FARMERS WILLINGNESS TO PAY AND CHOICE OF SMALLHOLDER WATER LIFTING TECHNOLOGIES: EVIDENCE FROM ADAMI TULU, LEMO, DANGELA AND BAHIR DAR ZURIA WEREDAS, ETHIOPIA.

MSc THESIS

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JUNE, 2015

ARBA MINCH, ETHIOPIA

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A THESIS SUBMITTED TO THE
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ARBA MINCH, ETHIOPIA

DECLARATION

I hereby declare that this MSc thesis is my original work and has not been presented for a degree in any other university, and all sources of material used for this thesis have been duly acknowledged.

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This is to certify that the thesis entitled "**Farmers Willingness to Pay and Choice of Smallholder Water Lifting Technologies: Evidence from Adami Tulu, Lemo, Dangela and Bahir Dar Zuria Weredas, Ethiopia**" submitted in partial fulfillment of the requirements for the degree of **Master's** with specialization in **Economic Policy Analysis,** the Graduate Program of the **Department of Economics** and has been carried out by **Meneyahel Zegeye** Id. No RMSc/113/06, under our supervision. Therefore, we recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the department for defense.

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ACRONYMS

ADLI	Agricultural Development Led Industrialization
ATA	Agricultural Transformation Agency
CEM	Choice Experiment Method
CRV	Central Rift Valley
CSA	Central Statistical Agency
CV	Contingent Valuation
CVM	Contingent Valuation Method
ILRI	International Livestock Research Institute
ILSSI	Innovative Laboratory for Small Scale Irrigation
IWMI	International Water Management Institute
Mha	Million Hectares
MOA	Ministry of Agriculture
MoWIR	Ministry of Water, Irrigation and Energy
PASDEP	Plan for Accelerated and Sustainable Development to End Poverty
SDPRP	Sustainable Development and Poverty Reduction Program
SSI	Small Scale Irrigation
SWLT	Smallholder Water Lifting Technology
TCM	Travel Cost Method
WLT	Water Lifting Technology
WTA	Willingness to Accept
WTP	Willingness to Pay

ABSTRACT

This paper analyzes the farmers' willingness to pay (WTP) and demand for the smallholder water lifting technologies (SWLTs). The study employed Contingent valuation method (CVM), and 208 farmers' were selected based on multi-stage sampling technique from four weredas, Adami Tulu, Lemo, Dangela and Bahir Dar Zuria. The selected sample households were asked a contingent valuation question using a double bounded elicitation with open ended follow up question. To examine the determinants of WTP and to compute the mean WTP for the SWLTs, probit and bivariate probit model were used. Using multinomial logit model determinants of demand for the SWLTs namely, motor pump, rope and washer and pulley were also examined. The probit model result shows that age of the household head, family size, household income, initial bid values, access to credit, off-farm activity, tropical livestock unit and land size significantly affect the probability of the households' WTP for the SWLTs. From the bivariate probit model, the computed mean WTP for the SWLTs using double bounded elicitations (DBE) are 18,192, 5,370 and 1,842 birr for motor pump, rope and washer and pulley respectively. The computed open ended elicitation mean WTP values are 13,750, 3,550 and 1,195.5 birr for motor pump, rope and washer and pulley respectively. Likewise, the total WTP for motor pump, rope and washer and pulley from the DBE method is 22,030,512, 5,928,480 and 1,648,590 birr respectively. The total WTP for motor pump, rope and washer and pulley from open ended elicitation is 16,651,250, 3,919,200 and 1,069,973 birr respectively. The multinomial logit model result shows that, sex of the household head, family size, education level, access to credit, household income, off-farm activity, access to market, quality of soil, ownership mode, agro-ecological zone and land size are found to be significant in affecting the probability of the households' demand for the SWLTs. The main findings of this paper is that farmers' are willing to pay for the SWLTs. But, the level of WTP and choice of technology is contingent upon and different from location to location. The DBE result shows that market price of rope and washer and motor pump lies between farmers' upper and lower range of WTP bound but farmers' are more willing to pay for pulley higher than what the existing market reveals. Also, the mean values obtained from the open ended elicitation is lower than the values from the double bounded elicitation. Thus, policy makers should be careful on the selection of the elicitation technique to elicit the farmers' WTP. Moreover, the comparative analysis between male and female headed household shows that females are less willing to pay for the SWLTs.

Key words: *Bivariate probit, contingent valuation, multinomial logit model, Smallholder water lifting technology, willingness to pay*

CHAPTER ONE

1 INTRODUCTION

1.1 Background of the Study

Water is one of the essential but scarce natural resource. In many parts of the world, increasing demands for water for irrigation, domestic, industrial and environmental uses have created scarcity and competition for this resource. Agriculture is the main sector of the economy that consume more than 90% of the water resource. However, the sector's water resource utilization is inefficient (Birgitte, 2007). But, an efficient use of available water resource for agricultural and non-agricultural use is essential. Hence, understanding the way farmers allocate and use the available water resource is important (Savenije & Van Der, 2006).

Demand for irrigation water seems to increase over time due to rainfall irregularities. Since source of water for irrigation can be diverse, such rivers, dams and reservoirs and ground water. It plays a role in easing the effect of rainfall uncertainty on agricultural production (FAO, 2004; McCornick, Smakhtin, Bharati, et al, 2013, and Rogers, Llamas and Cortina, 2006).

Despite such roles, the literature on the effect of irrigation on agriculture and poverty alleviation is of recent origin, scant, and shows mixed effect. Studies which do not find a significant link between irrigation, agricultural production and poverty alleviation include Fan et al. (2000); Huang et al. (2006); Wang et al. (2003) and Ghosh, Panda, Nanda & Kumar, (2006). Those studies found either only the modest effect or no positive effect of investment in irrigation to agricultural productivity and poverty alleviation.

In contrast, there are also other literature which advocate the positive impact of irrigation on agricultural performance. These studies use two linkage, direct and indirect linkage to show the effect of irrigation to agricultural productivity and poverty alleviation. Much of the literature suggests the indirect linkage, where irrigation contributes to reduction of poverty through employment generation, rural non-farm multiplier effects and food price effects (Schneider & Gugerty, 2011; Thuon et al., 2007; Hussain & Wijerathna, 2004). Analysis by Mwakalila (2004) shows the irrigation importance in the past and future poverty alleviation in Tanzania. Similar analysis by Bhattarai, & Narayanamoorthy, (2003) indicates the strong effect and marginal impact of availed and well managed irrigation on poverty reduction.

Despite this argument, literatures which focus on Sub Saharan African (SSA) countries and other developing countries (such as Etissa et al, 2014; Ayele, 2011; Desilva et al, 2014) shows the positive impact of irrigation on agricultural productivity and poverty reduction. Irrigation has served as one key driver behind growth in agricultural productivity and alleviation of rural poverty (Ayele, 2011). It increases agricultural production through protecting crops against risks of uneven, unreliable or insufficient rainfall. It also increases agricultural production by enabling higher crop yields and multiple cropping. Irrigation creates additional employment and helps to smooth seasonal shortfalls in food supply and encourage the production of crops that contribute towards a more varied and nutritious diet. It also benefits the urban poor by keeping food prices low despite growing demand for food (Girma & Awulachew, 2007 and FAO, 2004).

Ethiopia, which referred as the water tower of Africa, has a ground water potential of 2.6 billion m^3, eleven major lakes and total annual surface runoff of 123 billion m^3, which shows the country’s huge potential for irrigation (Awulachew, Yilma, Loulseged, et al, 2007). Despite this potential, the economy is dependent on rain fed agriculture, where rainfall is erratic and often insufficient.

One way of addressing the problems of agricultural production dependence on erratic and insufficient rainfall and inefficient use of available irrigation water is by increasing smallholders’ access to water and water saving, but affordable irrigation technologies including, Rope and Washer, Pulley and Motor pumps. The technologies ease the farmers’ inadequate water access during dry seasons and thus raise the farmers’ capacity to grow crops two or more times annually.

The economic concept of Willingness to Pay (WTP) is commonly used to determine the amount of money that farmers’ are willing to pay for the supply of SWLTs (Mezgebo et al, 2013). WTP is one of the standard approaches that is used by market researchers and economists to determine the value of goods and services based on hypothetical questions using CVM. WTP estimation of the farmers’ valuation of WLTs using CVM and examining the determinants of SWLTs preference is one way of identifying the problems regarding with the underutilized irrigation and the smallholder WLTs.

1.2 Statement of the Problem

Ethiopia comprises 112 million hectares (Mha) of land. The cultivable land area estimates vary between 30 to 70 Mha (Awelachew, 2010). Many studies, however, showed that a significant portion of cultivated land is not irrigated. One of the recent study showed that only 15 Mha of land is under cultivation, of which only about 640,000 ha (4.3 percent) is irrigated (Awelachew, 2010). The water resource of the country is also underutilized. According to Gebregziabher (2012), the country has uses 5% of its water resources to irrigate only 5% of its irrigation potential.

Irrigation sector accounted for the largest share (93%) in water consumption (FAO, 2004). But the sector is also criticized for high wastage and inefficient use of the available water (Birgitte, 2007, and Fraiture and Perry, 2007). This inefficient utilization coupled with the increasing water demand for industrial use, human and livestock consumption results in lower agricultural output and food insecurity (Gichuki, 2002). Hence, utilization of available limited water resources more efficiently is necessary than an option. One way to doing this is through the adoption of improved water lifting technologies which has significant impact on water saving, efficient utilization of irrigation water, agricultural productivity and household food security.

However, given the mentioned importance of the technologies and their availability in the market, most farmers are not using them. It may be the case that the technologies are tagged with high price than they deserves. The purchase price of the technologies and running cost are the reason for the low level of uptake of the WLTs (Nunes and Boatwright, 2004). It may also be the case that the availability/supply of the technologies are limited. On time and at affordable prices availability of the technology are the factor for the low adoption rate of the SWLTs (Ngigi, 2003). It still may be due to lack of knowledge/knowhow on the WLTs, their aforementioned importance and market structure. Farmers' WTP for a technology may also differ from location to location and type of irrigation water sources.

The knowledge of the farmers' demand for agricultural technologies and the factors that influence their WTP for these technologies can be an input in the design of sustainable and effective irrigation policies. However, there is acute information gap regarding the type of technology suitable for the specific geographic area and socioeconomic status of households in the study area. Information/knowledge on farmers' preference of water lifting technologies and their capacity or willingness to pay for their preferred technology is also scant. To the researcher's knowledge only few studies focusing on the choice/preference and adoption of smallholder water lifting technologies are found in Ethiopia. To mention, Gebergziabher, Giordano, Langan, and Namara (2014), analyze the economic factors influencing adoption of motor pumps in Ethiopia; Gebergziabher (2012), examined the challenges and opportunities of adopting water lifting technology in Ethiopia.

Those previous works focus on the theoretical and empirical review of analyzing the adoption and preference of WLTs, but did not estimate the farm households' WTP for the technologies which is a gap to be filled by this study. The studies also did not see a comparative analysis between different smallholder water lifting technologies. Therefore, this study examine the farmers' WTP and choice of technology by taking three weredas (districts) farm household data. This paper also considers one more aspect, the effect of gender in the farmers' WTP for water lifting technologies.

1.3 Objectives of the Study

The general objective of this study is to identify the determinants of farmers' willingness to pay and demand for smallholder water lifting technologies.

Specific Objectives

In line with the general objective, the study has the following specific objectives to be achieved at the end of the study

- To identify the major socioeconomic determinants of farmers' willingness to pay for smallholder water lifting technologies in the study areas.
- To elicit the mean farmers' willingness to pay for smallholder water lifting technologies using CVM.
- To estimate the aggregate demand for the smallholder water lifting technologies (motor pump, rope and washer and pulley) in the study area.
- To identify the determinants of households demand for different water lifting technologies.
- To identify whether female headed household are more willing to pay for the water lifting technologies compared to their male counterpart.

1.4 Hypothesis of the Study

The study tentatively hypothesizes that

- ✓ Education level and household income increases farmers' willingness to pay for the SWLTs while initial bid value and family size decrease.
- ✓ Farmers in the study areas are willing to pay for the smallholder WLTs.
- ✓ Farmers' in the study areas have demand for smallholder water lifting technologies.
- ✓ Land size, household income and age of the household head increase farmers' demand for the SWLTs whereas, distance to the nearby market decreases.
- ✓ Male headed household are more willing to invest in the new water lifting technologies

1.5 Significance of the Study

Efficiency, equity and effective utilization of irrigation water and water lifting technologies are promoted with an effective estimation of farmers' WTP. In a developing country like Ethiopia, appropriate estimation of farmers' WTP and identification of farmers' choice of water lifting technologies is important for the following reasons.

First, the low level of smallholder irrigation technology adoption due to technical and socioeconomic factors, and the rain fed agriculture did not bring the desired result. Second, Ethiopia has one of the highest population growths, and to meet the growing demand for food, agricultural output should also increase at least by the same level. Preliminary production cost and market price are existing for various water lifting technologies. However, the price that farmers are willing to pay for those technologies is not very clear. The price that farmers are willing to pay for those water lifting technologies is critical for evaluating the need for the government involvement in the subsidization of the farmers' to acquire the technologies and to design a pro-poor agricultural policies. These all call for the appropriate utilization of water through developing various water lifting technologies and the need to increase in farmer's knowhow and potential for using of irrigation technologies.

This research work elicits farmer's willingness to pay for irrigation technologies in Adami Tulu, Lemo, Dangela and Bahir Dar Zuria weredas' irrigation project. To the knowledge of the researcher there is no research work conducted in the valuation of smallholder water lifting technologies using CVM based on a cross wereda reference. Therefore, determining the economic value of the SWLTs based on how farmers' value the technologies, could be one way of addressing the scant knowledge regarding the farmers' capacity and preference of the water lifting technology.

In this respect, this study has a significant contribution to the existing literature, and can be used as an input for informed policy making and further studies in relation to irrigation technologies. It will also shed some light on the problems of management and sustainability of agricultural technologies in the study areas and it also serves as a benchmark to see the farmers' WTP characteristics over time.

1.6 Scope and Limitation of the Study

This study is delimited to the analysis of smallholder water lifting technologies of Adami Tulu, Lemo, Dangela and Bahir Dar Zuria weredas' small scale irrigation projects based on the information obtained from farmers using a contingent valuation method. Though CVM are widely applied and have a number of advantages, it also has its own limitation like other valuation approaches.

One of the limitations is the difficulty in getting proper responses from sample respondents concerning their economic well-being status. The availability and accuracy of data can also affect the study. The fact that primary data are based on respondent's memory may have effects on the study and hence it treated as having high error terms. However, the data generated in the survey are used with much care to minimize the small sample bias. The cross section analysis in the study areas may not explicitly explain the households' characteristics because of different biases stated in the literature review and heterogeneity problem associated with cross section analysis and hence it is advisable to include a time dimension in the analysis.

1.7 Organization of the study

The remaining part of this thesis is organized as follows. Chapter two reviews the related theoretical and empirical literature by including overview of water lifting technology and small scale irrigation practices in Ethiopia. Chapter three consists of the methodology part that introduces the study areas, data type and source, sample size determination, sampling techniques, method of data analysis, and empirical model specifications. Chapter four contains the descriptive and the econometric analysis of farmers' willingness to pay for the smallholder water lifting technologies, the demand for the technologies and their determinants. Finally, chapter five deals with the conclusion and policy implications based on the empirical findings.

CHAPTER TWO

2 REVIEW OF THE RELATED LITERATURE

This chapter discusses about theoretical and empirical literatures. Under theoretical literatures definitions, measurement and theories of WTP and choice of technologies are briefly discussed. While under empirical literatures, empirical studies on farmers' willingness to pay and choice of SWLTs in Ethiopia and outside Ethiopia are discussed. Overview of Ethiopian small scale irrigation systems is also discussed in this chapter.

2.1 Theoretical Literature

2.1.1 Definition of willingness to pay and valuation of economic resources

The concept of willingness to pay or reservation price is defined as the maximum price that a given consumer accepts to pay for a given quantity of goods and service while remaining on his/her indifference curve. The concept first appeared in economic literature more than a century ago by Davenport in 1902. WTP and its methods were designed to determine prices for pure public goods and services. It is still used for subjects as varied as the value of human life or minimization of risks threatening human life, public financing of the arts, sanitation services, water quality improvement, real estate market and supply of improved agricultural technologies (Marine, 2009 and Mattia, Oppio & Pandolfi, 2010).

The term value in economics is the price individuals are willing to pay in order to obtain a good or service. The basic demand and supply economic concepts (called consumer surplus and producer surplus, respectively) are employed to estimate the WTP of economic agents (Lipton et al, 1995). Similar studies by Haab & McConnell (2002) also suggest that valuation is the application of welfare economics when the differences in circumstances relate to the uses or states of the valued goods.

Economic value is a measure of what the maximum amount an individual is willing to forego in other goods and services in order to obtain some particular goods, service or state of the world. Such a measure of welfare is formally explained by the concept called WTP. WTP is about measuring the use and nonuse value of resource and there are generally two recognized methods of estimating WTP of economic agents for economic resources. These are the revealed preference technique which is based on indirect observations of behavior and the direct technique which is based upon stated preference (Lyford et al, 2002).

2.1.2 Measuring the Value of Marketed and Non-Market Goods and Services

In the absence of ownership and efficient pricing, we need special techniques to place consumer preferences. Economists have devised innovative techniques for measuring changes in value for natural resources and the environment called nonmarket valuation methods (Lipton et al, 1995).

Non-market valuation methods applies to market and non-market goods. For the non-market goods and service, for which, typically there is no producer, or the consumer by itself is both the producer and consumer, the measures of non-market benefits are concerned with estimates of consumer demand and consumer surplus (Freeman, 2003). Using market-based techniques to measure the monetary value of the goods and service is feasible provided there is sufficient market data. In the absence of sufficient market data, and existence of imperfect market, the consumers' true valuation of the goods and service is not known (Freeman, 2003 and Andersson et al., 2008).

There are two types of valuation of non-market goods and service. These are the direct technique and the indirect technique. The indirect technique involves travel cost, random utility, hedonic and factor income method to indirectly determine what a market might reveal in value if it did exist. The direct valuation technique includes the contingent valuation, conjoint analysis and choice experiment method (Saleamlak, 2013).

Indirect Techniques

The indirect (inferential) approach (or revealed preference method) rely on observable behavior in order to deduce how much something is worth to individuals even though it is not traded in markets. These methods produce value estimates that are conceptually identical to market values, but they must be measured more creatively since market data are not available. Revealed preference measure only the use value of the good in question. The technique includes travel cost models, random utility models, the hedonic pricing method and the factor income method (Lipton, 1995; Freeman, 2003 & Tietenberg, 2003).

1. **Travel Cost Model**

The travel cost method is popular for describing the demand for the natural resource service and environmental attributes of specific recreational sites. People usually visit recreational and scenic sites from different points of origin at diverse distances. This observed travel behavior is then used to evaluate the WTP of the agents to visit the site. This technique assumes that visitors to a particular site incur time and travel expenses and such economic expenditures indirectly reflect the minimum amount that a visitor is willing to pay for the use of the site (Assefa, 2012).

The method has a number of applications; it can be used to measure the effects on a consumer's WTP because of changes in access costs to a recreational area, or the elimination of a site, or changes in environmental quality. The technique is advantageous since it is relatively uncontroversial because it mimics empirical techniques used elsewhere in economics. In the travel cost model, individuals are actually observed spending money and time, and their economic values are deduced from their behavior (Bane, 2005).

The model is technically and statistically complicated. In addition, the data must be employed to statistically estimate increasingly sophisticated econometric models that take into account such factors as sample selection problems and non-linear consumer surplus estimates. Finally, the resulting estimates sometimes have been found to be rather sensitive to the arbitrary choices of the functional form of the estimating equation and the treatment of time (Lipton et al, 1995).

2. **Random Utility Model**

Random utility models are conceptually linked with the travel cost models in that they seek the same sorts of values and use the same sort of logic. However, random utility models focus on the choices of recreationists among alternative recreational sites not on the number of trips recreationists make to a given site in a season and hence it provides a different structure in which to model recreational demand. This type of model is particularly appropriate when substitutes are available to the individual so that the economist is measuring the value of the quality characteristics of one or more site alternatives.

Random utility models originated in the transportation literature (McFadden, 1998 and Ben-Akiva & Lerman, 1985) as cited in Hausman, J., et al (1995) and only recently have been applied to recreation issues. The random utility model has been used chiefly to value changes in the specific characteristics of a site such as catch rates or water quality. In explaining how individuals allocate their trips across sites, the site characteristics are included in the estimation. This model goes beyond the scope of the travel cost method since it can be used to value the losses from eliminating a site as well as the value of introducing a new site.

The same advantages that apply to travel cost models are applicable with random utility models. Relative to the travel cost model, this approach deals well with substitute sites and environmental quality considerations. The approach has all the disadvantages of the travel cost method, though it is much more data intensive and also cannot explain the total number of trips an individual is taken to a given site in a season (Hausman, J., et al, 1995).

3. **Hedonic Pricing Methods**

The hedonic pricing method provided an inferential measure of people's WTP for the amenity under study. This method is mostly used to estimate willingness of the economic agents for variations in property values due to the presence/absence of specific environmental attributes like air quality, noise and scenic views. By comparing the specific environmental attributes of two properties over time, it is possible to determine the implicit price of the amenity. This is done by correcting for other factors that might influence the value of the subject property and hence economists able to isolate the implicit price of some or bundle of amenities which have changed over time (Freeman, 2003).

This method, like the previous two models depends on the actual observed behavior of the individuals. Amenity prices are less affected by environmental incidents and it is difficult to estimate the amenity price using econometric methods, even for those which affect it since many of which are correlated. The connection between the implicit prices and value measures is technically complex and often empirically unobtainable (Tietenberg, 2003).

4. **Factor Income Method**

The factor income method is used as a means of valuation in applications where natural resources are used as inputs in the production of other goods and services. Accordingly, the resulting economic costs of production are an important source of information on applying the factor income approach. There are several types of resources for which the factor income approach is potentially well-suited, including surface water and groundwater resources, forests, and commercial fisheries.

The factors are an important inputs for irrigated agriculture, manufacturing, or for privately owned municipal water systems which yield returns (agricultural products, manufactured goods, and municipal water respectively) that have market prices. Such variation on these themes are useful in valuing damages to water resources (Lyford et al, 2002). Require additional technical information concerning the supply and demand of the underlying resource for valuation (Lipton, et al. &Tietenberg, 2003).

Generally, indirect valuation techniques cannot be employed without some easily observable behavior that can be used to reveal values. The methods lack measurement of non-use values of the goods in question. In the case of non-use values, there is no observable interaction between the individual and the goods in question.

Direct Techniques (Stated Preference Technique)

The direct approach (or stated or expressed preference method) refers to the direct expression of individuals' willingness to pay or willingness to accept in compensation for any change in quantities, qualities, or both of the goods in question. The method involves direct estimation of values based on the hypothetical valuation questions which presented to individuals, and hence it does not depend on market information (Freeman, 2003). The stated preference technique could potentially applied in almost any valuation context (Mattia et al., 2010). The technique includes the contingent valuation method, conjoint analysis method and the choice experiment method.

1. **Choice Experiment Method (CEM)**

The pioneer of this method is said to be Lancaster (1966) and the econometric model used for analysis is mainly due to McFaden (1974). The basic idea of this method is individual consumers derive utility/satisfaction from the goods through the attributes they provide. The CEM is based on the idea that any goods can be described in terms of its attributes and the levels it take. For example, irrigation water can be described in terms of the quality of water, the stock of fish, the size of cropping/grazing land/and its aquatic species, etc. In this method respondents are asked to rank the various alternatives from the presented alternative descriptions of a good that differentiated by their attributes and levels (Hanley et al., 2001).

The practice in using such method is becoming popular in economic evaluation of environmental goods and some marketed goods. In the CEM, data on stated preferences are used to estimate the individuals' WTP for a non-market commodity or its attributes (Weldeselassie, 2009).

2. **Conjoint Analysis Method**

Conjoint analysis is a marketing method that allows to know the expectations of consumers about a product and to model their choices. Understanding of how people make choices between goods and services, so that businesses can design new products or services that better meet customers' underlying needs is the idea of conjoint analysis. This new marketing and economic research phenomenon has been found to be powerful in capturing what drives customers choice of one product over the other and how much they value. The model estimates the customers' WTP and preference of one technology over the other based on the technologies attributes and the assigned levels (Breidert, Hahsler, & Reutterer, 2006). However, the method does not provide the respondent with an opportunity to say 'no' to the good and complex with multiple attributes (Nakanyike, 2014).

3. **Contingent Valuation Method (CVM)**

CVM is a survey or questionnaire based stated preference method that provides respondents the opportunity to make an economic decision about the market and non-market good. This method has been in use for over 30 years of estimating a wide variety of use and non-use values. It measure non-market values by asking people directly using questionnaires how much they would be willing to pay for the resource, avoid any damages that might be sustained by the resource or compensation for damages. Recently, it can also be used for marketed goods valuation for which the product is new, unknown and when the reliability of the data are in question. It is also be used with the intension to increase the reliability of the market value of the goods (Mattia et al., 2010).

Mattia, Oppio and Pandolfi, 2010 states that

"Market solve only a tiny corner of the overall problem of valuation, even for goods that are regularly and efficiently brought and sold….."

CVM got its name, Contingent Valuation (CV), since measures obtained using this technique relies on peoples hypothetical WTP rather than actual market information. Compared with any of the other techniques, this method has greater flexibility and enables valuation of a wider variety of non-market and market goods (Hanley et al., 2001; Omondi et al, 2009; Mattia, 2010 and Omondi, 2014).

Main steps in CVM

The major steps involved in CVM as used by Davis (1963 as stated by Khan, 2010) are the following. The first step is the design and development of questionnaires for eliciting individuals' willingness to pay (or willingness to accept) for a certain environmental attributes, compensation for a forgone benefit, or an incurred cost. The survey is developed primarily to generate data on respondents' WTP/WTA for any program or plan that will impact their well-beings. Each respondent is then asked how much he/she would be willing to pay either to avoid the negative occurrence or bring about the positive occurrence. The mode of payment (i.e., the payment vehicle) can take on any number of different forms, including a direct tax, an income tax, or an access fee with a different form like direct question ("how much?"), a bidding procedure (a ranking of alternatives), or referenda votes. A referendum (yes or no) response method to elicit values is the most preferable method since peoples are most familiar with it. Even though the questions are hypothetical, respondents are expected to behave as if they were in a real marketplace.

The second step in CVM analysis is identifying the target population and administering the survey instrument to a sample. To conduct the survey various methods can be used such as telephone, face-to-face, ordinary mail and e-mail etc.

The third step is analyzing the survey responses like estimating the average WTP/WTA for the population and assessing the survey result to ascertain its accuracy. These responses are gathered along with socio-demographic information and test statistics required to determine the consistency of responses and the sensitivity to scope.

The fourth step of the CVM exercise is estimating and aggregating WTP/WTA for the population using econometric techniques. Therefore, following a precise procedure to develop the questionnaire is the base for accurate conclusion. The final step in the CVM is conducting of sensitivity analysis like multivariate, threshold analysis and justification given for the choice of variables and the ranges over which they are varied.

A wide variety of CV studies have been carried out on a wide range of marketed and non-marketed goods and services issues like preserving biodiversity; water and nature, recreation; water supply and the supply of sewerage; newly produced technologies, real estate, various agricultural technologies and this is due to the fact that the method is advantageous to estimate the economic value of anything, even if there is no observable behavior available to deduce values through other means. It can be used to valuate non-user values or the value of non-traded goods and services (Khan, 2010).

However, it also has some demerits and limitations because it is very expensive due to the extensive pre-testing and survey work. The method is criticized mainly in which it explained what exactly has to be valued by the respondents and realistic monetary choices. A limitation is the “income restraint” (poor people will be less willing to pay, so average income levels influence the outcomes of the studies). In addition, while this technique appears easy, according to Gundimeda (2012) and Titenberg (2003) its application is fraught with the following major types of biases:

***Starting point bias*:** The starting point can influence the respondent’s answer about WTP. This occurs when the respondent’s WTP amount is influenced by a value introduced by the scenario. For example, if we start with an inappropriate price we may obtain inappropriate responses in the final bid. The CV method is prone to strategic biases on the part of respondents or to structural problems in the design of the questionnaire. To overcome this problem the payment card approach is advised, even if this one is also not free of bias.

Payment Vehicle bias*:* this type of bias arises if the WTP/WTA varies depending on the mode of payment. The response of respondents on their WTP estimates may be different if the mode of payment available to them is different. For example, if the respondent is asked how much they would be willing to pay in the form of a price also increase other modes of payment like tax, user fee etc., and the response may be different. The resulting bias from such mode of payment is called payment vehicle bias.

Hypothetical bias: in hypothetical market respondents may view the question as unrealistic, and may respond with an equally unrealistic estimate of WTP. Such kind of bias can be minimized by using different elicitation formats and by making the hypothetical situation as believable as possible and motivating the respondents well.

Strategic bias: this occurs when a respondent does not disclose his/her true preference of the good or service, i.e., he/she behaves strategically with the promise of free ride. Sometimes, especially in the case of public goods, respondents under estimate their WTP to free ride if they know that bids are actually going to be collected. This bias also occurs if an individual feels that the good would be provided anyway if others contribute. Even if respondents know the intention of the analyst because of human behavior and to be free riders respondents may not give their true WTP. The problem associated with such bias can be reduced using referendum format.

Compliance bias: this happens when respondents in a particular cultural context feel it inappropriate to answer some kind of questions in specific ways. Another reason for this bias is the respondents attempt to give answers that they think will satisfy or resent the researcher, especially when they have been called upon frequently to answer questions without any benefit. This bias results in substantial deviation between the reported and the actual values.

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

Information Bias: this can arise either as a result of providing too little information about the choice offered or from misleading statements by the interviewer. For instance, if a respondent provides information about the mean cost of providing the good, the respondent may be willing to pay differently than they would if they were not informed about the average cost of providing the good.

Here, in this section the researcher tries to mention the some of the major biases of CVM analyses and the emphasis are given on the best way to minimize these biases by using different elicitation formats and by attempting to create a common understanding on the good or service going to be valued between respondents and the researcher.

Elicitation formats in CVM analysis

There are many elicitation formats stated in the CV literature. Among them, following the work of Hanley et al., (2001), Gundimeda (2012), Assefa (2005), open-ended, bidding game, payment card single and double bounded dichotomous choice are the most used one.

Open ended format- a CV question in which respondents are asked to provide the interviewer with a point estimate of his/her WTP; it has the advantage of relative computational easiness and counter starting point bias. In this method, respondents faced to pick a value out of the air without some form of assistance. A major problem associated with this elicitation format is it is exposed to strategic bias and loose answers or do not know the answers. To solve the problems associated with such method, economists proposed the following elicitation formats even if they are not also free of bias.

Payment card approach– in this approach, respondents are asked to choose WTP/WTA estimate or a range of estimates from a range of values shown to respondents on a card. This method is better than open ended format as it could be simpler for the respondents and a large proportion of responses could be obtained. However, the method requires the respondent to be literate that makes it of little use in developing countries where a considerable proportion of the population is illiterate.

Bidding game format- is a CV question format in which individuals are iteratively asked whether they would be willing to pay a certain amount, by raising/lowering the amount based on the respondents answer for the previous offered value. The least amount can be taken as his/her maximum WTP and if he/she accepts to pay the proposed amount then he/she will be asked to pay a larger value until he/she says no to the proposed WTP amount. Likewise the last offer will be taken as the maximum willingness to pay to the respondent. This method exhibits very strong starting bias, i.e. if we start at inappropriate amount we will arrive at inappropriate WTP estimates, and also it may be boring to the respondents and thus they may give answers only to avoid additional questions.

Closed-ended approaches (Dichotomous or discrete choice format) - respondents are asked simply whether he/she is willing to pay (by saying yes or no) for the assigned value of the goods in question. This method is advantageous over open ended question format in eliciting WTP because of the simplicity of "yes "or "no" answers for the respondents and thus reduce the problems of strategic bias (Bateman, Langford, Turner, Willis and Garrod, 1995). It has also advantages of being much more similar to the choice that individuals are asked to make in real markets when faced by market prices. It has the gain in efficiency over the single bounded elicitation format by asking respondents a second follow up binary question based on the response of the first offer. If the first response is ''yes'' the second bid is some amount higher than the first bid and if the first response is "no" the second bid will be some amount lower than the second bid. But the method suffers from starting point bias, shortage of information, reducing efficiency and requirement of large sample to estimate benefits as maximum WTP is not directly obtained from this format. This study uses double bounded elicitation format with an open-ended follow up questions.

2.1.3 Comparison of CVM with CEM, CAM and other indirect methods

According to Assefa (2012) and Hanley et al., (2001) the CVM has the following strong advantages over the other methods,

- It can be used to investigate peoples' maximum willingness to pay for different levels of service that are not yet established. Therefore, it should capture a fuller range of the benefits of the service improvements and can accurately estimate what proportion of households are likely to switch to improve service levels at given tariff levels.
- The revealed preference methods are used to estimate people's WTP of the goods from actual consumer behavior and hence failed to capture non-use values of the goods and thus are inadequate for assessing new policy initiatives. But the stated preference methods such as CVM is used to estimate both use and non-use values indicating that CVM can measure the price of the improvement and establishment of smallholder water lifting technologies.
- It is able to measure a wide range of goods, including those not yet supplied in a manner consistent with economic theory.
- The respondent's answers can be easily understood by non-economists and therefore used by social development, environmental health, and engineering experts for other aspects of demand responsive planning.
- More specifically, the technique will enable simple financial models to be developed. This enables the government and local service providers to understand clearly the types of subsidies to the poorest households and realistic service levels that can be sustained.
- The choice experiment method has complexity in the experimental design of the data and difficulty in the selection of attributes and its levels. But unlike to the CEM, the CVM has been judged to be superior due to its potential validity and ease with which the method can be implemented.
- The applicability of this method is larger compared with other valuation methods in terms of completeness.

Despite the widespread use of stated preferences approach in the literature, many researchers question their use in determining the WTP for a given good or service. But, yet in the absence of data and when it is believed the existing market does not reveal the real market situation, economists used contingent valuation surveys to reveal producers' and consumers' preferences. A caveat of this approach is that, the WTP is a hypothetical value and hypothetical values need not be correlated with the readiness to pay. This methodology is much appropriate when farmers know the existing scenario and able to estimate closer to the existing market value of the goods and service to be estimated. On such cases, WTP estimation using a contingent valuation method yield a more accurate result (Liebe, Peter & Jürgen, 2011; Botelho & Costa, 2002).

Estimation of WTP for marketed goods, using a Contingent Valuation Method is relevant in testing the validity of CVM and to assess how the real market is operating (Perman. R, Ma.Y, McGilvray, and Common, 2003). Perman et al (2003) further mention that constructing a validity test or comparing CVM result with the existing criterion is a way for checking validity of the result obtained from CVM method. The construction of validity checking method concerns the degree to which the estimated CVM measure agrees with other measures as predicted by theory. The Validity test which compare the CVM result with the existing criterion can be done by cross checking the mean values/prices obtained from the CVM estimation either with the existing market prices of the goods in question or other valuation method results. However, such convergence to the market price does not definitively establish that the CVM result is correct or the market is perfectly operating since various biases are attached with CVM. But it gives an insight in deviation between hypothetical market price of the technologies and the existing real market price of the technologies and to reason out the factors which account for the deviation.

Generally, from the theories and available choices, the contingent valuation method is the best fit model in estimating a farmers' willingness to pay for smallholder water lifting technologies.

2.1.4 Theoretical Framework for the Determinants and Choice of WLT

There are few competing theories in explaining the consumers' willingness to pay for environmental and novel goods. These theories are different in terms of their ability in explaining WTP, the variable they used in explaining the determinant and the disciple they practiced. The study by Liebe U. et al (2011) identify the basic economic model, altruistic/moral behavior, Ajzen's theory of planned behavior and the Norm-Activation Model (NAM) as a theories for examining consumers' willingness to pay. Similar studies by Sillano, & Dios Ortúzar, (2005) identifies the existence of various theories from diverse perspectives such as the altruistic approach and the basic economic model which explain willingness to pay of the economic agents.

Models of Altruistic/Moral Behavior

The altruistic approach includes the studies on WTP given ethical motivation as the main determinants of preferences for public goods. Theories of altruistic behavior are based on a broader motivational structure than standard economic models. The explanations of the WTP for the environment are based on choices where individuals do care for others' wellbeing too beside their self-interest. Altruistic behavior in economic terms can be achieved by using utility function which incorporates other people/environmental amenities' better off. The model is derived from Normative Economics and Environmental Psychology (Antonio, José & Javier, 2011).

Altruistic motivation can lead to perceived obligations to contribute to the preservation of environmental goods. For instance, an individual might think that he/she is obliged to do something about global warming, and as a result may contribute something in kind or financially to a specific environmental good which may give personal satisfaction. The contribution yields an individual utility when there are feelings of moral obligation. This is like doing well irrespective of specific environmental goods for whatever reason. In this respect, contributions to environmental goods are just one way of obtaining satisfaction among many others. The economic term for such general feelings of obligation are called a warm glow of giving or purchase of moral satisfaction (also known as impure altruism) (Sillano & Dios Ortúzar, 2005 and Kahneman & Knetsch, 1992).

According to Johansson (1998) the altruistic approach deals with seven altruistic alternative motivations for WTP. This are impure altruism, pure altruism, genuine altruism, paternalistic altruism, altruism towards non-human creatures, social norms and commitments. Studies by Kahneman and Knetsch (1992) and Liebe et al (2011) are proponent of this model.

In the model of Sillano, & Dios Ortúzar, (2005), people may derive utility from altruistic behavior, independent of the fact that others will be better off which leads to impure altruism. Kahneman and Knetsch (1992) use these concepts to explain what is known as the embedding effect, that is, the observation that sometimes WTP does not vary with the quantity of the good in question. If people only derive utility from the act of giving, then it does not matter what quantity of the good is provided. However, Kahneman and Knetsch (1992) pointed out that the moral satisfaction may vary with the good: some goods give more satisfaction than others.

Generally, in the altruistic approach, a *subjective obligation to pay* for the specific good and a *general warm glow* which is independent of the specific good in question expected to influence WTP positively.

Attitude-Behavior Paradigm and Theory of Planned Behavior

The theory of planned behavior (TPB) is one of the most widely cited and applied behavior theories. It is one of a closely inter-related family of theories which adopt a cognitive approach to explaining behavior which centers on individuals' attitudes and beliefs. Psychologists and sociologists rely on the attitude of an agent in valuing the economic values of the goods and service. A "classical" attitude-behavior paradigm would assume that behavior can be predicted by attitudes. This would mean that general attitudes such as *environmental concern* have a direct and positive effect on WTP.

According to Ajzen's (1991) theory of planned behavior intention of interest is determining the intention to purchase a given product or service. Similar studies by Nisbet and Gick (2008) also identifies three major determinants of the behavioral intention. These are attitude toward the behavior, subjective norms, and perceived behavioral control.

The attitude toward the behavior refers to an individual's positive or negative evaluation of performing the behavior and it is determined by accessible beliefs about the consequences of doing so, each belief weighted by the subjective value of the consequence in question. An individual's perception of social pressure from reference group members to enact the behavior is captured by the subjective norm. Perceived behavioral control includes the perceived ease or difficulty of performing the behavior. In this regard, the issues of financial constraint and the availability of the product to be valued is expected to influence WTP. Theories which advocate this model include Ajzen, 2008; Munro et al., 2007; Haugtvedt, & Cardes, 2008). Studies by Armitage and Conner (2001) also used planned behavioral model to predict the consumers' behavior in health sector.

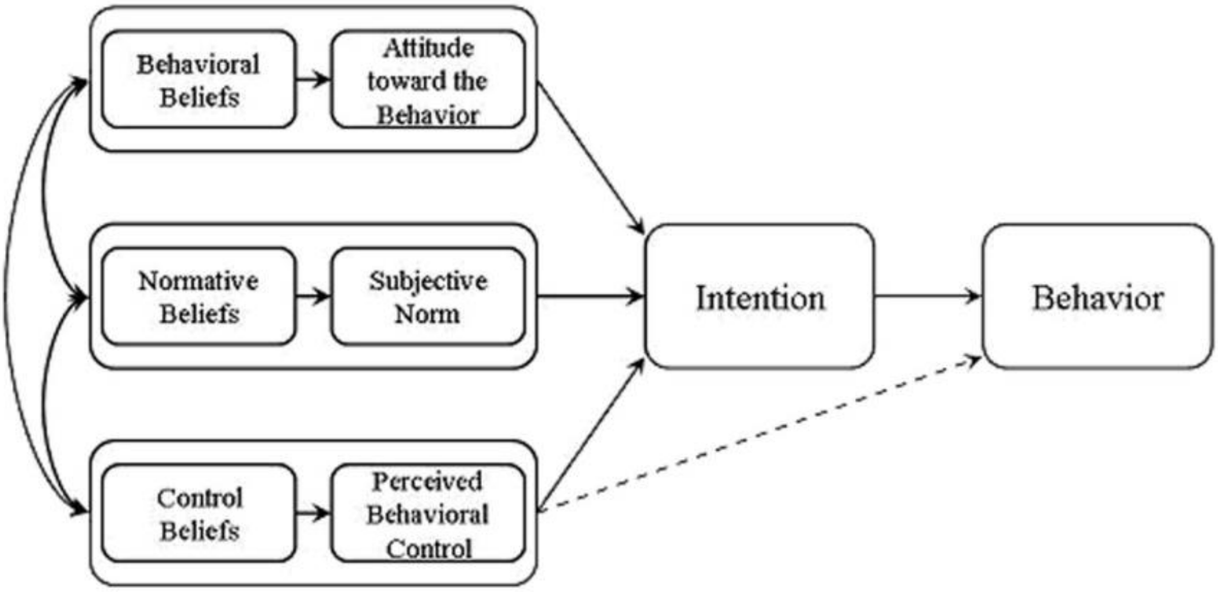


Figure1: Theories of planned behavior (adopted from Haugtvedt & Cardes, 2008)

Norm-Activation Model (NAM)

Schwartz's norm-activation model (NAM:Schwartz, 1977) has been broadly applied for predicting a number of environmental behaviors such as individuals' WTP. According to the NAM, environmental behavior can be explained by three psychological dimensions related to environmental problems: Personal Norms (PN), awareness of consequences and awareness of responsibility. Similar studies by Liebe et al (2011) also specifies the model by including the awareness of need and the awareness of responsibility as determinants of norm-activation for the WTP of an individual. The study further explain this determinants as follows.

"Awareness of need refers to the precondition that individuals must recognize that something has to be done concerning the object in question. Awareness of responsibility means that individuals must recognize that they are responsible for doing something. Given awareness of need and awareness of responsibility, a perceived moral obligation can result

in specific behavior. Both determinants mediate the effect of a perceived moral obligation on behavior." Liebe et al (2011, p112).

This difficult and complex model of Schwartz is a cognitive and sequential decision model that covers the entire process from norm-activation to action. In this model, it is expected that awareness of need and the awareness of responsibility positively affect WTP.

Harland et al (2007), though no study based on NAT has yet investigated the contribution of efficacy and ability activators to promote pro-environmental behavior, earlier environmental studies based on NAT have focused only on two situational activators: awareness of need and situational responsibility. According to NAT, however, these two activators did not provide a complete figure pro-environmental behavior. Therefore adding the efficiency and ability aspect in NAM induce the power of the the schewarz's model capability in explain the environmental behavior ofan individual regarding willingness to pay (as summarized in the following graph).

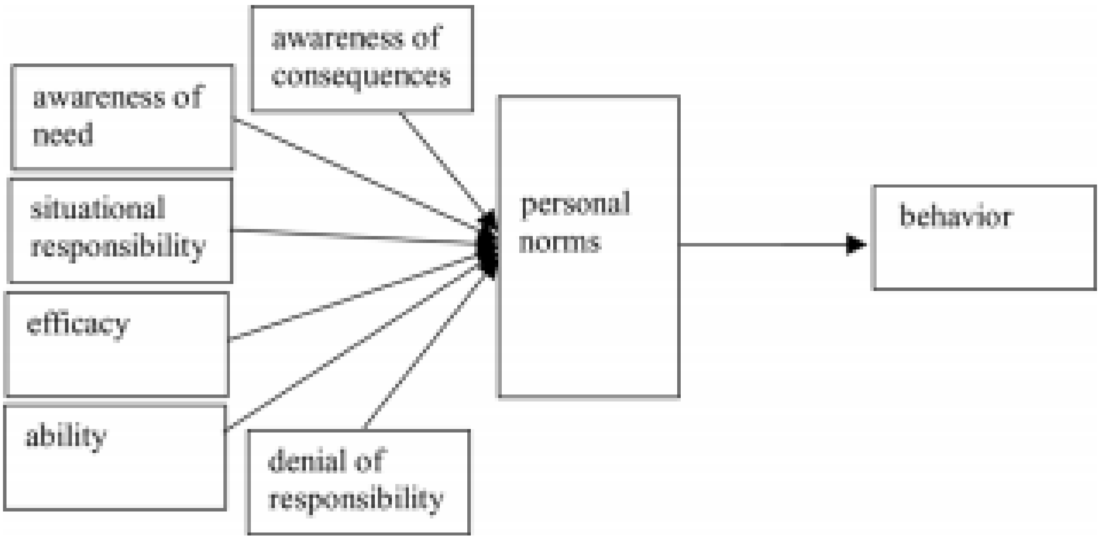


Figure 2. Schematic overview of Norm Activation Model (adopted from Harland et al, 2007)

The Basic Economic Model

In the theory of basic economic model which focus on the individualistic behavior for the WTP decision of an individual, there are three important factor which determine willingness to pay decision of an individual. These are demographic factors such as gender, age, level of education, or political orientation; factors which refer to individuals' attitudes towards the good being valued; and economic factors like income, profession, or employment status.

Studies by Jaime-Castillo, Echavarren, & Álvarez-Gálvez, (2013) identifies income as a major determinant variables in WTP studies. Similar studies by Jacobsen, 2009; and Carson et al., 2001 and Bane, 2005 significant effect of income on WTP was found. The nature of the good (luxury versus normal, normal versus inferior goods), the budget availability as a constrained for optimization are the reasons for the positive effect of income to WTP.

The water lifting technologies are normal goods and the economic theory for the normal goods suggests that, other things being constant, the higher income household are more willing to pay for the goods than those low income household. This shows that nature of the good to be studied is also an important variable in determining the consumers' willingness to pay (Liebe et al 2011).

Change in the values of the goods can affect individual's welfare through changes in prices they pay for private inputs and goods in the market, and changes in the quantities of non-marketed goods. This welfare changes can be measured using ordinary consumer's surplus, which holds income constant but not the level of utility. Compensating surplus, compensating variation, equivalent variation and equivalent surplus can also be used as a method for measuring welfare change.

Compensating variation and compensating surplus measure the gains or loss from environmental goods and services, and hold utility constant at the initial level. However, equivalent variation and equivalent surplus measure welfare change and hold utility constant at some specified alternative level. Generally, these four welfare measures involve either payment or compensation to maintain utility at the specified level (Mitchell & Carson, 1989). If the proposed change is welfare increasing through changes in the quantity of the goods availability, which is the focus of this study, the appropriate welfare measure is the compensating surplus. This measure can be interpreted as the consumer's WTP in order to gain the quantity increase and still maintain their initial utility level (Mitchell and Carson 1989).

The concept of contingent valuation method which require hypothetical market scenario that is similar to actual market situation for the smallholder water lifting technologies can generate WTP data, which will be used to conduct valuation process of the technologies.

This concept can be further emphasized from the relationship between the expenditure function and Hicksian compensated surplus measure. According to Haab and McConnell (2002), the expenditure function that provides the theoretical structure for welfare estimation is specified as

$$M = e(p, q, u) = \min_x\{p.x/u(x,u) \geq u\} \quad \text{.........} 1$$

Where: M is the minimum amount of income needed to maintain utility level given the price and the good vectors; q= is the vector of the technologies; p= is a vector of prices; u=is level of utility when u=V(p, q, y), x= is the vector of private goods and y= income. Let p_0, q_0, u_0, m_0 represent some initial level of those respective arguments and p_1, q_1, u_1, m_1 represent some succeeding levels. We can represent the compensation surplus by

$$WTP = CS = [e(p_0, q_0, u_0) = m_0] - [e(p_0, q_1, u_0) = m_1] \quad \text{.........} 2$$

q_1 is preferred q_0 for proposed new project brings welfare gain. In this case, the compensated surplus (CS) measure tells us the consumers' WTP for welfare gain. Contingent valuation is capable of obtaining the appropriate Hicksian measure for a proposed change in the public good (Mitchell and Carson 1989). It can be viewed as a way of estimating the change in the expenditure function (Haab and McConnell 2002). This study employed CVM using a basic economic model to determine the farm households' WTP for the smallholder water lifting technologies.

2.2 Empirical Literature

A study by Breidert et al (2006) and Wicker & Hallmann (2013) validate the importance of WTP estimates for developing an optimal pricing strategy. Similar arguments about the importance of WTP and valuation of both marketed and non-marketed goods also given by Carlos, et al. (2005) and Arcadio, et al. (2012). WTP estimates can be used to assess the price elasticity of demand and for modeling demand functions. Renee (2012) also indicate the advantage of WTP estimation in identifying and measuring brand equity for monetary added value endowed by a brand to a specific product vi s-à-vis its' competitors or an unbranded baseline product. Willingness to pay analysis also allows to observe the deviation in market price and peoples' perception of valuing goods and service, and to identify the reason which account for this deviation.

Despite these importance, however, literature on WTP for agricultural technologies in Africa and particularly in Ethiopia is scant. But, since the work of Davis (1963), various studies in different parts of the world conducted to estimate willingness to pay of economic agents in various sectors of the economy using a contingent valuation method and other direct and indirect valuation methods. Research results reveal that the magnitudes of households' WTP for agricultural technologies, as well as the type of payment, vary with the nature of the technology. Empirical literature which conducted to elicit household's willingness to pay and choice of agricultural technologies and small scale irrigation water in different parts of the world including Ethiopia are reviewed as follows

2.2.1 Empirical Literature on Measurement and Determinants of WTP for Agricultural Technologies and Irrigation Water outside Ethiopia

Zongo B. et al (2015), analyzes farmers' practices and willingness to adopt supplemental irrigation on rain fed crops in the long dry spell areas of Burkina Faso. Agricultural technologies adopted by farmers to increase agricultural productivity are organic manure, crop diversification, rotation, improved seeds, techniques and water conservation. Over 65% of farmers believe that supplemental irrigation is a good way to mitigate the adverse effects of dry spells on crop yields. From a logistic estimation socio-economic variables such as marital status, age of the head of household, household size, and the number of active laborers, equipment, and farm income significantly affected farmers' willingness to adopt supplemental irrigation.

Nakanyike S. (2014), estimate farmers willingness to pay for virus free sweet potato vines in Uganda from the randomly selected 200 households using a contingent valuation method. Her Tobit model result shows that farmers are willing to pay prices above the production cost for virus-free sweet potato vines. Revenue from sweet potato, market access, purpose for sweet potato production, farmer having used high yielding varieties and district of residence were explained as a determinant variable for farmers' WTP for virus-free sweet potato in the study. The study also estimate the market potential for the sweet potato vines and shows vine production was an economically viable enterprise and vine producers should target commercial sweet potato farmers.

Ulimwengu & Sanyal (2011), analyze the joint estimation of farmers' stated willingness to pay for agricultural services for Uganda using a contingent valuation method. The paper use a multivariate probit approach to investigate farmers' stated willingness to pay for different agricultural services. The agricultural service included in the study are soil fertility management, crop protection, farm management, improved produce quality/varieties, on-farm storage (post-harvest), improved individual and group marketing, and disease control. The result shows that access to extension service, access to information, access to market, income, land ownership and distance from the nearby market significantly affect farmers WTP for those agricultural services. The further recommends that, the joint supply of those services are fruitful since farmers' decisions to pay or not to pay for these services are significantly and positively correlated with their WTP for other services. Results suggest that access to information on the proposed agricultural services reduces farmer willingness to pay for information, easy market access increases farmers' willingness to pay for agricultural services and the bigger the land under agricultural production, the higher the farmer willingness to pay for agricultural services.

Falola A. et al (2013), examines willingness to take agricultural insurance by cocoa farmers in Nigeria. Probit regression model is used. Their study showed that 77.5percent of the farmers were aware of agricultural insurance but only 50percent were willing to take it. The average willingness-to-pay for agricultural insurance by the respondents was 69.85/ha USD. The study indicate age of the household head negatively influences the tendency of taking agricultural insurance by farmers. This could be largely due to less receptivity of older farmers to innovation unlike young educated farmers who have high receptivity to innovations. educational level of household head affect WTP positively implying that the higher the educational level of the household head, the more likely he would take agricultural insurance. The result also shows that access to extension services and farm income are the significant factors influencing willingness to take insurance by the farmers.

Mwaura F. et al (2010), examine crop and animal husbandry farmers' willingness to pay for agricultural services in Uganda. From the probit model, the study established that about 35 and 40 percent of the farmers were willing to pay on average 1.8USD and 2 USD per trip for extension services in crop and animal husbandry respectively. Education level of the individual played an important positive role in the WTP for extension services for both type of farmers. Increasing age is associated with reducing likelihood of willingness to pay for extension services for both crop and animal husbandry. Young people are risk takers, a likely to be more educated, have more avenues for information, more likely to change perception and have disposable income. On such cases, young peoples are more willing to pay for agricultural technologies. Presence and ease of access of good roads has a large bearing on the access and WTP for services. Household sex, regions of residence and preferred means to receive the services are also found to be a key farmer's attributes that influenced WTP for extension service.

Omondi et al (2014), using a contingent valuation method elicit the farmers' WTP bids in Ahero Irrigation Scheme in Kenya. The study suggests that the farmers are being overcharged by about 11.8percent by the National Irrigation Board (NIB) to meet the Board's costs of scheme operation and maintenance. By using the ordinary least squares (OLS) regression method the result from the study implied, off-farm income, access to credit and satisfaction with the management of water supply system was found to be a significant factor that in affecting the farmers' WTP for irrigation water.

Kanayo et al (2013) identified the determinants of the peoples' WTP for improved water supply in Nsukka, Nigeria using the CVM. The study tried to find out what peoples are willing to pay to support government, and determine the amount of revenue that the government could generate. Their Tobit (censored) model estimation showed that the willingness to pay for water was sensitive to the level of education and occupation of the household head, prices charged by water vendors, expenditure on water vending and the average monthly income of the households.

Tang Z. et al (2013) elicits the farmer's willingness to pay for irrigation water using a CVM for northwest china. The result of their dichotomous choice elicitation format questionnaire shows a vicious cycle of less willingness to pay and poor services exist in irrigation water management. Bid, income, land size, household size and irrigation water source type, current water management are the significant determinants of willingness to pay for irrigation water in the study area.

Omondi et al. (2009) used contingent valuation method in the form of close ended questions to determine the factors contributing to WTP for irrigation water in south India in the dry and wet seasons. Their result from the Logit model reveals that the mean WTP of farmers for irrigation water was 218 Indian rupee/ha/year, and family size, age of the respondent, educational level of the head of the household, family labor force, area under cultivation, and water requirement at farm level are the main determinants of farmers' WTP for irrigation water.

2.2.2 Empirical Literature on Measurement and Determinants of WTP for Agricultural Technologies and Irrigation Water in Ethiopia

Gebergziabher G, Giordano M, Langan S, and Namara R., 2014, analyze the economic factors influencing adoption of motor pumps in Ethiopia. The study shows lack of access to low cost irrigation technologies is one of the major bottlenecks to increase smallholder irrigation. Their multivariate probit model shows the existence of positive correlation between motor pumps and other water lifting technologies. The paper adopt a probit model to determine farmers' motor pump adoption decision. The study shows male headed farmers dominate the farming system and technology adoption like many other Sub Saharan African countries indicating that motor pump adoption less likely to benefit female headed households than male headed households. With increasing of age adoption decline explaining older farmers are risk averse and usually stick to traditional farming system. Wealth factor, access to extension service, farmers' perception about the availability of surface and shallow ground water positively affect farmers' willingness to invest in agricultural technologies. The region specific socioeconomic and biophysical characteristics difference, such as rainfall, topography, erosion, and soil and water conservation influences farmers' decision of motor pump adoption.

Gebergziabher G. (2012), examined the challenges and opportunities of adopting water lifting technology in Ethiopia using a binomial logit model from 800 nationwide sample. The result show that among the water lifting technology adopting households, 1.66; 2.99; 79.40; 6.98 and 8.97 percent have adopted buckets, treadle pumps, diesel/petrol motor pumps, electric pumps and other types of water lifting technologies, respectively. The regression results confirm that male headed households are more likely to adopt motor pumps compared to female headed households. Access to extension (contact with extension workers) and ownership of a radio exposed farmers' to information regarding the new technology and hence positively affect the adoption rate. Access to input such as fuel affect adoption positively and significantly implying that improving the input supply chain could be an entry point to address the slow adoption of motor pumps. The study also shows that farm size, access to finance, off farm employment, physical characteristics (the type of water source) significantly affect the farmers' willingness to invest in new technologies.

Asrat S. et al (2010), analyze the farmers' preferences for crop variety traits using a choice experiment method. They found that environmental adaptability and yield stability are important attributes for farmers' choice of crop varieties. Their random parameter logit model result shows that farmers are willing to forgo some income or output in order to obtain a more stable and environmentally adaptable crop variety. Among household-specific and institutional factors, household resource endowments (particularly land holdings and livestock assets), years of farming experience, and contact with extension services governed the preferences crop variety.

Alemayehu (2014) estimates the mean WTP of smallholder farmers for improved irrigation water using a CVM with a double bounded dichotomous choice question format in the case of the Koga irrigation project, Ethiopia. By applying seemingly unrelated bivariate Probit regression model the study shows that the majority of the sample households has been affected by irrigation water scarcity problems mainly due to soil erosion and deforestation. The study further identifies household size, education level, gender, total family income, cultivated land size and first bid as the main determinants of households' WTP for improved irrigation water.

Mezgebo et al (2013), attempts to determine the economic value of irrigation water using CVM in the form of double bounded closed ended WTP questions with open ended follow up questions from a sample of 154 randomly selected households. Their Bivariate probit and probit models shows that the total willingness to pay from double bound and open ended elicitation method was computed at 156,785.1 birr and 128,264.55 birr per year (1 US$=17 birr) per annum for five years respectively. The study further empirically proved that household income, cultivated land, age, awareness, educational level, and initial bids are the key determinants of demand for irrigation water.

Saleamlak F (2013) analyze the determinants of households' WTP for improved water services by applying the single bounded dichotomous choice value elicitation format using CVM for Mekelle city. Their study shows that sex of the respondents, monthly income of the household, satisfaction with the existing service and education level of the respondents significantly affects both the probability of households' WTP for improved water services in the Probit model and the maximum amount they are willing to pay in the Tobit model.

Bane (2005), analyze WTP of the rural people for non-agricultural uses of irrigation water using CVM and identify major socio-economic determinants of respondents WTP for non-crop purposes of irrigation water for Abbay River-Basin of Ethiopia. The study employed double-bounded and single-bounded referendum style elicitation format with open ended follow up questions. The study using probit model estimation indicates that income, education, quantity of water consumed, land size, initial bid, quality of irrigation water, irrigation water management and open access are significant variable in determining irrigation water provision.

Tsegabirhan W.G (1999) used CVM for investigating farmers WTP for irrigation water in Wikro, Tigray, Ethiopia. The study from OLS and Ordered Probit regression model estimates shows that birr 586 is the average WTP of small holder farmers for irrigation water. The study further indicates that credit availability, age, family size, experience with irrigation, education, number of livestock owned by a household, total area cultivated, total revenue and fertilizer supply are major determinants of respondents' WTP.

In general, these and other CVM empirical studies on water quality improvement, other non-marketable environmental goods and services and agricultural technologies imply that the CVM can be successfully applied to estimate farmers' willingness to pay for smallholder water lifting technologies in Ethiopia. Previous research works conducted in Ethiopia mainly focus on estimating the economic value of irrigation water, provision and improvement of potable water supply for urban people, and few agricultural technologies such as extension service. In this regard, this research which focus on estimating farmers' WTP for smallholder water lifting technologies will contribute for the scant literature in the sector.

2.2.3 Empirical Literature on the Determinants of Farmers' WLTs Choice

Since the adoption of every technology have its own pros and cons, the farmers' decision in which technology they are investing is determined by various factors which are stated in the literature. Some of them are discussed as follows;

Takeshima H, Adeoti A, Okoli S, Salau S and Rhoe V. (2010), analyze the demand characteristics for small-scale private irrigation technologies in Nigeria. The study indicates that farmers' demand for small scale private irrigation is potentially affected by diverse sets of agro ecological, socioeconomic and risk factors. Among agro ecological factors such as climatic condition (the length of the dry season) and vegetation (time taking for land clearing) are the significant one. Among the socioeconomic factors favorable output market conditions due to the growing demand for vegetables positively affect the farmers choice in investing for new motorized water lifting technologies while price of the technology, shortage of maintenance personnel and spare parts for the motorized pumps, lack of access to other inputs such as fertilizer, improved seeds, credit, fuel, and electricity negatively affect the farmers' decision of investing in new motorized pumps. Gender also affect the farmers' preference. Female farmers predominantly tend to use traditional water lifting devices such as buckets, in contrast to their male counterparts who tend to use motorized pumps. Land tenure and joint ownership of the technologies also affect the farmers' preference of investing in the technologies. Risk factors include the possibility of equipment damage/breakdown or theft, poor quality and limited accessibility of water shared with other farmers, and changes in inputs costs and output prices.

Ndunda, E. N., & Mungatana, E. D. (2013), on their work of determinants of farmers' choice of innovative risk-reduction interventions to wastewater-irrigated agriculture examine the factors which affect the farmers' decision of investing in low risk agricultural technologies. The result shows that household size, farming experience, membership to farmers group, access to credit, joint ownership of the technology, access to certified seed, access to media, crop income, and awareness to wastewater hazards affect the farmers' decision of investing in new low risk agricultural technologies.

Amankwah, A., & Egyir, S. I. (2013), examine irrigation technologies choice of farmers' in Ghana for sample of 107 respondents using a multinomial logit model. The study identifies farmers with credit access, frequent contact with extension agents, larger farm size, high labor cost of farm operations, group ownership of the technology and use of river as source of irrigation water were likely to use the motorized pump than those who do not have these agricultural services. Intensification of education of the farmers on the benefits of modern water lifting technologies and provision of credit by the government and other development partners will enable farmers' to invest in water-saving and resource efficient irrigation technologies.

Evans, A. E. V.; Giordano, M.; Clayton, T. (2012), also identifies that the cost of irrigation technology is the main driving factor for the adoption of different water lifting technologies. Wider access to ground water resource and the quality of soil is also a significant factor in determining the farmers' choice of water lifting technology investment.

Green G, Sunding D, Zilberman D & Doug P (1996), explain irrigation technology choices using a micro parameter approach. The study uses field-level data to assess the effect of economic variables, environmental characteristics, and institutional variables on irrigation technology choices. The results show that water price is not the most important factor governing irrigation technology adoption rather physical and agronomic characteristics such as land size, field slope and water source appear to matter more.

2.2.4 Overview of Ethiopian Small Scale Irrigation System

Irrigation is the artificial application of water to soil for the purpose of crop production. Irrigation water is supplied to supplement the water available from rainfall and the contribution to soil moisture from ground water. It is a method by which land precipitation may be maintained by supplying water to the intended farmland. It can also be defined as watering of land to make it ready for agriculture (Nigussie, 2002).

Like any other privately or publicly owned development activities, irrigation projects also come to the ground with expectation of economic, social, equity, or any other policy directed goals. At macro level, however, any activity must be justified for its net economic benefit to the whole society under consideration. While private investments are primarily for maximization of profit.

There are a number of advantages associated with irrigation. Irrigation enables to bring uncultivated lands under cultivation. Irrigation increases agricultural productivity. The use of irrigation contributes to stabilize fluctuation in food supply. It facilitates agricultural production intensification and helps to diversify product types. Irrigation can facilitate to provide alternative cropping pattern decision between cash and food items. It also contributes to increase in land value since it provides watering facilities to barren land. Generally, irrigation is one way for mitigating the negative impacts of drought in the drought prone areas, and it can improve the livelihood of the rural poor.

Despite those mentioned importance coupled with the irrigation and water potential of the country, irrigation is the least practiced and unutilized in Ethiopia. In the next subsections we examine the Ethiopia’s irrigation management and policies with particular focus on small scale irrigation.

Types of Irrigation and Irrigation Management in Ethiopia

Irrigation systems can be classified according various criteria such as size, the source of water (i.e. canal diversion, ground water or rain fed), management style, degree of water control, source of innovation, type of technology, primary function (i.e. irrigation, flood control, electricity generation).

Following these, there are different types of irrigation schemes: for instance, traditional and modern. Traditional irrigation schemes were developed in different parts of the world by communities as a response to climatic challenges over time. Modern irrigation systems basically serve the same purpose as those of traditional systems, except the differences in their technological advancement. Irrigation schemes can also be classified on the basis of their structure, into two groups: river diversion and dam construction. As regards the ways of supplying irrigation water to the farm, the following four types are identified. These are sprinkling or spray irrigation, drip irrigation, furrow irrigation and flood irrigation (Deribe, 2008 and FAO, 2004). Irrigation structures can also be divided into different scales based on their irrigating potential of a given land.

Associated with such classification, different countries use different criteria for classification of irrigation. For example, in Sri Lanka irrigation is classified in to small scale, medium and large based on size of their command. India used the number of beneficiaries for classification (Nigussie, 2002).

According to IWMI (2005) and ATA (2014), irrigation schemes in Ethiopia is classified as small scale, medium and large scale irrigation based on the size of land area irrigated.

1. *Large scale irrigation*

Irrigation projects in Ethiopia are identified as large-scale irrigation if the command area is greater than 3,000 hectare and are either commercially or publicly sponsored. There are a number of large-scale irrigation projects in Ethiopia, including the Wonji-Shoa, Methara, Nura Era and Fincha irrigation schemes. Even though these types of irrigation schemes are considered important; the number of such projects has remained stagnant in the last decade. They are associated with useful infrastructure development, create job opportunities, and contribute to agricultural growth and the macro economy.

2. *Medium scale irrigation*

Medium-scale irrigation projects are typically community-based and publicly sponsored, and cover a command an area between 200 and 3,000 hectares. Examples include the Sille, Hare and Ziway irrigation schemes.

3. *Small scale irrigation(SSI)*

Small-scale irrigation is irrigation on small plots where farmers have the major controlling influence and using a level of technology which farmers can effectively operate and maintain. Small-scale irrigation is farmer-managed scheme particularly with decisions about boundaries, the layout of the canals, and the position of outlets and bridges. Although some SSI systems serve an individual farm household, most serve a group of farmers, typically comprising between 5 and 50 households. This scheme is conventionally discharge water up to 200 hectares of land.

This system is not understood in the same way in the different places of the country. Sometimes the term is used for small-scale schemes of less than one hectare developed at household level, such as rainwater harvesting. Others consider SSI irrigation in relation to the technology used. For example, drip irrigation needs treadle and small power pumps to lift water; and a variety of irrigation application technologies, such as small bucket and drip systems and small sprinkler systems. They are efficient in use of water with high productivity, with improving crop quality and reducing labor costs. Currently, the use of SSI in Ethiopia is low with regard to area covered or volume of water used. Its introduction is a recent phenomenon and the use of micro irrigation by poor farmers are not well known in the country (IWMI, 2005).

According to Carter, R., & Danert, K. (2006), small-scale irrigation is a wide range of approaches by which soil-water can be increased and soil-water management improved. These approaches include techniques for catching, storing and using rainfall at or near the place where it falls (usually called rainwater harvesting); diverting flowing water by gravity; lifting water by human or motor power (lift irrigation); conveying water by canal or pipe; and applying water to land by controlled or uncontrolled flooding (gravity), overhead sprinklers (pressurized), or drip irrigation.

SSI is different from medium and large scale irrigation not because of the physical size of the farm plot or the irrigation scheme or system (although these are usually small), but it is because the plots and the irrigation schemes are managed and owned by the farmers themselves (Deribe, 2008). SSI schemes in Ethiopia include traditional small–scale schemes up to 100 hectare and modern communal schemes up to 200 hectare. There might also be especial instances, such as the traditional spate irrigation in Tigray which would cover up to 400 hectare. The construction of these kinds of schemes by the farmers' is assisted by the government (IWMI, 2005).

Household irrigation technologies comprise the full set of simple technologies that set up farmers for irrigation at the household level. At a high level, the technologies involved are water lifting technologies, water harvesting technologies and water saving technologies.

Water-lifting technologies comprise different types of irrigation pumps and lifting mechanisms and can tap into surface water or groundwater made accessible by a tube well. There are different types of water lifting devices which run by humans, animals, electric motors, renewable energy sources like sunshine, wind, and biological energy sources. The most common smallholder water lifting devices that used in Ethiopia are rope and washer, motor pump, pulley, treadle pump, and bucket. These devices are used to lift and discharge water from the ground, river or surface water. The technologies can be owned and operated by smallholders, privately or communally, and by commercially oriented large-scale farmers.

Water-harvesting technologies catch and store water from various sources (rainwater, river diversion, or pumps). Storage of harvested water can occur in small tanks if water supply is regular, or large, underwater tanks for longer periods of time (as common with rainwater). Water-saving technologies enable frequent application of small amounts of water to crops' root zone. They include drip, micro sprinkler, bubbler, and micro jet irrigation systems. In addition to reducing water use, these systems can preserve soil conditions and improve product quality.

The commonly used water lifting technologies in Ethiopia are explained briefly as follows:

Motorized pump: it can be powered by diesel, petrol, electricity, wind, or solar power, and are similarly available in a wide range of styles. It have varied price depending on type and channel of procurement, in addition to ongoing fuel and maintenance costs. It requires a reliable supply of fuel or electric power and spare parts. It enable to irrigate larger areas of land with a single well and hence reduced labor requirement. It has high capacity than treadle pumps, rope and washer or other manual pumps. It is portable and can be kept at home. It is easy to share among groups. High cost of fuel is a disadvantage of this pump.

Rope and washer: - The rope and washer pump is a low-cost hand pump capable of pumping water from up to 10 meters depth ground. The pump can be manufactured locally. Operation and maintenance for the pumps is low in comparison with other low cost hand pumps, and due to the simple design spare parts available from the local private sector. It is advantageous for farm lands of less than two hectares. Rope and washer pumps tend to have rope failure, though this is a more addressable problem with replacement ropes. It require a great labor input for water delivery, with inefficient labor conversion, greatly limiting farmers' irrigation area.

Pulley: - Pulleys are conventionally used for drawing water from the open wells. The process of drawing water from deep wells using the pulley is energy exhaustion. The pulley is very strong & durable. There are no chances of either the rope or the bucket to dissociate from the pulley. Pulley is a very simple yet robust technology and does not have any complex components. Any local fabricator can make it and repair it without needing any formal training.

Government Policies, Strategies and Experience to SWLTs in Ethiopia

Ethiopia is a rich country in having considerable water resource potential and considered as a water tower of Africa. However, the level of development of the sector is very low despite the country's considerable endeavors to promote development of the sector. The country has a long history of traditional irrigation systems. Simple river diversion still is the dominant irrigation system in Ethiopia.

Modern irrigation had started at the beginning of the 1950's by private investors and was concentrated in the middle Awash valley. Then, expanded to the Awash Basin and the Wabi Shebele Basin. At the beginning of the 1970s, about 100 thousand ha of land was estimated to be under modern irrigation in Ethiopia, about 50% of which was located in the Awash Basin. The irrigation development trend in Ethiopia seems very low even when compared with other African countries. With the 1975 rural land proclamation, the large irrigated farms were nationalized and placed under the responsibility of the Ministry of State Farms while small scale irrigation schemes were transformed into Producers' Cooperatives. After the major famines of 1984/85, the government began to focus on the potential of small-scale irrigation as food security and started promoting farmer and community-oriented small scale irrigation (Ayalneh, 2004).

According to Awulachew (2010) as sited in Getaneh (2011), estimates of the irrigation potential of Ethiopia may be as large as 4.3 million hectares. The total current irrigation covers only about 6percent of the estimated potential land area.

To cop up with the irrigation development problems, Ethiopian government has formulated policies and strategies for water resources and agricultural development. The Rural Development Strategy, the Water Resources Management Policy, the Water Sector Policy and SSI capacity building strategies are some of them. These initiatives aim to enhance the efficient, equitable and optimal utilization of water resources for sustainable agricultural and socioeconomic development, and place small-scale irrigation as a key priority (Evans et al, 2012).

The agricultural development led industrialization (ADLI) which is implemented since 1994 with an economic development strategy for Ethiopia. It aimed at boosting agricultural production and productivity through integrated application of appropriate technologies and improved farming management practices. Expansion of small- and medium- scale irrigation and water conservation schemes; and ensuring prudent utilization of natural resources is one of ADLI's key areas of focus (MOA, 2011 and Yalew, 2013).

Following economic development strategy, industrial development strategy in 2002 and a three-year poverty reduction program called Sustainable Development and Poverty Reduction Program (SDPRP) was launched covering the period from 2002/03 to 2004/05.This was followed by Plan for Accelerated and Sustainable Development to End Poverty (PASDEP), having poverty eradication as the main development objective of the

Government. The PASDEP carries forward important strategic directions pursued under SDPRP related to infrastructure, human development, rural development, food security, and capacity-building. PASDEP also planned to promote and strengthen small-scale irrigation schemes, and improved water use efficiency, including strengthening water harvesting and utilization practices through provision of appropriate technologies (MOA, 2011).

According to Yalew (2013), the water sector policy and strategies also specifically prepared and adopted by Ethiopian government since 2001. The sector policy includes the water supply and sanitation, hydropower, irrigation and drainage and cross-cutting issues like water allocation, environment, disasters, and trans-boundary water sources. The overall goal of the national water resources management policy is given so as to enhance and promote all national efforts towards efficient, equitable, and optimum utilization of the available water resources of Ethiopia for significant socio-economic development on a sustainable basis.

The current household irrigation development (HHI) strategy which implemented since 2014 have the following overall objective regarding the smallholder irrigation technology.

"Smallholders are able to access and afford household irrigation technology, after-sale services, and spare parts. Domestic producers are able to meet demands for inputs."

Household irrigation pumps are low in quality and have high failure rate, inefficient supply chain and procurement procedures for household irrigation technologies; tariffs on private imports drive up cost of irrigation technology, limited credit available for household irrigation technologies and associated inputs are the major bottlenecks identified by the document.

Generally, the country's irrigation policy have an objective of exploiting the agricultural production potential to achieve food self-sufficiency at the national level. The government‘s strategy also emphasizes the importance of enhancing small farm productivity and irrigation as key factors of success in increasing the overall agricultural productivity and crop diversification. However, despite these policies and strategies the commensurate demand among farmers for agricultural water management solutions, water resources remain poorly developed and the utilization of existing schemes, including small-scale agricultural water management, is inefficient (Evans et al, 2012).

2.3 Research Gap and Theoretical Framework

When there is a market for the good, that price reflects willingness to pay. However, does this market really reflect the true willingness of the consumer? Is remain the main question in the micro economic and marketing analysis as of today. Even in the presence of market for the goods, analyzing the consumers' willingness to pay have a number of advantages in marketing and micro economic disciplines. According to Dost (2012), WTP measure ensures the knowledge about consumers' valuations and choice behavior which helps marketers and companies in setting optimal pricing decisions and predictions of individual consumer choice.

It also helps to apply market segment based on demand functions. McFadden (1998) and Breidert (2005) also suggests that, with willingness to pay estimation it is possible to observe the deviation in what consumers' want to pay at maximum and actually pay. Similar studies by Jesdapipat S (2009), also suggests that WTP estimation is important in setting price, predicting future demand and price for the existing and novel goods.

Estimates of product demand under different price schedules might suffer from the distance to the market and the consumers, and WTP shows this effect by giving an insight in identifying the deviation in households' WTP for the technologies and how much they are actually pay in real market. It also identify the reason which account for this deviation.

Liebe, Peter and Jürgen, 2011; Botelho and Costa 2002 suggests that theoretical studies which focus on a single theory as a base for analysis results in incomplete result. Therefore, in this study we use basic economic model, by incorporating some important WTP determinants such as awareness from Norm Activation model and variables which affect attitude from theory of planned behavior. The study also uses CVM for WTP estimation. Though, many researchers question CVM use in determining the WTP for a given good or service, in the absence of data and when there is a need to see how the market is operating, economists used CV surveys to reveal producers' and consumers' preferences.

However, despite these widespread advantages of this measurement, WTP estimation for the marketed goods is scant and of recent origin. Notable exceptions are Lan (2014) for biodiesel fuel; Andersson et al (2008) for safety car; Philip, H (2012) for mobile application, and Nysveen, Pedersen, & Thorbjornsen, (2005) for mobile technology; Arcadio, Leidy, Samuel & Álvaro (2012) for organic apples; Nakanyike (2014) for virus free sweet potato vines and some few others. Empirically, most previous works in Ethiopia focus on water quality improvement, other non-marketable environmental goods and services, provision and improvement of potable water supply for urban people, and few agricultural technologies such as extension service. To the researcher's knowledge, there is no significant work in Ethiopia which focus on the estimation of WTP and demand/choice of smallholder water lifting technologies.

Therefore, this study will fill the gap in the theoretical literature, and contribute for the scant empirical analysis and contribute for informed policy making regarding the improvement and establishment of SWLTs and thereby the development of the sector. It also add some empirical knowledge to the limited agricultural technology related contingent valuation studies in Ethiopia.

CHAPTER THREE

3 METHODOLOGY OF THE STUDY

3.1 The Study Areas

This study uses data from four weredas', Adami Tulu of Oromia regional state, Dangela and Bahir Dar Zuria of Amhara regional state and Lemo of SNNP regional state irrigation water practices. The areas are well known for the shortage of rainfall, but potentially suitable for irrigation from underground or surface water. In those study areas and generally in the country the potential of irrigation is underutilized despite the great potential (Awulachew, 2010). From the following section we can also notice that the majority of the farm household is practicing rain fed farming system and food security is not yet ensured. Therefore, it is necessary to study the socioeconomic condition of the weredas' farm household and their WTP for product enhancing technologies so as to increase agricultural production and productivity.

The geographic and socioeconomic conditions of the study areas are explained as follows:

1. **Adami Tulu Wereda**

Adami Tulu Wereda is located in the rift valley in East Shoa zone of the Oromia Regional State, southwest of Lake Ziway at altitude of 1500-2300 M ASL. The capital of this wereda, Ziway, is one of the major towns in the central rift valley and it is located about 163 kilometers south of Addis Ababa, capital of Ethiopia. The total area of the wereda is estimated to be 1403.25km^2. In the wereda, there are 6 urban kebeles[1] and 32 rural Kebeles. The Wereda agro climatic zone is situated in dry and tropical rainy climatic zone. Minimum and maximum annual temperatures and rainfall vary between 14 and 27^{0}C, and 600-1000 mm respectively.

According to CSA (2013), the wereda total population is estimated at 172,649. 83% of the population dwells in rural areas. Of the total population, males are 86,643 constituting 51%,

[1] Administrative units below the wereda (District) is Kebele (sub-district), which consists of a number of villages. Wereda is a local administrative unit, which together form Zones.

while the females are 86,006 constituting 49%. In the wereda there are about 82 water supply schemes of different types. Of which 31 schemes are functional. Mixed farming agriculture is the dominant economic activity of the Wereda. Maize, Wheat, Teff, Barley and Sorghum are the dominant crops that grow in the wereda. Households who practice irrigation farm activity mainly produce onion, tomato, green beans and cabbage for market consumption at large. The commons reared livestock are Cattle, Goat, Sheep, Horse, Mule, Donkey and Poultry.

2. **Lemo Wereda**

Lemo wereda, one of the 10 weredas in Hadiya Zone of SNNPR of Ethiopia covers an area of 38,140 ha. The wereda is found around the capital of Hadiya zone, Hosanna town, which is located 232 km away from the South of Addis Ababa. The wereda has 33 rural kebeles and two rural municipal towns under its administrative hierarchy. Agro-ecologically, the wereda's land mass lies between 1900 - 2700 M ASL altitudes. About 91% of the wereda covers sub-tropical (weina-dega) land and 9% dega or high altitude areas. Annual minimum and maximum temperature are 13^{o}c and 23^{o}c respectively. Rainfall distribution is seasonal. The amount of rainfall received ranged from 250 mm to 1200 mm.

According to CSA population projections (2013), the total population of Lemo wereda is estimated to be 134,966, of which 97.25% accounts rural dwellers. Females are 50.5% of the rural population. The total rural household head is 19,166 of which 16.3% are female headed households. SSI using River, dam, pond and deep well is one of practicing technology to produce vegetables and a few other crops. There is a total of 108 water supply schemes in the Wereda of which 76 are functional. Farmers in the wereda have only a marginal land and practice manly mixed farming. The common annual and permanent crops of the wereda are Wheat, Teff, Maize, Sorghum, Bean, Enset, Barely and chat. Commonly reared livestock are cattle, sheep and goats, equine, poultry and honey bee.

3. Dangela Wereda

Dangela wereda is one of the eighth weredas and three town administrations of the Awi zone in Amhara regional state. It is located about 80 km southwest from the regional capital, Bahir Dar. According to CSA (2013) population projection, the wereda have a total population of 187,209 of which 94,707 (50.58%) are males and 92,502 (49.42) are females. From the total population 147,216, constituting 78.63% are rural population. In the wereda, there are 27 rural Kebeles among which 16 of them have access to a perennial river. Average annual rainfall varies between 1180-2000 mm.

Like most other rural wereda of the country, the bases of the livelihood of the wereda are basically rain fed agriculture. The dominant crops in the wereda are Maize, Millet, Teff and potato. Cattle, sheep, equine animals and goats are also the commonly reared livestock in the wereda (Dangela wereda agricultural office, 2014).

4. Bahir Dar Zuria Wereda

Bahir Dar Zuria wereda is found in West Gojam Zone of Amhara regional state. Geographically, the wereda is located between 11.40^{0}N and 37.27^{0} E. The agro ecological converge of the wereda is sub-tropical (*Weina Dega*). According to CSA (2011) population projection, the wereda have a total population of 202,960 of which 104,009 are males and 98,951 are females. From the total populations, 84% are rural population and the remaining 16% are urban dwellers (Bahir Dar Zuria Wereda agricultural Office, 2014). Agriculture is the base for the livelihood of the rural households. Crop production, livestock and chat productions are principal sources of livelihood for farmers. Maize, Millet, teff, and legume crops are the main crops grown in the area, while cattle, sheep and equine animals are also the commonly reared livestock in the wereda.

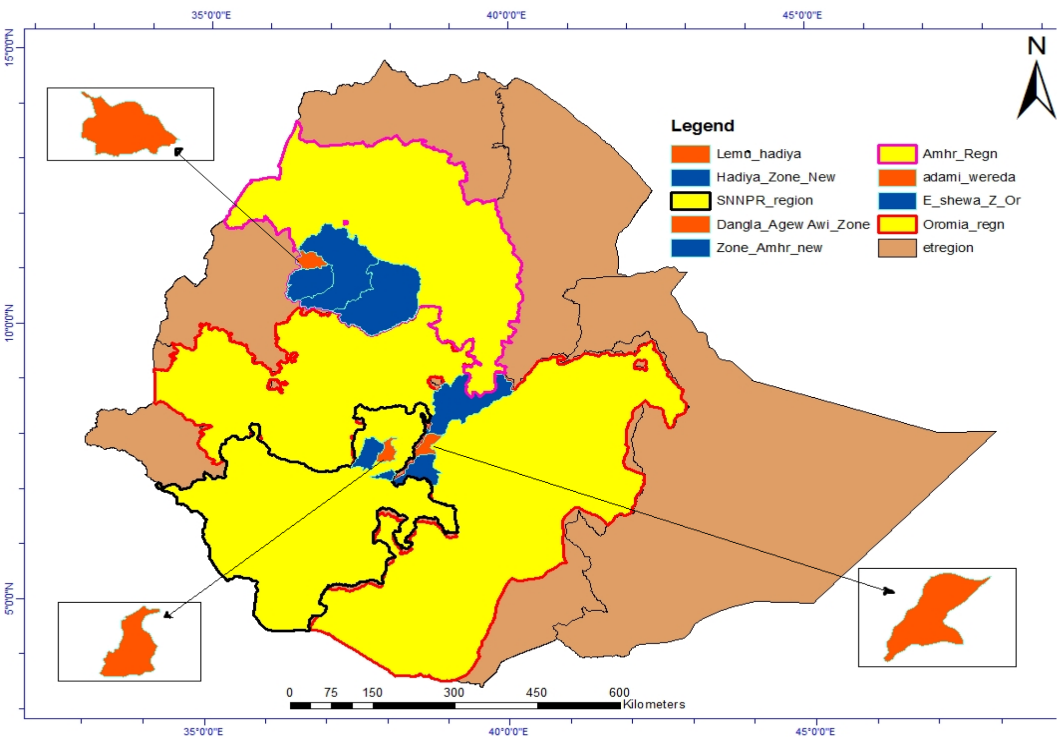


Figure 3.1. Location map of the study areas

3.2 Source and Type of Data

The research work mainly uses a primary data which was collected from the study areas. To obtain information on the socio economic condition of the households in the wereda the data is collected through questionnaires having a close ended elicitation format with open ended follow up questions. The CV questionnaires were posted to the heads of the households with face to face interviews. The questionnaire includes the following socioeconomic aspects. Demographic characteristics (sex and age distribution, marital status, family size and dependency ratio), social situation, economic situation, education, credit access, fertilizer availability and WTP questions (see appendix 1).

To supplement the primary data, secondary data such as information on existing social service, agricultural services, geographical and agro ecological feature, and concerned stakeholders and their capacities also used and obtained from the Zonal and Wereda administration and finance office, CSA, MoWIE, and IWMI.

3.3 Data Collection Instruments and Techniques

For data collection enumerators were selected based on their educational qualification, knowledge about the study area and work experience. The survey was conducted for six weeks in the months of March and April, 2015. Before the main survey, the enumerators were given a training mainly focusing on the technicalities of the questionnaire. A pilot survey was conducted to check its wording, ordering, and timing. Interviewers were supervised by the researcher. In the pilot survey, an open-ended elicitation format was employed to determine the starting bids for the technologies. Farmers are asked to state a price they would be willing to pay for three WLTs after they identify their preference. This is strategically done to reduce the effect of start-up bias which is normally encountered while using double-bounded dichotomous choice approaches. Based on the pilot results and existing market price, five starting point prices were introduced and the total sampled households divided randomly into these five equal groups for each of the selected WLT.

During the interviews, efforts were made to collect information from the head of the household. In the event the household head is unavailable, the interview conducted by a member of the household above the age of 18, who are able to provide reliable information about the household.

3.4 Sample Size Determination and Sampling Technique

Sample size: A total of 2**08** respondents were surveyed from the study areas. This 208, sample is determined using the minimum sample size formulae of Fowler (2001) given by the following formula.

$$n_0 = \frac{(t^2)(p)(q)}{(\alpha^2)} \quad \text{...} \quad (3)$$

Where, n_o = sample size, α= the level of risk the researcher is willing to take that true margin of error may exceed the acceptable margin of error = 0.07^2, t= value for selected alpha level of .025 in each tail = 1.96. And (p) (q) = estimate of variance = .25.

Based on the above formula, the sample size becomes:

$$n_0 = \frac{1.96^2 * 0.5 * 0.5}{0.07^2} = 196 \quad \text{...} \quad (4)$$

This sample size then adjusted to final sample size by considering the total target population of the study area. Therefore, Cochran's (1977) formula should be used to calculate the final sample size by considering the total target population (Glenn, 2013). These calculations are as follows:

$$n_1 = \frac{n0}{1 + \frac{n0}{N}} \quad \text{..} \quad (5)$$

Where, N= total number of the target population of the study area, n_0= required return sample size according to Cochran's formula= 196, and n_1= the final sample size.

From the CSA (2013) population projection, rural household head of the Adami Tulu, Lemo, Dangela and Bahir Dar Zuria wereda are 20,477, 19,166, 21,028 and 20,764 respectively.

[2]The study uses 7% precision level. Even though 3%, 5% and 10% precision levels are the most common, 7% precision level with confidence level of 95% and P=0.5 is also used in the standard literature. Israel G., 2013.

The total sample size for the study areas becomes:

$$n_1 = \frac{196}{1+\frac{196}{81435}} \cong 196 \quad \ldots\ldots (6)$$

The sample is further increased by 6% to account for contingencies such as non-response or recording error. Since we suspect there will be some incomplete survey and recording error, we add 6% of the n_1 (12 farm household) which increased the final sample into 208 households.

The total sample size is equally divided among the four weredas that results in a sample of 52 households from each study area.

Sampling Technique: Once the total sample size is determined, the next step is to decide on how the sampled household is selected. In this study, multi-stage sampling technique is employed. The data is also being collected as part of the study on Innovative laboratory for small scale irrigation (ILSSI) project in Ethiopia, which carried out by the International Water Management Institute (IWMI), International Livestock Research Institute (ILRI) and other various international and local partners. Thus, the sampling technique is chosen in consultation with IWMI to accommodate the need of the institution. In the first two stages non-probability sampling were used to select weredas and kebeles. Information from the regional bureaus of agriculture and water resource is used to identify wereda (districts) with a high concentration of smallholder irrigation practices. Accordingly, four weredas, namely Adami Tulu (from Oromia), Lemo (from SNNP), Dangela and Bahir Dar Zuria (from Amhara) were selected. In the second stage, information from agricultural offices of the selected weredas were used to select the kebeles of the sampled households. Based on this information, five kebeles were purposively selected because they were identified as intensive users of small scale irrigation. The selected kebeles are Bochesa (from Adami Tulu), Upper Gana and Jawe (from Lemo), Dangishta (from Dangela) and Robit (from Bahir Dar Zuria). Finally, probability sampling (a random sampling technique) is used to select 208 (52 from each wereda) sample households who participated in this study.

3.5 Method of Data Analysis and Respective Empirical Models

To achieve the objectives of the present study, different methods of data analysis were used. The study uses both descriptive and econometric analysis. More specifically, to answer the third and fifth specific objective, a descriptive method of data analysis were used. The descriptive analysis uses percentages, graphs and tabulations to explain and characterize the farmers' willingness to pay for SWLTs. The first, second and fourth specific objectives are answered via empirical models as presented in the next sub-sections. The econometric analysis includes the use of empirical probit, bivariate probit and multinomial logit models to examine factors affecting farmers' WTP for the technologies, to determine the mean values of WTP and to determine farmers' choice from the given set of the technologies respectively. Tools and statistics used in descriptive and econometric are generated with the help of econometric software, namely STATA.

3.5.1 Determinants of farmers' willingness to pay for the smallholder WLTs

When the dependent variable in the regression model is continuous the analysis can be conducted using linear regression models. However, when the dependent variable in a regression model is dichotomous, the analysis could be conducted using linear probability or logit or probit models. But, the results of the linear probability model may generate predicted values less than zero or greater than one, which violate the basic principles of probability. However, logit or probit models generate predicted values between 0 and 1, and they fit well to the non-linear relationship between the probabilities and the explanatory variables (Gujarati, 2004).

Probit model

Given the binary nature of the data a probit model is used to estimate farm households' WTP for the water lifting technologies. The Probit model is among the most widely used members of the family of generalized linear models in the case of binary dependent variables. The analysis employed data that resulted from CVM. Willingness to pay was conceptualized as a consumer choice problem.

Hanemann (1991) developed the basic model to analyze dichotomous responses based on the random utility theory. The key idea of this hypothesis is that although individual knows his/her utility certainly, it has some parts which are unobservable from the perspective of the researcher. As a consequence, the researcher can only make probability statements about respondent's "yes" or "no" answers to the suggested scenario. Furthermore, following Haab and McConnell (2002), this model specified by indirect utility function for each respondent assuming that the representative household gains utility from the use of the WLTs in relation to the status quo.

Suppose $u_{ij} = u_i (y_i, x_i, \varepsilon_{ij})$ is indirect utility function for ith respondent.

Where, Y_j = jth respondent's income; i =1 denotes the final state and i =0 the status quo (or the initial state); X_j = vector of household characteristics and attributes of a given choice and ε_{ij} = random component of the given indirect utility

If a payment, the initial bid, ρ_i* is introduced due to changes in a measurable attribute (like in quality or quantity), the consumer accepts the proposed bid only if

$$U_{1j} (y_i, - \rho_i^*, x_i, \varepsilon_{1j}) > U_{0j} (y_i, - \rho_i^*, x_i, \varepsilon_{0j}) \quad \text{……………………………………(7)}$$

For the researcher, however, the random components of preferences cannot be known and he/she can only make probability statement of "yes" or "no" responses. Thus, the probability that the respondent says "yes" is the probability that he/she thinks that he/she is better off in the proposed program. For individual i, the probability is given by;

$$P \text{ (yes)} = P[U_{1j} (y_i, - \rho_i^*, x_i, \varepsilon_{1j}) > U_{0j} (y_i, - \rho_i^*, x_i, \varepsilon_{0j})] \quad \text{……………………..… (8)}$$

By assuming the utility function is additively separable in deterministic and stochastic preferences, we have: $u_{ij} = u_i (y_i , x_i) + \varepsilon_{ij}$

The probability statement for respondent j having the additive specification of the utility function becomes:

$$P \text{ (yes)} = P [U_{1j} (y_i, - \rho_i^*, x_i,) + \varepsilon_{1j} > U_{0j} (y_i, - \rho_i^*, x_i,) + \varepsilon_{0j}] \quad \text{…………………….(9)}$$

This probability statement provides an intuitive basis to analyze binary responses to initial bid, ρ_i*. Therefore, the probability that an individual is willing to pay for the technologies can be identified using a probit model given the assumption of normality and Y_i follows standardized normal CDF.

$$P_i = P(Y=1/X) = P(Y_i^* \leq Y_i) = P(Z_i \leq \beta'_i x_i) = F(\beta'_i x_i) \text{ …………………(10)}$$

Where P(Y=1|X) means the probability that an event occurs given the values of the X, or explanatory variables and where Zi is the standard normal variable, i.e., $Z \sim N(0,\sigma^2)$. F is the standard normal CDF, which written explicitly as:

$$F(Y_i) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{Y_i} e^{-z^2/2}\, dz$$

$$= \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\beta_1 + \beta_2 X_i} e^{-z^2/2}\, dz \text{ ……………………………………...........… (11)}$$

Since, P represents the probability of farmers' WTP, it is measured by the area of the standard normal curve from $-\infty$ to Y_i. We take the inverse of equation #11 to obtain the probit model as follows;

$$Y_i = F^{-1}(Y_i) = F^{-1}(P_i)$$

$$Y_i = \beta_1 + \beta_2 X_i$$

Therefore, the probit model can be specified as:

$$Y_i = \beta'_i x_i + \varepsilon_i \text{ ………………………..…………………………..………. (12)}$$

Where -β' is vector of parameters of the model β

- X_i is vector of explanatory variables
- -ε_i unobservable random component distributed $N(0, \delta^2)$
- Y_i =unobservable households' actual WTP for the provision of WLTs.
- Y^*_i is simply a latent variable but what we do observe is a dummy variable WTP_i, which is defined as: $Y_i = WTP_i = 1$ if $Y^*_i \geq \rho^*_i$

  $Y_i = WTP_i = 0$ if $Y^*_i < \rho^*_i$ ……………………………………… (13)

Therefore, the probit model for the determinants of farmers' WTP for the SWLTs in line with the recommendation made by Nakanyike, 2014; Falola et al., 2013; Mwaura et al., 2010; Gebergziabher et al., 2014, and Ulimwengu and Sanyal, 2011 is specified as:

$$WTP_i = \beta_0 + \beta_1 AGE + \beta_2 SEX + \beta_3 HFS + \beta_4 LIVESTK + \beta_5 EDUC + \beta_6 HHINC + \beta_7 BIDV + \beta_8 OFA + \beta_9 LANDSIZE + \beta_{10} CREDIT + \beta_{11} MKT + \beta_{12} INFO + \varepsilon_i \text{ …………………….. (14)}$$

Variable Description and their Expected Sign

Different socio-economic factors are expected to affect the farmer's willingness to pay for agricultural technologies. The major expected determinants of the farmers WTP for smallholder water lifting technologies and their expected sign are mentioned as follows:

Age of the household head (AGE)

This variable is households' age measured in years as a continuous variable. The age of a farmer is expected to influence a farmer's willingness to pay for agricultural technologies. This is based on the fact that age impact is a combination of farming experience and planning horizon. Although older farmers have proved to be willing to pay for new technologies given their longer farming experience and better production resource endowment, young farmers may have longer planning horizons and, hence, may be more likely to invest in agricultural technologies (Ulimwengu, & Sanyal, 2011). Therefore, it is expected that younger farmers would be more willing to pay for new technologies than older farmers.

Sex of the household head (SEX)

The female headed households compared to the male headed household are relatively poor (Bane, 2005). Poor households generally have low income, which in turn limit their willingness to pay for agricultural technologies. Therefore, it is expected that male-headed households are willing to pay more for agricultural technologies compared to female-headed households. Or positive relationship is expected between the WTP and the sex of the household head (where 1= the presence of a male head household, and 0 otherwise).

Household Family size (HFS)

This is the family size measured as the total number of people in the respondent's household. It is argued that households with larger family sizes have high consumption expenditure they have low income left over to pay for new technologies and hence households with large family size is expected to affect households' WTP for agricultural technologies negatively. Therefore, a negative relationship is expected between family size and the probability of choosing new agricultural technologies.

Household head level of Education (EDUC)

Education widens horizons of an individual. Since education creates awareness of the benefit of new technologies, a positive relationship is expected between the level of respondent's education and their willingness to pay for agricultural technologies. In this study education is dichotomous variable where 1= formal education attainment of the head, and 0 otherwise.

Household Income (HHINC)

This is the total income of the respondent; both farm and off-farm income measured in thousands of Ethiopian birr per year. Economic theory shows for normal goods and services the income of the individual and quantity demanded have a positive relationship. Since the WLTs are normal good, increase in income increases the probability of farmers willing to pay for the technologies. Therefore, it is expected that households with higher income have more ability to pay and hence respondents' income affects their WTP positively.

The Initial Bid Values (BIDV)

Initial bid value for the WLTs are different and identified in the pilot survey in line with the market price of the technologies. In the double bounded dichotomous choice format they have a negative expected sign since higher offers are more likely to be rejected by respondents if the good or service going to be valued is a normal good. In other word, the higher the starting point bid is the lower number of respondents who accept the initial bid and hence it is expected an inverse relationship between initial bid and the yes responses to that bid. However, the coefficient of these variables are difficult to determine a prior in the open-ended format since it is determined by the respondents.

Off-Farm Activities (OFA)

This is a dummy variable OFA=1 if the respondent participates in off farm business and 0 otherwise. It has an ambiguous effect based on household expectation of return from agriculture and off farm activity. According to Assefa (2012), if households believe that irrigation agriculture has a lower expected return than the off-farm business, they may not place a high value on the sustainability of irrigated agriculture and the associated agricultural technologies.

The size of the cultivated land (LANDSIZE)

This is the size of potentially irrigable land a particular household possesses measured in hectares. An increase in the size of land a household possesses expected to have a positive effect on the farmer's willingness to pay for the new technologies since the large farm size demanded more water resource and provides an opportunity to generate cash either from land rent or the sale of crops.

Access to Credit (CREDIT)

It is the amount of credit obtained from formal institutions in the preceding year. Access to credit creates an opportunity for farm households to invest in new technology that enhances productivity. Therefore, a positive relationship between credit availability and willingness to pay for the water lifting technologies are expected.

Households market access (MARKET)

Access to markets is measured by the time required walking to the nearest market. As the time required to reach the nearest market rises the probably of households willing to pay for agricultural technologies falls. So a negative relationship is expected.

Tropical livestock Unit (LIVESTK)

The number of livestock a particular farmer holds is one measure of wealth in the areas. Thus, it is expected that farmers with more livestock unit are willing to pay more for agricultural technologies and hence positive relationship is expected.

Information access (INFO)

Available information influences both knowledge and attitude toward the proposed service. Following the work of Gebergziabher G. (2012), household information of the water lifting technologies was used as proxies of awareness. It is captured by dummy variable, measured as (1= prior information/awareness of WLT, 0 otherwise). Uncertainty and risk aversion nature of the farmers regarding the adoption and willingness to invest in the technologies can be alleviated by creating awareness. Therefore, the awareness level of farm household expected to increase the farmers' WTP for agricultural technologies and hence positive relationship is expected.

The description and expected sign of the determinants of farmers' WTP for SWLTs are summarized in the following table

Table 3.1 Descriptions and expected signs of the determinants of WTP for SWLTs

Variable name	**Description of variables**	**Measurement**	**Expected sign**
AGE	Age of the household	Continuous variable, measured in year	-
Family size (HFS)	household size of a farming family	Continuous variable, measured in number	-
SEX	Sex of the household head	Discrete variable(1 = male head, and 0 otherwise	+
EDUC	education level of the household head	Discrete variable(1=formal education attainment and 0 otherwise)	+
LIVESTK	Tropical livestock unit	Continuous variable, measured in number	+
HHINC	Household income level	Continuous variable, measured in birr	+
BIDV	The initial bid value	Continuous variable, measured in birr	-
Off-farm (OFA)	Farmers off farm activity	Dummy variable (1 = participates in off farm business and 0 otherwise)	+/-
LANDSIZ	Cultivated land size	Continuous variable measured in ha	+
CR	Access to credit market	Discrete variable (1= access to credit, and 0 otherwise)	+
MKT	Households market access	Continuous variable & measured in hours it takes to the nearby market	-
INFO	Information (awareness) level of WLT	dummy variable (1=prior information on the WLTs, 0 otherwise)	+

3.5.2 WTP for the Smallholder Water Lifting Technologies (CVM)

Bivariate Probit Model

The main objective of estimating econometric model in WTP survey is to calculate mean WTP and to allow inclusion of respondents' socioeconomic factors into WTP functions. The double bounded (or bivariate) CVM was first proposed by Hanemann (1985) and applied by Hanemann, Loomis and Kanninen (1991) with the main aim to show how the statistical efficiency of single-bounded dichotomous choice pioneered by Bishop and Heberlien can be improved by asking respondents further questions with a higher or lower bid based on the responses to the initial bids (Bane, 2005).

The model used to estimate the mean WTP from the double bounded dichotomous elicitation method with an assumption of the estimated correlation coefficient of the error terms follow normal distributions with zero mean and constant variance distinguishable from zero. According to Greene (2003, p.710), a bivariate probit model is specified as:

$$y^*_1 = x'_1\beta_1 + \varepsilon_1$$

$$y^*_2 = x'_2\beta_2 + \varepsilon_2$$

$$E(\varepsilon_1/ x_1, x_2) = E(\varepsilon_2/ x_1, x_2) = 0$$

$$Var(\varepsilon_1/ x_1, x_2) = Var(\varepsilon_2/ x_1, x_2) = 1$$

$$Cov\ (\varepsilon_1, \varepsilon_2/ x_1, x_2) = \rho \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (15)$$

Where:

y^*_1 = i[th] respondent unobservable true WTP at the time of the first bid offered.

WTP = 1 if $y^*_1 \geq \rho_i$* (the initial bid),

= 0, otherwise

y^*_2 = i[th] respondent implicit underlying point estimate at the time of the second bid offered.

x_1 and x_2 = The first and second bids offered to the respondents(from household and technology related vector, x'_1 *and* x'_2) the respectively.

ε_1&ε_2, and β_1 & β_2 are error terms & coefficients for the first and second equations of equation #15

In the double-bounded CV format, the respondent is presented with two bids where the level of the second bid is contingent upon the response to the first bid. If the individual responds "no" to the first bid (denoted by ρ_i*), the second bid is a lower amount $\rho_l < \rho_i^*$, while if he/she responds "yes," it is some higher amount $\rho_u > \rho_i^*$. Thus, there are four possible outcomes: (*a*) both answers are "yes," i.e., (Yes, Yes); (*b*) a "yes" followed by a "no," i.e. (Yes, No); (*c*) a "no" followed by a "yes," i.e., (No, Yes); and (*d*) both answers are "no," i.e., (No, No). Following Hanemann, Loomis, and Kanninen (1991), the probabilities of these response outcomes can be expressed as:

$\Pr\{yes/yes\} \equiv p(\rho_u \le y_i) = G(\rho_{u;}\ \theta)$,

$\Pr\{yes/No\} \equiv p(\rho_i^* \le y_i < \rho_u) = G(\rho_u;\ \theta) - G(\rho_{i;}\ \theta)$,

$\Pr\{No / yes\} \equiv p(\rho_l \le yi < \rho_i^*) = G(\rho_i^*;\ \theta) - G(\rho_{l;}\ \theta)$,

$$\Pr\{No / No\} \equiv p(\rho_l > y_i) = 1 - G(\rho_l;\ \theta) \quad \ldots\ldots \quad (16)$$

Where, $G(\rho_i^*; \boldsymbol{\theta})$ denotes the cumulative probability distribution (e.g., normal or logistic) of the bid with the parameter vector **θ**.

The respondents know their own maximum WTP, y^*_i but to the researcher it is a random variable with a given cumulative distribution function (CDF) denoted by $G(y^*_i, \theta)$ where θ represents the parameters of this distribution, which are to be estimated on the basis of the responses to the CV survey. In the double bound elicitation method given a sample of *N* respondents, the log-likelihood function for the responses to a CV survey is specified as:

$$\ln L^{DB}(\theta) = \sum_{i=1}^{N} \left\{ \begin{array}{l} d_i^{YY} \ln G(\rho_u; \theta) + d_i^{YN} \ln[G(\rho_u; \theta) - G(\rho_i^*; \theta)] + \\ d_i^{NY} \ln[G(\rho_i^*; \theta) - G(\rho_l; \theta)] + d_i^{NN} \ln[1 - G(\rho_l; \theta)] \end{array} \right\} \ldots\ldots \quad (17)$$

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

The maximum-likelihood (ML) estimator for the double-bounded model is the solution to the first-order condition,

$$\frac{\partial lnL^{DB}(\hat{\theta})}{\partial \theta} = 0, \quad \ldots\ldots \quad (18)$$

Since CVM only captures a single commodity, the mean values for the technologies (motor pump, rope and washer and pulley) were estimated independently for each of the technologies.

According to Haab and McConnell (2002), for the double bounded CV, the mean WTP_j for the technology j (μ) is given by;

$$\mu_j = \frac{-\beta 0 + \sum_{i=1}^{m} \beta\mu_{ij}}{\beta} \quad \text{…………………………………………………………….. (20)}$$

Where β_i-are the coefficient of the i^{th} explanatory variable

μ_{ij} - are the mean of the i^{th} explanatory variable for technology j. β_0 = is the intercept (constant) term and β= is the coefficient of the bid proposed to the respondent

Bivariate probit model estimation deliver two parameter estimates from the two rounds of bidding game. However, parameter estimates from the first equation (β_0**)** are generally used in the computation of mean WTP. This is due to the fact that the second equation parameters are likely to contain more noise in terms of anchoring bias where the respondents is assumed to take the cue from the first bid while forming his response for the second question. Other explanatory variables such as socioeconomic variables are omitted from double-bounded model as most of them are statistically insignificant in the second equation (Palanisami, Ranganathan, Udaya, 2014). Therefore, the mean WTP_j for the technology j is,

$$\mu_j = \beta_0/\beta_1. \quad \text{………………………………………………………… (21)}$$

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

$$\textbf{Mean } \boldsymbol{WTP} = \sum_{i=1}^{n} (y_{ij} / \text{n}) \quad \text{………………………………………………………….. (22)}$$

Where n is the sample size and each y is reported willingness to pay amount by surveyed households for technology j (Haab and McConnell, 2002).

3.5.3 Determinants of household demand/choice for different WLTs

This is examining the choice/preference of farm household to the technologies and why they prefer a particular technology over the other. The study analyze the factors that determine the demand/choice of the technologies using a Multinomial Logit (MNL) model following its merits over the other models. MNL allows the transformation of a dichotomous dependent variable in to a continuous variable ranging from $-\infty$ to $+\infty$ which avoid the out of range problem of the linear probability. The logit analysis provides results which can be easily interpreted and the method is simple to analyze. It gives parameter estimates which are asymptotically consistent, efficient and normal, so that the analogue of the regression t-test can be applied. However, the major drawbacks of this model is the assumption of the independence of irrelevant alternatives (IIA) which states that the ratio of the probabilities of choosing any two alternatives is independent of the attributes of any other alternative in the choice set (Hausman and McFadden, 1984). Even though, multinomial probit model is free from the assumption of IIA, it require multivariate normal integrals estimation to estimate the unknown parameters. This complexity makes the MNP model an inconvenient than the MNL model (Hausman and McFadden, 1984; Hassan and Nhemachena, 2008).

Multinomial logit model

Model of consumer choice is based on random utility theory (McFadden, 1974). The basic idea of this method is individual consumers derive utility/satisfaction not from the goods themselves but from the attributes they provide.

Logistic regression is well suited for describing and testing hypotheses about relationships between a categorical dependent variable and one or more categorical or continuous explanatory variables. Specifically, multinomial logit model was used to identify the farmers' choice amongst these three technologies for two reasons. First, multinomial logistic regression provides an effective and reliable way to obtain the estimated probability of choosing a specific technology and the estimate of odds ratio of the technology. Second, multinomial logistic regression is a procedure by which estimates of the net effects of a set of explanatory variables on the dependent variable can be obtained (Peng, Lee, & Ingersoll, 2002).

Technology choice of the farmers' is modeled using a random utilities model in which individuals face three choices: motor pump (m), rope and washer (rw) and pulley (p). The utilities associated with each of these choices are designated Um, Urw, and Up respectively. This utility is modeled as a function of individual specific characteristics, X, that effect the utility associated with each choice differently. Hence,

$$U_{ji} = X_i\alpha_j + \varepsilon_{ji}$$

Where, subscript j denotes the choice and subscript i denotes the individual.

While we never observe utility, we can infer from the choices people make how they rank the alternatives. Thus, if an individual chooses to persist, it must be the case that Umi> Urwi and Umi>Upi.

For a dummy variable with M categories (in our case M = 3), this requires the calculation of M-1 equations, one for each category relative to the reference category, to describe the relationship between the predictors and the category variable.

Following the agricultural choice literature by Takeshima, Adeoti, Okoli, Salau & Rhoe, 2010; Ndunda & Mungatana, 2013; Amankwah & Egyir, 2013 and Evans et al, 2012, the explanatory variable which are expected to influence farmers' choice of technologies are education, age, family size, gender, access to market, access to credit, household income, participation in the off-farm activity, tropical livestock unit, agro-ecological zone difference, household farmland size, source of available water, soil type, and ownership mode.

The empirical model for the choice of each water lifting technologies except the reference group is specified as follows

$$Yij = \beta_0 + \beta_1 AGE + \beta_2 SEX + \beta_3 HFS + \beta_4 + LIVSTCK + \beta_5 EDUC + \beta_6 HHINC + \beta_7 REGION + \beta_8 OFA + \beta_9 LANDSIZE + \beta_{10} CREDIT + \beta_{11} MKT + \beta_{12} SOURCEWA + \beta_{13} SOIL + \beta_{14} OWNERSHIP + \varepsilon_{ij} \quad (23)$$

Where β_0 is a constant and β_j is a vector of regression coefficients, for j=J-1.

Following Greene (2003), in the multinomial logit model we assume that the log-odds of each response follow a linear model

$$\eta ij = \log\frac{pij}{piJ} = \beta 0 + X_i{}' \beta_j$$

$$\ln\frac{p(Yi=j)}{p(Yi=1)} = \beta_m + \sum_{k=1}^{k} \beta_{jk} X_{ik} = \beta_0 + X_i{}' \beta_j \quad \text{………………….……………..(24)}$$

hence, for each case, there is M – 1 predicted log odds, one for each category relative to reference category

Assuming IID (independently identically distribute), log–Weibull distribution from the disturbance ε_{ij}, the P_{ij}, the probability that individual *i* choose technology j is specified as

$$P_{ij} = \frac{\exp(\beta 0 + Xi' \beta j)}{\sum_{j=1}^{j} \exp(\beta 0 + Xi' \beta j)} \quad \text{…………...……………….……………….. (25)}$$

Assuming Yi be a random variable indicating the choice made, the probability of choosing technology j is:

$$P_{ij} = \text{prob } (Yi=J) = \frac{\exp(\beta 0 + Xi' \beta j)}{1 + \sum_{j=1}^{j} \exp(\beta 0 + Xi' \beta j)} \quad \text{…………………….…. (26)}$$

For the reference category

$$P_{ij} = \text{prob}(Y_i = 1) = \frac{1}{1 + \sum_{j=1}^{j} \exp(\beta 0 + Xi' \beta j)} \quad \text{……………………… (27)}$$

Where, P denotes the probability that the i^{th} farmer has chosen technology j, X_i captures household and farm level characteristics that affect household decision of choosing technology j, while β_i is a parameter to be estimated.

The log-likelihood for this problem is

$$\ln Li = D_{ij} \ln Pr(Y_i=j), \quad \text{……………………………………………………. (28)}$$

Where, D_{ij} is 1 if individual i choose alternative j (i.e., if Yi=j) and 0 otherwise.

The dependent variable is choice/preference of SWLTs. The alternative water lifting technologies are motor pump (reference category), rope and washer, and pulley. Our response variable, WLT is going to be treated as categorical under the assumption that the choice of WLT has no natural ordering.

The description of the determinants of farmers' choice of smallholder WLT are summarized as follows

Table 3.2. Summary of variable description of the determinants of choice of SWLTs

Variable name	Description of variables
Age (AGE)	Continuous variable for age of the household head, measured in years
Family size (HFS)	Continuous variable for household size measured in number
Sex (SEX)	Discrete variable for the sex of the household head(=male headed, 0 otherwise)
Education (EDUC)	Discrete variable for education of the head (1=attainment of formal education, and 0 otherwise)
Income(HHINC)	Continuous variable for household income level as measured in birr
Agro-ecology (ECOREGION)	Dummy variable for ecological zone (= kola/dry area, 0 otherwise)
Off- farm(OFA)	Dummy variable for farmers off farm activity (1= off farm participation and 0 otherwise)
LANDSIZE	Continuous variable for cultivated land and measured in hectares
Credit access (CREDIT)	Discrete variable for access to credit (1= access to credit, and 0 otherwise)
Market access (MARKET)	Continuous variable for market access (hours it takes to the nearby market)
Tropical Livestock Unit (LIVESTK)	Continuous variable for the total livestock a farmer possesses (in number)
Water source (SOURCE)	Dummy variable for irrigation water source(1= open source of water, 0 otherwise)
Soil quality (SOIL)	Dummy variable for soil type (1= if the soil is perceived to be good and 0 otherwise)
Ownership mode OWNERSHIPM	Dummy variable for ownership mode of the technology (1= joint ownership, 0 otherwise)

CHAPTER FOUR

4 RESULTS AND DISCUSSIONS

This chapter is organized as follows. The first section provides descriptive analysis of the survey data. The second section discusses the econometric result of probit, bivariate probit and multinomial logit models. In this sub-sections, determinants of farmers' WTP for the SWLTs are analyzed using probit model. In the second sub section, mean WTP, total WTP and aggregate demand for SWLTs are computed using bivariate probit model. Next to the probit and bivariate probit analysis, farmers' demand for the different water lifting technologies are examined using multinomial logit model. Finally, in the last section comparative analysis of WTP between male and female headed households are discussed.

4.1 Descriptive Analysis of the Survey Data

4.1.1 Basic characteristics of the surveyed household

The study uses a total of 208 farm household data for analysis which was collected from the four weredas. In the surveyed area, sex composition of sampled households indicates that 82.21% of the households are male headed and the rest 17.79% are female headed. The survey result shows that, about 78.95% and 64.86% of the male and female headed households are willing to pay for the WLTs and the difference is found to be significant in the chi-square test. By willing household, we are referring the household who is willing to forgo some fraction of his/her income to obtain the SWLTs while keeping his utility constant. The survey result shows that, among the willing households, the sex composition of the households who prefer motor pump, rope and washer, and pulley are 0.94, 0.76 and 0.8, showing that being male increases the farmers' preference to motor pump, followed by pulley and rope and washer.

The sampled households have a total number of 1332 family sizes with a minimum of 1 member and a maximum of 18 members. Average family size in adult equivalent is 6.4 persons. The surveyed result shows that, 76.45% of the households are found to be willing to pay for the SWLTs. The average family size in adult equivalent for willing and unwilling household is 6.56 and 5.48 respectively. The difference in the family size is significant in the t-test, implying that a household with a large family size tend to invest more in the water lifting technologies than a household with a small family size.

The survey result shows that, among the willing households, the average family size of a household who prefer motor pump, rope and washer and pulley is 7.01, 5.97 and 6.65 respectively. This shows that families with a highest family member tend to choose motor pump, followed by pulley and rope and washer. This may be because, with the increase in the member of the household, income obtained from the farm and off-farm activity increase. This in turn increases the ability of the household to pay for the most appropriate and affordable water lifting technologies.

Table 4.1: Summary statistics of the surveyed households' basic characteristics

Variable	*Total*				*Willing*	*Non-willing*	*Mean diff*
	Mean	*Std.dev*	*Min*	*Max*	*Mean*	*Mean*	t/x^2 *test*
SEX	0.82	0.38	0	1	0.85	0.69	0.73*
HFS	6.40	2.49	1	18	6.64	5.63	1.008**
AGE	43.59	11.06	18	76	42.61	46.75	4.15**

Note: Mean diff= mean (unwilling - willing), H_0*: diff=0 Ha: diff > <=0*

**significance at 10%, ** significance at 5%, ***significance at 1%*

Source: survey result, 2015

The mean difference of household's size who prefer among motor pump and rope and washer is significant in the t-test. However, it is insignificant between motor pump and pulley, and rope and washer and pulley showing that household size does not affect the choice between motor pump and pulley, and rope and washer and pulley. The insignificance difference of the t-test between rope and washer and pulley may be attributed by the following reasons. One, both technologies are tagged with low price comparing to motor pump and hence low income earned households purchase either of the appropriate technology. Second, both rope and washer and pulley are labor intensive and require a great deal of labor force relative to motor pump which makes the farm household indifferent in the choice between the two depending on the family size. Also, the insignificance difference between motor pump and pulley may be due to the fact that motor pump preferred household contribute to the farm through the income which obtained from the high participation in the off-farm activity. Likewise, pulley preferred household may contribute through their on-farm work since pulley require a great deal of labor force.

The age composition of the surveyed household indicates that, the age of the household head ranges from 18 to 76 year with an average age of 43.59. Average age of the male household head is 43.33 years with a range of 18 to 76 years and that of the female counterpart's is 45.64 years with a range from 22 years to 65 years. The average age of the willing and unwilling household is 42.61 and 46.76 respectively, indicating that the younger household is more willing to pay for the SWLTs. The implication is that older farmers have more farming experience, but they are less likely to have formal education and tend to stick to traditional farming systems. The t-test shows that the difference is statistically significant.

Age of the household head is also a factor for the technology choice decision of the farmers. Among the willing surveyed household, the average age of the household head who prefers motor pump and rope and washer and pulley are 44.87, 40.96 and 42.37 respectively. The mean age difference who prefer motor pump and rope and washer is significant. However, the mean age difference among the household head who prefer motor pump and pulley, and rope and washer and pulley is statistically insignificant in a t-test.

Table 4.2. Surveyed household basic characteristics and choice of WLTs

Variable	*Choice of technology*		
	Motor pump	*Rope and washer*	*Pulley*
Gender of the head (SEX)	0 .9411 (0.0611 ***^{a})	0.7692 (0.0814^{b})	0.8039 (0.0588**^{c})
Household family size (HFS)	7.0147 (0.4751**^{a})	5.9615 (0.4469^{b})	6.6470 (0.4953^{c})
Age of the head (AGE)	44.86 (2.0765^{a**})	40.96 (2.0815^{b})	42.37 (1.9506^{c})

**significance at 10%, ** significance at 5%, ***significance at 1%.*

Source: Survey result, 2015

Numbers in parenthesis with superscript a, b and c indicates the standard error of the mean difference between motor pump and rope and washer, rope and washer and pulley, and motor pump and pulley respectively.

4.1.2 Socioeconomic characteristics of the surveyed households

In the study areas, the education level of the household head ranges from unable to read and write (illiterate) which considered as a zero grade to secondary school graduate, with an average of 3.83 years school attainment. Out of the total number of household respondents' 69.23% attend formal education while the rest 30.77% are illiterate. Implying that majority of the household heads attends formal education. The average educational attainment of willing and non-willing is 4.02 and 3.2 years of schooling respectively. Showing that, there is no significant difference in school attainment for the willing and unwilling household. The t-test also confirm this insignificant difference.

Education affect the farm households' technology choice. This may be because educated farm households has more awareness and can have a more developed way of technology usage and hence income. As a result, they are more willing to pay for the most appropriate and affordable water lifting technologies. The t-test shows the significant difference between the education levels of the household who prefer motor and rope and washer.

Average annual income of the surveyed household is 21,798 birr ranging from 1,578 to 126,480 birr. This income is obtained either from the farm (harvesting of crop and/or rearing of livestock) or off-farm activities. Average household income for those willing and non-willing farm household is 23,980.72 and 14,713.31 respectively. The t-test shows there is a significant difference in income between the two groups (see table 4.3). The implication is that, income increase the purchasing power of the farm household to pay for the (most appropriate and affordable) water lifting technologies.

The average yearly income of households who prefer motor pump is 23,766.18 birr. While the average income of the household who prefer rope and washer and pulley is 13,579.04 and 22,951.08 birr respectively. This implies that households with the highest income prefer to own motor pump and pulley. This may be due to the following two scenarios. First, for those who practice in extensive farming, motor pump is appropriate as it is labor saving and can irrigate large farm size. Second, other farmers may want to diversify their businesses in the off-farm activity. Farmers who only practice farming in their backyard and small plot of land may want to practice both on-farm and off-farm activity and hence, pulley is more appropriate. A t-test shows a significant difference in the mean income of households who prefer motor pump and rope and washer, and pulley and rope and washer (see table 4.4).

Income from rain fed or irrigated agriculture is the main source for the livelihood of the farm household in the study area. However, among the surveyed households 43.75% of the household head or its member engage in one or more of the following off farm activities: working as daily laborers (39%), fishing (24%) and obtaining remittance (13%). The rest 24% are engaged in selling of alcohols and beverages, and trading in grains and livestock together (13%) and other activities (11%).

In Adami Tulu wereda the farm household head or one or more of its members are mainly engaged in fishing activity (51%) followed by daily laborer (34%) and other activities (15%). Remittance (34%) is the dominant source of income for Lemo wereda farm household followed by working as a daily laborer (31%) and other activities such as trade in grains and livestock, handicraft and others making a total of 35%.

However, off-farm activity is very least practiced in the Dangela and Bahir Dar Zuria wereda, in which farmers' are mainly engaged in farm land activities. This may be because of the fact that farm household in this weredas is dominantly practice mixed farming and hence the farmer or one or more of its members engage in livestock rearing in the off-farm period. It is also may be the attribution of cultural and other exogenous factors in which the farmer refrains himself from any activities in the holidays. Off farm income for the willing and non-willing farm household is 2,739.55 and 5,351.22 birr respectively, but a t-test shows that the difference is statistically insignificant. From table 4.3 we can also understand that off-farm activity for willing and unwilling household is 0.39 and 0.59. But the chi-square test shows the significant difference in the values.

Off-farm activity is one of the factor in determining the farmers' technology choice decision. In the study areas, 38.46% of farmers who participate in off farm activity prefer motor pump while 27.47% and 17.59% percent prefer to own rope and washer and pulley respectively (see table 4.4). While the remaining 16.48% are unwilling to pay for any of the technologies. This shows that household who participate in off farm activity tend to prefer motor pump followed by rope and washer and pulley. This is likely because participation in the off-farm activity is a means of generating additional income which increase the purchasing power of the household to pay for the technology. A t-test confirms the difference in mean value between motor pump and pulley is statistically significant.

The average farmland holding is 1.42 hectares, the least being 0.2 hectares and the maximum being 6 hectares. Farmers' on average have 0.81 hectares of irrigable land. Site wise, in Adami Tulu and Lemo wereda farmers have a potential of irrigating (or currently practicing) 0.67 and 0.31 hectares of land respectively. The number is 0.11 and 0.27 hectares for Dangela and Bahir Dar Zuria wereda. Average irrigable land (including the potential) for the willing and non-willing household is 0.35 and 0.31 hectares. The average land holding for willing and non-willing household is 1.46 and 1.31 hectares. A t-test result shows that the difference is statistically insignificant.

Farm size of the farmer also influences the choice of WLTs. Farm size of the household who prefer motor pump, rope and washer and, pulley is 1.62, 1.43 and 1.26 hectares respectively, showing that, farmers who prefer motor pump has relatively large land holding than rope and washer and pulley preferred farmer. In fact the technologies are also suited to cultivate a different range of farmland as stated in the literature review. A t-test confirms that there is a significant difference in the mean value of land holding among motor pump and rope and washer, and motor pump and pulley. However, there is no significant difference between rope and washer and pulley preferred household's farm land.

Table 4.3: Summary statistics of the surveyed households' socioeconomic characteristics

Variable name					Willing N=170	Unwilling N=42	Mean differ
	Mean	Std.dev	Min	Max	Mean	Mean	t/x^2 test
EDUC	3.82	3.61	0	12	4.02	3.2	0.815
HHINC	21,798	20268.1	1578	126480	23980.72	14713.31	9267.41***
OFA	0.4375	0.4973	0	1	0.3899	0.5918	-0.2018 **
LANDSIZ	1.4226	1.0297	0.2	6	1.45578	1.3147	0.1409
LIVESTK	4.5838	3.00052	0	18.51	4.9820	3.2915	1.6904***
CR	0.5240	0.50062	0	1	0.5723	0.36734	0.2049**
MKT	1.3452	0.73156	0.08	3.5	1.4007	1.1651	0.2356**
INFO	0.4038	0.49185	0	1	0.4276	0.3265	0.1011

Note: diff= mean (unwilling) –mean (willing), H0: diff=0 HA: diff > <=0 and
**significance at 10%, ** significance at 5%, ***significance at 1%*

Source: Survey result, 2015

The average tropical livestock (TLU) unit for the farm household in the study area is 4.58 units with the minimum and maximum of 0 and 18.51 units. TLU, which used as a proxy for wealth measure in the study areas is measured as by counting all livestock units of different type the farm households possess and converting to the same unit using a standard conversion factor (see appendix 2). There is a slight difference in livestock possession among the sampled weredas. Dangela has the largest livestock unit (5.63) compared to Bahir Dar Zuria (5.36), Adami Tulu wereda (3.24) and Lemo wereda (4.1). Average tropical livestock unit for the willing and non-willing household is 4.98 and 3.29 unit. This shows that the willing households have more livestock unit (i.e., wealthier) than the unwilling. The t-test also confirms the significance of this difference.

From the total surveyed farm household, 52.4% of the household have access to credit. Among those farmers who have access to credit, 40.38% are able to borrow. The average credit households received from formal lending institutions in the year 2006E.C is birr 2768.90, with a minimum and maximum of 0 and 70,000 birr. Average credit a willing and unwilling household accessed for that particular year is 3139.2 and 1567.35 birr respectively. Access to credit between willing and unwilling household is 0.57 and 0.37 respectively. The chi-square test shows there is a significant difference between the values. Lending institutions/individual's perception that the money will not be used for the targeted objective, the absence of formal and informal lending institutions in the area, higher lending interest rate, lack of sufficient and required type of collateral, poor knowhow of the farmers and high credit rationing are the major reasons for the low level of credit access in the study areas.

Credit access in this study refers either the eligibility of farmers' to borrow money from the financial institutions or the possibility of the farmers to own the technologies in credit term. Farm household entitled the ownership of the technologies either in cash payment or credit term. Credit based ownership mode of the technologies by the farm household increase their ability to pay for the technologies. In the study areas, all the surveyed farm households prefer either annual or semi-annual based credit term as a payment mode for the technologies. None of the farm household chose to pay at the time they possess the technology. This implies that, credit term ownership increases the farmers' willingness and ability to pay for the technologies.

The level of credit access among households who preferred motor pump, rope and washer, and pulley is 0.5, 0.5 and 0.67 respectively. The chi-square (χ^2) test shows that mean difference is significant between motor pump and pulley, and rope and washer and pulley. However, there is no significant credit access difference between motor pump and rope and washer preferred household implying that, farm household who have more access to credit prefer pulley then rope and washer followed by motor pump. The implication is that, the average credit the farm household obtains is only large enough to buy either pulley or rope and washer. This may be due to the risk averse nature of the household to take a large amount of money or lack of sufficient and required types of collateral to borrow large amount.

The average hours that take the household to the nearest market for selling their agricultural product is used as a proxy for access to market and it is on average 1.4 and 1.2 hours for willing and unwilling households. This implies that there is only slight difference in market access between the willing and unwilling farmers'. Unlike to this, for the farm household who prefer motor pump, the average time for that particular farmer (to take its agricultural product to the nearest market) is 1.08 and it is statistically different by the chi square (χ^2) test from the time which take a rope and washer (1.5) and pulley (1.57) preferred farmers.

Among the surveyed household only 40.38% of the household have awareness or practical experience of using the water lifting technologies. Information access of the willing and non-willing farm group is 42.76% and 32.65% respectively, indicating that information access and practical use of irrigation technologies for the willing household is higher than the unwilling group. However, the chi-square (χ^2) test shows the difference is insignificant.

Bid values of the water lifting technologies influence the smallholder farmers' willingness to pay and demand decision. The average bid values for motor pump, rope and washer and pulley is 16,964, 4,170 and 1,166.59 birr respectively. Price of the water lifting technology is a factor in determining the choice decision of the farmer. Market price for the water lifting technologies are significantly different to each other.

Joint ownership of the water lifting technologies increases the farmers' willingness and ability to invest in the technologies since the amount an individual bear decrease due to the sharing of the cost among the group. From the total surveyed household who are willing to pay for the chosen technology, about 33.9% are preferred to own the technology jointly. However, the rest 66.1% of the household is willing to possess the technology individually.

Table 4.4: Summary statistics of the surveyed households' socioeconomic and choice of technology characteristics

Variable	Choice of technology		
	Motor pump	Rope and washer	Pulley
Education level (EDUC)	3.35 (0.397**[a])	4.75 (0.734[b])	3.88 (0.6294[c])
Income (HHINC)	23,766.18 (3215.5***)	13579.04 (3395.081[b***])	22,951.08 (3981.66[c])
Agro-ecological zone (ECOREGION)	1.3235 (0. 1399[a])	1.2307 (0.1822[b])	1.235 (0.1493[c])
Off-farm activity (OFA)	0.5147 (0.0917[a])	0.3846 (0.0946[b])	0.3137 (0.0905[c**])
Farm land size (LANDSIZE)	1.6165 (0.2022[a*])	1.4378 (0.1973[b])	1.2647 (0.1673[c**])
Access to credit (CREDIT)	0.5 (.0928[a])	0.5 (0.0967[b*])	0.666 (0.0911[c*])
Access to market (MARKET)	1.0839 (0.132[a***])	1.5015 (0.1397[b])	1.5737 (0.1335[b***])
Source of water (SOURCE)	1.6176 (0.1789[a**])	1.1153 (0.1610 [b])	1.274 (0.1969 [c*])
quality of soil (SOIL)	0.89705 (0.0628[a])	0.82692 (0.0799[b])	0.7647 (0.0726[c**])
Ownership mode (OWNERSHIPM)	0.5294 (0.0876[a***])	0.25 (0.0827[b])	0.19607 (0.0855[c***])

**significance at 10%, ** significance at 5%, ***significance at 1%*

Source: Survey result, 2015

Numbers in parenthesis with superscript a, b and c indicates the standard error of mean difference between motor pump and rope and washer, rope and washer and pulley, and motor pump and pulley respectively.

Apart from the above mentioned socioeconomic and institutional variables, agro-ecological/bio-physical factors such as available water source for irrigation, the perceived quality of soil, agro ecological zone difference also consider as a factor in determining the choice of the technologies.

Source of available water for irrigation practice influences the type of WLT a particular farmer has to willing and invest in. From the theories and available practices, motor pump is suitable for pumping from the open source/surface water such as river and lakes but also from ground water. Rope and washer, and pulley are mainly suitable for pumping water from shallow wells. From the total respondent 65.38% of the farmers have access to shallow wells (ground water), implying that ground water is the main source of water for the farmers who practice irrigation. River and lake is used by 12.44% and 3.4% of the farmers, respectively. Spring as a source of water for irrigation accounts 4.81%. The rest 13.97% of the household does not have water source for irrigation and they practice rain fed farming.

The other bio-physical factor which the theory and empirical works suggest to influence the demand of WLT is the perceived quality of soil. With a belief to generate a high income, farmers who perceive their land is fertile/good will choose the most appropriate (but may be costly) technology. This may be because farmers' borne their trust on their land. Soil type also affects the irrigation cost in the farmland since the soil's extent of water-holding capacity and water infiltration rates affect the amount of water requirement and hence labor cost. Therefore, the perceived quality of soil affects the demand decision of the farmer.

Among the surveyed household who perceived their farmland soil quality is good, 36.53% preferred motor pump, 28.14% and 23.35% preferred rope and washer, and pulley respectively. The rest 11.98% are zero bidders (unwilling to participate in the water lifting technology). The good perceived quality of the soil leads to the decision to prefer motor pump for a particular farmer followed by rope and washer and pulley. The chi-square test also confirms the significant difference of the perceived quality of soil among motor pump and pulley preferred household.

Among the physical characteristics, climatic conditions like rainfall, temperature, humidity and length of dry season affect the type and system of irrigation used. The dry ecological zone demand more water since there is high osmosis and evaporation. Therefore, high demand for water calls high irrigable capacity and less labor intensive technology. On the other hand, in the moderate ecological zone, the precipitation is high and hence they require less water. As a result, using more labor intensive technology may also provide the necessary watering. In semi-arid and arid region's rainfall is erratic, highly variable, and have prolonged dry season up to eight months, except in areas where the short rainy season prevails. The demand for motor pump and, generally smallholder water lifting technologies are relatively higher in the arid areas than in areas with sufficient precipitation. This implies that the technology preferred in arid and semi-arid areas should enables the smallholder to work intensively in his farm land. Among the motor pump preferred households, 47.06% are dwelled in the dry area and the rest 52.94% reside in the sub-tropical region.

4.1.3 Farmers' demand/choice of smallholder water lifting technologies

In the study areas, as it is seen in the following graph, 38% of the household are willing to pay for motor pump. The remaining 33% and 29% of the household are willing to invest in rope and washer, and pulley respectively.

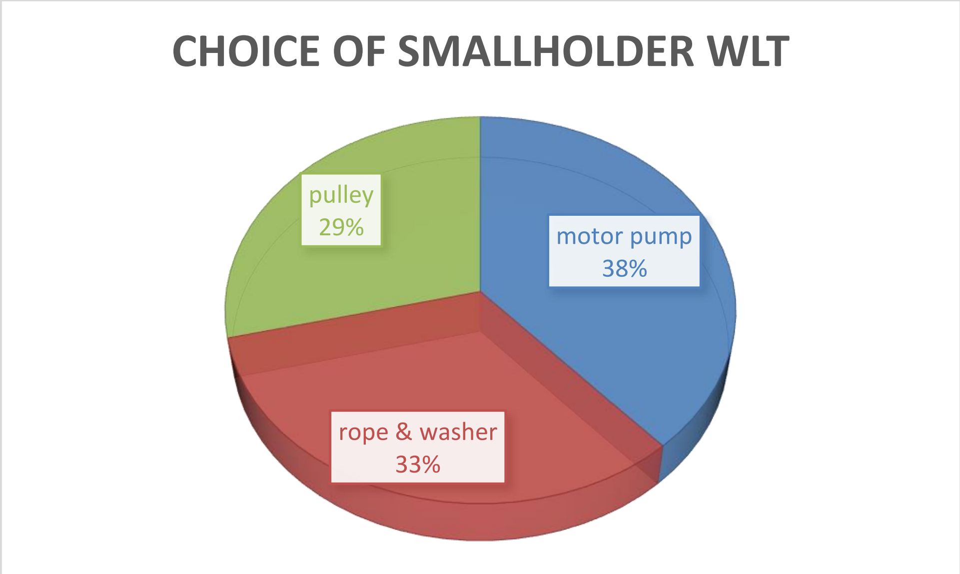


Figure 4.1 Farmers' choice of the smallholder water lifting technologies

More specifically, 69.57%, 28.26% and 2.17% of the farmers in Adami Tulu prefer motor pump, rope and washer, and pulley respectively. These figures are 15.91%, 40.91% and 43.18% for the farm households' in Lemo wereda. The majority of the farmers' in Dangela wereda prefer to own rope and washer (65%) followed by pulley (27.5%) and motor pump (7.5%) while farmers in Bahir Dar Zuria wereda demand more motor pump (55.32%) followed by pulley (42.55) and rope and washer (2.13%). This implies that farmers' in Adami Tulu and Bahir Dar Zuria wereda prefer (and more willing to pay for) motor pump while farmers in Dangela wereda prefer rope and washer as their prime choice. This may be due to the fact that, farmers' in Adami Tulu and Bahir Dar Zuria have more surface water like river and lake as a source of available water than the two weredas which is more favorable to motor pump. Moreover, agro-ecological difference, distance to the nearby market and access to credit are different for these wereda farmers'. Since, the farm household of these weredas have different access and endowment to the mentioned resources, results in the difference in the choice of the technologies.

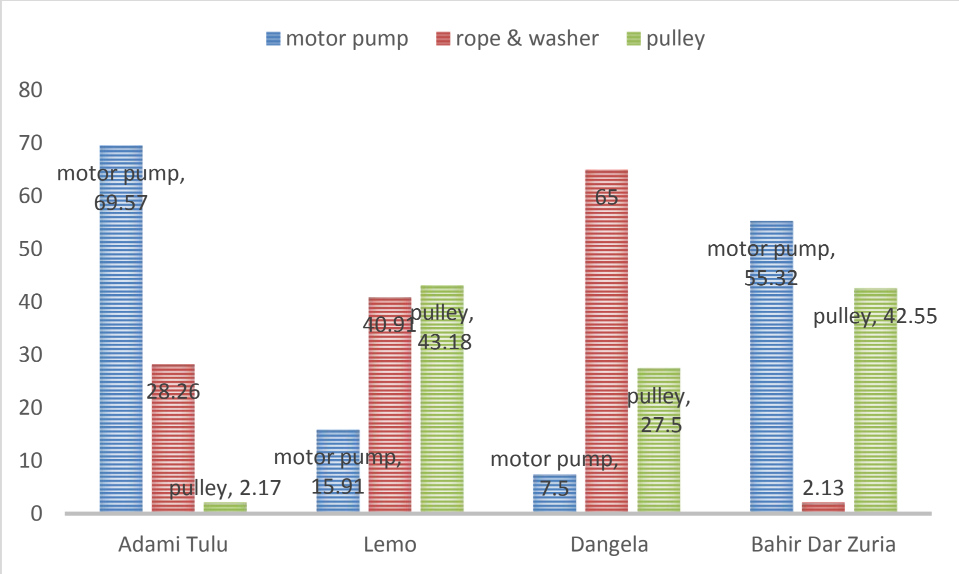


Figure 4.2. Farmers' choice of the smallholder WLT in each of the study areas

4.2 Econometric Result

4.2.1 Probit Model Estimation result

Probit model was used to factor out the major determinants of farmers' WTP for the smallholder water lifting technologies. This section discuss the probit model estimation result.

The study test the joint significance of the explanatory variables by using the Wald test with a null hypothesis of coefficients of all explanatory variables included in the models are equal to zero. The Wald test, which follow χ^2 distribution with 12 degrees of freedom (*DF*) is about 61.40. From $\chi2$ distribution table with 12*df* the critical value is 5.23 at 5 % level of significance. This implies that the null hypothesis of slope coefficients of all explanatory variables are jointly equal to zero is rejected (see Table 4.5). Thus, the overall significance of the model is good (i.e. Explanatory variables have some joint effect on willingness to pay). Another method of goodness of fit is pseudo R^2, which measures how well the model fits the data and it is 0.2196 for this study showing the very good model fit.

The summary results of these conventional probit model with its marginal effect for identifying the factors affecting WTP are reported in table 4.5 and 4.6.

The Probit Model Estimation Result

Table 4.5. The probit model estimation (with robust standard error)

Dependent variable is discrete response (yes=1/no=0) to initial bid (ρ_i*)						
Variables	Coefficient	Std. Err.	Z-Value	P>z	[95% Conf. Interval]	
AGE	-0.03396	0.01034	-3.28	0.001***	-0.05425	-0.01369
HFS	0.12141	0.04055	2.99	0.003***	0.04193	0.20088
SEX	-0.33754	0.31460	-1.07	0.283	-0.95414	0.27907
EDUC	-0.16024	0.27416	-0.58	0.559	-0.69758	0.37709
HHINC	0.00002	7.26e-06	2.27	0.023**	2.28e-06	0.000031
BIDV	-0.00003	0.00002	-2.17	0.030**	-0.00005	-2.78e-06
OFA	-0.43148	0.22403	-1.93	0.054*	-0.87057	0.00762
LANDSIZE	-0.22253	0.11197	-1.99	0.047**	-0.44198	-0.00307
MKT	0.16318	0.14769	1.10	0.269	-0.12629	0.45265
LIVESTK	0.10187	0.041222	2.47	0.013**	0.02107	0.18266
INFO	0.06697	0.21581	0.31	0.756	-0.35600	0.48995
CREDIT	0.54281	0.20462	2.65	0.008***	0.14176	0.94386
_cons	0.84106	0.60269	1.40	0.163	-0.34018	2.02231
Number of observations			208			
Log pseudo likelihood			-107.38947			
Wald chi^2(812)			61.40			
Pseudo R^2			0.2196			
Prob > chi^2			0.0000			

**significance at 10%, ** significance at 5%, ***significance at 1%*

Source: Stata output

The probit model estimation result shows that among the variables included in the model eight variables have the expected sign and more than half of them were found to be significant in affecting WTP decision. These include household family size, age of the household head, farm land size, initial bid values, household income, off-farm activity, access to credit and tropical livestock unit. Among the significant variable, family size, household income, tropical livestock unit and access to credit affect WTP positively but off-farm activity, initial bid value, farm land size and age of the household head affect WTP decision negatively. On the other hand, sex of the household head and education level have the wrong sign but statistically insignificant.

For this model the existence of heteroscedasticity and multicollinearity were checked and it is found that the problems are not serious. Even though there are a number of ways to deal with heteroscedasticity, checking whether each explanatory variable is responsible for the existence of heteroscedasticity or not is one way in dealing with such problem (Assefa, 2012). The likelihood ratio test for probit model shows the absence of heteroscedasticity in the error variance (see appendix 3).

The existence of multicollinearity among explanatory variables is another problem in econometric analysis, and its severity can be checked using correlation matrix and standard errors. Theoretically, multicollinearity is considered a serious problem if the correlation matrix is in excess of 0.5 (Gujarati, 2003). In this study, the correlation matrix found less than 0.5 (see appendix 4a). Also the standard errors are found less than 2, indicating that multicollinearity is not a severe in the data (Starkweather & Amanda, 2011 and Gujarti, 2004).

In the probit model estimation, only the sign of the variable are important since the magnitude does not show the effect of each independent variable on the probability of farmers' WTP for the water lifting technologies. In order to analyze the effects of each explanatory variable on the probability that respondents accept or reject the initial bid (ρ_i*), the partial derivatives of explanatory variables with respect to discrete responses must be taken (Greene, 1993). i.e., we need to estimate the marginal effects.

The marginal effects of the probit model estimation results are reported in the table 4.6.

Table 4.6: Marginal effect estimates of the probit model (with robust standard error)

Dependent variable is discrete response (yes=1/no=0) to initial bid (ρ_i*)							
Variables	dY/dx	Std. Err.	Z	p>|Z|	[95% Conf. Interval]		x-bar
AGE	-0.01248	0.00383	-3.26	0.001***	-0.01998	-0.00498	43.5865
HFS	0.04462	0.01494	2.99	0.003***	0.01533	0.07390	6.40385
SEX[a]	-0.11759	0.1031	-1.14	0.254	-0.31967	0.08449	0.82212
EDUC[a]	-0.05808	0.09776	-0.59	0.552	-0.24968	0.13351	0.69231
HHINC	6.06e-06	0.00000	2.29	0.022**	8.8e-07	0.00001	21797.5
BIDV	-0.00002	0.00000	-2.18	0.029**	-0.00002	-1.1e-06	6994.65
OFA[a]	-0.15919	0.08234	-1.93	0.053*	-0.32058	0.00219	0.4375
LANDSZ	-0.08178	0.04114	-1.99	0.047**	-0.16242	-0.00114	1.42257
MKT	0.05997	0.0545	1.10	0.271	-0.04685	0.16679	1.34524
LIVSTK	0.03744	0.01525	2.46	0.014**	0.00756	0.06732	4.58377
INFO[a]	0.02454	0.07903	0.31	0.756	-0.13035	0.17943	0.40385
CR[a]	0.19846	0.07376	2.69	0.007***	0.05389	0.34303	0.52404
Number of observations			208				
Log pseudo likelihood			-107.38947				
Wald chi^2(12)			61.40				
Pseudo R^2			0.2196				
Prob > chi^2			0.0000				

**significance at 10%, ** significance at 5%, ***significance at 1%,*

([a]) dY/dx is for discrete change of dummy variable from 0 to 1

Source: Stata output

Age of the household has a negative and statistically significant (1% level of significance) effect on the farmers' decision to pay for the water lifting technologies as expected. The marginal effect shows that, other things remain constant a one year increase in the age of the household head decreases the probability of accepting the initial bid by 1.25% indicating that younger farmers have more willingness to pay for the WLTs. This is may be due to the fact that younger farmers have longer planning horizons than the elder ones. This result is consistent with the works of Mezgebo et al. (2013) and Alebel et al, (2009).

Holding other things remain constant, a unit increase in the family size of the farm household increases the probability of accepting the first bid by about 4.46%. This is unlike to the hypothesized one, indicating that additional member brings additional income and labor force to the farm household, so it is not surprising that the households with large family size is willing to pay for the WLTs. Studies by Whitehead et al (2008) and Alhassan, Loomis, Frasier, Davies and Andales (2013) also found similar results.

Households average yearly income (farm + off-farm income) has a positive and statistically significant (at 5% level of significance) effect on accepting the initial bid which is consistent with economic theory. The marginal effects shows that keeping the influences of other factors constant at their mean value, a one birr increase in income of the respondent increases the probability of accepting the first bid by about 0.001%. This implies that a household with a higher income is willing to pay more for the water lifting technologies. The result is also consistent with previous works made by Mezgebo et al. (2013); Bane (2005) and Assefa (2013).

In line with the priori expectation, the initial bid values for the SWLTs have negative effect and it is significant at 5% level of significance. The marginal effect of the initial bid values shows that, holding other socioeconomic and institutional variables constant, a one birr increase in the bid values of the technologies decreases the probability of accepting the initial bid values by 0.002%. This explains the fact that higher bid values for the valued goods results in lower ‘yes’ response/WTP to the proposed initial and follow up bid values.

Farmers’ participation in off farm activity is found to have an adverse effect on the probability of a household willingness to pay for the initial bid value. The negative coefficient suggests that, households involved in off-farm activities are less willing to pay for the SWLTs. This may be the case that additional income from the off-farm activity only helps the farm household for sustaining the household livelihood. In the surveyed area, 39% of the farm households were engaged in daily laborer as a means for additional income showing that off-farm activity is mainly realized by capital constrained poor households. The marginal effect of the off-farm activity shows that keeping other variable constant, changing the off-farm dummy from 0 to 1 will decrease the probability of accepting the initial bid values by about 15.92%.

Unlike to the prior expectation, size of farm land has a negative effect on the probability of accepting the initial bid values of the WLTs and it is statistically significant at 5% level. One possible reason could be households with large land holding have enough option to diversify their rain fed crops. It may also be the case that, households with large land holding tend to prefer other irrigations systems such as gravity irrigation. This result is consistent with the work of Gebregziabher (2013).

Access to credit from the financial institution or credit term ownership of the technologies have the expected positive sign in affecting WTP and found to be significant at 1%. The marginal effect shows that, when the credit dummy changes from 0 to 1, the probability of the household willing to pay for the technologies increase by 19.84%. This result suggests that access to credit from financial institutions and credit term ownership of the technologies increase the farmers' willingness and ability to pay for the most appropriate an affordable water lifting technology.

4.2.2 Bivariate Probit Model Estimation Results

To examine the effect of initial bid values and to obtain the beta coefficients which used for computing the mean and total WTP values, bivariate probit models were estimated. The bivariate probit model estimation is a first step in the estimation of farmers' mean willingness to pay for the smallholder water lifting technologies. These bivariate probit models (or the double-bounded probit models) are estimated using farmers' responses to the first and the second bids (see section 3.5.2 for the formula). Since, we have three smallholder water lifting technologies with different initial and follow up bid, we estimate the bivariate probit model for each of the technology separately. The next three tables (Table 4.7a, b, and c) summarize the bivariate probit model estimation for motor pump, rope and washer and pulley.

Table 4.7 (a). Bivariate estimates for Motor Pump

Variables	Coefficient	Std. Err.	Z	P>Z	[95% Conf. Interval]	
Dependent variable (yes/no1=1 if yes to the initial bid, 0 otherwise)						
Initial bid	-0.0001778	0.000036	-4.93	0.000	-0.00025	-0.00011
Constant	3.234576	.6364361	5.08	0.000	1.98718	4.481968
Dependent variable (yes2=1 if yes to the second bid, 0 otherwise						
Second bid	-0.0002192	0.000046	-4.75	0.000	-0.00031	-0.00013
Constant	3.256793	.7127406	4.57	0.000	1.85984	4.653738
Athrho	3.060797	84.47927	0.04	0.971	-162.515	168.6371
Rho (ρ)	0.9956197	0.738467			-1	1
Wald(χ2) Prob > $chi^2(2)$ Log likelihood	29.76 0.0000 -51.3547					

Likelihood-ratio test of rho=0: chi^2 (1) = 22.5589   Prob > chi^2 (2) = 0.0000

Source: Stata Output

Table 4.7 (b). Bivariate estimates for Rope and Washer

Variables	Coefficient	Std. Err.	Z	P>Z	[95% Conf. Interval]	
Dependent variable (yes/no1=1 if yes to the initial bid, 0 otherwise)						
Initial bid	-0.0006641	0.00017	-3.99	0.000	-0.00099	-0.00034
Constant	3.566118	.799697	4.46	0.000	1.99874	5.133495
Dependent variable (yes2=1 if yes to the second bid, 0 otherwise						
Second bid	-0.0003022	0.00015	-1.98	0.047	-0.0006	-3.75e-06
Constant	0.5607065	0.62083	0.90	0.366	-0.65611	1.77752
Athrho	2.52825	116.277	0.02	0.983	-225.371	230.4274
Rho (ρ)	0.987345	2.92435			-1	1
Wald(χ2) = Prob > chi^2(2) Log likelihood	16.47 0.0003 -51.76785					

Likelihood-ratio test of rho=0: chi^2 (1) = 7.77023   Prob > chi^2 (2) = 0.0053

Table 4.7 (c). Bivariate estimates for Pulley

Variables	Coefficient	Std. Err.	Z	P>Z	[95% Conf. Interval]	
Dependent variable (yes/no1=1 if yes to the initial bid, 0 otherwise)						
Initial bid	-0.0014623	0.00072	-2.04	0.041	-0.00287	-0.00006
Constant	3.06099	0.99861	3.07	0.002	1.10376	5.018224
Dependent variable (yes2=1 if yes to the second bid, 0 otherwise						
Second bid	-0.002419	0.00058	-4.15	0.000	-0.00356	-0.00128
Constant	3.116845	0.73437	4.24	0.000	1.67751	4.556185
Athrho	2.069122	8.90749	0.23	0.816	-15.3893	19.5275
Rho (ρ)	0.9685992	0.55062			-1	1
Wald(χ2) = Prob > chi^2(2) Log likelihood	17.43 0.0002 -37.07054					

Likelihood-ratio test of rho=0: chi^2 (1) = 7.4751   Prob > chi^2 (2) = 0.0063

Source: Stata output

Table 4.7 (a, b, c) shows the bivariate probit model result for which the initial bids and the second bids have the expected signs and statistically significant at most at 5% level of significance. Implying that higher initial bids and second bids leads to lower probability of accepting the bids. Therefore, the initial bids and the follow up bids of the water lifting technologies have a negative and significant effect in determining farmers' WTP.

The correlation coefficient of the error terms of the double-bounded model, Rho (ρ), which shows the relationship between the random components of the responses to the initial bids and the second bids are positive and statistically significant at 1% level of significance. Less than unity value for Rho (ρ) implies that the correlation between the random components of the responses to the initial bids and the second bids are not perfect. The result is consistent with economic theory and the empirical works of Falola et al, (2013), Nakanyike, (2014) and Mezgebo et al, (2013).

Following this, using the values obtained from the bivariate probit model, willingness to pay for the SWLTs can be calculated. But, before discussing the mean WTP and total WTP, it would be good to discuss the farmers' response to the initial and follow up bid in the study areas for the WLTs.

Based on the pilot survey results and existing market price of the SWLTs, five starting point bid values were identified and introduced to the farmer randomly. The first question the respondent asked is, their preference and their willingness to pay for the selected water lifting technology at the initial bid. The farmers who accepted the first bid, were given a second bid, which is higher than the first bid. On the other hand, if the interviewee say 'no' to the initial bid, they would be asked a follow up question which is lower than the initial bid values.

Table 4.8 summarizes the bids and responses to the double-bounded questions. For each bid offered for the technologies, there are two possible responses. The first row of each technology choice summarizes the "yes" responses to the initial bid and the "yes-yes and yes-no'' response to the second bid for the respective technology. Likewise, the second row summarizes the "no" response to the first bid and the "no-yes and no-no'' response to the second bid for the respective technology.

For example, for the initial bid values of motor pump, 57.35% respond "yes" and 42.65% respond "no" (i.e. 57.35% of the farm households are willing to pay at the initial bid value and 42.65% rejected the proposed bid). Of the 57.35% "yes" responses to the initial bid for motor pump, the follow-up bid results in 56.4% "yes" responses and 43.6% "no" responses (i.e. 56.4% of the farm household who were willing to pay the initial bid value again says yes for the next increased bid price, indicated by “yes-yes” (YY) response. The rest 43.6% of the farm households say no to the next increased bid price (YN) though they were willing to pay for the initial bid value. The rest of the cells of the table interpreted in a same fashion.

Table 4.8: Summary of the WLTs’ bid responses to the double-bounded questions

Technology	Initial Bid (%)		Second Bid (%)	
			Yes	No
Motor pump	Yes	57.35%	56.4%(YY)	43.6%(YN)
	No	42.65%	58.62%(NY)	41.38%(NN)
Rope and Washer	Yes	72.41%	34.88% (YY)	65.12%(YN)
	No	27.59%	62.5% (NY)	37.5% (NN)
Pulley	Yes	80.39%	73.17% (YY)	26.8% (YN)
	No	19.61%	100% (NY)	0% (NN)

From the table we can understand that, farmers who prefer pulley are more willing to pay for the initial bid value followed by rope and washer and motor pump. In all the cases, the ‘yes’ response to the second bid is lower than the initial bid values. This is in line with the economic theory, the higher the bid values ends up with the lower the WTP (yes response to the follow up bid).

The next table summarize farmers’ WTP and their bid responses in each of the study areas.

Table 4.9: WTP response to the first and second bid for the WLTs in the study areas

Site								Total sample	
Adami Tulu		Lemo		Dangela		Bahir Dar Zuria			
Unwilling household									
34.6%		21.15%		23.1%		15.38%		23.56%	
Willing household									
65.1%[a]		78.85%		76.9%		84.62%		76.44%	
1st bid	2nd bid	1st bid	2nd bid	1st bid	2nd bid	1st bid	2nd bid	1st bid	2nd bid
61.8% (Y)	47.6%YY[b]	79.5% (Y)	56.4%YY	82.5% (Y)	33%	70% (Y)	68.6%	77%	55%
	52.4%YN		43.6% YN		67%		31.4%		45%
38.2% (N)	52% NY	20.5% (N)	66.6% NY	17.5% (N)	100%	30% (N)	78.6%	23%	67%
	48%NN		33.4% NN		0%		21.4%		33%

Table 4.9 summarizes the farmers' willingness to pay for the water lifting technologies. It shows the proportion of the farm household who is willing and unwilling in the study areas. It further shows, the proportion of the willing household with yes and no response to the first and second bid. For example, cell indicated by superscript 'a' shows that, 65.1% percent of the surveyed household in Adami Tulu are willing to pay for the WLTs. From those willing farmers', about 62% are willing to pay the initial bid value. This willing/'Yes' response farmers' further asked their willingness to the second proposed bid value for their preferred technology, and results in 48% 'yes' and 52% 'no'. The 'yes' response for the second proposed bid value following yes response to the first bid value for Adami Tulu is 48% and cell indicated by superscript "b" shows this 'yes-yes' response. The other 52% of the farm household are unwilling to pay for the second increased bid price. The remaining cells of the table interpreted in the same way.

From the total sample of 208 respondents, 159 (76.4%) households were found to be willing to pay for the proposed bid for the ownership and access of water lifting technologies and their purposes. The remaining 23.6% are not willing to participate in the WLT program. Site wise, farmers' non-zero response for WLT in Bahir Dar Zuria wereda is (84.62%) followed by Lemo (78.85%). Willingness to pay for the WLT in Dangela and Adami Tulu wereda is 76.9% and 65.1% respectively.

As mentioned above, 23.6% of the farmers' have '0' willingness to pay for the water lifting technology (respond 0 WTP). These zero responses are either genuine zero or protest zero. Even though there is no established criteria for classifying zero response in to genuine zero and protest zero bidders, asking the unwilling respondent a follow up questions is a method proposed by Boyle, (2003) to identify such responses as genuine zero and protest zero (Freeman, 2003; Alhassan et al, 2013 and Bane, 2005).

Responses like, I cannot afford to pay any amount for the technology, is classified as genuine zero bidders (Alebel et al, 2009). Also reasons like the technology is no worth to me, I am satisfied with the existing technology I have, I am old aged and no capacity to engage in irrigation farming can be considers as genuine zero responses. Genuine zero bidders are respondents who truly assign zero values for the good.

Protest zero bidders are those households who state a zero value/demand for the technologies even though their genuine value/demand is greater than zero. This behavior reflected due to ethical reasons or simply in a wish to obtain the technology free of charge. Rejection of some aspects of the CVM such as the scenario or the payment vehicle is also a reason for the protest zero responses (Boyle, 2003). Technologies should be provided free of charge, it is the responsibility of the government to provide, I do not believe that the money we pay will actually be used for the proposed change and risk averse nature of the farmers can be considered as protest zero bidders because the respondents seem to have value for the technologies though they assign zero value.

In this study based on the above Boyle (2003) criteria, about 36.7% and 63.3% of the unwilling sampled households were categorized as genuine zero and protest zero bidders respectively. Inclusion of protest zero bidders' in the estimation of mean and aggregate WTP results in biased aggregate demand values. Though, there are a number of arguments on how to treat, the protest zero bidders, exclusion of the protest bidders from the estimation is the most common and results in more robust value (Alebel et al, 2011 and Mezgebo, 2013). Therefore, this study exclude farm household with zero bid responses in the estimation of the aggregate demand for the water lifting technologies.

Estimation of mean WTP, total WTP and aggregate demand for the WLTs

Mean WTP, total WTP and aggregate demand for the WLTs are computed using bivariate probit model estimated coefficients of the bid values. The next table summarize the mean and total WTP of the farmers' from the open ended and double bounded responses to the bid values.

Table 4.10: Summary of farmers' mean and total WTP for the open ended & double bounded question

Technology	Total Household	Double Bounded			Open Ended	
		Mean WTP^1	Mean WTP^2	Total WTP	Mean WTP	Total WTP
Motor Pump	1211	18,192	14,858	22,030,512	13,750	16,651,250
Rope and Washer	1104	5,370	1,855	5,928,480	3,550	3,919,200
Pulley	895	2,093	1,288	1,873,235	1,195.5	1,069,973

Mean WTP^1 and WTP^2 are mean WTP for the technologies computed using initial and follow up bid respectively.

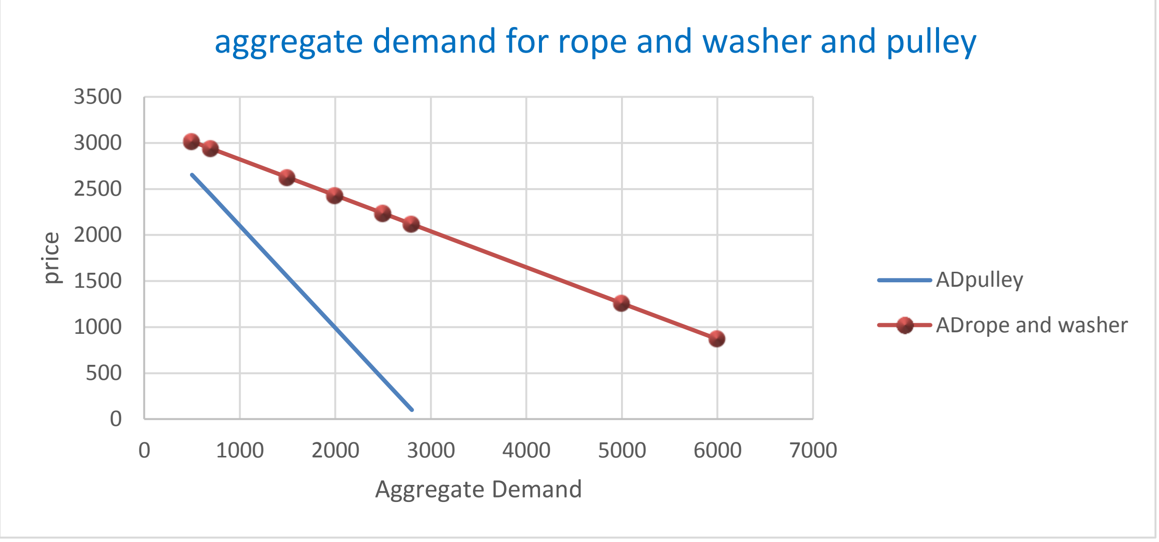
Source: own computation from the survey data

Based on the double-bounded model estimates, the mean WTP varies from 14,858 birr to 18,192, 1,855 birr to 5,370 and 1,288 birr to 2,093 birr for motor pump, rope and washer and pulley respectively. The mean WTP of the farm household from the open ended elicitation is 13,750, 3,550 and 1,195.5 birr for motor pump, rope and washer and pulley. This shows that, the mean WTP from the open-ended elicitation is clearly lower than the double bound elicitation mean WTP (mean WTP^1 which calculated at the initial bid value) in all cases.

The aggregate demand for the WLTs is also lower for the open ended elicitation than the double bounded method. Possible explanation for this lower mean WTP from the open ended response is that, farmers' want to benefit from the free riding or free service provision by the government or they may believe that the technology is provided at the discount rate which is lower than the market values of the technologies. The result is also consistent with the previous works of Assefa (2012) and Mezgebo (2013).

According to Alebel et al, (2009), the total economic benefit that can be obtained from the establishment and improvement of the smallholder water lifting technologies are considered as a total WTP (aggregate benefit). However, Mitchell and Carson (1989) indicates that, before computing total WTP, we should be careful on population choice bias, sampling frame, sample non response bias, and sample selection biases to have valid aggregation of benefits. Using of random sampling method in selection of the final household, using of in person interview, exclusion of protest zero bidders, using of mean WTP for measuring aggregate value minimize the occurrence of such biases and hence valid estimation of aggregate demand (Mezgebo et al, 2013).

Total WTP for the WLTs computed by multiplying the mean WTP (from both open-ended and double bounded responses) by the total number of households (mezgebo et al, 2013). Following this, the total WTP for the water lifting technologies from the double bounded response is 22,030,512; 5,928,480 and 1,873,235 birr for motor pump, rope and washer and pulley respectively. Using the open ended elicitation, the total WTP for motor pump, rope and washer and pulley are 16,651,250; 3,919,200 and 1,069,973 respectively.



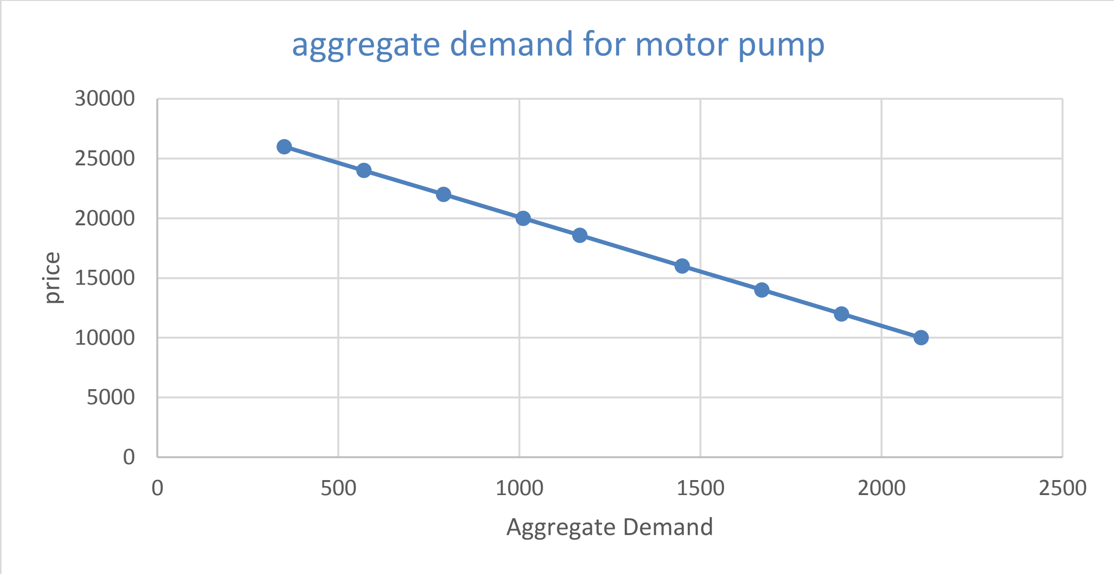


Figure 4.3 Aggregate demand for the smallholder water lifting technologies

The negatively sloped aggregate demand curves for the water lifting technologies ascertains the law of demand given the technologies are normal good showing that, with a price increasing/decreasing the farmers' WTP for the technologies decrease/increase.

4.2.3 Multinomial Logit Model Estimation Result

To identify the determinants of demand/choice of smallholder water lifting technologies multinomial logit model is employed. In estimating the multinomial logit model, motor pump is used as reference group with which choice of rope and washer, and pulley are compared. Therefore, the choice of rope and washer and pulley are interpreted in relative to the reference group.

Before estimating the demand analysis of the water lifting technologies, the explanatory variables in the fitted model are evaluated for their joint significance in affecting the choice of WLT using Wald test. The Wald test which follows a chi square distribution with 28*df* is 70.27, where the null hypothesis of all regression coefficients are equal to zero can be rejected at 1 percent significance level. Thus, the explanatory variables have joint power in affecting the choice of the water lifting technologies. This result is also supported by the high pseudo R^2.

The multinomial logit and marginal effect estimation for the choice of the technologies are presented in table 4.11 and 4.12.

Table 4.11 Multinomial Logit Regression Results for Rope and Washer, and Pulley relative to Motor Pump (with robust standard error)

Dependent variable: choice of WLT (motor pump as a reference group)				
	Rope and washer		Pulley	
Variable	Coefficient	Standard errors	Coefficient	Standard errors
AGE	-.001822	.0250556	-.0110553	.0277767
SEX	-2.357647	.7461379***	-2.207852	.7656958***
HFS	-.237202	.1167562**	-.0819999	.1023368
EDUC	1.261486	.6434193**	1.163793	.5851725**
HHINC	-.0000563	.0000157 ***	-7.84e-07	.0000161
MKT	.9547896	.3970294**	.9980719	.4606182**
ECOREGION	-1.344024	.5858945**	-1.295293	.6386162**
OFA	-.3524592	.5060103	-.9566479	.5583889*
LANDSIZE	.0799833	.2293472	-.5261348	.2589686**
CR	1.272181	.7313175*	1.873377	.7878887**
LIVSTCK	.0912514	.0941742	-.0410225	.0840995
SOURCEWA	-.1493951	.2434796	-.156775	.2642917
SOIL	-1.048899	.7885173	-1.518373	.8312578*
OWNERSHIPM	-1.436702	.5194754***	-1.59059	.5026819***
Constant	4.882366	1.645752	4.633923	1.763574
LR chi2(28) = 70.27 Prob > chi^2 = 0.0000 Pseudo R^2 = 0.2517 Log likelihood = -144.57989				

**significance at 10%, ** significance at 5%, ***significance at 1%*

Source: Stata output

From table 4.11 it can be seen seven variables are found to be significant in explaining households' choice among the different WLTs. Sex of the household head, family size, household income, agro-ecological zone difference and ownership mode of the technology are expected to reduce the multinomial log-odds of rope and washer to motor pump.

Age of the household head, off-farm activity, source of available water and the perceived quality of soil are also expected to reduce the multinomial log-odds of rope and washer to motor pump. But the coefficients of these all variables are not statistically significant. The estimated coefficients of access to market, access to credit, education level of the head, tropical livestock unit and farm land size have a positive sign though the coefficients of tropical livestock unit and farm land size are insignificant.

On the other hand, sex of the household head, ownership mode, farm land size, off-farm activity, agro-ecological zone difference and perceived quality of soil are expected to reduce the multinomial log-odds of pulley in favor of motor pump. The coefficient of these variables are statistically significant. Age of the household head, household family size, household income, tropical livestock unit and source of available water are also expected to reduce the multinomial log-odds of pulley in favor of motor pump. But the coefficients of these all variables are not statistically significant.

Likewise, access to market, access to credit and education level of the household head increase the multinomial log-odds of pulley relative to motor pump. The coefficient of these variables are significant at 5% level of significance.

The result of the relative odds ratio, which computed using the relative risk ratio of the multinomial logit model is attached in the appendix (see appendix 5). The marginal effect of the multinomial logit model is discussed as follow.

Table 4.12 Marginal effects of the multinomial logit for choice of WLTs

Variables	Motor pump		Rope and washer		Pulley	
	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.
AGE	.0013967	.00521	.0008146	.00456	-.0022112	.00491
SEX[a]	.3501085	.06982***	-0.21367	0.12738*	-.1364421	.12609
HFS	.0360646	.02151*	-0.04447	0.02199**	.0084049	.01818
EDUC	-.2824548	.12468**	.1590655	.10197	.1233893	.09108
HHINC	6.55e-06	.00000**	-.000013	.00000***	6.07e-06	.00000**
LIVSTCK	-.0060806	.01771	0.02515	.01776	-.0190742	.01507
MKT	-.216908	.08484**	0.10492	.06147*	.1119878	.07004
OFA[a]	.1425706	.10405	0.02281	.08974	-.1653774	.094*
ECRGION[a]	.2935571	.12423**	-0.15985	.0809**	-.133704	.08595
LANDSIZ	.0473129	.04553	0.07641	.04466*	-.1237202	.04782**
CR[a]	-.341027	.14345**	.0843645	.10446	.2566625	.10149**
SOIL[a]	.2375773	.10588**	-0.02787	.10978	-.2097039	.12609*
SOURCWA	.0340046	.0509	-0.01635	.04422	-.0176552	.04654
OWNRSHP[a]	.3451326	.09483***	-.157628	.08688*	-.1875043	.07897**

**significance at 10%, ** significance at 5%, ***significance at 1%*

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

Source: Stata output

From the marginal effect result it is seen that, among all explanatory variables included in the model, six variables were found to be significant in affecting the probability of the household to prefer rope and washer in favor of motor pump. These includes, household head sex, agro-ecological zone difference, household family size, household income, access to market and ownership mode of the technology. Among the significant variable, household head sex, agro-ecological zone difference, household family size, household income and ownership mode of the technology are expected to reduce the probability of the household to prefer rope and washer comparing to motor pump. On the other hand, access to market is expected to raise the probability of the household to prefer rope and washer to motor pump.

Household income and access to credit affect the probability of the choice of pulley in favor of motor pump positively and significantly. Also household family size, education level of the head and access to market affect the probability of the choice of pulley in favor of motor pump positively but the coefficients are insignificant. On the other hand, farm land size, ownership mode of the technology, perceived quality of soil and off-farm activity negatively affect the probability of the choice of pulley compared to motor pump. The coefficients are also significant. Moreover, age of the household head, sex of the head, tropical livestock unit, agro-ecological region difference and source of water negatively affect the probability of the choice of pulley compared to motor pump.

Sex of the household head negatively and significantly affect the probability of the household's demand for rope and washer relative to motor pump. The marginal effect shows that being male decrease the probability of household's demand for rope and washer by 21.36% in favour of motor pump. This is due to the fact that, female headed are among the class of poor than the male headed household (Gebregzabhair, 2013; Bane, 2005 and Habtamu, 2009), leading them to prefer a less expensive technology.

As the marginal effect result shows that a unit (1 birr) increase in the household income reduce (increase) the probability of the farm households' demand for rope and washer (pulley) in relative to motor pump. A unit increase in income of the household leans the farmers' probability to demand pulley relative to motor pump by 0.00061% but the coefficient is economically insignificant. This shows that households with the highest income prefer to own motor pump and pulley than rope and washer. Farmers prefer to own motor pump since it have labor saving while farmers prefer pulley may be because they want to diversify their business in the off-farm activity other than farming in their farm land. Studies by Habtamu (2009) and Gebregezabher (2013) shows that farm income is a key determinant in farmers' decisions to invest on agricultural technologies and adoption of motor pump.

Ceteris paribus, the change of dummy of the agro-ecological region from 0 to 1 (being in a dry area) decrease the probability of the farmers' demand for rope and washer relative to motor pump by 16%. Similar studies by Gichuki (2002) shows the demand for irrigation water in a dry area is high due to low precipitation and high evaporation and hence require a more extensive way of farming. This calls for the increase in the farmers' probability of demanding the most appropriate and affordable technology from the available given set of technologies.

Holding other things unchanged, additional hectare of land that a smallholder farmer possesses will decrease the probability of farmers' WTP for pulley compared to motor pump by 12.4% (significant at 5%). However, a unit increase in the land size of the smallholder farmer increase the probability of farmers' WTP for rope and washer comparing to motor pump by 7.6% but insignificant.

Access to credit by the farmers' has a positive and significant effect on the probability of demanding pulley than motor pump. Other things remain constant a change in dummy of access to credit (from 0 to 1), increases the probability of demanding pulley by about 25.6%. One possible reason could be, the actual credit that farmers' access from the formal and informal financial institution may not be equivalent to the price of the motor pump and rope and washer. In such case the farmers' have options to purchase pulley. From the descriptive analysis it is seen that, average credit the farmers' obtain from the formal and informal financial institution is 2768.90 birr, which is much lower than the market price of motor pump and slightly lower than the market price of rope and washer. But such average credit is higher than the price of pulley.

Joint/group ownership of the technologies by the farm household decrease the probability of the household to pay for rope and washer and pulley in relative to motor pump by 15.76% and 18.75% respectively. The reasons are explained as follows. One, motor pump is relatively expensive WLT than rope and washer and pulley. Two, from their physical characteristics it is noticed that motor pump can irrigate relatively large area of land (more than 2ha) than pulley and rope and washer. These two reasons, have their own implication. First, joint ownership of the technologies increase the farmers' ability to pay since the cost of owning the technologies are distributed among the group. However, the other two technologies can be owned individually since they have relatively moderate price than motor pump. Second, in the study areas, the average land size of the farm household is 1.42 hectares but, since motor pump can irrigate more than 2 hectares of land it can irrigate the members' farmland in queue effectively depending on the size of the group. On such case joint ownership of the technology promote efficiency and save the idle resource.

Households demand for rope and washer and pulley is positively affected by the average hours that take the farm household to the nearby market to sell its agricultural products.

Other things remain at their mean value, the probability of the households to demand rope and washer and pulley relative to motor pump increase as the time to reach to the nearby market increase by 10.5% and 11.2% respectively. Possible reason could be, the opportunity cost of selling of once agricultural product in long distance may reduce the farm profit and the left over profit may only help the farmers' to pay for rope and washer and pulley. However, the coefficient of market access for the case of pulley is insignificant.

The farmers' perception of their soil quality negatively and significantly affect the probability of farmer's choice of pulley in favor of motor pump. Other variables remain unchanged, the probability of the household to prefer pulley in favor of motor pump is expected to reduce by 2.8% for a change of soil dummy from 0 to 1 (1= good perceived quality of soil). Possible reason could be, the good quality soil perception increase farmers' additional investment on their farm land and hence demand for most appropriate and affordable WLT. This result is consistent with the works of Amankwah and Egyir (2013).

The marginal effect result also shows that education level of the head, age of the household head, tropical livestock unit and source of water are statistically insignificant in affecting the technology choice decision of the farm household. Also, off-farm activity, land size, credit access and the perceived quality of soil have insignificant effect in determining the probability of choosing rope and washer in favor of motor pump. Likewise, household family size, market access, sex of the head and agro-ecological zone difference have insignificant effect in affecting the probability of preferring pulley in favor of motor pump.

The existence and severity of multicollinearity among explanatory variables are evaluated with correlation matrix. The correlation matrix value of the variables are less than 0.5 implying the low level of multicollinearity (Starkweather & Amanda, 2011 and Gujarti, 2004) (see appendix 4b). Also, the standard errors of the models are less than 2 implying that among other things, multicollinearity is not a serious problem.

Moreover, this study uses Hausman test to validate the assumption of Independence of Irrelevant Alternatives (IIA). The Hausman test failed to reject the null hypothesis on the IIA assumption at 95% confident level. This suggests that the MNL model is appropriate to identify the determinants of farmers' choice of water lifting technologies in Ethiopia (see Appendix 6).

Comparative analysis of WTP based on the gender of the household head

To support the argument what we infer from the probit and multinomial logit model, in this section we use a comparative analysis between male and female headed household on their WTP and choice of technology decision. This section answers two aspects of gender. First, does gender affect the decision of WTP for the technologies? (i.e., which group is more willing to pay for the technologies?) Second, which technology does female headed household need most and why?

The following table summarizes the total WTP of the female and male head household to each technology in the study areas.

Table 4.13. Male and female headed farmers' WTP and choice of technology

Sex	WTP (In %)	Study area	Technologies		
			Motor Pump	**Rope and washer**	**Pulley**
Male headed	78.95	Adami Tulu	73.3%	23.3%	3.4%
		Lemo	20%	34.28%	45.72%
		Dangela	9.1%	60.6%	30.3%
		Bahir Dar Zuria	59.46%	2.7%	37.84%
		Average	**40.47**	**30.22**	**29.31**
Female headed	64.86	Adami Tulu	25%	75%	0%
		Lemo	0%	50%	50%
		Dangela	0%	85.7%	14.3%
		Bahir Dar Zuria	14.3%	0%	85.7%
		Average	**9.82**	**52.68**	**37.5**

From table 4.13, in the study areas female headed household are less willing to pay (64.86%) for the new WLTs compared to the male headed household (78.95%). This is may be because females are among the class of poor. As shown in table 4.14, the average annual income of the male head household (12,156birr) is higher than the female head household (23,884birr).

The difference in the WTP is also accounted for the households' access to credit. Credit access and the actual credit that female headed household borrow from the formal and informal financial institutions are less than the male headed household. It is shown that, 53.22% and 48.65% of the male and female headed household reported that they have access to credit. Given the access to credit, the average actual loan that female and male headed households received in the year 2006EC were 2,969.20 and 1843.20 birr, respectively. This shows that there is a significant difference in the financial sector knowhow and utilization of the available fund among the male and female headed household.

Low level of income among female headed household compared to their male counterpart makes the female head household risk averse since their ability to pay for their debt (pay back) is affected by the level of income obtained. This risk averse nature of the female headed household is also reflected in their willingness and access to credit service. About 47% of the female headed household responds that, I am afraid to pay back the loan (considered as risk averse household) are the main reasons for their low level of credit access. Lack of knowhow, I do not need credit and lack of sufficient and required type of collateral is also another reason for the low level of credit access. This low level of credit translated in to low level of WTP for the technologies comparing to the male headed household.

Furthermore, household head age, household family size and tropical livestock unit (proxy for wealth) of the two groups are also different and they are also a potential source for the low level of female headed households WTP comparing to their male counterpart.

Table 4.14. Gender based classification of the household socio-economic characteristics

	AGE In year	HFS In num	HINC In birr	OFA In %	LANDSIZ In ha	CR In %	TLU In num
Female head	45.2	5.2	12,156	43	1.24	48.6	2.45
Male Head	43.3	6.67	23,884	43	1.46	53.2	5.05

From table 4.13, female headed households generally are more willing to pay for rope and washer followed by pulley. Given their constrained capital and insufficient access to credit, female head households' preference to motor pump is low. More specifically, female head households in Adami Tulu and Dangela wereda are more willing to pay for rope and washer than motor pump and pulley. While in Lemo, pulley is more preferred by female head household followed by rope and washer than motor pump. The following graph also summarize female heads technology preference against the male head household.

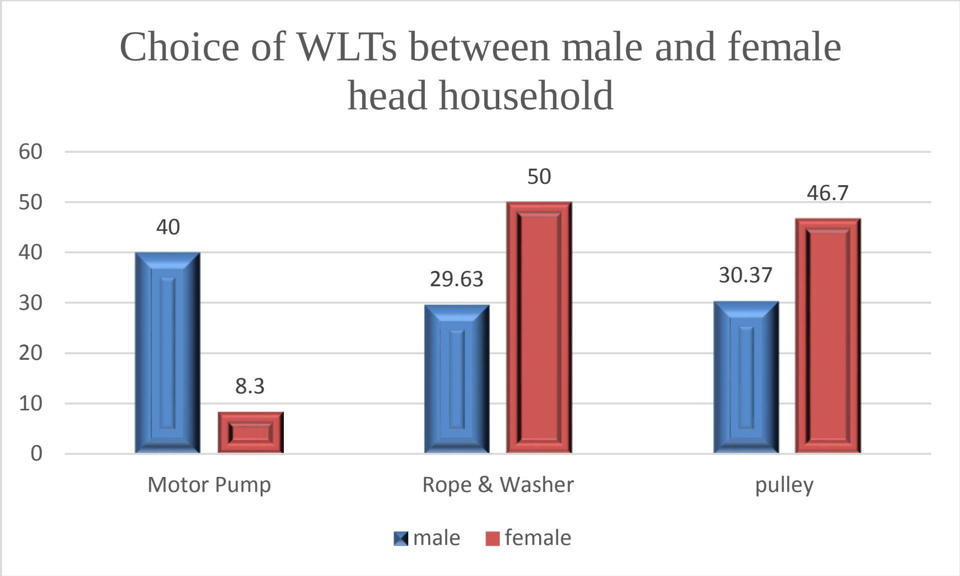


Figure 4.4 choice of water lifting technologies among male and female head household

From those willing female headed household, 50% are willing to invest on rope and washer, and the remaining 46.7% and 8.3% are willing to invest in pulley and motor pump. Unlike the female headed household, male headed household are more willing to invest (40%) in motor pump followed by 30.37% willingness for pulley and rope and washer (29.63%). This is not only associated with the level of income and credit that a household could get or possess rather it also depend on the farm land the two groups owned. The average land holding of female headed household is 1.24hectares which is less than the male headed household land holding (1.46hectares). Moreover, females are willing to invest on the technology which helps them in domestic activity aside from watering of their backyards and farm lands. Rope and washer and pulley is suitable for such purposes than motor pump. These shows that gender of the household head matter the investment and choice of technology decision.

CHAPTER FIVE

5. SUMMARY, CONCLUSION AND POLICY IMPLICATIONS

5.1 Summary and Conclusion

Agriculture is the mainstay of Ethiopian economy with about 40% contribution to the national output. Despite its large contribution to the economy, the sector is predominantly subsistence and hence, could not meet the growing demand for food. Among other things the sector's dependence on erratic and insufficient rainfall is one reason for its subsistence nature. One way of addressing such problem is by increasing smallholders' access to water and affordable water lifting technologies including, Rope and Washer, Pulley and Motor pumps. However, farmers are not also exposed to such technologies widely and hence, analyzing why farmers demand to the technology is low and examining their willingness to pay for the different water lifting technologies is worth full.

This study analyzes the farmers' willingness to pay and determinants of demand/choice of smallholder water lifting technologies. The study used 208 sample households which was collected from Adami Tulu, Lemo, Dangela and Bahir Dar Zuria weredas. To elicit farmers' WTP for the SWLTs, the study used double bounded elicitation method with an open ended elicitation format of the contingent valuation method.

The descriptive analysis shows that in the study areas 76.4% of the farmers are willing to pay for the new water lifting technologies. Site wise, farmers' in Bahir Dar Zuria wereda is more willing to pay (84.62%) for the new water lifting technologies followed by the Lemo (78.85%), Dangela (76.9%) and Adami Tulu (65.1%) weredas. It is also seen that 69.5% and 55.32% of the farmers' in Adami Tulu and Bahir Dar Zuria wereda are willing to pay for motor pumps respectively. While farmers' in Lemo and Dangela are more willing to pay for rope and washer and pulley than motor pump. The implication is that farmers' WTP and choice of technology is different from location to location.

The Probit model which used a data from the CV survey shows that, high purchase price of the technologies (shown by the initial bid values) have negative and significant effect in affecting the probability of farmers' WTP for the WLTs. Farmers' participation in the off-farm activity, land size and age of the household head are found to reduce the probability of the households' WTP for the WLTs. The implication is that, farmers who have participated in off-farm activity, have large land size, relatively aged households are less likely to be willing to pay for the WLTs. Thus, land size, age of the household and participation in the off-farm activities limit the wide use of the technologies. On the other hand, access to credit, household income, tropical livestock unit and family size has put positive effect on the probability of household WTP for the water lifting technologies. This implies that, increasing household's access to credit, improving their income level and livestock possession are imperative to increase the diffusion of water lifting technologies.

Preliminary production cost and market price are existing for various water lifting technologies. However, such price tag does not reflect the farmer's willingness to pay for the technologies since price schedules might suffer from the distance to the market and the consumers (Jesdapipat, 2009). Thus, mean and total WTP which is calculated from the bivariate probit model shows that, the mean WTP for motor pump, rope and washer, and pulley is 18,192, 5,370 and 1,842 birr, respectively. It is 13,750, 3,550 and 1,195.5 birr for motor pump, rope and washer, and pulley respectively using open ended elicitation method. This shows that the mean WTP computed from the open ended elicitation is lower than the mean values from the double bounded elicitation.

The mean WTP from the DB elicitation method shows that market price of rope and washer and motor pump lies between farmers' upper and lower range of WTP bound. However, farmers' are more willing to pay for pulley higher than what the existing market reveals. Showing that among other things, farm households are willing to pay for the WLTs even more than the current market price of the technologies despite the high price, of course, with credit scheme.

The total benefit (aggregate demand) for the technologies calculated from the double bounded elicitations are 22,030,512, 5,928,480 and 1,648,590 birr for motor pump, rope and washer, and pulley respectively. The total WTP for motor pump, rope and washer, and pulley using the open ended elicitation method are 16,651,250, 3,919,200 and 1,069,973 birr respectively. This also shows that the total WTP computed from the open ended elicitation is lower than the total WTP computed from the double bounded elicitation. The implication is that farmers want to benefit from free riding and a discount rate provision of the technologies.

Using multinomial logit model the study also shows the determinants of household demand for the technologies. It has been observed from the marginal effect output that sex of the household head, household family size, household income, agro-ecological zone, the perceived quality of soil and ownership mode of the technology are important variables that increase the probability of the farmer's choice of motor pump. This leads one to conceive that the choice of motor pump over the other technologies is associated with availability of more family labor, conservation of agro-ecological zone, the good perceived quality of soil and extent of joint ownership of the technology. Whereas education level, access to credit and distance to the nearby market reduce the probability of the households' demand of motor pump.

Furthermore, the comparative analysis of WTP and choice of technology by gender shows that female headed households are less willing to pay for the SWLTs compared to their male counterpart. Among other things, low level of income, low level of credit access, risk averse nature, being aged and small household family size comparing to their male counterpart are the reasons for their low level of WTP for the WLTs. This study also revealed that, there exists gender difference in the choice of different water lifting technologies. The implication is that, female headed households are more inclined to choose rope and washer and pulley in favour of motor pump. Female headed household's demand of rope and washer and pulley in favour of motor pump is not only because the technologies are mainly affordable on their level of income rather it is also due to their large non-agricultural (for domestic use) values of the technologies.

To sum up, empirical findings of the study shows that boosting the income level of households, increasing the livestock ownership and access to credit with credit term ownership of the technology are main policy instruments to expose households with different WLTs. Finally, the study concludes that household's level of WTP and choice of technology is contingent upon and different from location to location. Hence, context specific policies are at the heart of policy makers.

5.2 Policy Implications

Following the results from descriptive and econometric analysis, the following policy implications are forwarded as alternatives for efficient utilization of the available irrigation water and to promote efficiency in the small scale agriculture.

It has been noted that farmers are willing to pay for the WLTs and to boost such level of farmers' WTP for the technologies further and their participation in the small scale irrigation, exposing farmers' to a more credit access (both the availability and size) is important. Designing a way to increase the income of the household and farm households' market access for their agricultural products improve the farm households willingness to pay for the WLTs and could break the vicious circle of low agricultural production and income level.

The lower farmers' mean WTP values of the open ended elicitation comparing to the double bounded elicitation may indicate that farmers want to benefit from the discount rate provision of the technologies by the government and hence it is advisable for the policy makers to carefully select the target elicitation technique to question farmers' WTP. The estimated mean and total WTP values for the technologies comparing to the existing market price are relatively large. Thus, with quality and affordable SWLTs, existing firms can scale up their production and new entrants can also penetrate to exploit the surplus market.

Increasing once farm lands soil fertility using organic and inorganic fertilizer, increasing the social ties which helps to own the technologies jointly and empowering women to close the economic gap between male and female headed household, all enables the farmers to demand the most affordable and appropriate smallholder water lifting technology. Moreover, works which is done to improve the farmers' market access, off-farm activity, household income and environmental protection to protect the agro-ecology have a significant impact in determining the probability of the household demand to different WLTs. Empowering and equipping women through the provision of affirmative actions and various credit schemes, improves the female headed households' low level of WTP for the technologies.

Generally, this study examined the demand side of the WLTs. To have a complete picture of the economic values of the WLTs, the supply side such as availability and distribution of the WLTs should be studied. Furthermore, we had seen that farmers' value the technologies even more than what the current market reveal, but why those technologies are not shown in abundance at the farm plot? Why their use is not developed well? Is still untouched and cannot be answered in a single study. Methodologically, this research work used contingent valuation method to examine the farmers' WTP and the choice of the technology. Using other valuation methods can also be a way forward.

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APPENDICES

APPENDIX 1. Questionnaire for the study

Questionnaire on Farmer's Willingness to Pay (WTP) for Smallholder Water Lifting Technologies

Interviewer name________________________________

Place of interview (write Kebele) __________________

Date of Interview______________________

Length of Interview____________________ (minutes)

Farmers Code ________________________

Introduction to the Interviewee

The intension of this note is to introduce a study on "farmers' WTP for smallholder water lifting technologies in Adami Tullu, Dangela, Bahir Dar Zuria and Lemo wereda, Ethiopia". The study is carried out by Meneyahel Zegeye as part of the requirements for the award of MSc in economic policy analysis from Arba Minch University. Findings of this study will help in facilitating access to the more various water lifting technologies in the country and to streamline markets for the technologies.

As you know, rope and washer, motor pump and pulley are currently distributing and installed in the current study areas namely, Adami Tulu, Lemo, Bahir Dar Zuria and Dangela by the joint working project called Innovative Laboratory for Small Scale Irrigation(ILSSI) which funded by USAID. This questionnaire has been prepared to gather information about farming practices, socioeconomic conditions of the households, farmers' choice and willingness to pay for irrigation technologies in the study areas. So, your view could be used as an input for all stakeholders, and for informed agricultural policy making. The information that you have delivered will only be given to a third party anonymously. In answering the questions, please remember that there are no correct or wrong answers. The researcher is just after your honest opinion.

Thank you in advance!!

I. Socio-economic characteristics of the respondent

1. Name of the household head ___________
2. Name of the respondent (if not the head) _________________

Names of household members	Sex	Relationship to head	Age	Marital status	Is member able to work/ currently working? (Yes or No)	Occupation	Can s/he read and write? (Yes or No)	Highest grade of schooling/ program attained

3. What is your average yearly farm income in the previous year, 2006 E.C? _______ (in birr) (use the following table)

Crop type	Output in Kg	Average price in Kg	Revenue
Wheat			
Teff			
Maize			
Barely			
Pea			
Bean			
Finger millet			
Sorghum			
Tomato			
Potato			
Noug			
Onion			
Carrot			
Garlic			
Cabbage			
Ethiopian kale			
Enset			
Total			

Income from livestock

Type (source)	Output in Kg/no./liter	Average price/unit	Revenue
Ox			
Cow			
Calf			
Heifer/bull			
Goat			
Sheep			
Donkey			
Horse			
Mule			
Chicken			
Other			
Total			

4. What is your average yearly expenditure (for food, other expenses)? ________ (in birr).
5. How many livestock do you have?

Livestock	Unit (in number)	Conversion factor	TLU
Ox			
Cow			
Calf			
Heifer/bull			
Adult Goat			
Young Goat			
Adult Sheep			
Young Sheep			
Adult Donkey			
Young Donkey			
Horse			
Mule			
Chicken			
Other			

6. Do you have other business (you or your family) or means of income other than agriculture (off-farm activity) to support your livelihood? 1. Yes ☐ 2. No ☐

Off farm activities	Working day	Daily wage (in birr)	Total income
Fishing			
Charcoal production			
Trade in grains and livestock			
Handicraft			
Beverage selling			
Daily laborer			
Remittance			
Others (specify)			

II. Credit, land certification, market and information access situation of farm household

1. Do you have formal or informal credit access whenever you want to borrow?

   1. Yes ☐ 2. No ☐

2. If you say No to question #1, what is the reason? Because
   1. Institutions/individuals think that the money will not be used for the targeted objective
   2. There is no formal and informal lending institutions in the area
   3. Lending institution provide loan with a higher lending interest rate
   4. Lack of sufficient and required type collateral to get credit
   5. Other (please specify) ____
3. If your answer to question #1 is yes, how much have you borrowed for agricultural production in the preceding agricultural season (2006 E.C)? ___________Birr.
4. How much time do you take to travel the nearest market to sell your agricultural products? __________hrs.
5. How many hectares of land do you have? ________________
6. Do you have land certificate (tenure security)? 1. Yes ☐ 2.No ☐

7. How many hectares of land did you cultivate (own and rent) in 2006? ___________
8. Are you a member of any agricultural association? 1. Yes ☐ 2.No ☐
9. Do you have an irrigable land? 1. Yes ☐ 2. NO ☐
10. If your answer is yes to question #9, what size? _____________ (in terms of hectares)
11. What is your main sources of water (if you have before)?

    1. Ground water 3. River

    2. Lake 4. Other (specify) ___________

12. Do you think the soil quality of your farmland is good?
    1. Yes ☐ 2. No ☐
13. Do you have information/experience of using either rope & washer, motor pump or pulley so far?
    1. Yes ☐ 2. No ☐
14. If your answer is yes to question #13, how many year is it? ____________ Years
15. If your answer to question #13 is no, what are the main reasons (multiple answer is possible)
    1. Have no enough irrigable land 3. No capacity to pay for water lifting technology

    2. Shortage of water supply 4. My land is too far from the water source

    5. Others, please specify________________________

III. Willingness to Pay (WTP) Questions

I would like to ask you how much it is worth to you in money terms, the provision of the smallholder water lifting technologies.

The improvement of water lifting technologies among other things means providing adequate water which is safe for crop production and improving cropping for the dry season. These water lifting technologies will also help the farm household to produce permanent crops, to have two or more cropping seasons, for domestic water supply and for livestock water supply etc.

The water lifting technologies are rope and washer, motor pump and Pulley. The specific characteristics (or scenarios) of these technologies are explained in the following table.

Type of Technology	Characteristics (scenarios)
Motor pump (picture: Adopted from ATA, 2014) 	• Relatively expensive • Running cost (fuel) • Less labor intensive • Can irrigate large land size • portable • Can be shared with groups • Relatively higher maintenance cost
Pulley 	• Easy to operate • Low cost • Irrigate a small land • Easy to maintain • moderate labor cost
Rope and Washer 	• Low cost • Easy to operate • Irrigate small land (less than 1ha) • Can be used in shallow water (<10m depth) • Easy to maintain • Fair cost of maintenance • Require a great of labor input

(Photograph from Robit and Lemo wereda farmers)

Having these features in mind, to sustainably deliver these water lifting technologies for all farmers in the area, the cost should be covered by the beneficiary households in the command area. Thus, to maximize the benefits from agricultural technologies, beneficiary households are expected to pay back the operation and water lifting technology cost by different mode of payment as convenient.

1. Are you willing to pay for the new water lifting technologies? 1. Yes☐ 2. No ☐
2. Which water lifting technology do you prefer and are you willing to pay?

   1. Motor pump ☐ 2. Rope and washer. ☐ 3. Pulley ☐

3. If your answer to question #1 is yes and if you prefer ____ (choose from #2) _water lifting technology, why it that? (Multiple answers are possible)

   1. source of available water
   2. The size of the land I have
   3. The water withdrawal amount
   4. Market price of the technology
   5. Operational cost and maintenance cost
   6. Labor force requirement
   7. Durability and spare part availability
   8. Other (please specify) ________________

4. If your answer to question #1 is yes, would you be willing to pay __________ birr for the water lifting technologies? (NB for interviewer: use different initial bid values for the WLTs)

   1. Yes ☐ 2. No ☐

5. If your answer to question #4 is yes and if the price of the technology from the improved service is increased to__________ birr, would you be willing to pay?

   1. Yes ☐ 2. No☐

6. If your answer to question # 4 is ‘No’ and if the price of technology from the improved service is decreased to __________ birr, would you be willing to pay?

   1. Yes ☐ 2. No ☐

7. What is the maximum amount you would be willing to pay for the chosen water lifting technology? _________________ Birr.

8. If your answer to question #1 is yes, which mode of payment is convenient for you?

   1. Once (at the time you get the technology) ☐ 4. yearly ☐
   2. At the end of each harvesting period ☐ 5. Other (specify)________
   3. Semi-annually ☐

9. If your answer to question #1 is yes, do you need the ownership individually or in group?
   1. Individually ☐ 2. In group ☐
10. If your answer to question #9 is in group, how much the group would have? ________persons
11. If your answer to question #1 is No, what is your reason?
   1. The technologies should be provided free of charge
   2. I am satisfied with the existing irrigation technology I have
   3. It is the responsibility of the government to provide
   4. I do not have enough money 5. Other reasons, specify___________________
12. What do you recommend to make irrigation and agricultural technology distribution sustainable in the future? (Multiple answers are possible)
   1. Government has to cover all the costs incurred to provide the technologies
   2. The government have to provide the technologies on credit term and then people have to take the ownership to manage the technologies
   3. Beneficiary households and the government have to share the cost of provision of the technology equally
   4. Other (specify) ________________

Thank you very much for your cooperation!!!

Appendix 2: Conversion factors used to compute tropical livestock units

Animal category	TLU
Calf	0.25
Weaned calf	0.34
Heifer	0.75
Cow and ox	1.00
Horse	1.10
Donkey (adult)	0.70
Donkey (young)	0.35
Camel	1.25
Sheep and goat (adult)	0.13
Sheep and goat (young)	0.06
Chicken	0.013

Source: Storck et al. (1991).

Appendix 3. Heteroscedasticity test for the probit model

```
Heteroskedastic probit model                     Number of obs     =        208
                                                 Zero outcomes     =         78
                                                 Nonzero outcomes  =        130

                                                 Wald chi2(12)     =       1.17
Log likelihood = -103.7289                       Prob > chi2       =     1.0000

------------------------------------------------------------------------------
   wtpij1_01 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
wtpij1_01    |
         sex |  -.5828032   .6432494    -0.91   0.365    -1.843549    .6779426
         hfs |    .111434   .1453509     0.77   0.443    -.1734486    .3963166
         age |  -.0385702   .0430883    -0.90   0.371    -.1230217    .0458812
        educ |   .0864084    .205605     0.42   0.674      -.31657    .4893868
     livstck |   .0610932   .0891776     0.69   0.493    -.1136916    .2358781
         ofa |  -.3719346   .4073542    -0.91   0.361    -1.170334    .4264649
       hhinc |   .0000428   .0000491     0.87   0.384    -.0000535    .0001391
      credit |    .533523   .6605893     0.81   0.419    -.7612083    1.828254
      market |  -.1105441    .199434    -0.55   0.579    -.5014276    .2803393
    landsize |   .2274798   .3210627     0.71   0.479    -.4017915    .8567511
        info |   .2365782   .5599653     0.42   0.673    -.8609336     1.33409
        bidv |  -.0000369   .0000404    -0.91   0.362     -.000116    .0000423
       _cons |   .8047035   .8511654     0.95   0.344      -.86355    2.472957
-------------+----------------------------------------------------------------
lnsigma2     |
    landsize |   1.051759   .5948706     1.77   0.077    -.1141661    2.217684
         ofa |  -.2003804   .5060194    -0.40   0.692     -1.19216    .7913993
     livstck |  -.3085155   .3090379    -1.00   0.318    -.9142187    .2971877
        educ |   .5247488   .5807625     0.90   0.366    -.6135249    1.663022
         age |  -.0060873   .0202561    -0.30   0.764    -.0457886     .033614
         sex |   .3918343     .88421     0.44   0.658    -1.341185    2.124854
         hfs |  -.0554502   .1260348    -0.44   0.660    -.3024738    .1915734
       hhinc |   .0000127   8.78e-06     1.45   0.147    -4.47e-06      .00003
------------------------------------------------------------------------------
Likelihood-ratio test of lnsigma2=0: chi2(8) =      7.32   Prob > chi2 = 0.5024
```

Appendix 4(a). Correlation matrix for the probit model of WTP

. estat vce, correlation

Correlation matrix of coefficients of probit model

e(V)	wtpij~01 age	hfs	sex	educ	hhinc	bidv	ofa	landsize	market	livstck	info
wtpij1_01											
age	1.0000										
hfs	-0.2856	1.0000									
sex	0.1531	-0.1947	1.0000								
educ	0.3881	-0.1304	-0.2488	1.0000							
hhinc	-0.2036	0.0325	-0.1000	-0.1687	1.0000						
bidv	-0.0775	-0.0388	-0.1478	-0.0137	-0.0347	1.0000					
ofa	-0.0316	-0.0819	0.0252	-0.1492	-0.0890	-0.0387	1.0000				
landsize	0.0155	-0.1689	0.0393	0.2110	-0.2995	-0.0254	0.1657	1.0000			
market	-0.0442	-0.0443	0.1011	-0.1399	-0.0942	0.1208	0.2940	0.0245	1.0000		
livstck	-0.2536	0.1132	-0.3200	-0.1431	-0.0375	-0.0559	0.0978	-0.2858	-0.0782	1.0000	
info	0.0978	-0.0441	0.0035	0.0818	-0.2130	-0.2548	-0.0183	-0.0455	0.1901	0.0351	1.0000
credit	0.0827	0.0218	0.0296	-0.0333	-0.0254	0.0451	0.1144	-0.1005	-0.0037	-0.0580	-0.1045
_cons	-0.7052	-0.0987	-0.2810	-0.3405	0.2122	0.0131	-0.2358	-0.1326	-0.3295	0.1199	-0.1761

e(V)	wtpij~01 credit	_cons
wtpij1_01		
credit	1.0000	
_cons	-0.2000	1.0000

Appendix 4(b). Correlation matrix for the choice of WLTs

. estat vce, correlation

Correlation matrix of coefficients of regress model

e(V)	age	sex	hfs	educ	hhinc	market	ecoreg~n	ofa	landsize	credit	livstck
age	1.0000										
sex	0.0297	1.0000									
hfs	-0.2406	-0.0635	1.0000								
educ	0.4005	-0.2937	-0.1211	1.0000							
hhinc	-0.1316	-0.0895	-0.0909	-0.1363	1.0000						
market	-0.0429	0.1120	0.0061	-0.1171	-0.0262	1.0000					
ecoregion	0.0156	0.0680	0.3910	-0.0300	-0.0495	-0.0129	1.0000				
ofa	-0.1134	-0.0040	-0.0157	-0.1874	0.0348	0.3178	0.0425	1.0000			
landsize	-0.0731	0.0018	-0.1003	0.1130	-0.3114	-0.0205	-0.0567	0.1007	1.0000		
credit	0.1205	0.0059	-0.2527	0.0221	-0.1274	-0.0268	-0.5264	0.0523	0.0248	1.0000	
livstck	-0.2428	-0.2339	-0.0512	-0.1928	-0.0640	-0.0243	-0.1937	0.1690	-0.2078	-0.0188	1.0000
sourcewa	-0.1323	-0.0640	0.0045	0.0302	-0.1531	0.0357	-0.1184	-0.0647	-0.0836	-0.0820	0.1867
soil	-0.0238	-0.0036	-0.0117	0.0724	-0.0649	0.0464	-0.2379	0.0574	0.1059	0.0925	-0.0111
ownership	0.1226	0.0108	-0.1043	0.0333	-0.1136	0.1669	0.0895	-0.0525	0.0565	0.1361	-0.0438
_cons	-0.5800	-0.2495	-0.2214	-0.3114	0.2100	-0.3390	-0.2366	-0.2011	-0.0854	-0.0252	0.1375

e(V)	sourcewa	soil	owners~p	_cons
sourcewa	1.0000			
soil	0.0051	1.0000		
ownership	-0.1077	0.0134	1.0000	
_cons	-0.0465	-0.3143	-0.2227	1.0000

Appendix 5. The Relative Risk Ratio (odds ratio of the multinomial logit model)

```
. mlogit, rrr

Multinomial logistic regression                   Number of obs   =        177
                                                  LR chi2(28)     =      97.29
                                                  Prob > chi2     =     0.0000
Log likelihood = -144.57989                       Pseudo R2       =     0.2517
```

preference	RRR	Std. Err.	z	P>|z|	[95% Conf.	Interval]
1	(base outcome)					
2						
age	.9981797	.0242622	-0.07	0.940	.9517416	1.046884
sex	.0946427	.0804104	-2.77	0.006	.0179015	.5003636
hfs	.7888319	.08663	-2.16	0.031	.6360701	.9782818
educ	3.530663	2.21394	2.01	0.044	1.033002	12.06734
hhinc	.9999437	.0000178	-3.16	0.002	.9999088	.9999786
market	2.598124	.9550859	2.60	0.009	1.264017	5.340312
ecoregion	.2607941	.119314	-2.94	0.003	.1063826	.6393295
ofa	.7029572	.3532399	-0.70	0.483	.2625399	1.882186
landsize	1.083269	.2986506	0.29	0.772	.6310521	1.859548
credit	3.568627	2.15159	2.11	0.035	1.094703	11.63338
livstck	1.095544	.1001397	1.00	0.318	.9158508	1.310494
sourcewa	.8612288	.2149129	-0.60	0.549	.5280899	1.404524
soil	.3503232	.2605909	-1.41	0.159	.0815258	1.505367
ownership	.2377105	.1231183	-2.77	0.006	.0861356	.6560159
3						
age	.9890056	.0261983	-0.42	0.676	.938968	1.04171
sex	.1099365	.0969428	-2.50	0.012	.019523	.6190668
hfs	.921272	.0972227	-0.78	0.437	.7491345	1.132964
educ	3.202057	2.097375	1.78	0.076	.8869203	11.56042
hhinc	.9999992	.0000138	-0.06	0.955	.9999721	1.000026
market	2.713046	1.018781	2.66	0.008	1.299633	5.663612
ecoregion	.2738175	.1314279	-2.70	0.007	.1068805	.7014939
ofa	.3841785	.2101866	-1.75	0.080	.1314725	1.122616
landsize	.5908844	.1841662	-1.69	0.091	.3207754	1.088439
credit	6.510243	4.348365	2.80	0.005	1.758155	24.10668
livstck	.9598075	.0894785	-0.44	0.660	.7995221	1.152226
sourcewa	.8548964	.2049788	-0.65	0.513	.5343436	1.367749
soil	.2190681	.1646287	-2.02	0.043	.0502232	.9555501
ownership	.2038053	.1069833	-3.03	0.002	.0728442	.5702112

Appendix 6. Hausman Test for the IIA assumption

	Coefficients (b) partial	(B) all	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
age	-.0236986	-.001822	-.0218766	.0096757
sex	-2.510736	-2.357647	-.1530897	.559841
hfs	-.2891553	-.237202	-.0519533	.061536
educ	.7488892	1.261486	-.5125964	.2190811
hhinc	-.0000638	-.0000563	-7.54e-06	.0000154
market	1.597134	.9547896	.6423443	.3393195
ecoregion	-1.727009	-1.344024	-.3829849	.2801255
ofa	.0908442	-.3524592	.4433034	.2774516
landsize	.011275	.0799833	-.0687083	.1064845
credit	1.621505	1.272181	.3493237	.2446534
livstck	.1171429	.0912514	.0258915	.052597
sourcewa	-.4747451	-.1493951	-.32535	.1598197
soil	-.416432	-1.048899	.6324673	.2181644
ownership	-1.296806	-1.436702	.139896	.2205243
_cons	5.846669	4.882366	.9643029	.9660753

```
                  b = consistent under Ho and Ha; obtained from mlogit
   B = inconsistent under Ha, efficient under Ho; obtained from mlogit

Test:  Ho:  difference in coefficients not systematic

              chi2(14) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                       =        5.46
             Prob>chi2 =      0.9784
             (V_b-V_B is not positive definite)
```