to identify the key determinants of farmers' willingness to pay for improved irrigation water use. The important variables identified in this study to determine farmers' WTP for improved irrigation water are, education level of the household head, family size, irrigable land size, number of oxen, total annual income, experience in irrigated farming, dissatisfaction, credit utilization, cash crops growing, and initial bid. All these variables were found to positively and significantly influence the probability of WTP for improved irrigation water use, except the initial offered bid value that was negatively and significantly related to WTP of the farmers.

In general, the study founds the willing of farmers to pay for improved irrigation water use, and determinants of willingness to pay for improved irrigation water use in the study area. Thus, appropriate irrigation water pricing will make the user more aware of the resource scarcity, creating more value for the improved irrigation, leading to efficient management of the improved system. Accordingly, farmers are more beneficiary and profitable enterprise.

5.2. Recommendations

Based on the findings of this study, the following recommendations are forwarded: The positive relationship between education of the household and WTP indicates that, the water authorities must urgently embark on an empowerment of farmer through education, to create awareness the people about the benefits associated with the need to pay for an improved irrigation water use is necessary for the sustainability of an improved irrigation water system. Until they are made aware of the issues related to pay for improved irrigation water use, overexploitation and misallocation of the resource will persist.

Moreover, they will never value the irrigation water resource, nor be willing to pay for it. Thus, there is a need to educate farmers on irrigation water factors, more so on the concept of water scarcity.

The positive relationship between household family size and their willingness to pay for the improved irrigation water use shows that households with large family size need the provision of the improved irrigation water more. So, in designing the improved irrigation system for the farm households, policy makers need to take the household size into consideration as one of the factors that influence households' willingness to pay for the improved services. Moreover, the government should ensure the more supply of improved irrigation water service which can accommodate the large family size of the households in the study area.

The positive relation of irrigable land size and WTP of the household indicate that large irrigable farm size encouraging WTP of households. Therefore, higher supply of improved irrigation, and irrigation technology that enhances crop productivity should be taken into consideration while designing and planning for the improved irrigation water provision in the study area. Even though irrigable land size is one of the determinant factors of WTP for improved irrigation water, because of its limitedness there is no room for area expansion in most parts of the country. As such, improved agricultural technologies that enhance the productivity of land per unit area should be developed and training of farmers on land management should be given a due emphasis.

The positive relationship between the number of oxen and farm households' WTP for improved irrigation water implies oxen contribute to the probability of WTP through increasing the capacity of farmer to produce crops, so additional income generation. In line to this, there is a need to motivate farm households of the area to rear a reasonable and quality number of oxen which they are able to increase their production and provide improved irrigation water supply. Therefore, by giving training on modern oxen management system, households could generate more income and products and improve their well-being.

The strong positive relationship between the annual income of the households and their willingness to pay for the improved irrigation water use points out that there is a need to

consider farmers' income characteristics of the households in designing policies related to supply of improved irrigation water services. That means the irrigation water price charged should reflect the income characteristics of the households and also the irrigation water setting should deem lower income society not to be lacking of from access to the minimum irrigation water requirement to sustain to produce. Moreover, it implies that planning income-generating programs that solve the poor households can assist to sustain the system to function healthy way.

The positive relationship between the experience in irrigated farming of the farmers and willingness to pay for the improved irrigation water use implies that more experienced peoples have more interest to pay for the improved irrigation use. Thus, in designing the improved irrigation system for the farmer policy makers needs to take the experience of the farmers into consideration as one of the factors that affects households' willingness to pay for the improved irrigation water use. It is also recommended that farmer experience be promoted in the area through training, communication, awareness creation and other skills that enable to realize the available benefit from improved irrigation water provision.

The positive relationship between the dissatisfaction and farmers' willingness to pay for the improved irrigation water use signify that the farm households are not satisfied with existing irrigation system. This implies that if the farmers get the improved reliable water services, they would pay more for the water services they would get from the improved source. Hence, in designing the irrigation water system of farmers, policy makers should take the poor satisfaction of existing system into consideration and emphasis should be given in providing the improved irrigation water provision that would satisfy the farm households more and meet the gap between increasing demand and existing supply. Furthermore, a needed well-constructed irrigation scheme, proper canals and other infrastructures that could substantially assist in better way of irrigation utilization should be getting high attention by government and other responsible body.

The significance of credit utilization in the estimated model indicates that in order to have an effective irrigation pricing system, motivation the households in utilization of credit is an important for farmers of the study area. Thus, any irrigation expansion endeavors should be accompanied by promoting farmers to utilize affordable credit that increase the productivity of the irrigation users. These may include establishment of an agricultural

bank or micro-credit institutions where farmers can access and utilize credit at more affordable rates compared to commercial banks. However, the supply of this service should be based on the locality specific requirements and effectiveness. This will increase the farmers' ability to invest in farm inputs and other requirements, receive better returns and willingly pay to maintain the flow of the improved irrigation water.

Growing of cash crops has been found to be important factor that positively determines the probability of the willingness of households to pay for improved irrigation water use. Thus, appropriate policy to be followed should focus on encouraging the farmer to diversify the types and purposes of cash crops. Some barriers that hinder many farmers to hesitate from growing cash crops should be revisited. Farmer participation in growing different types of cash crops should be promoted and continued. The irrigation water pricing structure should also capture the water need of the crops grown in the area.

Since irrigation water charge promote the sustainable use of irrigation water and manage it effectively, and also farmers are willing to pay for improved irrigation water in the study area, the government should strengthen this system by fixing rational water charges for irrigation water use and collect it from the farmers to meet operation and maintenance costs in the study area.

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7. APPENDICES

Appendix Table 2: Parameter estimates of Seemingly Unrelated Bivariate Probit model

Variables	Coefficients	Standard Error	Z-Value
Answer for initial bid			
IBID(Initial bid)	-0.0039872***	0.0004139	-9.63
Constant	2.293553***	0.2283608	10.04
Answer for the second bid			
SBID(second bid)	-0.0025791***	0.0001763	-14.63
Constant	1.853782***	0.1515109	12.24
Rho	0.98	0.0006013	

Number of Observations = 251; Log-likelihood = -252.49891

Wald chi2 (2) = 215.67; Prob > chi2 = 0.000

Likelihood-ratio test of rho = 0: chi2 (1) = 25.5935; Prob > chi2 = 0.0000

*** Significant at 1% significance level.

Source: Own computation- result based on the 2017 survey data.

Appendix Table 3: Summary of Discrete Responses to the Double- Bounded Questions

Offered bids	Frequency of respondents				Total
	YY	YN	NY	NN	
200	36	4	1	7	48
300	34	7	0	5	46
400	31	13	5	5	54
600	1	24	22	9	56
700	0	11	30	6	47
Total	102	59	58	32	251

Source: Own computation- result based on the 2017 survey data.

Appendix Table 4: Conversion for adult equivalent

Labor class	Age (years)	Conversion factor
Children	Less than 7	0
Children	7-14	0.4
Adult male	15-64	1.0
Adult female	15-65	0.8
Old male	Greater than 65	0.5
Old female	Greater than / equal 65	0.5

Source: Stork *et al.* (1991).

Appendix 5: Summary of survey questionnaire

**SURVEY QUESTIONNAIRE ON THE FARMERS' WILLINGNESS TO PAY FOR
IMPROVED IRRIGATION WATER USE: THE CASE OF WOLISO DISTRICT,
SOUTH WEST SHOA ZONE, OROMIA NATIONAL REGIONAL STATE,
ETHIOPIA**

Interviewee's _____ Kebele _____ Village _____
 Date of interview _____ Supervisor _____
 Interview started _____ Interview ended _____
 Signature _____

Hello, how are you? First of all I would like to thank you in advance for giving your precious time for this interview. My name is _____. This interview is a main body of a research Mr. Tadesse Tolera, who is currently studying at Haramaya University. This research is in partial fulfillment for the awarded of MSc. in Agricultural Economics. He is conducting a survey which focuses on the farmers' willingness to pay for improved irrigation water use.

You are selected randomly from people living in your area. The information you provide could help to have a common understanding about the problems in utilization of the irrigation water. Moreover, it will enable to design an appropriate policy for the sustainable utilization of the irrigation through informed decision making. Further, this information will help the government to design an appropriate policy for the development, conservation and sustainable use of irrigation by concerned body and help policy makers make conscious decisions about irrigation water use problem. Whatever information you provide will be completely confidential and strictly, this is purely for an academic purpose only. Your name will never be associated with your answers. There are no correct or wrong answers. Hence, I kindly request you to give me a genuine answer for the following questions honestly and as truthfully as you can. The interview will take a few minutes.

Thank you for taking part in the survey.

Part I: Questionnaires on Socio economic and demographic characteristic of the respondents (Please use ✓ for your choice)

A. Household Characteristics

1. Age of the household head _____ in year.
2. Can you read and write? 1 = Yes, 0 = No
3. If yes to Q2, which type of education? 1 = Formal education, 2 = Religious education
4. If formal education, _____ class year.
5. Sex of household head? 1 = male, 0 = Female
6. Family members of the household
Children < 7 _____, Children 7-14 _____, Adult male 15-64 _____,
Adult female 15-65 _____, Old male > 64 _____, Old female ≥ 65 _____
7. Do you have practical irrigated farming experience? 1=Yes 0=No
8. If 'Yes' to Q7, how many years of experience do you have? _____ years.
9. Did you have labor shortage of farming in 2008 E.C? 1=Yes, 0=No
10. If Yes to Q9, did you try to solve the problem? 1=Yes 0=No
11. If Yes to Q10, how did you solve the shortage?
a) Hiring b) Support (friends and relatives) c) Communal labor
d) Other (specify) _____

B. Institutional characteristics of the household

12. Did you receive credit in the year 2008 E.C? 1=Yes 0=No
13. If No to Q12, what was the reason?
a) No access b) high interest rate c) I have sufficient capital d) Collateral e) Others
(specify) _____
(If your answer to Q12. is yes, answer Q14-17)
14. How much have you borrowed for agricultural production in the preceding agricultural season? _____ Birr.
15. What was/were the credit source/s from which you usually borrow money?
a) Cooperatives b) Micro Finance Institutions c) Banks d) Merchants e) Friends and relatives
f) Money lenders g) others, specify _____

16. Was the credit adequate to your demand? 1=Yes 0=No

17. For what purposes did you use the credit?

- a) To purchase irrigation facilities b) To buy fertilizer c) To buy seed
- d) To buy oxen e) Petty trade f) Livestock rising g) Consumption
- h) Others, specify_____

18. How much time does it take you to travel the nearest market to sell your agricultural products and buy the necessary items? _____ Hours

C. Farm related characteristics and resource ownership of the household

19. Total farm size of house hold _____ *timad*

19.1. Total cultivated land _____ *timad*

19.1.1. Annual crops _____ *timad*

19.1.2. Perennial crops _____ *timad*

19.2. Grazing land _____ *timad*

19.3. Fallow land _____ *timad*

19.4. Forest land _____ *timad*

19.5. Others, specify _____ *timad*

20. How many *timad* potential irrigable land you have?

21. How can you explain the trends in your agricultural output over the last four year per *timad* of land in rain-fed agriculture? 1=Decreasing 0 = Increasing (Not Changed)

22. If your answer on Q21 is choice 1 that is “decreasing”, what do you think the causes of decrease in crop productivity?

- a) Rainfall variability b) Lack of improved seed c) Lack of fertilizer
- d) Low fertility of the soil e) others, specify_____

23. Are you dissatisfied with the existing irrigation water supply system? 1. Yes 0. No

24. If Yes for Q27, what kind of challenges and problems you have faced/observed in the existing irrigation schemes? Specify all bellow

- 1. Seasonality of irrigation water 2. Imbalance between the demand and the existing system of water supply 3. Distance from water source 4. Conflict 5) Others _____

25. How much do you walk on foot from the water source of irrigation? _____ Hrs.

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

27. If yes to Q26, which cash crop you are growing?

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

28. Household's oxen ownership, income from livestock sales and livestock by products during the last year (2008 E.C)

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	Poultry				
10	Bee colony				
11	Sheep				
12	Goat				
13	Other				
Subtotal – 1					

29. Income gained from sales of livestock and livestock products during 2008 E.C

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			
4.1	Hide and skin			
4.2	Manure/Dung			
Subtotal -2				

30. Income gained from annual crop sales during 2008 E. C

No.	Crop	Total income
1	Barley	
2	Wheat	
3	Maize	
4	<i>Teff</i>	
5	Pea	
6	Bean	
7	Sorghum	
8	<i>Noug</i>	
9	Others (specify)	
10	Lentil	
11	Chickpea	
12	Linseed	
13	Finger-millet	
Subtotal – 3		

31. Income gained from vegetables, fruits, woodlots and cash crops sales during 2008 E. C.

Vegetables, fruits, woodlots and cash crops		Total income
Vegetable		
1	Onion	
2	Potato	
3	Tomato	
4	Garlic	
5	Carrot	
6	Cabbage	
7	Lettuce	
8	Pepper	
9	Others (specify)	
Fruit		
1	Avocado	
2	Papaya	
3	Mango	
4	Lemon	
5	Banana	
6	Others	
Woodlots and other perennial crops		
1	Eucalyptus	
2	<i>Gesho</i>	
3	<i>Enset</i>	
Cash crops		
1	<i>Khat</i>	
2	Coffee	
3	Sugarcane	
Subtotal – 4		

32. Income gained from non/ off-farm activity in 2008 E.C

No.	Type of nonfarm activity	Total income
1	Petty trade	
2	Hand craft	
3	Carpenter	
4	Weaving	
5	Remittance	
6	Aid	
7	Daily labor	
8	Sale of charcoal	
9	Sale of firewood	
10	Sale of forest	
11	Sale of grass	
12	Driver (mini bus, Bajaj, chart or others)	
13	Rent of land and pack animal	
14	Sales of local drink and food (<i>tela, teji, arekie, injera</i> and bread)	
15	Others (specify)	
Subtotal – 5		

33. Total income in the year 2008 E.C _____

Part II: Questions about Farmers' Willingness to Pay for Irrigation Water Use

In this section , I would like to ask you how much you are willing to pay given the proposed programs (measures) to solve the problems in sustainable use irrigation. Thus, please listen carefully the scenario that will be presented.

“There is a water source which is suitable to develop and maintain irrigation project scheme, which is found around Walga River, and resolve the dependency on rain fed agriculture. However, there is no a well-constructed irrigation scheme and regulation to use the resource. Despite the River has enough amount of discharge in the rainy season, it seems to decrease its flow in the dry season in large amount. Yet the irrigation provisions around the River have no water storage capacity since water comes out to the command area from the rivers through traditional means. This will create a problem at the time of dry season at which more water for irrigation is needed by huge number of users. Not only this, but also there are other problems regarding the use, such as traditional means of water distribution, which means the scarcity of water as flooding and leakage of water created, and absence of users’ schedule that might lead to conflicts among users. Moreover, there is no lined canal, and the water wastage is a serious problem of the area. Hence, in order to

improve the existing irrigation water supply, the water storage capacity should be enhanced. To do so, dam construction is a prerequisite to reserve water which enables farmers to get sufficient water flow throughout the year

Once the dam has been built, people will be able to irrigate their land throughout the year. However, the high cost of construction of a dam makes 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. Adequate maintenance funds should be provided to the implementing project to carry out both regular and emergency maintenance. Accordingly, to optimize long-run and short-run benefits from irrigation water, irrigation beneficiary households often contribute money to sustain the project's dam and channels."

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

34. Are willing to pay for irrigation water? 1=Yes; 0=No;
35. If Yes to Q34, would you willing to pay Birr Y per *timad* (0.25 hectare) of irrigable land? 1=Yes 0=No
36. If Yes to Q35, will you be willing to pay Birr 2Y per *timad* of irrigable land? 1=Yes 0=No
37. If No to Q35, will you willing to pay Birr 0.5Y per *timad* of irrigable land? 1=Yes 0=No
38. What is the maximum amount you are willing to pay per *timad* of irrigable land per year? _____Birr.
39. What is the main reason for your maximum willingness to pay?
 - 1) I can afford more 2) It solves problems related to dependence on rain fed production 3) I think it worth that amount 4) Other reason (specify)_____
40. If No to Q34, can you tell me the reason why you do not want to pay anything for irrigation water?
 - 1) I cannot afford it 2) I am satisfied with the rain fed 3) The government should subsidize 4) I don't belief new policy of government 5) I don't like these

hypothetical questions 6) I believe that money will not be used properly 7) I don't think that the proposed program is effective 8) Other reasons (specify) _____

41. If yes in Q35 and Q36 and if the respondent maximum willingness to pay in Q36 is greater than in Q38, then ask, you said that you are willing to pay _____ ETB (in Q36) but when I ask you your maximum willingness to pay you said _____ ETB (in Q38) which is less than the amount you already agreed to pay previously, Why?

42. If yes in Q35 and no in Q36 and if the respondent willingness to pay Q35 is greater than in Q38, then ask, you said that you are willing to pay _____ Birr (in Q35) but when I ask you your maximum willingness to pay you said _____ Birr (in Q38) which is less than the amount you already agreed to pay previously, Why?

43. If no in Q35 and yes in Q37 and if the respondent willingness to pay Q37 is greater than in Q38, then ask you said that you are willing to pay _____ Birr (in Q37) but when I ask you your maximum willingness to pay you said _____ Birr (in Q38) which is less than the amount you already agreed to pay previously, Why?

44. What do you recommend to make irrigation water sustainable throughout the year? (Multiple answers are possible).
 - a. Government has to cover all the costs incurred to provide water
 - b. The people have to take the ownership to manage it properly after finalization
 - c. Beneficiary Households has to contribute money for the proper maintenance of the dam
 - d. Irrigation water should be provided free of charge
 - e. Other (specify) _____
45. Do you have any comment to add? Please specify?
46. If Yes for Q38, what is the reason for your willingness to pay?
 - i. For my own benefit ii. For society as a whole
 - iii. For the next generation iv. Other (specify) _____

Bear in mind that: Reasons above can be categorized as use-value, option value and bequest value. This will capture the use and non-use value of the respondent's WTP. The respondents can choose more than one answer to the above questions.

Thank you for your cooperation!!

Focus Group Discussion Checklist

Date: _____ *Kebele* _____

FGD members: Male: _____ Female: _____

1. What are the opportunities, challenges and constraints of using irrigation water in your area?
2. Does irrigation water supply is a serious problem in your area? (Why or why not?)
3. In your view, what is (are) the main cause(s) of this problem?
4. How would you describe water security/supply/access? Do you have rights/entitlements to the water?
5. What should be done to increase the improved irrigation water supply and sustainability of your area?
6. What kind of irrigation methods are practiced in the area? How much it is effective and efficient? How much (on average) one incurs a cost for irrigating *timad* of farm per year?
7. Which crops do you deem as the most profitable in: i) Summer ii) Winter
8. What is/are the existing rules and regulations practiced on water usage in the area?
9. Do you think that water is free good?
10. Since developing or constructing irrigation scheme requires lot finance, it is important to consider which sources of financing are available. Who do you think the source of finance?
11. What do you comment if the government construct irrigation scheme in the area and impose a charge on water users that covers the initial investment cost and/or operation and maintenance costs?
12. As an irrigation water user of this area, what can you do to improve the quality and quantity of irrigation? If you are asked to contribute to pay for the improved irrigation use in your area that may enhance water management, are you willing to pay a certain amount of money for such a project? Why or why not? If yes how many Birr would you pay per *timad* per year?

Thank you for your cooperation!!

Key Informant Interview

Name of organization: _____

Name of interviewee: _____

Position: _____

- 1) How is water accessed in your area? Are the irrigation users of your area currently getting adequate supplies thereof? If no, why? What mechanism could you think as solution as result? Who is also a responsible body for that action?
- 2) What is the irrigation potential of the water resource (both in terms of farm area and number of households)? How many hectares of land currently irrigated by using different methods?
- 3) Who is/are the most user of water resource of the area?
- 4) What is the prevailing management system of the irrigation water resource in the area? What is/are the potential challenges in using the water resource?
- 5) What is/are the roles of your office in managing and controlling the water resource? Are there other formal or informal rules and regulations for managing the irrigation water resource in the area?
- 6) Did the office teach and train farmers in relation to the water resource? If yes, in what area(s)?
- 7) Is there any institutional support for the farmers of the area as to encourage the using of irrigation water?
- 8) According to your understanding, irrigation water charging system could have any advantage in managing water distribution? How?

Thank you for your cooperation!!