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**ECONOMIC VALUATION OF IRRIGATION WATER, THE CASE OF
ERERE WOLDIA IRRIGATION PROJECT IN HARARI REGIONAL
STATE, ETHIOPIA**

BY
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ECONOMIC VALUATION OF IRRIGATION WATER, THE CASE OF ERERE WOLDIA IRRIGATION PROJECT IN HARARI REGIONAL STATE, ETHIOPIA

A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES OF ADDIS ABABA UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS IN DEVELOPMENT STUDIES, RURAL LIVELIHOODS AND DEVELOPMENT



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**ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES**

**COLLEGE OF DEVELOPMENT STUDIES
(CDS)**

Title

*Economic Valuation of Irrigation Water, The Case of
Erere Woldia Irrigation Project in Harari Regional
State, Ethiopia.*

By
Addis Teshome

DEVELOPMENT STUDIES

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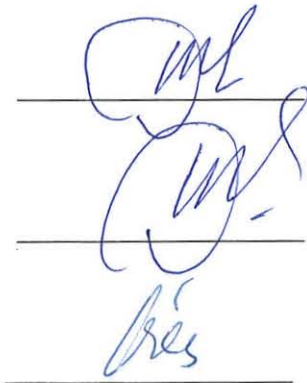
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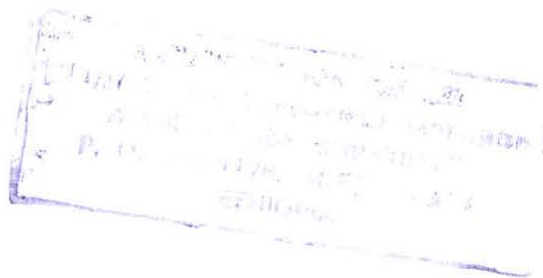
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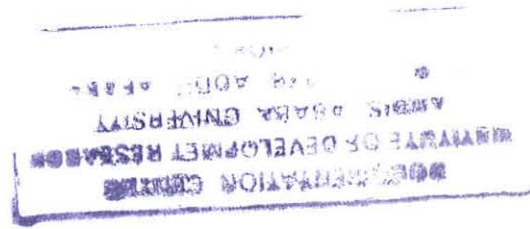


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Abbreviation

CDF	cumulative distribution function
CV	Contingent Valuation
CVM	Contingent Valuation Method
EDA	Explanatory Data Analysis
FAO	Food and Agriculture Organization
KII	Key Informant Interview
LPM	linear probability model
ML	Maximum Likelihood Approach
MoWR	Ministry of Water Resources
NOAA	National Oceanic and Atmospheric Administration
OLS	Ordinary Least Square
O&M	Operation and Maintenance
PSNP	Productive Safety Net Program
TWTP	Total Willingness to Pay
WTA	Willingness to accept
WTP	Willingness to Pay

Abstract

The growing demand for water in different sectors of the economy due to population pressure, expansion of economic activities combined with the increased climatic variability calls for the efficient utilization of the resource. Accordingly, the Ethiopian water policy and strategy considers water as an important economic good with some social objectives. To this effect, the policy advocates the introduction of site specific irrigation water fee as a tool to stimulate the sustainable development of the sector. The most important site specific factor is the willingness to pay of the farmers. Since any irrigation pricing endeavor should consider this factor, this study was undertaken in Harari Regional state, Erere Weldia small scale irrigation project, so as to provide a baseline information for the local authorities on the willingness to pay of farmers for improved irrigation water services. The study employed a multi- stage purposive sampling and random sampling techniques in the selection of the study site and the respondents, respectively. Primary Data was collected through structured questionnaire, in-depth case study and key informant interviews. Relevant secondary data was also collected. Both quantitative (descriptive statistics and econometric estimation) and qualitative data analysis methods were employed. A contingent valuation method was employed to elicit farmers' willingness to pay for improved irrigation water. The open and closed ended elicitation techniques were used to estimate farmers' willingness to pay. In determining the factors that affect the maximum price farmers are willing to pay, the OLS method was used. Nine variables out of fifteen were significant. Size of cultivable land, access to cash credit, experience with irrigation, land fertility, perception about water scarcity and dissatisfaction with the existing project have a positive effect while age, household size and cultivating water demanding crops have a negative effect. In addition, to determine the factors that affect the willingness to pay (accept) the bid price, the Logit model was employed. Seven variables were significant. Frequency of DA visit, experience with irrigation, income and perception about water scarcity were found to have a positive effect, while the size of cultivable land, amount of fertilizer used and dissatisfaction with the existing project have a negative effect. The fact that the variables: the size of cultivable land and dissatisfaction with the existing project are significant in both models but have a different sign necessitate further study on the effect of these variables on the decision of the farmers'. Among the surveyed households, 98% have shown their willingness to pay if the current water supply situation is improved. And hence this gives good reason for investment to expand the irrigation project and introducing water fee by taking into account the effect of the significant variables in both models.



Chapter one Introduction

1.1 Background

Ethiopia has 12 river basins with an annual runoff volume of 122 billion m³ of water and an estimated 2.6 - 6.5 billion m³ of ground water potential and which makes an average of 1,575 m³ of physically available water per person per year (Awulachew *et al*, 2007). The potential irrigable land in Ethiopia is estimated to be 3.7 million hectares (ha) (MoWR, 2002). [I]n 2005/2006 cropping year, the total estimated area of irrigated agriculture in the country was 626,116 ha, which, in total, constitutes about 18% of the potential. It is also planned to expand irrigation development in the country by an additional 528,686 ha by the year 2010, which will constitute about 33% of the potential (MoWR, 2006).

According to Fitsum *et al* (2009), irrigation /in Ethiopia/ generates an average income of approximately US\$323/ha under smallholder-managed irrigation systems compared to an average income of US\$147/ha for rain fed systems. Irrigation contributed approximately 5.7 and 2.5% to agricultural Gross Domestic Product (GDP) and the overall GDP, respectively, during the 2005/2006 cropping season. Further by the year 2009/2010, the contribution of irrigation to agricultural GDP and overall GDP is estimated to be approximately 9 % and 3.7%, respectively

In terms of regional distribution, Afar and Oromia have the bulk of the share in irrigated agriculture accounting for 45 and 31%, respectively, of the total irrigated area. Amhara, Southern Nations Nationalities and People's Region (SNNPR) and Tigray account for 8, 7 and 5%, respectively, of the total irrigated area (Awulachew *et al*. 2007).

The central challenge facing irrigated agriculture today and in the foreseeable future is how to produce more food with less water (Chaminda and Francis, 1998). [A]gricultural water supply in many parts of the world is entering an era of physical scarcity. The growing demand for water in household, commercial and industrial sectors as a result of population and industrial growth combined with frequent occurrence of droughts have raised increasing concerns about the conventional wisdom of perceiving irrigation water as a free gift of nature. In many part of the world both the free distribution and under pricing of water have caused serious misuse of the resource (Petit, 1994; WB, 1993). [B]oth under pricing of water and lack of cost recovery mechanisms in government managed irrigation systems have resulted on poor operation and maintenance practices (Sampath, 1992; Howe and Dixon., 1994).

The Ethiopian water sector development strategy considered water as an economic good. The strategy emphasis the establishment and implementation of norms and procedures for financial sustainability and viability of irrigated schemes. To this end, it stress the implementation of a stage by stage cost recovery procedure for all irrigation schemes (initial grace period; O & M costs borne by the beneficiaries from the beginning; cover costs of minor structures beyond the primary off takes; finally, total costs of scheme are to be recovered). The strategy further indicates that medium and large scale irrigation development schemes are generally considered to operate on full cost recovery principle; although a transition procedure may be justified to stimulate development of the region/area (MoWR, 2001a).

1.2 Statement of the problem

Conceptually correct and empirically accurate estimates of the economic value of water are essential for rational allocation of scarce water resource across locations, uses, users, and time periods (Ward and Michelson, 2002). [I]n principle, water pricing policies has the potential to mitigate water scarcity. As far as the agricultural water use is concerned, it is argued that water pricing can play a significant role in making this use more efficient, while at the same time reducing pressures on the environment and freeing water resources for other competing uses (Latinopoulos, 2005).

The Ethiopian water policy has also highlight the importance of irrigation water fee for the sustainable development of the sector. The policy urges the Promotion of site specific tariff settings in all irrigation schemes depending on the nature of the project, location, the users, the cost and other characteristics of the schemes (MoWR, 2001b). [T]he water development strategy has also reinforced the setting of site specific irrigation water users' fee based on cropping pattern, farm level profit; scheme efficiency and etc. And further the strategy recognizes the powerful imputes of the willingness to pay of the irrigation users for the financial sustainability of the scheme (MoWR, 2001a).

As stated in the policy, the effectiveness or the success of irrigation water fee for the sustainable development of the sector highly depends on a number of site specific factors. Thus prior to the introduction of irrigation water use fee, the examination of the farmers' willingness to pay has a paramount significance. So far in the study area there is no study conducted to assess the willingness to pay of the farmers'. Accordingly, this study was undertaken to provide base line information for the local authorities' so that they can make an informed decision in the introduction of irrigation water fee.

1.3 Objective of the study

General objective

- Assessing the farmers' economic valuation of improved irrigation water in the study area.

Specific objective

- To elicit the farmers' willingness to pay for improved irrigation water.
- To examine the determinants of farmers' willingness to pay for improved irrigation water.
- To estimate the aggregate demand for improved irrigation water supply and
- To estimate the potential revenue (irrigation water use fee) collectible by the supplying agency.

1.4 Significance of the study

The finding of this study is useful in many ways. To begin with, it provides base line data on the determinant of farmers' willingness to pay for improved irrigation water provision in the study area. The elicitation of the farmers' willingness to pay values and the estimated potential revenue from water pricing will serve for the local authorities as a spring board to introduce water pricing. Since irrigation pricing is a national agenda, the result of the study will have a significant contribution for an efficient implementation of irrigation pricing in other parts of the country. In addition the finding of the study can also contribute in building the knowledge base for academic and research endeavors.

1.5 Limitations of the study

- Due to the absence of volumetric pricing mechanism for irrigation water in Ethiopia, the study focused on water pricing based on per unit area of cultivated land. Thus the research did not focus on the price farmers' are willingness to pay for a specific volume of water (like one buckets or 20 liters, etc...) rather it focused on the amount of money that farmers' are willing to pay for the amount of water which is enough to irrigate one Timad of land.
- Since all of the respondents practiced inter cropping system, they were not able to give accurate information on the size of land devoted to each crops. As a result, the study used the proportion of land devoted to cash crops as a proxy to measure crop mix.
- Due to the absence of a pre specified bid price level in the feasibility study documents of the Erere Weldia Irrigation project, the study has utilized the result of the mean willingness to pay of farmers in Eastern Tigary form a previous study as a bid price in the open ended elicitation format.

1.6 scope of the study

- The study has only focused on the farmers' economic valuation of improved irrigation water supply and hence did not include the environmental cost incurred due to irrigation water supply.

1.7 Organization of the thesis

This thesis is organized into six chapters. Chapter two, deals with reviewing related theoretical and empirical literatures on willingness to pay both in Ethiopia and in some other countries. Chapter three focuses on: description of the study area, research design, data sources, survey questioner and elicitation format, hypothetical scenario and method of analysis.

Chapter four focuses on the descriptive analysis of the survey data, while chapter five explains the econometric analysis of the survey data. Chapter six draws conclusions and recommendations of the study.

Chapter Two Review of related literature

Chapter two has two parts. The first section has focused on theoretical literature review while the second part deals with reviewing related empirical literature review.

2.1 Theoretical literature review

2.1.1 Introduction

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

[T]here had been substantive discussion in several major irrigating countries, such as India, Pakistan, Egypt, Thailand, Vietnam, China and Indonesia, on the introduction of 'full cost' irrigation charging (usually referring to full supply cost). However, there has been little effective implementation. In some areas, there has been a reverse trend, where water charges have been abolished (Taiwan, Poland, Punjab and India), recovery rates have decreased (Eastern Europe and Pakistan) or the introduction of irrigation charges has been stalled (Indonesia) (ibid).

The concept of economic value of water is defined in different ways by different authors. Some of the definitions given are:-



According to Ward and Michelson (2002),

“The economic value of water comes from the many uses to which water can be put in satisfying people’s needs. Water has economic value only when its supply is scarce relative to its demand. Whenever water is available in unlimited supply, it is free in the economic sense. Scarce water takes on economic value because many users compete for its use”

Marglin (1962) defined the economic value of water as,

“the amount that a rational user of a publicly or privately supplied water resource is willing to pay for it. Willingness to pay for water reflects the water user’s willingness to forego other consumption and is measured by a demand schedule relating the quantity of water used at each of a series of different prices.”

Briscoe (1996) explained that

“The idea of “water as an economic good” is simple. Like any other good, water has a value to users, who are willing to pay for it. Like any other good, consumers will use water so long as the benefits from the use of an additional cubic meter exceed the costs so incurred. Thus, the value of water to a user is the maximum amount the user would be willing to pay for the use of the resource.”

2.1.2 Demand and supply for irrigation water

The characteristics of demand for water for irrigation relate to quantity, location, timing and quality. Irrigation generally requires large volumes of water, which can be low in quality. This is in contrast to household use of water, which requires low quantities of water with high quality. The large volumes of water required for irrigation usually have to be transported over some distance to the field. For surface water, canals and pipes can enable conveyance; in the case of groundwater, extraction is provided via tube wells. In terms of timing, demand for irrigation water can extend through the growing season and, where adequate supplies are available; extend into the dry season for multiple cropping (FAO, 2004b).

The quantity of irrigation water supply cannot be readily specified. It is determined by various processes: the flow of water; evaporation from the surface; and percolation into the ground. In the case of surface water, supply is determined largely by the climate. Consequently, the quantity supplied is variable and can be unreliable (ibid).

2.1.3 Economic valuation of irrigation water

There are various methodological and practical issues involved in measuring the economic value of irrigation water. The first issue concerns the application of available methods for determining the economic price of water. Which valuation method – the stated valuation methods (contingent valuation method) or the revealed valuation methods (Hedonic pricing, travel cost) - should be used for determining economic value of water (Tiawari, 1998)?

The second issue concerns the basis for pricing water. From the standpoint of economic efficiency, water prices should relate to the marginal value product or the opportunity costs (Easter, 1993, Howe, 1993; WB, 1993; Sampath, 1992). From the government's viewpoint, water price should at least cover capital costs as well as operation and maintenance expenses (Rogers, 1993). [F]rom the farmers' viewpoint, prices should not exceed maximum ability to pay; and from the standpoint of feasible revenue collection, water charges depend highly on farmer's willingness to pay. In addition, the increasing environmental degradation costs of water resources development such as upper watershed degradation, water logging, potential ground water and surface water pollution due to excessive use of agrochemicals impose additional costs to the society. From the societal viewpoint, these external costs have also to be considered while determining the economic value of water (Tiawari, 1998).

The third issue is related to the unit of pricing, which largely depends on the available physical structures and existing institutional mechanisms for water distribution. Increasing water scarcity requires volumetric pricing for increasing water use efficiency (WB, 1993; Sampath, 1992). However, [l]ack of measuring devices, clearly defined water rights and knowledge of exact quantity of water applied at the farmer's plots present problems for volumetric pricing (Latinopoulos, 2005). Issues related with the method of valuing and the unit of pricing will be briefly discussed in subsequent section.

2.1.3.1 Valuation methods

[T]here is wide interest in, and support for, the idea of treating water as an economic good. However, the application of price-based instrument is particularly difficult in the case of water. This is so because the flow of water through a basin is complex and provides wide scope for externalities, market failure, and high transaction costs (Ward and Michelson, 2002). While judiciously applied market tools can be expected to have benefits in many cases, the necessary and sufficient conditions that defines and enforce water rights are not yet in place (Peery *et al.*, 1997). Well-defined market institutions that could generate prices that could serve to allocate water resources are lacking (Ward and Michelson, 2002). Thus irrigation water is a classic non-marketed resource (Dinar *et al.* 1997; Agudelo, 2001; Ward and Michelsen, 2002).

[T]here are two broad categories of non-market valuation techniques for valuing the value of public environmental resources. These are revealed preference valuation methods and the stated valuation method (Ward and Michelsen, 2002). Appropriate valuation techniques are based upon either observed behavior toward some marketed good, somehow connected to the non-marketed good in question called revealed preference approach, or on stated preferences in surveys with respect to the good in question (Garrod and Willis, 1999; Agudelo, 2001).

2.1.3.1.1 The revealed preference method

The revealed preference/indirect approach/ methods infer the value of environmental goods by studying their actual or revealed behaviors in closely related markets through the application of some model of relationships between marketable goods and environmental services (Bockstael *et al* 2005). The Indirect approaches rely on observed market behaviors to deduce values (FAO, 2004b).

Some of the revealed preference methods that are in use in relation with water resource valuation are hedonic pricing method and the travel cost method.

Hedonic pricing

[T]he hedonic pricing method is the most commonly used revealed preference valuation techniques. It is derived from the characteristics theory of value and seeks to explain the value of commodities as a bundle of valuable characteristics (Young, 2005).

[H]edonic pricing employs differences in the prices of marketed goods to derive the value of environmental characteristics. Marketed goods can be viewed as comprising a bundle of characteristics; for some goods, these include environmental characteristics. The differential prices that individuals pay for such goods reflect their preferences for environmental quality. Statistical analysis of the prices and characteristics of the goods is employed to derive an implicit value for environmental quality (FAO, 2004b).

Hedonic methods assume that the price of a marketed good, (such as housing) is dependent on that good's characteristics- such as location, size, the number of years since the house was built and environmental amenities (FAO, 2004b). [T]heoretically, by comparing data on house prices for which all variables, except the environmental good in question, are held constant, it would be possible to estimate willingness to pay for some quantity (quality) of the

environmental good. In practice this is done using multiple regression analysis on cross section data (Rosen, 1974; Palmquist, 1991).

The hedonic pricing method for it is based on actual market prices, its application is straight forward and uncontroversial (Young, 2005). The main shortcoming of the method is it does not capture non-use values of environmental resource and requires real property markets (Bockstael *et al*, 2005). For this reason, hedonic pricing is rarely applied in developing countries (FAO, 2004b).

Travel cost method

The travel cost approach takes the costs of travel that are incurred by individuals in visits (the costs of transport plus the value of time) made to recreational sites as implicit prices to value the service provided and changes in its quality. Travel costs measure only the use value of sites and are usually limited to recreational use values (*ibid*). Further, [a] fundamental criticism centers on the inclusion of a value for time spent traveling to the amenity. Whilst it is theoretically correct to account for time spent in travel, assigning a value to it is somewhat arbitrary (O'Doherty, 1993 cited at FAO, 2004b).

2.1.3.1.2 The stated valuation method

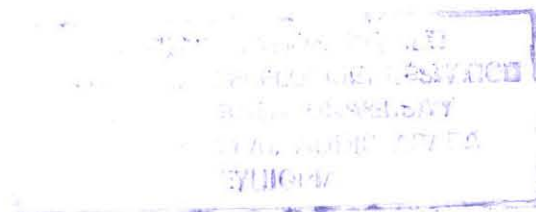
[T]he stated preference methods are the direct valuation methods used to solicit value measures by asking individuals hypothetical questions. In the stated preference techniques individuals are directly asked to state their willingness to pay (WTP) and/ or willingness to accept (WTA) compensation for change in public environmental resources from hypothetical market scenario (Frey *et al*. 2004). Direct valuation method involves direct estimation of environmental value based on the responses of individuals to the hypothetical valuation questions and hence it does not depend on market information (Freeman, 1993).

The original and the most commonly used stated preference method is the contingent valuation method (CVM) and it can be used for valuing both use and non-use values of environmental resources (Bockstael, *et al* 2005,).

[I]t is Ciriacy-Wanstap who first proposed the CVM as a method of valuation for non-marketed environmental public goods in 1947. However, it is Robert K. Davis who did the first empirical research in 1961 in valuing out door recreation. Since then the method become one of the widely used valuation approach in water and sanitation services, urban air pollution, soil erosion, deforestation, biodiversity, water shed management and ecosystem valuation (Whittington, 2002).

The CVM uses survey methods to elicit consumers' preferences by finding out how much consumers would be willing to pay for specified changes in the level of provision of a public good (Yuying and Roberto, 1996). This method is called contingent valuation for it is contingent on the hypothetical market (Perman *et al*, 2003).

The contingent valuation method uses survey techniques to obtain individuals' willingness to pay for the hypothetical provision of a public good (or willingness to accept compensation for its hypothetical loss). These monetary values are taken to represent the benefit to the individual of the proposed change and may then be aggregated for use in making public decisions that potentially improve social welfare (cooper *et al*, 2002).



A good CVM survey should contain the following (Bateman and Turner, 1992; Carson, 2000):

- An introductory section that enables the decision making to pay or not,
- A detailed description of the good and the characteristics of its provision,
- The institutional setting in which the good will be provided, as well as the manner in which the good will be paid for,
- A method by which the survey elicits the responder's preferences with respect to the good, including their willingness to pay specific amounts to secure its safe provision and
- In the last phase of a CVM, proper numerical (i.e. statistics and regression) analyses of the collected data lead to an estimate of the value of the good.

[T]here is a number of different elicitation methods used in CVM. Open ended and dichotomous methods are the main ones (Turner *et al*, 1995 cited in Geberegiorgis, 1999). [I]n the Open ended elicitation methods the respondent is asked "How much are you willing to pay?" .The respondent is therefore free to state any amount (Brookshire *et al*, 1983). In Dichotomous choice model, respondents are asked "Are you willing to pay a specific amount of money for a pre- specified change?" (Cameron and James,1987).

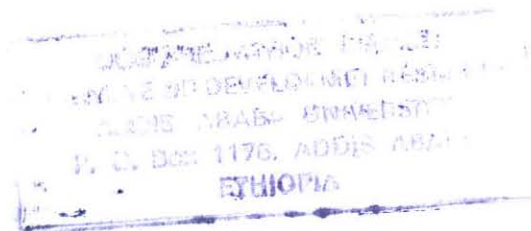
[T]he CVM despite its wide application it suffers from number of biases. The four major potential biases in the contingent valuation surveys are: strategic bias, starting point bias, hypothetical bias and information bias (Tietenberg, 2003).

Strategic Bias: this occurs when a respondent does not reveal his/her true preference of the good or service, i.e., he behaves strategically with the hope to “free ride” (Tietenberg, 1999).

Starting Point Bias: [T]his occurs when the respondent’s WTP amount is influenced by a value introduced by the scenario. The bidding game elicitation techniques pose the most obvious threat of this kind since it directly confronts the respondent with a proposed amount that the respondent is asked to accept or reject. Thus the choice of a low (high) starting point leads to a low (high) mean WTP (Bateman and Turner, 1993). [W]hile the use of starting points may reduce non response and variance in open ended questionnaire, “bidding hints” might lead respondents to take cognitive short-cuts to arrive at a decision rather than thinking seriously about their true WTP (Mitchell and Carson, 1989).

Hypothetical Bias: [T]he potential error induced by confronting the individual with an imaginary situation, i.e., people would not behave the same way in actual market. Respondents are confronted by an artificial set of alternatives rather than actual choices. Since the respondents are not actually expected to pay the estimated values, the respondents may treat the survey by providing ill considered answers (Tietenberg, 2003).

Information Bias: [T]he problem of information bias may arise in the situation where respondents are asked to value attributes with which they have no or little experiences. Thus, if respondents have no experiences about attributes of resources they are asked to value, the valuation will be based on an entirely false perception (Tietenberg, 2003).



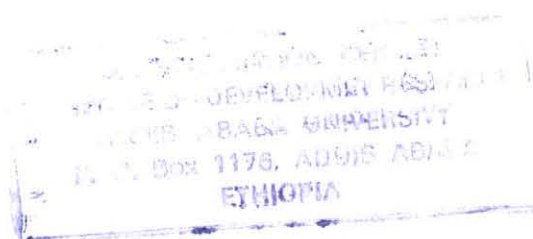
However, when surveys are properly planned and executed, most of the CVM problems can be eliminated, thus offering the best hope for estimating environmental benefits (Whittington *et al*, 1993).

According to Hoevenagel (1994), the CVM has the following strong advantages over the other methods:-

- The applicability of this method is better compared with other valuation methods in terms of completeness.
- It is able to measure a wide range of goods, including those not yet supplied in a manner consistent with economic theory.
- The method can measure non-use values.
- CVM has been judged to be superior due to its potential validity and ease with which the method can be implemented.

Moreover according to O'Doherty (1993), cited in FAO (2004b), Careful use of CVM can elicit both use and nonuse values for an amenity. In addition, CVM focuses on *ex ante* (forecasted) behaviors before some change occurs whereas the travel cost and hedonic pricing methods produce values *ex post*. Thus, estimates of changes in welfare of interest to the policymaker are theoretically better approached using CVM than using the observed-indirect methods.

Thus due to the above advantages, the CVM was used in this study to measure the farmers' economic valuation of improved irrigation water services.



2.1.4 Unit of pricing

There are two units for pricing irrigation water. These are non volumetric pricing /area pricing/ and volumetric pricing of water.

The most popular non volumetric pricing method of irrigation water is area pricing, according to which farmers are charged a fixed price per unit of irrigated land (FAO, 2004a). According to Latinopoulos (2005), it is a method easy to implement with low water administration costs. It does not require metering of water provision and is best suited to continuous flow irrigation. However, he indicates that area pricing is based on the assumption that irrigated land surface is an adequate proxy for the volume of water received, which is not actually true. Furthermore, he stated that area pricing has little effect on water use equity and efficiency, as charges are not a direct function of water consumption and the marginal cost of irrigation water is zero

[O]ther non-volumetric methods described in the literature are: output pricing, where the water fee is levied on each unit of output produced by the user; and input pricing, where a farmer pays for irrigation water indirectly through higher prices for inputs purchased from the government or water agency. Both input and output pricing avoid the need to measure the volume of water diverted or consumed (FAO, 2004a). However, neither measure is favored by economists because of distortion effects on the price of crops (Rhodes and Sampath, 1988 cited at FAO, 2004a). In addition FAO's (2004 a) review of the irrigation charging practices in the world found no evidence of the application of these two methods in practice.

B) Demand management, water allocation and pollution control

- To reduce excess demand
- To provide an incentive for the efficient use of scarce water resources.
- To allocate water to the highest priority uses.
- To provide incentives to improve water quality, reduce pollution levels or protect the environment.
- To encourage wise investment decisions by public and private organizations.

C) Social objectives

- To create a benefit tax.
- To ensure equity of access to water or the benefits of its use.

However, the same study has indicated, in practice, the achievement of some level of cost recovery and reducing excess demand are the over riding objectives behind irrigation water pricing. And also Perry (2001), emphasis the use of water charges to generate resources for maintenance and to reduce demand as the main objective.

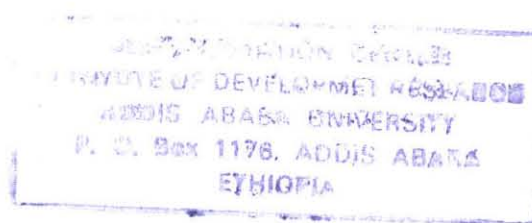
2.1.6 Institutional and organizational issues affecting irrigation Water pricing

A large number of institutional and organizational issues can affect the implementation of a charging policy. The OECD (1999) highlights the fact that agricultural water pricing policies do not occur in a vacuum but are often driven by factors outside the irrigation and agricultural sectors. In addition Molle (2001), emphasized that institutional and technical reform of the water sector is imperative and must often precede water pricing.

According to Ahmad (2000), there exists no general strategy or model to adopt for a specific water pricing policy of a country. Every country has to develop its own strategy. He further indicates that there is a danger of pursuing a 'one-model-fits-all approach' because administrators find such an approach easier to implement. Therefore, there needs to be a change of attitude within agencies implementing reforms.

According to FAO (2004a), the institutional and political factors that can hamper full supply cost recovery include:

- Lack of political will to impose higher costs on farmers.
- Lack of motivation on the part of agencies responsible with fee collection, as fees return to the treasury and recovery is not linked to funding.
- A vicious circle of low O&M expenditure leading to poor performance and increasing reluctance on the part of farmers to pay when they see no benefit.
- Insufficient resources (time, money and training) for planning and implementing effective charging mechanisms.
- Failure to enforce pricing policies.
- Failure to improve infrastructure, operation and service delivery.
- Failure to promote more profitable agriculture.



2.2 Empirical literature review

In recent years CVM has been extensively applied to variety of water related issues in different frameworks. However, [M]ost of the CVM studies carried out in developing countries are limited to the measurement of users WTP under improved water supply conditions for drinking water supply (Tiawari, 1998). Some of the CVM studies done on improved irrigation water supply are cited below.

Geberegiorgis (1999) had undertaken a study to estimate farmers' willingness to pay for small scale irrigation schemes in Ethiopia by taking a case study in the eastern zone of the Tigary regional state by employing the contingent valuation method. A total of 82 farmers' were included in the survey from Genfel kebele of Wekero Woreda. The open ended elicitation method was used to elicit farmers WTP. The analysis was carried out by using the OLS (ordinary least square) method and ordered probit analysis. In the study the variables identified to determine the WTP of the farmers' were age, credit, education, experience with irrigation, total area cultivated, number of oxen owned by a household, family size, total revenue and quantity of fertilizer used.

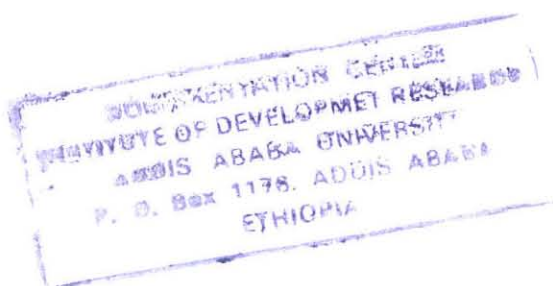
Geberegiorgis found out that, credit availability and education level of the respondent were important variables to explain the variation in the willingness to pay of farmers for irrigation water, both for seasonal and annual WTP equations. Total earning of the respondents was also significant in explaining the variation in the annual willingness to pay but it was not significant for the seasonal WTP values. Farmers' application of fertilizer was a significant variable in explaining variation in WTP in the dry season but it was not significant in the annual willingness to pay. Further the other variables were found out to be insignificant in explaining the variation in the farmers' WTP.

Chandrasekaran *et al* (2009) have undertaken a study on farmers' Willingness to Pay for Irrigation Water in South India. In their study, the economic value of tank irrigation water was determined through Contingent Valuation Method by analyzing farmers' willingness to pay for irrigation water under improved water supply conditions during wet and dry seasons of paddy cultivation. In addition the indirect (crop-water production function analysis) methods were also used. The variables, the education level, family size, age of the household head, area under rice cultivation, water requirement and family labor were used to explain the variation in the WTP of the farmers'. They employed the Logit model to identify the variables that affect farmers' WTP. Accordingly they found out that, the family labor force, area under rice cultivation and the water requirement are the significant factors in influencing farmers WTP in the wet season. While in dry season, area under rice cultivation and the water requirement were found out to have a significant influence on the farmers' WTP for irrigation water.

Herata and Gichuki (2006) utilized a contingent valuation method to measure farmers' willingness to pay for irrigation system for the recovery of operation and management cost in Sri Lanka. The closed ended and open-ended types of technique were used to elicit farmers' willingness to pay. The study considered respondents' willingness to pay for irrigation water to be dependent on their education level, family size, age, family labor force, area of paddy cultivation, perception on water sufficiency, total agricultural income. The regression result showed that the age of the respondent has a positive and significant impact on the WTP and also perception about water sufficiency have a negative but a significant role in the WTP of the respondents. The study further indicated that the negative coefficient of the variable, perception about water sufficiency implied that when farmers are satisfied with existing irrigation system, they are reluctant to pay for improved irrigation water provision.

Bjornlund and Rossini (2005) had undertaken a research to identify factors impacting farmers' willingness to pay for irrigation water in Australia by analyzing a ten years data on monthly prices paid for irrigation water and indicators of the hypothesized drivers of price by applying Correlation, regression and different time series techniques. According to their study, the main factors that affect farmers' willingness to pay are the level of water scarcity determined by the annual availability of water (allocation levels) and demand factors determined by the level of natural precipitation and evaporation. Further the study has found out that Irrigators with significant investments in permanent plantings, pastures, dairy herds, and milking equipment are willing to pay prices in excess of water's value in productive use in order to protect the production, and therefore the value, of their assets. They also indicate that Commodity prices and macro-economic indicators have only had a minor impact on WTP.

Mallios and Latinopoulos (2001) tried to determine the factors that influence farmers' WTP for irrigation water in Greece. A CVM study was used to analyze farmers' attitudes towards an efficient water provision system. A logistic regression model was used to assess the factors that influence the responders' behavior as well as to estimate their WTP. The study found out that, the main factors which dictated farmers' WTP were the perception of risk towards water shortage and the effectiveness of the proposed water users Association. The study further indicates that farmers behaved according to economic theory, by showing a conservative attitude towards payment. In addition they said that, personal attributes, like education level and the problems farmers' face in everyday practice were additional factors which influence their WTP.



Tiawari (1998), tried to elicit farmers' willingness to pay, in the Phitsanulok irrigation Project in Thailand, by using both the open ended and closed ended elicitation technique. A total of 209 sampled households were included in the survey. A logit model was used to analyze the closed ended question and ordinary least square method was used to analyze open ended question. In the study the variables; education, sex, family size, age of the household head, family labor force within the age of 10 and 60, number of family members temporarily migrated outside, total land size, perception about water sufficiency, land mortgaged in the bank, farmers attitude, area planted in the dry season and total agricultural income from both seasons cultivation were used to explain framers WTP for improved irrigation water supply. The result of the logit model found out that, the sex and agricultural income of the respondent have a significant and positive impact on the WTP of the respondents. The other variables that have a significant but negative effect on the WTP of the respondents were; farmers' perception on water sufficiency, education, family size, age and total land size. The results of the ordinary least square analysis of the study has indicated that, farmers attitude towards paying water fee, out migration and total agricultural income have significantly and positively affected the price farmers' are willing to pay. Further the study identified household family size, area planted in the dry season and lands mortgaged in the bank were the other significant variables with negative effect the price farmers' are willing to pay.

There are some studies undertaken in Ethiopia by using the CVM to estimate the value of improved drinking water supply conditions. Some of the studies are cited below.

Fanta (2007), carried out a CVM study to analyze households' willingness to pay for improved water services in Debre Zeit town. The study uses survey responses from 234 randomly selected sampled households from all kebeles of the town. The Probit and OLS econometric models were used to identify factors that determine households' willingness to pay for improved water services. The results of both Probit and OLS model show that age, household size, reliability of the water supply and the income variables influences households' willingness to pay for improved water services in Debre Zeit town.

Fissha (2006), used the CVM to analyze the determinant of households' willingness to pay for improved water service in Addis Ababa. The study used cross sectional data collected from 250 households living in different areas of the city through single bounded elicitation format with an open ended follow up question. The Probit and Tobit models were adopted to determine factors influencing households' decisions to connect to the pipe water scheme. The results of the study showed that respondents' WTP is affected by a number of factors. Accordingly, Income, education, perceived water quality, sanitation facility, age, and water related disease had significant impact on the respondents WTP.

Bayrou (2005), has undertaken a study to analyze the affordability and willingness to pay of the Nazareth town residence for improved drinking water supply service. The CVM method was employed to examine the determinants of WTP for improved water service. The bidding game was used as elicitation method in the study. The censored least absolute deviation (CLAD) estimator and the Probit models were employed to analyze the determinants of households' willingness to pay for the improved water services. The findings of the study indicated that, male respondents showed more willingness to pay for

improved water supply than the female respondents. The coefficients of water expenditure, household's perceptions of existing water quality, monthly income, and time taken to fetch water had a significant impact on the WTP of the respondents.

Bekele (1999), employed CVM to analyze the determinant of household's WTP for improved water service in Harer town. In the study the bidding game elicitation technique was employed. The ordered Probit and ordinary least square models were used to estimate the relationships between the household responses with the set of hypothetical determinants. The explanatory variables used in the study were socio economic, demographic factors and the status of water provision at the time of the study. The findings of the study indicates that the coefficients of income, education, gender of the household head, starting point bid game and quality of the water provision during the survey time were statistically significant and determines households' willingness to pay for the improved water services.

Lemessa (1998), used CVM to assess the WTP for rural water supply by taking Ada'a-Liben district as a case study. The study analyzed the household's WTP for improved water supply by taking socio economic, demographic characteristics and status of water used by households as explanatory variables. The ordered probit model was employed to analyze the variation of WTP for improved rural water supply. The findings of the study indicate that the coefficients of income, time, and status of water quality, education and credit availability had positive sign and were statistically significant.



Chapter Three Research methodology

3.1 Description of the study area

3.1.1 Location

This study was conducted in one of the rural weredas of the Hareri regional state. Erere Weldia small scale irrigation project was used as a study site. The site is found in the Erere Weldia wereda specifically in a place called Melka Idda. It is almost 18 km from the main road that joins Harar- Jijiga, if one has taken the left turn. It is located approximately at an altitude of 1500m above sea level. Latitude of 9° 20' N and longitude 42° 14' E.

3.1.2 Population and major economic activity

There are four kebeles in the wereda. According to the wereda Agriculture and rural development bureau head, the population of the Erere Weldia Wereda in 2009 was estimated to be 17,420 and he added that there are about 3,800 households in the wereda. Furthermore 1400, 1080, 720 and 600 households live in Weldia, Haweye, Dodota and Eulane ula kebeles' respectively. The head has also reported that there are about 2,686 households in the wereda who participate in PSNP.

The crops grown in the area includes maize, sorghum, groundnut, sesame, mango, lemon, banana, sugarcane, sweat potato and "Khat". Farmers in the area employed intercropping as a mechanism to optimize the utilization of their land and as a risk aversion mechanism in the case of drought situation.

Maize and sorghum are the main kind of cereals grown for household consumption. Maize is considered as a "keremet" crop where the land preparations commence around the month of March. The planting months are April and May. Harvesting usually start around early October. Sorghum is also considered as a "keremet" crop. The planting months are April, May and half of June and the harvesting months are September, October and November. The

other most important food crop in the area is sweet potato. “Khat”, groundnut, banana, sesame and mango are important cash crops in the area.

The major livestock resources of the area include cattle, goats, poultry and donkeys. As compared to other Weredas’ of the region, the Erere Weldia Werda has a relatively small number of animals. The main reasons are shortage of grazing land and the prevalence of animal disease (black leg and anthrax) in the area. Farmers mostly use traditional methods for treating cattle attacked by either black leg or anthrax. There is only one veterinary clinic in the Wereda.

The nearest market used to sell the agricultural products is the Harar town. The products are usually transported on the back of females and donkeys. Since the road has a number of hilly parts it is very hard and inconvenient for most of the farmers.

3.1.3 Climate condition and topography

The Wereda is found in the low land and has Kola agro ecology. It usually has high mean temperature and uni-modal rainfall pattern with low annual mean rainfall. The area frequently suffers from drought due to rainfall shortage and usually have a below average crop production.

Due to climatic reasons, malaria is the major health problem that severely affects the population of the Wereda followed by Diarrhea.

Except along the river valley the topography of most of the area is made up of steep slop hills. The soil in the area can be characterized as moderately deep, brown to dark brown and reddish, slightly dry and hard but when moist it is slightly sticky and plastic.

3.2 Research design

This study was designed as a cross-sectional contingent valuation survey with farm households, Development Agents, and other relevant stakeholders in the study area. The study design combined a multi-stage purposive sampling and random sampling techniques in the selection of the study site and the respondents respectively. In the first stage, the study site-Erere Weldia irrigation project- was purposively selected mainly because it is the largest irrigation project in the Harari regional state.

In the second stage, from the total of four kebeles in the wereda, three kebeles namely Weldia, Haweye and Dodota which the irrigation project encompasses are included in the study. There are 480 irrigation beneficiary households in these kebele's. Fifty of the irrigation users are in Weldia, 25% are in Haweye and the remaining 25% are in Dodota. Thus the sampling frame of this study consist all the 480 households who participate in the Erere Weldia irrigation project.

In the third stage, the total sample size (200) was distributed to the three kebeles based on the number (proportion) of irrigation beneficiaries in each kebeles. Accordingly 50% of the samples (100 households) were drawn from Weldia and 25 % (50 households) from each of the other two kebeles. Finally, by applying the technique of random sampling, individual respondents were selected from each kebeles.



Table 3.1 Sample size distribution

Name of the kebele	No. of irrigation users	Percentage from the total users	No. of sampled households
Weldia	240	50	100
Haweye	120	25	50
Dodota	120	25	50
Total	480	100	200

3.3 Data sources

In order to meet the research objectives both primary and secondary data were collected from different sources.

A) Primary data

Household survey

Household survey was conducted with the selected sampled households in the study area. To generate the required information at household level structured questionnaires were used. The nature of the questionnaire is discussed under the data instrument section.

In-depth case study

Three household heads were selected (one from each kebele) for the in-depth case study. In the in-depth case study the three individuals were investigated through discussion for their understanding of the economic value of water. The result was compiled in the form of Narratives and stories. A check list was used to guide the discussion.

Key Informant Interview (KII):

To gather concrete facts about the project and farmers' participation, seven key informants from the Regional Agriculture and Rural Development Bureau, Wereda administration, irrigation experts and development agents were interviewed. A check list was used to guide the interview.

B) Secondary data

Secondary data that were relevant for this study was gathered from different sources. Reports and other documents from the Regional and Wereda Agriculture and Rural Development Bureau, Bureau of Finance and Economic Development and also from different relevant published documents, statistical abstract, books, journals and thesis were reviewed to gather more information and insight.

3.4 Hypothetical scenario

A hypothetical market scenario was designed based on the improvement of existing water supply of the Erere Weldia irrigation project. In the hypothetical scenario the respondent were proposed that through appropriate water development investment, the Erere Weldia irrigation project will provide sufficient amount of water both in the dry and rainy season, which enable them to grow crops throughout the year.

3.5 Survey questionnaire and elicitation format

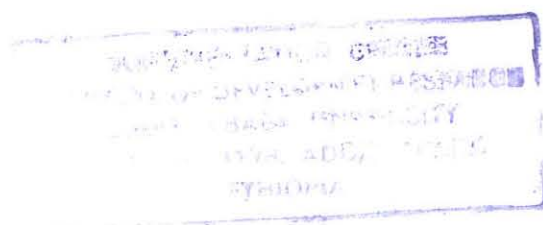
The contingent valuation questionnaire was designed following the recommendation of the international NOAA panel as cited in Portney (1994). Accordingly the most important points in the design of CV questionnaire are 1) the interview should be done on face to face; 2) willingness to pay should be about a future event and not one that already occurred; and 3) the hypothetical facts provided to the respondents must be precise, understandable and constant across the sample. By applying these recommendations the accuracy and reliability of the survey data was enhanced. Two types of willingness

elicitation techniques were used in this study. The closed ended (single bounded) elicitation format with an open ended follow up question was applied to elicit farmers' willingness to pay.

Using a closed ended elicitation format requires a pre specified bid price. In contingent valuation surveys, it is a common practice to use the price level stated in the project document during the feasibility study as a bid price. However there is no specified price, which the irrigation users are going to pay, in the feasibility study document of the Erere Weldia irrigation project. In the absence of such pre determined price level, the possible option is to use the bid price that other researchers used in similar study with in the country. Accordingly the study undertaken by Geberegiorgis (1999) in Tigray region was used as base to obtain the bid price for the closed ended questions. However, Geberegiorgis only employed the open ended elicitation format as a result there is no specified bid level in his research. But the study was able to elicit the mean willingness to pay of the farmers' to be 220,340 and 560 Birr / Timad for the rainy season, dry season and for the whole year, respectively. Thus, the current study has used the above prices as a bid prices for the improved provision of irrigation water services as described in the hypothetical scenario.

In the open ended elicitation format the respondents were asked to state the maximum amount of price that they are willing to pay for the rainy season, dry season and for the whole year if the irrigation water supply is improved as described in the hypothetical scenario.

In the structured household interview questionnaire, questions about demographic and socio economic characteristics, income and income sources, modern agricultural input, and farmers' perception about water scarcity, farmers experience about irrigation and farmers willingness to pay for improved irrigation water provision were included.



Prior to conducting the survey, the household questionnaire was pre-tested on 6 respondents and remedial action was made accordingly. Before the collection of the data, one supervisor and five enumerators were trained on the household questionnaire for one day.

3.6 Method of data analysis

In order to meet the general and specific objectives of the study both qualitative and quantitative methods of data analysis were employed. In analyzing the qualitative data, the method of triangulation was used to explore the data from the in-depth case study and KII sessions. In analyzing the quantitative data descriptive statistics (mean, range, and percentile and cross tabulation) and econometric models (OLS and Logit) were employed. The standard software STATA version 10 was employed to organize, arrange and analyze the quantitative data.

3.6.1 Model specification

The analysis of survey data obtained from closed ended and open ended elicitation formats requires different models (FAO, 2007). Thus to analyze the survey data, two different econometric models were specified. One for the open ended and one for the closed ended survey responses.

3.6.1.1 Econometric model specification for the open ended elicitation format

In this study, the whole process of model specification and selection followed the principle of the explanatory data analysis (EDA) approach. When one follows the EDA approach, the selection of the model for analysis will be determined by the characteristics of the data. Unlike the classical ways of fitting the data into the pre- determined model, in the EDA method the type of the available data dictates the type of the models to be used and hence a model that best fits (suit) the data will be used. To do so the approach suggests that all the independent variables have to be diagramed in scattered plot. To this

effect all the explanatory variables of this study were plotted against the dependent variable – the maximum price farmers' are willing to pay (MWTP)- in a scatter diagram by using the regression diagnostic plots of the STATA software version 10 (Annex 1A).

The scattered plot diagram has revealed the exact relationship between the dependent and the independent variables. The graph indicated the existence of some sort of linear relationship between the dependent and the independent variables. However it also showed the presence of outliers in the continuous variables. The causes of this outlier were investigated if they were caused by human error when the data is entered into the computer. It was learned that it was not caused due to typing error. Among other methods of correcting the effect of the outlier value, the median value was used in this study to replace the outliers. The median value was selected mainly because of the fact that the median value of the distribution is not affected by the existence of an outlier Value (Maddala, 1992). Once the extreme values were corrected, all the continuous variables were plotted in a box diagram to check whether all the value of the variable falls within the acceptable range (Annex 2). The diagram has shown that all the values lie within acceptable range. Furthermore, the relationship between the independent variable and the dependent variable was investigated again by using the scattered plot (Annex 1B).

From the plot it was learned that there exist some sort of linear relationship between the independent variables and the dependent variable. The values of the dependent variable - the maximum price farmers' are willing to pay - was found out to be continues and positive.

According to Siglman and zeng (1995), when there exist a linear relationship between the dependent and the independent variables/ WTP/, OLS and Tobit are the candidates. They added that Tobit will be appropriate if the dependent variable has some discrete value, while OLS can be used if the dependent variable is continuous.

Since the dependent variable is continuous and positive, this study has utilized the OLS method to assess the factor that determine the exact (maximum) price farmers' are willing to pay for the provision of improved irrigation water per Timad in a year. It is to be noted that, this study had not only analyzed the farmers' annual WTP values and its determinant factors but also the seasonal /rainy and dry season/ valuation of the farmers were estimated. But in order not to go into unnecessary details, the main discussion will focus on the annual valuation since it captures the variation (average situation) in the two seasons. The result of the two seasonal valuations will be used to supplement the analysis of the annual WTP values [For further investigation the result of the regression values of the two seasons are captured in the annex section (Annex 18 & 19)].

According to Maddala (1992), the linear regression equation is specified as

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n + \varepsilon \text{ ----- (1)}$$

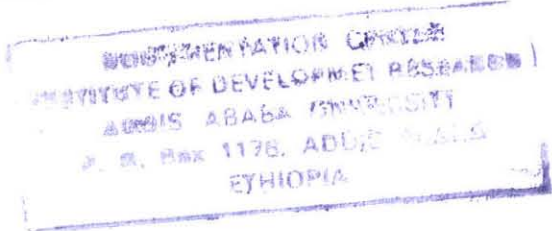
Were Y= the dependent variable

X_i = the independent variables

α = the constant (intercept)

β_i = the regression parameter

ε = the error term



Based on the above theoretical background, we can specify the linear regression model for this study as

$$\text{MWTP} = \beta_0 + \beta_1 \text{AGE} + \beta_2 \text{HHS} + \beta_3 \text{EDU} + \beta_4 \text{LAND} + \beta_5 \text{FERTI} + \beta_6 \text{INC} + \beta_7 \text{FATTEN} + \beta_8 \text{HWDC} + \beta_9 \text{MAR} + \beta_{10} \text{DAVI} + \beta_{11} \text{FER} + \beta_{12} \text{CREA} + \beta_{13} \text{EXP} + \beta_{14} \text{SCA} + \beta_{15} \text{DISSAT} + \varepsilon$$

Where MWTP = the maximum price farmers' are willing to pay

β_i = regression parameters

ε = the error term, and all the explanatory variables are described in the variable description section

The regression parameters in the linear regression method represent the change in the dependent variable – MWTP- for a unit change in the independent variable (Gujarati, 2005).

3.6.1.2 Econometric model specification for the closed ended elicitation format

As discussed in the preceding sections, the surveyed households were offered a single bound dichotomous choice question to indicate their willingness to pay by answering “yes” or “no” to the specified prices. Thus the response is qualitative in nature, i.e. it is either yes or no. [I]n models where the dependent variable is qualitative, the job is to find the probability of something happening – in our case the probability that the farmer is willing to pay (accept) the bid price or not. Thus qualitative response regression models are often known as probability models (Gujarati 2005).

In this study the dependent variable is discrete dummy variable (willing to pay = 1, otherwise= 0). According to Wooldridge (2000), in situations when the dependent variable is a discrete dummy variable, the linear estimation is inappropriate for at least three reasons. First, the error term cannot be normally distributed since it takes only two values. Second, the error is hetroscedastic because it can be shown that the variance of the error term is

not constant. Third, the estimated probabilities generated via a linear estimation would not necessarily lie between zero and one. The probability value greater than one or less than zero are not acceptable. For example, farmers' decision to pay for irrigation water cannot be predicted with over one hundred percent certainty.

According to Gujarati (2005), there are three approaches in developing a probability model for a binary response variable. These are the linear probability model (LPM), the Probit model and the Logit model. The choice between these models depends on the suitability to fit the data. However the LPM has its own limitation. First the heteroscedasticity of the error term (the variance of the error term is not constant). Second, the possibility of getting the probability function result out of 0 and 1, and most importantly the general lower R^2 value is a questionable measure of goodness of fit. Due to these problems the LPM is not an attractive model for dummy response variable.

[H]owever the Cumulative Distribution Function (CDF) known as Logit and Probit can be used for dummy response variables. In most application the two models are quite similar and therefore there are no compelling reasons to choose one over the other. In practice many researchers choose the Logit model because of its comparative mathematical simplicity (Gujarati, 2005). Thus in this study, the Logit model was used to identify the determinants of farmers' willingness to pay for a pre-specified irrigation water use fee.

It has to be noted that the Logit model does not actually measure the exact price that the farmers are willing to pay. Due to this the parameters of the model are to be estimated by the maximum likelihood approach (ML) (Wooldridge, 2000).

Following Gujarati (2005), the probability of the respondents' willingness to pay can be expressed as

$$P(\text{willing to pay}) = \frac{e^{z_i}}{1 + e^{z_i}} \quad \text{-----} \quad (2)$$

Or the probability of not willing

$$P(\text{not willing to pay}) = 1 - P(\text{willing to pay}) = \frac{1}{1 + e^{z_i}} \quad \text{-----} \quad (3)$$

Where e = the base of the natural logarithms

Z_i = the linear combination of independent variables written as

$$Z = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n$$

Equation (2) represents the (cumulative) logistic distribution function and varies between 0 and 1 as Z varies from positive infinity to negative infinity.

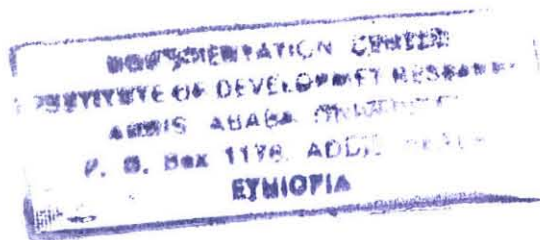
If we take the ratio of equation (2) and (3) (the ratio of the probability of willingness to pay to the probability of not willing to pay)

$$\frac{P(\text{willing})}{P(\text{notwilling})} = \frac{1 + e^{-z_i}}{1 + e^{z_i}} = e^{z_i} \quad \text{-----} \quad (4)$$

Equation (4), express simply the odds ratio in favor of willingness to pay. This indicates the probability that a farmer will be willing to pay to the probability that he will not be willing to pay.

Taking the logarithm of Equation (4)

$$\text{Log}(e^{z_i}) = L_i = Z_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n \quad \text{-----} \quad (5)$$



And hence, Equation (5) is called the Logit model

Where $L =$ the log of the odds ratio which is not only linear in x , but also linear in the parameters.

$\beta_0 =$ the intercept

β_1, β_2, \dots and β_n are slopes of the equation in the model.

In the Logit model the slope coefficient of the variable gives the change in the log of the odds associated with a unit change in the independent variable, holding all other variables constant.

However it would be easier to think of odds rather than log odds, so equation (5) can be re-written by taking the antilog of the estimated Logit. Thus the odds ratio is:

$$\frac{P(\text{willing})}{P(\text{notwilling})} = e^{\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n} \quad \text{----- (6)}$$

The coefficients in equation (6) measure the change in the odds in favor of willingness to pay for a unit change in the explanatory variables. In general, if one takes the coefficients in the equation (6) and subtracts 1 from it, and multiply the result by 100, the result is the percentage change in the odds in favor of willingness to pay for a unit change in the explanatory variables.

Thus we can specify the Logit model for our equation

$$\begin{aligned} WTP_i = & \beta_0 + \beta_1 AGE + \beta_2 HHS + \beta_3 EDU + \beta_4 LAND + \beta_5 FERTI + \beta_6 INC + \\ & \beta_7 FATTEN + \beta_8 HWDC + \beta_9 MAR + \beta_{10} DAVI + \beta_{11} FER + \beta_{12} CREA + \\ & \beta_{13} EXP + \beta_{14} SCA + \beta_{15} DISSAT \end{aligned}$$

Where WTP is response to the bid price =1 if the response is yes, = 0 if the response is no.

3.6.2 Description of explanatory variables and their expected effect

The variables that are used to estimate the farmers' willingness to pay for improved irrigation water provision and the expected effect of these variables are discussed below.

AGE: - age of the household head in years. It is believed that older people prefer to keep tradition and therefore they are less likely to support idea of paying for irrigation water and hence the expected sign is negative.

HHS:- household size. Family size is one of the determinant factors for households' willingness to pay for irrigation. Households with large family size will have more labor input that can utilize the increased water availability but on the other hand large family size requires relatively large amount of money to feed the family and in such situation the household will be resistant to the idea of paying for the improved irrigation water provision. Thus it is very difficult to determine the sign of this variable a prior.

EDU: - education level of the household head in grade. More educated people have a better understanding on the benefit of the improved irrigation water provision and are more likely to support the idea. Hence the expected sign of this variable is positive.

LAND: - the total cultivable land holding of the households in Timad. Households with large farm land are expected to benefit more from the improved service due to the scale factor and hence the expected sign of this variable is positive.

FERTI:- fertility of the farm plot. Dummy variable 1 if at least the land is moderately fertile and 0 unfertile. If the land is fertile then the higher the output of the farmer as a result of using irrigation water and hence the expected sign of this variable is positive.

INC:- Last year's annual income of the household in birr. The higher the income of the household, the higher the capacity of the household to pay for improved provision of the irrigation service and hence the expected sign of this variable is positive.

FATTEN:- keeping animals for fattening. It is used as dummy variable. 1 if the household is involved in fattening and 0 otherwise. Families who fatten animals are expected to have a better financial capacity and hence the expected sign of this variable is positive.

HWDC:- growing sugarcane, banana and "Khat" were used as a proxy for growing a high water demanding crops. Dummy variable 1 if the household grow high water affiliate crops, 0 otherwise. Growing water affiliate crops will induce the farmer to seek more water and hence to accept the improvement scheme. But on the other hand if the respondent has more of these crops, the higher the water that he needs and consequently the higher the price that he will be charged and this might force the farmer to decline the idea of paying for improved provision of water. Thus it is very difficult to determine the sign of this variable a prior.

MAR:- the proportion of land devoted to growing cash crops. Dummy variable 1 if the household devote more than 1/2 of his plot, 0 otherwise. Those households who devote more than 1/2 of their plot for cash crop were considered to be more market oriented than others. If the respondent has more cash crops he will have more capacity and ability to pay. Thus the expected sign of this variable is positive.

DAVI: Frequency of DA visits in a year. It is believed that households who have been frequently visited by the DA are expected to have a higher understanding on the benefits of improved irrigation provision and hence the expected sign of this variable is positive.

FER:- amount of fertilizer used last year in kg. The use of more fertilizer will induce farmers to demand more water and hence accept the proposed improved provision of the service. Thus the expected sign of this variable is positive.

CREA:- access to credit. Dummy variable 1 if the respondent has obtained cash credit in the last three years, 0 otherwise. Access to credit will give the household to invest in the necessary complementary inputs that would enhance his ability to effective utilization his irrigable land and hence the expected sign of this variable is positive.

EXP:- irrigation experience in years. Households with more experience in irrigation better understand the importance of the improved provision of the service and are more likely to be willing to pay for the service and hence the expected sign of this variable is positive.

SCA:- perception of the household head about water scarcity in the area. Dummy variable 1 if the respondent feels that water scarcity is a real problem in the area and 0 otherwise. Households who feel that water scarcity is a real problem in their area will consider the water as an important economic good and will be more likely to pay more than those who do not consider water scarcity as a real problem in the area and hence the expected sign of this variable is positive.

DISSAT:- dissatisfaction with the existing irrigation project . Dummy variable 1 if the respondent is unsatisfied with the existing project and 0 otherwise. Households who are not satisfied by the existing project are more likely to support the idea of paying for the improved water provision and hence the expected sign of this variable is positive

The table below summarizes the above description of variables.

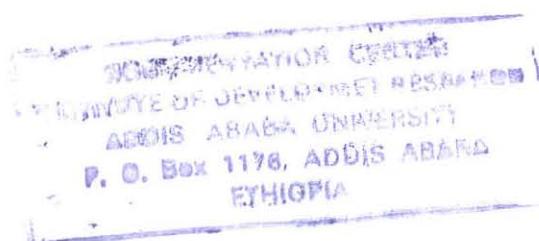


Table 3.2 Variable codes, definitions and measurement of the independent variables

Variable code	Variable type & expected sign	Definition	Measurement
AGE	Continuous (-)	Age of the household head	years
HHS	Continuous (+/-)	Household size	count
EDU	Continuous (+)	Education level of the household head	Grade
LAND	Continuous (+)	Total cultivable land holding of the household	Timad (1/6 th of a hectare)
FERTI	Dummy (+)	fertility of the farm plot	1 = at least moderately fertile 0= unfertile
INC	Continuous (+)	Last year's annual income of the household	Birr
FATTEN	Dummy (+)	Keeping animals for fattening	1= practice fattening 0= otherwise
HWDC	Dummy (+/-)	Growing a high water demanding crops	1= growing high water affiliate crops 0= otherwise
MAR	Dummy (+)	The proportion of land devoted to growing cash crops	1= devote more than 1/2 of the plot, 0= otherwise
DAVI	Continuous (+)	Frequency of DA visit in a year	Count
FER	Continuous (+)	Amount of fertilizer used last year	kg
CREA	Dummy (+)	Access to cash credit in the last three years	1 = obtained cash credit in the last three years, 0 = otherwise
EXP	Continuous (+)	Irrigation experience	Years
SCA	Dummy (+)	Perception of the household head about water scarcity in the area	1= water scarcity is a real problem in the area, 0= otherwise
DISSAT	Dummy (+)	Dissatisfaction with existing irrigation project	1=unsatisfied 0= otherwise

Chapter Four Descriptive *analysis of the survey data*

For this study a total of 200 households were interviewed in the three Keble's of the Erere Weldia Wereda. However 15 questioners were found to be incomplete at the data cleaning stage. Thus only 185 questioners were processed. The analysis is also supplemented by the findings from the three in-depth case studies and the KII sessions.

The household heads who are included in the in-depth case study are Abase, who is 35 years old from weldia Kebele. He has started irrigation 5 years before on 3 Timad of Land. Mohammed from Haweyi Kebele is also included. He is 43 years old and has started irrigation 8 years before on 2 Timad of land. The last one is Jemal from Dodota kebele who have practiced irrigation for 4 years on 3 Timad of land and he is 29.

The result of the household survey, the in-depth case study and the KII sessions are described below.

4.1 Demographic and socio economic characteristics of the sampled households

From the total surveyed households, 176 (95.1%) were Male respondents and only 9 (4.9%) respondents were female. With regard to marital status, 180 (97.3%) of the respondents were currently married; only 2 (1.1%) respondents were single and 3(1.6%) respondents were separated. And 172 of the male respondents were currently married, 2 of them are single and 2 were divorced. From the 9 female respondents, 8 of them were married and only 1 respondent was divorced.

The average age of the sampled respondent was 35.49 years with the minimum age of 18 years and a maximum of 60 years old. Out of the interviewed household heads, 34.6% of them were between the age of 18 and 30 years and 44.9% of the respondents were between the age of 31 and 40 years. The remaining 20.5% were between the age of 41 and 60 years (Annex 3).

The mean household size of the respondent was 6.23 with a minimum of 1 and maximum of 17 household members. And 40.5% of the respondents have a family size between 1 and 5 while 54% have a family size between 6 and 10. The remaining 5.5% have more than 10 family members (Annex, 4).

Concerning education level, 107 (57.8%) of them are illiterate and only 78 (42.2%) of the respondents were literate or attended formal education. From those who have attained formal education, 2 of them were able to obtain diploma, one has a certificate from Technical and Vocational School. 62 of them have attended between grade 2 and 5 and the rest were between 6 and 12 grades. Further, 116 (62.7%) of the respondents have attended informal education in local Quranic Schools. All of the respondents were Muslim.

The land holding size of the sampled households ranges from 1 Timad to 12 Timad (It is to be noted that unlike other areas where 1 Timad is about 0.25 hectare, in the study area it was found that 1 Timad is equal to 1/6 of a hectare). The mean landholding size of the sampled household is 5.06 Timad (0.83 hectare). Of the total, 21.1% owned 3 Timad or less than, while 58.4% of them possesses between 4 and 6 Timad. It was only 20.5 % of the sampled household who have more than 6 Timad (1 hectare) of land. (Annex 5).

Respondents were further asked how they accessed their farmland. Some respondents mentioned more than one source of access but the majority (65.4%) of the respondents claimed that they got access to the land through inheritance from their families. The second common source of access reported by 24.9% of them was through sharing the land with their relatives. The other sources of access identified by the respondents were, through land redistribution, shared cropping and renting. During the in depth case study with the farmers, it was learned that renting a land is not a common practices in the area. Kemale, one of the three household head selected for the in-depth case study said:-

“We don’t normally rent out the portion of our land which we don’t use it currently. If we are not using it, then we will give it to someone we know to use it on a temporary basis. In return we don’t expect any rental fees or any other payment for the land. It is a taboo in our society to rent out unused land because the land belongs to God.”

With regard to the general soil fertility of the farm land, only 16 (8.6%) respondents said that their land is of poor quality. The remaining 169 (91.4%) claimed that it is at least moderately fertile.

Table 4.1 A summary statistics for key continuous variables

Variable name	Mean	Minimum	Maximum
Age	35.49	18	60
Household size	6.23	1	17
Education Level	0.9	0	12+2
Land size in Timad	5.06	1	12
Frequency of DA visit in last year	34	0	150
Fertilizer used in kg in the previous year	64.12	0	200
Experience with irrigation in years	4.83	1	15
Total income in Birr	9999	1000	60000

Source: own survey, 2010



Table 4.1 B Summery statistics for key dummy variables

Variable	Average
Household who Fattens animals (dummy1= practice fattening 0= otherwise)	.578
Household who have access to cash credit (dummy1 = obtained credit in the last three years, 0 = otherwise)	.85
Household who grow high water demanding crops (dummy1= growing high water affiliate crops, 0= otherwise)	.5
Household heads who perceived water scarcity as a real problem in the area (dummy 1= water scarcity is a real problem in the area, 0= otherwise)	.77
Households who are dissatisfied with the existing project (dummy 1 unsatisfied, 0 =otherwise)	.833
Households whose plot of land is at least fertile (dummy 1 = at least moderately fertile, 0= unfertile)	.913
Households who devote more than 1/2 of their land for cash crops (dummy 1=devote more than 1/2 of the plot, 0= otherwise)	.52

Source: own survey, 2010

4.2 Income and income source of the sampled households

In the questionnaire households were asked to specify their main source of income. Of the total respondents, 145 (78.4%) respondents claimed that their only source of income is Agricultural activities. The remaining 21.6% obtained their livelihood both from agriculture and non agricultural activities. According to the Wereda Agricultural and Rural Development Bureau head, the main non-farm income activities in the study area are petty trading and participation in PSNP.

The mean annual income of the respondents was 9,999 birr per household with a maximum income of 60,000 birr and with a minimum income of 1,000 Birr. The majority of the respondents (66.5%) earn between 1,000 and 10,000 birr while 24.9% obtains between 10,000 and 20,000 birr. The remaining 8.6% of them have an annual income above 20,000 birr (Annex, 6).

Maize, Sorghum and sweet potato were the main crops grown for household food consumption reported by 143 (77.3%), 102 (55.1%) and 79 (42%) of the respondents, respectively, in the last Ethiopian fiscal year. Almost all of the respondents employed inter cropping system and together with the food crop production, they grow at least 2 cash crops. And 97 (52.4%) of the respondents have used more than 1/2 of their land for marketable crops while the remaining 88 (47.6%) of them have devoted below that. "Khat" was the most important cash crop grown by 165 (89%) of the respondents followed by groundnuts and mango grown by 146 (78.9%) and 137 (74.1%) of the sampled households, respectively. Sesame, Sugarcane, Lemon and Tomato were the other cash crops grown by the respondents (Annex, 7).

In terms of livestock ownership, 172 (93%) of the respondents owned at least one type of livestock. Cattle, goats, donkeys and hen are the main types of livestock owned by 164 (88.6%), 104 (56.2%), 101 (54.6%) and 101 (54.6%) of the respondent households, respectively (Annex 8).

The total number of cattle owned by the sampled households was 172 at the time of the survey. And 48 (25.9%) of the respondents have no cattle during the survey time and among the sampled households the maximum cattle ownership was 12 cattle. 16 (8.69%) respondents owned only 1 cattle while 39 (21.18%) of them own a pair of cattle. 32 (17.29%) respondents have 3 cattle and 43 (23.24%) own 4-6 cattle. The remaining 7 (5%) owned 7-12 cattle (Annex 9).

Muhamed has also said,

“The rain doesn’t start on time and even if it does, it is not enough for the growth of our crops. We always gather together to ask God for sufficient rain, but it is not happening. In the last few years, it is better to say that there was no rainfall in our Keble than to say the rain was not enough. Last year the growth of sorghum in our area was halted in its flowering stage because of the lack of water. Those who have access to irrigation were able to meet the rain water deficiency but those who have not, had no chance than using the stalk of the plant as a forage for there livestock. In short, I was able to feed my family only because of the Maize and Sorghum that I grew through irrigation.”

Some questions were also included in the questionnaire to obtain information about farmers Perception about the severity of water scarcity in the study area. Accordingly 42 (23%) of the respondent said that water scarcity is not a real problem in the wereda While 143 (77%) of the households said that water scarcity is a real problem in there community. The respondents suggested a number of remedial solutions to overcome the water scarcity problem. Among which, efficient utilization of irrigation water, construction of small dams and construction of a common water collecting ponds were the main ones.

4. 5 Farmers experience with irrigation

The farmers’ willingness to pay can be affected by their experience with irrigation and the benefits obtained, to this effect a number of questions were included in the questionnaire. The results are summarized as follows:

The irrigable land holdings of the sampled households range from 1 Timad to 10 Timad. The average irrigable land holding was 2.87 Timad per household. 136 (73.5%) respondents owned up to 3 Timad while 44 (23.7%) of them owned between 4 and 6 Timad and only 5 respondents possess more than 6 Timad of irrigable land.

The surveyed households' experience with irrigation ranges from 1 year to 15 years /It is to be noted that farmers in the study area used to practice traditional irrigation system prior to the construction of Erere Weldia irrigation project/. The average experience of farmers with irrigation was 4.83 years. 91 (49.18%) of the sampled households have the experience of 1-4 years while 62 (33.5%) were experienced between 5-9 years and 32 (17.3%) have the experience of 10 years and above (Annex 13).

The surveyed households have indicated that, they have obtained a number of benefits from irrigation. 177 (95%) of the sampled households reported that they have obtained the benefit of increased crop yield from a given area in a given crop season. The irrigation water has enabled 105 (56%) respondents to cultivate permanent/perennial crops. 95 (51%) of them have reported that their water supply security has been enhanced due to irrigation while 93 (50%) respondents obtained continued water supply for their livestock and also 93 (50%) said they were able to cultivate high water demanding crops . The other benefits identified by the respondents were additional one or two cropping season and increased domestic water supply. (Annex 14).

The story of Abase clearly indicates the benefits that the farmers' gain from irrigation

"It is through irrigation that we sustain the basic existence of our livelihood system. My life was on the breadline level some five years before. It is only after I started irrigation, that my life started to change in a better way. Now I am able to feed my family thanks to this project. I have no enough words to thank those who build this irrigation project. In the same year that I started irrigation, I got a new daughter, and I named her "Mesno" (Meaning Irrigation) just to show how much the project mean to my family."

While we discuss about water sufficiency with Jemale in his farmland under the shade of his mango tree, he said that by pointing at the revived mango tree's branches over our heads:

“ ... since my ancestors, we used to set under this mango tree to discuss the family issues. Last year unfortunately there was no rainfall at all in our vicinity. Due to that we lost not only the crops that we used to feed our family but also this mango tree, our family umbrella. It is only due to the irrigation that this mango tree has revived and we get back to our family meeting place.”

Only 30 (16.2%) of the respondents were satisfied with the existing water from the irrigation project. 155 (83.8%) of the sampled household however felt that the water from the irrigation project is not enough to grow crops throughout the year.

All of the key informants have also said that the water from the project is not enough for all farmers. In order to solve this problem they said that the Wereda Agricultural & Rural development Bureau is distributing a small water pumping motor on a credit basis, worth 5,000 birr, by organizing 10 households in one group, so that the farmers can divert water from other rivers. Some of the farmers are diverting water from a river located more than one km away from their plot. Currently 20 water pumping motors were distributed to the farmers. The bureau has planned to distribute one motor in every 5 km. The other action taken by the bureau was the distribution of a plastic cover for water collecting pond on a credit basis, worth of 2,900 birr to all farmers who can manage to dig a water collecting pond in their farm plot. The farmers will collect water in their pond when they get water from the project and will water there vegetation in the subsequent days. The water collecting pond has a maximum capacity of collecting 682 barrels of water. However, according to the Regional Agricultural & Rural development Bureau deputy head, more than half of the farmers have never paid back their debt.

Almost all of the respondents use irrigation in the dry season and 150 (81.1%) of them apply irrigation as a supplementary source of water. In the dry season, the surveyed households mostly use irrigation to grow cash crops. “khat”, sugar cane and lemon were the most important cash crop grown by 93%, 45.4% and 45% of the respondents, respectively. Sesame, tomato, banana and mango are the other important cash crops grown by the respondents. Sweet potato, Maize and Sorghum are also grown for household food consumption by 48%, 12.4% and 8.6% of the respondents, respectively (Annex 15).

Like the dry season, in the rainy season the respondents use the water to grow cash crops. “Khat”, sesame and lemon are grown by 74.1%, 58.4% and 42% of the respondents, respectively. The other cash crops grown by the respondents are Mango, groundnuts, tomato, banana, and sugarcane. Sweet Potato, Maize and Sorghum are also grown for household food consumption by 36.8%, 21.6% and 15% of the respondents in the rainy season irrigation, respectively (Annex 16).

The entire surveyed households said that the amount of irrigation water availability is decreasing in the last few years. The main reasons identified by the respondents were climate change; increase in the number of water users and inefficient water utilization.

4.6 Water management

From the in-depth case study and the KII session it was learned that unlike to other irrigation projects in many parts of Ethiopia, there is no established water users association in the Erere Weldia irrigation project. When the construction of the project was finalized in 2005, the wereda Agriculture and Rural Development Bureau gave training for 40 selected household heads on irrigation water management.

Though there is no explicit water user association in the wereda, there are 5 traditionally elected members of the society who are in charge of the irrigation system. They are known as “Meleqa”. One “Meleqa” is responsible for the administration of the irrigation water that goes to the farmland of 100 households. The practice of electing the “Meleqa” for the distribution of irrigation water was started before the construction of the Erere Weldia project. Farmers were used to elect the “Meleqa” for the administration of the traditional irrigation systems.

The “Meleqa” is responsible for the distribution of the water among the irrigators. Since the water is not enough to irrigate the plot of all farmers at a time, The “Meleqa” had developed schedules so that every farmer will irrigate his plots of land only when he gets his turn. The schedule will vary from places to place and also among seasons. Those farmers who are close to the main canal normally gets the water almost twice a month in the dry season and four times a month in the rainy season. However farmers whose plot of land is located far away from the main canal will get the water almost once in a month in the dry season and two to three times in the rainy season. Normally, in the day time the water will be used to irrigate fruits and vegetables and at night the ‘khat’ vegetation. According to the wereda irrigation expert, since the amount of rainfall in the wereda is low, farmers’ even in the rainy season depends on the irrigation project.

The other responsibility of the “Meleqa” is the collection of fines. If any farmer is found out to use the water (through diversion of any means) without his turn, he will be fined 50 birr by the “Meleqa”. The collected fine will be used to buy “Khat” for the farmers during community work. In case of any problem which is beyond the community’s capacity, it is the responsibility of the “Meleqa” to inform the problem to the Woreda Agricultural and Rural Development bureau. The “Meleqa” will work closely with the bureau to fix the problem. The “Meleqa” remain in charge until he is found out to be corrupted. As long as he is in charge there is no interference in his work from any government body. The decision of the “Meleqa” is always the final when there is a conflict between irrigators.

4. 7 Farmers’ willingness to pay for irrigation

Of all the interviewed households, only 4 respondents were not willing to participate in the program that necessitates payment for improved irrigation water provision. Because they argued that irrigation water should be provided free of charge and also claimed that they don’t have enough money to pay for the water. Given the fact that all of the respondents have never paid for irrigation water previously, the willingness of almost 98% of the respondents to pay for irrigation implies that the respondents have already considered water as an economic good. All of the three in- depth case study participant has expressed their willingness to pay for improved irrigation water, in their own words:-

Abase:-

“If I get enough water to cultivate different crops in my farm, I will be ready to pay all prices. If I don’t have money to pay for, I will even sell the cloth that I put on to get the water.”

Muhamed:

“If I get enough water, I am ready to pay whatever price deemed necessary.”

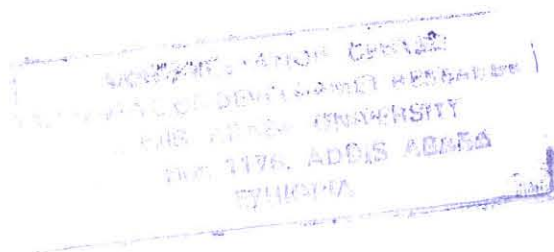
Jemale:

“I don’t have any problem with paying for the water as long as I get sufficient amount for the growth of crops.”

As stated in the methodology section, the open ended and closed ended elicitation techniques were used in this study. For the closed ended questions, respondents were asked whether they are willing or not to pay a specific price of 220 birr for the rainy season irrigation, 340 birr for the dry season irrigation and 560 birr per Timad for the whole year. Accordingly 54%, 56% and 50.27% of the respondents have agreed to pay the specified price for the provision of improved irrigation water in the rainy season, the dry season and for the whole year, respectively.

Households were also asked to specify the maximum amount they are willing to pay for irrigation water in the different seasons. Their average willingness to pay for the dry season irrigation is 337.7 birr per Timad while the willingness to pay for supplementary rainy season irrigation is 244.56 birr per Timad. The mean WTP for the whole year is 582.26 birr per Timad.

The minimum willingness to pay for the dry season irrigation is 40 birr per Timad but with zero payment for the supplementary irrigation. Where as the maximum willingness to pay are 1,500 birr both in the dry and rainy seasons and 3,000 birr for the whole year per Timad.



In the dry season, 42 (22.7%) of the sampled households are willing to pay between birr 40 and 200 per Timad. while 115 (62.2%) have quoted between 201 and 400 birr per Timad. The remaining are willing to pay above 400 birr per Timad. In the rainy season 45.4 % are willing to pay upto 200 birr and 45.9 % of the respondents have quoted between 201 and 400 birr per Timad. Only 8.58% are willing to pay in excess of 400 birr per Timad in a year. Whereas for the whole year (TWTP), 23 (12.4%) of the surveyed household are willing to pay between 40 and 200 birr per Timad while 28 (15.1%) respondents are willing to pay in the range of 201-400 birr per Timad and also 77 (41.6%) of them have quoted between 401 and 600 birr per Timad. The remaining 30.9% of the respondents are willing to pay in excess of 600 birr per Timad.

Table 4.2 Frequency distribution of WTP

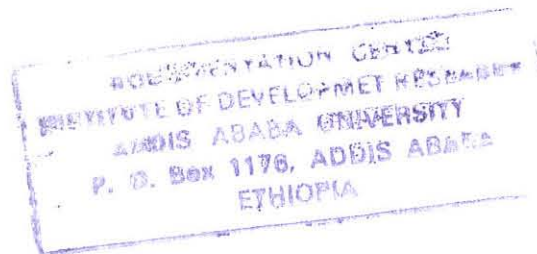
WTP intervals in Birr	WTP(dry season)		WTP(rainy season)		WTP (all seasons)	
	Frequency	Percentile	Frequency	Percentile	Frequency	Percentile
0-200	42	22.7	84	45.4	23	12.4
201-400	115	62.2	85	45.9	28	15.1
401-600	15	8.1	7	3.78	77	41.6
601-800	3	1.6	3	1.6	36	19.5
801-1000	3	1.6	3	1.6	6	3.2
Above 1000	7	3.8	3	1.6	15	8.1
Total	185	100	185	100	185	100

Source: own survey, 2010

4.8 The perception of the local authorities on water pricing

The regional Authorities believe that the farmers should pay for the water. They identified the issue of sustainability and sense of ownership as a main reason to introduce the pricing system. They explained that in other weredas' of the region where farmers had participated in the construction of the irrigation project, they tend to have a very high sense of ownership and at times they came into conflict in a number of places over the use of the water. They added that, however, in areas where the project is fully constructed by the Government or NGOs, the farmers don't really consider the project as their own and their utilization is highly inefficient.

Further the authorities emphasized the creation of awareness on the benefit of irrigation precedes any pricing issues. They believe that apart from the willingness of the farmers', the bases of pricing should include: Benefits obtained from the irrigation, depreciation cost of the structure, frequency of irrigation/hours, area of cultivation, experience of traditional water marketing.



Chapter five Econometric analysis of the survey data

5.1 Analysis of the result of the OLS model

As indicated in the model specification section, the OLS method is employed to analyze the response of the open ended contingent valuation survey responses.

Before estimating the effect of the explanatory variables on the farmers' WTP values, it is important to look for the existence of co linearity among the independent variables. [W]hen there is a high inter- correlation among the explanatory variables it is difficult to disentangle the effect of explanatory variables on the dependent variable (Maddala, 1992). Among other methods, the Variance Inflation Factor (VIF) method was used in this study to check for the existence of collinearity among the continuous variables and the contingency coefficient test was used to check collinearity among the dummy variables. The result indicated that multicollinearity is not a problem among the continuous variables as the values of are below 10 (annex 17A). [A]s the rule of thumb, multicollinearity is not a serious problem if the variance inflation factor is below 10 (Gujarati, 2005). Similarly the result of the contingency coefficient test indicates that multicollinearity is not a serious problem among the dummy variables (annex 17B).

The F- test for the regression model

The F test is a test against the null hypothesis that all the slope coefficients are equal to zero. The alternative hypothesis is at least one of the regression parameters is non- zero. The null hypothesis will be rejected if the calculated F test exceeds the critical value.

The F- test (calculated) of the regression model is 16.04, at 1 % of level of significance (the critical value is 2.87). Thus the calculated value exceeds the critical value and hence the model has some explanatory power.

Goodness of fit for the linear regression

The R^2 value of the regression line is 0.6272. This indicates that the linear regression model explains about 62.72% of the variation in the maximum amount of price the farmers' are willing to pay.

Result of the model

In the literature review part it was also indicated that a number of factors can affect the farmers' willingness to pay. But these factors are not equally important and similar in all places at all time. A decisive factor in one place at certain time may not necessarily be a significant factor in other places or even in the same places after some time. To this effect the OLS model was employed to determine the relative importance of different variable on the maximum price farmers' are willing to pay. Table 5.1 present the STATA output of the OLS model. Note that all the variables in this study are estimated at 95% confidence interval.

are willing to pay. This variable is also highly significant factor for the price farmers' are willing to pay for the provision of improved irrigation water both in the rainy and dry season.

The variable, the proportion of the land devoted to growing crops for the market was used as proxy to measure the effect of crop mix on the price farmers are willing to pay for improved irrigation water. The variable was expected to have a positive sign but the result indicates that it has negative sign. However the variable is not significant. This variable is also insignificant in both the rainy and the dry season WTP valuation.

C) Effect of modern agricultural inputs on the price farmers' are willing to pay.

The frequency of DA visit in a year has shown a positive sign. This indicates that those households who have been frequently visited by the DA are willing to pay a higher price. However this variable is not significant.

The variable fertilizer was expected to have a positive sign but it was found out that it has a negative sign indicating the use of fertilizer and the price farmers' are willing to pay are inversely related. But the variable is insignificant not only in the annual value but also in the seasonal valuations.

The variable access to cash credit has a positive sign indicating that access to cash credit has a positive influence on the price farmers' are willing to pay for the improved provision of irrigation water service. Thus the better cash credit access farmers have, the higher is the price that they are willing to pay. This variable is significant at 5%. When the Farmer get access to cash credit, the amount of price that he is willing to pay for the improved provision of irrigation water service will increase by 0.1338 Birr. Thus access to credit is one of the major determinants of the maximum amount of price that the farmers' are willing to pay. In the dry season's equation, this variable was also found to be significant factor. The result is in agreement with the work of Geberegiorgis

(1999), in Tigray region. He has found out that access to credit is a significant and positively related variable with the price farmers' are willing to pay.

D) Effect of farmers' experience with irrigation and perception about water scarcity on the price farmers' are willing to pay.

The variable, experience of the farmers' with irrigation has a positive sign as expected signifying that as the experience of farmers in using irrigation increase, the price they are willing to pay will increase. The variable is highly significant at 1%. As the farmer use irrigation for one more year, the amount of price that he is willing to pay for the improved provision of irrigation water service will increase by 0.4973 Birr. Thus experience of the farmers' with irrigation is one of the major determinants of the maximum amount of price that the farmers' are willing to pay. This variable is also a highly significant factor for both the rainy and dry season valuation of the farmers'. The sign of this variable is also in agreement with Geberegiorgis's (1999) study in Tigray region.

The variable, perception of the household head about water scarcity in the area has a positive sign as expected showing that there exist a positive association between farmers' perception of water scarcity as a real problem in the area and the price that they are willing to pay. The variable is highly significant at 1%. When the respondent feels that water scarcity in the area is a real problem, the amount of price that the he is willing to pay for the improved irrigation water service will increase by 0.3960 Birr. Thus perception about water scarcity is one of the major determinants of the maximum amount of price that the farmers' are willing to pay. This variable is also highly significant factor for the price farmers' are willing to pay for the provision of improved irrigation water both in the rainy and dry season. The result is in line with the finding of Herata and Gichuki (2006) in Sri Lanka.

The variable, dissatisfaction with the existing irrigation project has a positive sign as expected which indicates those household who are not satisfied with the existing irrigation project are willing to pay a higher price for improved irrigation water provision than those farmers who are satisfied by the existing amount of water from the project, keeping all things constant. The variable is significant at 1%. When a farmer is dissatisfied with the amount of water that he receives from the existing irrigation project, the amount of price that he is willing to pay for the improved irrigation water service will increase by 0.197 Birr. Thus satisfaction with the existing irrigation project is one of the major determinants of the maximum amount of price that the farmers' are willing to pay. This variable is also highly significant factor for the price farmers' are willing to pay for the provision of improved irrigation water both in the rainy and dry season. The finding of Tiawari (1998) has also indicated that dissatisfaction with current irrigation project is a major determinant variable on the price that farmers are willing to pay for improved irrigation water services in Thailand. He said, those farmers who did not receive water or, received less water compared to others (and hence dissatisfied), are willing to pay a higher price for the improved irrigation water service. In addition Herata and Gichuki (2006) have found out the same result in Sri Lanka. They found that when farmers are unsatisfied with the existing irrigation system, they are keen to pay a higher price for improved irrigation water services.

In summary, out of the 15 explanatory variables, 9 variables- namely age, household size, total cultivable land, land fertility, growing high water demanding crops, access to cash credit, experience of farmers with irrigation, perception about water scarcity and dissatisfaction with the existing irrigation project – were found to have significant effect on the price farmers are willing to pay.



5.2 Analysis of the result of the Logit model

In the methodology sections it was discussed that the logit model will be employed to identify the factors that determine farmers' willingness to pay for improved irrigation water for the single bound dichotomous choice question survey responses.

This section presents the result of the Logit model analysis. The Logit analysis identified those variables that affect the farmers' willingness to pay (accept) the pre specified bid price for the provision of improved irrigation water services. From the previous sections it was learned that multicollinearity is not a serious problem in our data.

The Likelihood Ratio Test (LRT) for the Logit model

According to Gujarati (2005), testing the null hypothesis that all the slope coefficients are simultaneously equal to zero -the equivalent of the F test in the linear regression model- is the likelihood ratio test (LRT) in binary response models.

This is given by

$$LRT = 2[L(\beta_0, \beta_i) - L(\beta_i, 0)] \text{ -----(7)}$$

Where the numerator of the above formula represent the maximized value of the log likelihood of the model being estimated, while the denominator represent the value of the likelihood estimated only with constant term. The null hypothesis of all slopes are equal to zero will be rejected if the LRT critical χ^2 value. In our model the maximized log likelihood value is -68.019067 and the value of log likelihood with only constant term is -109.4033. Thus

$$LRT = 2 (-68.019067 - (-109.4033))$$

$$LRT = 82.77$$

At 1% level of significance the critical $\chi^2(15)$ is 22.31. Thus the LRT is greater than the critical value and the null hypothesis of all slopes are equal to zero will be rejected. Thus, we can conclude that the model has some explanatory power.

Measures of Goodness of Fit

The conventional R^2 as a measure of goodness of fit is not applicable in binary probability models. A summary measure used similar to the conventional R^2 that have been suggested for models with qualitative dependent variable is calculated based on likelihood ratio and it is given by:

$$1 - \frac{L(\beta_0, \beta_i)}{L(\beta_0, 0)} \quad (8)$$

Where $L(\beta_0, \beta_i)$ is the maximized value of the log likelihood of the model being estimated, $L(\beta_0, 0)$ is the value of the likelihood estimated only with constant term. This measure has value 0, when the entire slope coefficients are zero, and value 1 when the model is perfect predictor. For our model it is

$$\begin{aligned} & 1 - \frac{(-68.019067)}{(-109.4033)} \\ & = .3783 \end{aligned}$$

Thus the model explains 37.83% of the variation. From this calculated value it would be wrong to conclude that the model did not adequately captured the variation in the farmers' willingness to pay. [I]t should be noted that in binary regressand models, goodness of fit is a secondary importance and one should not over play its importance. In such models what matters are the expected signs of the regression coefficients and their statistical and or practical significance (Gujarati, 2005).



Result of the logit model analysis

As stated in the preceding sections, the focus of discussion to identify the factors that affect farmers' willingness to pay for irrigation water is their annual valuation. The dry and the rainy season valuations will be used mainly to supplement the annual WTP values. The STATA output of the logit model is summarized in table 5.2

Table 5.2 Results of the Logit model estimation

Variable	Coefficient	Odds ratio	Std. Err	P value
AGE	-.0425685	.95832248	.0324481	.209
HHS	-.0773077	.925605	.1354848	0.597
EDU	-.0113238	.98874	.2361121	0.962
LAND	-.406586	.6659199	.1073895	0.012**
FERTI	-.9269526	.3957579	.3937319	0.351
INC	.0002252	1.000225	.0000716	0.002*
FATTEN	.6079229	1.836613	.8348314	0.181
HWDC	.4573643	1.579904	1.16624	0.536
MAR	-.3184346	.7272866	.5713483	0.685
DAV	.0843529	1.088013	.0329057	0.005*
FER	-.0733558	.9292701	.0334154	0.041**
CREA	-.3270837	.7210234	.4050415	0.560
EXP	.3436815	1.410129	.1945143	0.013**
SCA	2.466276	11.7785	10.0716	0.004*
DISSAT	-1.465547	.2309516	.1949358	0.083***

*significant at 1% level of significance

**significant at 5% level of significance

***significant at 10% level of significance

Note that the dependent variable is farmers' willingness to pay or accept the pre specified bid price for the provision of improved irrigation water services.

A) Effect of demographic and socio economic factors on farmers' WTP

The variable age has negative sign as expected indicating that the odds (the ratio of the probability of willingness to pay to the probability of not willing to pay) in favor of willingness to pay (accept) the bid price by the older people is lower. However the variable is not significant.

The sign of the Household size was not determined a priori. However the variable has a negative sign indicating the odds in favor of willingness to pay (accept) the bid price by the large family's households is lower. However the variable is not significant.

The variable education was expected to have a positive sign but the result showed a negative sign indicating the odds in favor of willingness to pay (accept) the bid price decreases as the education level of the farmers' increased. However the variable is not significant.

The total cultivable land holding of the respondent has unexpectedly a negative sign implying the odds in favor of willingness to pay (accept) the bid price by the farmer decreases as the size of his plot increase. The variable is significant at 5%. Keeping all other things constant, the probability of the farmer's willingness to pay (accept) the bid price, will decrease by 33.41% as the plot of the farmer increases by one Timad. Thus the size of cultivable land holding is one of the major determinants of the farmers' willingness to pay for irrigation water. One thing worth mentioning is the sign of this variable in the OLS model was positive but in the Logit model has a negative sign. The discrepancy is due to the fact that in Logit model the main issue is to find out what determines farmers willingness to accept (pay) a specified price but in the OLS the focus is what determines the actual (maximum) price that they are willing to pay. Thus in the study area the total cultivable land holding of the farmer has a positive relation with his maximum willingness to pay but it has a negative relationship

with accepting a certain specified price. This kind of difference in the sign of the variable was also reflected in the study of Tiawari (1998). Where he found out that the size of land holding has a positive sign in the OLS but it has a negative sign in the Logit. However, the sign and the significance of this variable are similar to Chandrasekaran *et al* (2009) study in south India. They found out that small and marginal farmers had relatively higher WTP for water when compared to medium and large farmers.

The variable, land fertility was expected to have a positive sign but the result shows that it has a negative sign implying that the odds in favor of willingness to pay (accept) the bid price will be lower for those farmers whose plot of land is fertile. However the variable is not significant.

B) Effect of income and income related factors on farmers' WTP

The variable, income of the household in the previous year has a positive sign as expected implying the odds in favor of willingness to pay (accept) the bid price will increase as the income of the household increases. The variable is significant at 1%. Keeping all other factors constant, the probability of the farmers' willingness to pay (accept) the bid price will increase by 0.0225% as the income of the farmer increase by one birr. Thus the income of the farmers' is one of the major determinants of the farmers' willingness to pay for irrigation water. The variable is also significant in both the rainy and dry season valuation. Herata and Gichuki (2006) have also found out that higher income farmers have a high probability of willingness to pay as compared to low income farmers.

The variable practice of fattening has a positive sign as expected indicating the odds in favor the willingness to pay (accept) the bid price is higher for farmers who fatten animals than who don't. However the variable is not significant.

The sign of the variable for growing high water demanding (affiliate) crop was not determined a prior. But the result indicated that the dummy variable has a positive sign. This implies that the odds in favor willingness to pay (accept) the bid price is higher for those farmers who grow water demanding crops than those who don't. However the variable is not significant.

The proportion of the land devoted to growing crops for the market was used as proxy to measure the effect of crop mix on the willingness to pay of the respondent. The variable was expected to have a positive sign but the result indicates that it has negative size. However the variable is not significant.

C) Effect of modern agricultural inputs on the farmers' WTP

The frequency of DA visit has shown a positive sign as expected demonstrating the odds in favor of willingness to pay (accept) the bid price increases as the number of visit of the household by the DA increases. The variable is significant at 1%. Keeping all other factors constant, the probability of the farmer's willingness to pay (accept) the bid price increases by 8.8% as the DA visit increases by one. Thus the frequency of DA visit is one of the major determinants of the farmers' willingness to pay for irrigation water. The variable is also significant in the rainy season valuation.



The fertilizer amount used was expected to have a positive sign but it was found out that it has a negative sign signifying that the odds in favor of willingness to pay (accept) the bid price decreases as the household uses more of fertilizer. The variable is significant at 5%. Keeping all other factors constant, the probability of the farmer's willingness to pay (accept) the bid price will decrease by 7.07% as the farmer increases his fertilizer utilization by 1 kg. Thus the use of fertilizer is one of the major determinants of the farmers' willingness to pay for irrigation water. However the variable is not significant in both the rainy and the dry season. The possible reason identified from the KII session for the negative sign of the variable is the bad experience of the farmer with the application of fertilizer in the previous year. In the preceding cropping season, farmers who used fertilizer had experienced that the crop growth has shown a luxurious growth up to its flowering stage. However due to lack of water, the seeding set was hampered and farmers were not able to benefit from the application of fertilizer. Since fertilizer adopters faced additional expense due to the crop failure as compared to the non adopters (i.e. the price of fertilizer), they are resistant to incur additional expense by paying for irrigation water.

The variable access to cash credit has unexpectedly a negative sign indicating the odds in favor of the willingness to pay (accept) the bid price is lower by those farmers who have access to credit than those who have no access to credit. However the variable is not significant.

D) Effect of farmers' experience with irrigation and perception about water scarcity on their WTP

The variable, experience of farmers' with irrigation has a positive sign as expected indicating that the odds in favor of willingness to pay (accept) the bid price will increase as the farmer's experience increases by one year. The variable is significant at 5%. Keeping all other factors constant, the probability of the farmer's willingness to pay (accept) the bid price will increase by 41.01% as the experience of the farmer increase by one year. Thus the experience of farmers' with irrigation is one of the major determinants of the farmers' willingness to pay for irrigation water. The variable is also significant in both the rainy and dry season valuation.

The variable, perception of the household head about water scarcity in the area has a positive sign as expected indicating that the odds in favor of willingness to pay (accept) the bid price is higher in those farmers who perceive water scarcity as a real problem in the area than those who don't. The variable is significant at 1%. Keeping all other factors constant, the willingness to pay (accept) the bid price by those farmers' who consider water scarcity as a real problem is higher by a factor of 11.7785 fold (1177.85%) as compared to the willingness to pay (accept) of those farmers' who consider water scarcity is not a real problem. Thus perception about water scarcity is one of the major determinants of the farmers' willingness to pay for irrigation water. The variable is also significant in both the rainy and dry season valuation.

The variable, dissatisfaction with the existing irrigation project was expected to have a positive sign but the result is a negative sign implying that the odds in favor of willingness to pay (accept) the bid price is lower in those farmers who are unsatisfied by the existing irrigation project than those who are satisfied. The variable is significant at 10%. Keeping all other factors constant, the willingness to pay (accept) the bid price by those farmers' who are not satisfied

by the existing irrigation project is lower than by a factor of 0.2309 fold (23.09%) as compared to the willingness to pay (accept) of those farmers' who are satisfied by the existing project. Thus satisfaction with the existing irrigation project is one of the major determinants of the farmers' willingness to pay for irrigation water. However this variable is not significant in both the rainy and the dry season WTP valuation. Furthermore, the sign of this variable in the OLS model was positive but in this model it is negative. The discrepancy is due to the difference in the emphasis given in the two models as explained previously.

In summary, out of the 15 explanatory variables, 7 variables- namely total cultivable land, income, frequency of DA visit, amount of fertilizer used, experience of farmers with irrigation, perception about water scarcity and dissatisfaction with the existing irrigation project – were found to have a significant effect on the farmers willingness to pay (accept) the bid price .



5.3 Estimating aggregate WTP and aggregate potential revenue

One of the objectives of this study is the estimation of the aggregate demand for irrigation water and the potential revenue that accrue due to irrigation pricing.

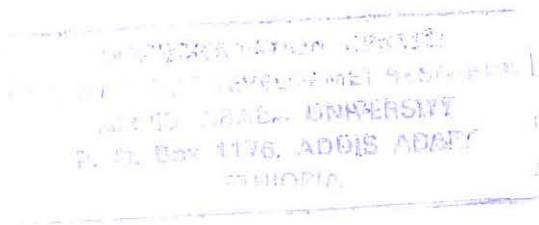
In contingent valuation studies, the estimation of aggregated values for the commodity is a common practice. However, there is a difficulty in defining the population over which the aggregation will take place when the commodity in question is irrigation. In other contingent valuation studies like improved urban drinking water supply, one can use the total population of the town in which the study is conducted to obtain the aggregate demand and revenue. This is not possible in this study since not every household in the survey wereda have access to irrigation. Due to natural and technical factors some households do not have access to irrigation water. Thus taking the whole population for aggregation purpose will over estimate the aggregate value. The population over which the aggregation takes place should include all households in the study area who have access to irrigation and or have at least a potential irrigable land.

A reasonable way to define the population is to have the total number of beneficiaries from the irrigation scheme if the actual irrigated area is equivalent to the potential irrigable area (Geberegiorgis, 1999). In our case, the irrigation project was designed to irrigate only 111 hectares. According to the irrigation expert in the wereda, currently more than 111 hectares of land is being irrigated by the water from the project. This is mainly because farmers who were not considered as a potential irrigator during the design stage due to distance factor has started using the irrigation water through the aid of water pumping motors. Thus using the entire 480 beneficiaries of the project will give a reasonable base for calculating the aggregate value.

Table 5.3 Estimated aggregate demand for improved irrigation water service and collectible revenue from irrigation water charging

WTP price Intervals in birr (1)	Sampled households distribution		Tot. population distribution	Total WTP of the population per Timad (5)	Cumulative User population (6)	Total revenue for the water provider (7)
	No (2)	% (3)	No (4)			
0- 200	25	12.7	61	6,100	480	137,760
201-400	28	15.5	75	22,500	419	360,759
401-600	77	41.5	199	99,500	344	493,640
601-800	36	19.8	96	66,500	145	291,305
801-1000	6	3.3	16	14,400	49	126,567
1001-1200	2	1.1	6	6,600	33	104,181
1201-1400	1	.6	3	3,900	27	100,737
1401-1600	2	1.1	6	9,000	24	103,320
1601-1800	0	0	0	0	18	87,822
1801-2000	3	1.7	9	17,100	18	98,154
2001-2200	0	0	0	0	9	54,243
2201-2400	1	.6	3	6,900	9	59,409
2401-2600	0	0	0	0	6	43,050
2601-2800	0	0	0	0	6	46,494
2801-3000	2	1.1	6	17,400	6	49,938
	185	100	480			

Source: own survey, 2010



5.3.1 Estimation of the aggregate demand for irrigation

The total population (480 households) is distributed to the different WTP intervals based on the response of the sampled households. To get the estimated number of households in each WTP intervals as shown in table 5.3 column 4, we multiply the percentage of sampled households (column 3) in each interval by the total number of households. The total willingness to pay of the population (the total demand) for the improved irrigation water service (column 5) can be obtained by multiplying the midpoints of the willingness to pay interval by the total population in each interval.

In addition Column 6 shows the cumulative population who are willing to pay for irrigation water at the corresponding WTP values. At the lowest WTP price of 100 birr, the entire 480 households are ready to pay for the improved supply of the water. At the price level of 300 birr the number of households who are willing to pay declines to 419. Likewise at the highest WTP of 2,900 birr only 6 households out of the total 480 are willing to pay for the improved irrigation water. From the table we can see that as the quoted price of irrigation water increase, the number of households who are willing to pay for the provision of the service decreases.

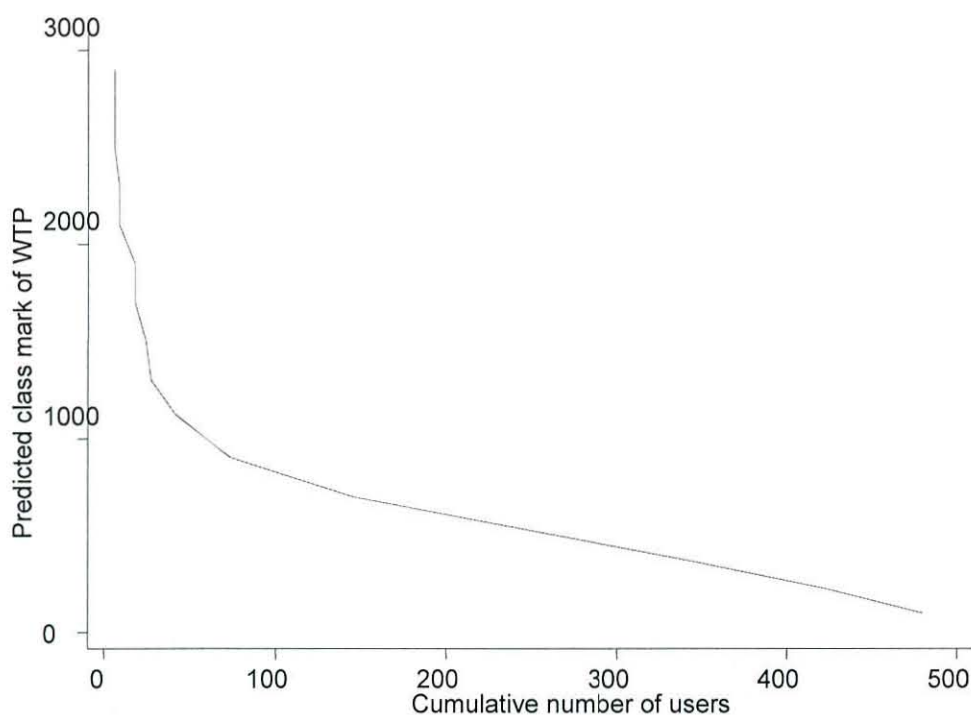


Fig 1 Total demand for improved irrigation water provision

The figure reflects the negatively sloped demand curve for improved irrigation water provision. This indicates that the households demand for improved irrigation water decreases as the price of water increases. The result is in line with the basic demand theory that states the quantity demand of the good decreases as its price increases.

5.3.2 Estimated aggregate potential revenue

The result of the survey has indicated that the average irrigable land holding in the area is 2.87 Timad. By taking this in to account, we can calculate the maximum potential revenue that can be collected at each price level. Multiplying the quoted price per Timad by the average irrigable landholding will give us the total price that an individual household is willing to pay. Multiplying this individual value by the cumulative users in that interval will give the total revenue (Column 7).

