Valuing the Economic Benefit of Irrigation Water: Application of Choice Experiment and Contingent Valuation Methods to Ribb Irrigation and Drainage Project in South Gonder, Ethiopia

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This is to certify that the thesis prepared by Nega Assefa, entitled: Valuing the Economic Benefit of Irrigation Water: Application of Choice Experiment and Contingent Valuation Methods to Ribb Irrigation and Drainage Project in South Gonder, Ethiopia and submitted in the partial fulfillment of the requirement for the degree of master of Science in Economics (Economic Policy Analysis) complies with the regulations of the university and meets the accepted standards with respect to the originality and quality.

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ABSTRACT

Valuing the economic benefit of irrigation water: Application of choice experiment and contingent valuation methods to Ribb irrigation and drainage project in South Gonder, Ethiopia

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This study analyses the determinants of households' willingness to pay for irrigation water supply by using contingent valuation and choice experiment methods. A sample of 300 farm households living in the command area was interviewed to obtain households' willingness to pay for irrigation water supply. A single bounded value elicitation format with an open ended follow up question were used for the CVM and four attributes were identified with three environmental attributes (irrigation water availability, fish stock abundance and productivity) and a monetary attribute (annual payment).

Probit, multinomial logit and random parameter logit models were used to analyze the factors influencing households' willingness to pay and estimate measures of welfare change for farm households. Results of the study showed households were willing to pay for the provision of irrigation water. The important variables identified in this study to determine households' WTP for irrigation water include practical irrigation experience of households, average annual income, participation in off-farm activities, and market access,. The mean willingness to pay from the single bounded and follow up open ended questions were birr 614 and birr 417.49 per 0.25 ha of irrigable land respectively. The expected aggregate willingness to pay for irrigation water supply for the closed and open ended questions is estimated to be birr 35,513,760 and 24,147,622 respectively.

Based on the willingness to pay of households for improvement of attributes irrigation water availability is the most preferred one followed by fish stock abundance. The mean willingness to pay for fish stock abundance, irrigation water availability and productivity were 748, 822 and 1.2 birr respectively from the implicit price estimates. Compensating surplus estimates which reflect overall willingness to pay for a change from the status quo (current situation) to alternative improvement scenarios were also calculated. The estimate for the high impact scenario was estimated to be 5610 birr, for medium impact scenario 4090 birr and for low impact scenario it was 2514 birr per annum.

An important policy implication drawn from the study is that farm households are willing to pay for irrigation water supply. If government designs and implements a proper charge of irrigation water in the area based on such studies it will avoid or at least reduce inefficient water use practices and there would be a more sustainable utilization of environmental resources.

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List of Abbreviations

ASC.................................Alternative specific constant

CDF.................................cumulative density function

CEM...............................Choice Experiment Method

CS................................. Compensating surplus

CV.................................Contingent Valuation

CVM ....Contingent Valuation Method

EDP.............................. Equivalence difference property

GMSSIP......................... Government Managed Small Scale Irrigation Project

GTP..............................Growth and Transformation Plan

Ha............................. .Hectare

HH......................... ....Household

HPM..............................Hedonic pricing method

IIA.................................Independence of irrelevant alternatives

INR............................. Indian currency (rupees)

MEDaC ....Ministry of Economic Development and Cooperation

MNL ....Multinomial logit model

MoFED.........................Ministry of Finance and Economic Development

MoWR...........................Ministry of Water Resources

NUV.............................. Non Use Value

O & M ....Operation and maintenance

OLS .... Ordinary least square

RIDP.............................Ribb Irrigation and Drainage project

RPL ....Random parametric logit

TEV............................. Total Economic Value

UV................................ Use Value

WTP..............................Willingness to Pay

CHAPTER ONE: INTRODUCTION

1.1 Back ground of the study

Water is an integral part of the ecosystem, a finite natural resource and a social and economic good. Hence, the issues of water availability, access and quality are of fundamental importance to development, poverty reduction and ecosystem sustainability (Ayleward et al., 2010).

Africa is home to about 13% of the world's population, but has only about 9% of the world's water resources. Average annual per capita availability of water resources in Africa is lower than the world average and higher than only that of Asia (PANAFCON, 2003). This low level of water availability in Africa is due to three basic sources of water risk: "*The first major source of risk is that of a significant decline in the average rainfall since the late 1960s. This is because in recent times many of the continents experienced increased aridity as the mean annual rainfall declined by 5% and 10% between1931-1960 and 1968-1997 respectively. The second basic concern with the water resource situation in Africa is that in terms of comparative hydrology, runoff is low in Africa due to high evaporative losses. The third major source of water risk in Africa is the high variability of supply, due to highly variable rainfall. The variability ranges from zero in some Namibian deserts to very high in the western equatorial areas* (PANAFCON, 2003)". The major outcome of these extremes of rainfall is a high frequency of floods and drought on the continent. The high variability of rainfall and river flow also reduces runoff and exacerbates vulnerability to erosion and desertification. This extreme variability of climate and hydrological conditions imposes high costs on livelihoods, and raises the riskiness of development interventions.

Ethiopia is "the water tower of Africa'', located in North Eastern Africa. The country has more than 10 river basins with an annual runoff volume of 122 billion m^3 of surface water and an estimated 2.6 billion m^3 of ground water potential, which makes an average of 1557.5 m^3 water available per person per year. This is a relatively large volume of water. Of the ten major river basins of the country the largest four river basins that is Abbay, Baro-Akobo, Tekeze and Omo-Ghibe account for 80%-90% of the country's water resource (MoWR, 2002).

Even if the country is considered as "the water tower of Africa'' due to the fact that many of the country's river are transboundary (it has political implication) and the country's reliance on rain fed agriculture associated with seasonal fluctuation and uneven distribution of rain water the country is affected by frequent drought .

In Ethiopia the agricultural sector heavily depends on rain fall, which is characterized by high spatial variability and seasonal fluctuation. The country is also characterized by rapid population growth. So as to meet the growing demand for food of this growing population the country need to have the right optimal resource use, like water utilization policy to increase production and productivity. In this regard irrigation will play a vital role to increase production to meet the growing food demand and to stabilize agricultural production and productivity. Ethiopia has an irrigation potential of 3.6 million hectares of which only 8% has been developed (MoWR, 2002). Given the significant irrigation potential of the country much has to be done on irrigation projects to raise agricultural production and productivity.

The government of Ethiopia has designed policy and strategy to eradicate poverty in its five year plan called GTP (growth and transformation plan) by maintaining agriculture as a major source of economic growth. To promote multiple cropping and better cope with climate variability and ensure food security, GTP will enhance the uses of the country's water resources. Expansion of small scale irrigation will be given priority while due attention will be given to medium and large scale irrigation to the extent possible (MoFED, 2010). Based on this different irrigation projects starting from small scale to large sale projects are under implementation. The Ribb irrigation and drainage project is one of these projects.

The pricing mechanism of irrigation water in the country is based on non-volumetric[1] measures and the existing irrigation policy of the country gives more emphasis on the construction of small scale irrigation projects rather than the valuation of the irrigation water. But the irrigation water policy has to focus on the pricing of irrigation water because valuation of irrigation water helps in an economy with high dependency on agriculture and a large percentage of the population lives in the rural areas. Furthermore the need to fill the information gap on the pricing of irrigation water based on volumetric measures for policy measures is required. Therefore a study on the valuation of irrigation water to understand the importance of valuing irrigation water service is decisive.

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[1] non-volumetric, refers to a pricing structure where water is billed in proportion to something other than the volume of water used (e.g. area irrigated or weight of crop produced).(Sonia Akter)

1.2 Statement of the problem

The government of Ethiopia is currently constructing the RIDP (Ribb irrigation and drainage project) in the Abbay river basin in Amhara regional state located in Fogera and Libbo Kemekem woreda on the east side of lake Tana between Gonder and Bahir Dar. The main purpose of the project is to change the rainfed subsistence agriculture to integrated commercial agriculture (MoWE, 2010). Dams in general are constructed for different purposes in any country like to provide hydroelectricity, water for irrigation, for domestic purpose, for industrial and mining use and for flood control (MEDaC, 1999). The irrigation dam constructed on the river Ribb has a primary purpose of irrigation water. It has also a significant importance in controlling flood in the area and for domestic purpose.

However, proper pricing of irrigation water in Ethiopia in general and the study area in particular are important because of the following benefits and problems. Firstly, water is scarce. Ethiopia is one of the countries projected to experience either water scarcity or water stress in 2025. It is projected to have an annual per capita availability of less than 1000 M^3 (UNEP, 2002).

Secondly, the common pool and public good nature of irrigation water or the old-age thinking of water as a free good makes it difficult to establish property right and costly to enforce and hence leads to inefficient utilization of irrigation water (Ayleward et al., 2010).

Thirdly, water charges are means of cost recovery. The cost of large and medium scale irrigation project cost is covered by either the federal government budget or from foreign loan/grant. In this regard the appropriate pricing of water is important so that farmers are involving in assisting the development process of their country by paying the proper amount of money for the service of irrigation water.

Fourthly, there is high demand for ground water partly because many of the rivers in Ethiopia particularly tributary rivers are not continuously flowing throughout the year because of their dependence on rainfall. Therefore, farmers need to extract ground water to cultivate crop more than once a year which may lead to over extraction of ground water and eventual reduction in its level.

Lastly, Ethiopia has one of the highest population growths, the majority of its population lives in the rural parts of the country; there is expansion of urbanization and increasing economic development and influence of climatic factors like flooding and drought. All these imply the need for pricing of water for appropriate utilization of water.

In general there is an inefficient water use practice and overall lack of incentives to water conservation in the area. All these problems are faced by the country at large and the study area in particular. One reason for these problems is absence of irrigation water charges. Hence a proper pricing of irrigation water is essential to rationally utilize irrigation water and to inculcate sense of responsibility among water users.

The study therefore attempts to determine the price of irrigation water by eliciting farmers' willingness to pay (WTP) on Ribb irrigation project using choice experiment method (CEM) and contingent valuation method (CVM).

1.3 Objective of the study

The general objective of this study is to analyze the economic value of different uses of Ribb irrigation and drainage project (RIDP) in south Gonder, Ethiopia. The specific objectives of the study are to:

- Elicit willingness to pay (WTP) of the rural people for irrigation water using choice experiment method (CEM) and contingent valuation method (CVM);
- Estimate the aggregate demand for the supply of irrigation water in the sample area;
- To estimate the mean WTP of attributes and to compare WTP across attributes;
- Identify the major socio economic determinants of respondents' WTP for irrigation water; and
- Draw policy implications relevant to the existing situation of the country.

1.4 Significance of the study

The research work is to elicit farmer's willingness to pay for different attributes of Ribb irrigation and drainage project (RIDP) for irrigation water. It is expected to provide basic information for policy makers regarding the environmental issues and the significance of this large scale irrigation[2] project in particular. To the knowledge of the researcher there is no research work conducted in the valuation of large scale irrigation schemes using choice experiment method (CEM) based on different attributes in Ethiopia.

There are limited studies conducted to estimate the benefit of irrigation water in Ethiopia. Notable exceptions are Tsegabirhan W/Giorgis (1999), Jonse Bane (2005), and Habtamu

[2] Large scale irrigation is with a command area greater than 3000 Ha (MEDaC, 1999).

Tilahun (2009) who employed CVM. But no one tried to determine the value of irrigation water by using multi-attribute based valuation technique (CEM) or a combination of both stated preference methods (CVM &CEM). Therefore in this respect this study conducted to estimate the value of irrigation water on RIDP has a significant contribution to the literature, and can be used as an input for different stakeholders for policy purpose and also as a basis for further studies. More particularly this study could contribute to agricultural water policy in order to enhance efficiency and to promote sustainability in irrigation water use.

Thus, this study, which combines CEM and CVM, will provide the basis for further empirical study in this area or serve as a literature for further study for researchers. Furthermore the outcomes this study are expected to be of interest to regional government officials and different stakeholders by providing information for guiding policy in relation to irrigation water pricing.

1.5 Scope and limitation of the study

The scope of this study is limited to the analysis of irrigation water pricing of one of the large scale irrigation and drainage projects being constructed in South Gonder based on the information obtained from farmer's willingness to pay for irrigation water. The study uses CVM and CEM. While these methods are widely applied and are very relevant for this study, like other valuation techniques these methods have their own limitations. In addition because of the time and financial constraint the sample survey will be limited to 300 of the farmers in the command area. However, the data generated in the survey will be used with much care to minimize the small sample bias.

1.6 Organization of the study

The thesis consists of five chapters including this chapter, which provides general information in its introduction. This chapter also provides or describes the objective, methodology, significance, scope and the stated problem of the study. Chapter 2 is a review of the literature. Chapter 3 presents the methodology used while the fourth chapter is about the analysis of the survey data. The last chapter, chapter 5, discusses the main findings of the study and the conclusions drawn from the results.

CHAPTER TWO: LITERATURE REVIEW

2.1 Theoretical background

2.1.1 Definition of economic valuation and its importance

Economists are striving in the valuation of environmental goods and services to give attention for the protection and wise use of environmental resources. A concise definition of valuation is "an attempt to put monetary values to environmental goods and services''. It is a key exercise in economic analysis and its results provide important information about values of environmental goods and services. The information can be used to influence decisions about wise use and conservation of the ecosystem. The basic aim of valuation is to determine people's preferences by gauging how much they are willing to pay (WTP) for given benefits or certain environmental attributes (Abila et al., no date).

The fact that the environment was viewed as an open access resource implied a zero price for the environment. This perception of individuals on the environment leads to unwise use of the natural resources which leads to environmental degradation because of the over use of such resources. Hence with a zero price for environmental use, the economic system does not include control mechanisms to check over use of the environment. So environmental valuation is desirable to introduce a control mechanism in the wise use of environmental resources (Folmer et al., 1989, p. 1-2)

The other aim of environmental valuation is to incorporate the environmental impacts in to cost benefit analysis and to allocate the environmental resources efficiently on the various competing uses in a way that brings the highest possible benefit to the society once monetary value of the non-priced goods are known(Perman et. al, 2003, p. 399).

2.1.2 Components of value of environmental resources

Economists have broadly decomposed the total economic value conferred by resources and the environment into use value and non-use value.

Use values can be broken down into direct and indirect use values.

Direct use values – are contributions that the assets make to current production/consumption or the value derived from directly consuming services provided by an environmental good.

Indirect use values – are benefits derived basically from functional services that the environment provides to support current production/consumption or value derived from indirect consumption of an environmental good such as the aesthetic and functional services it provides.

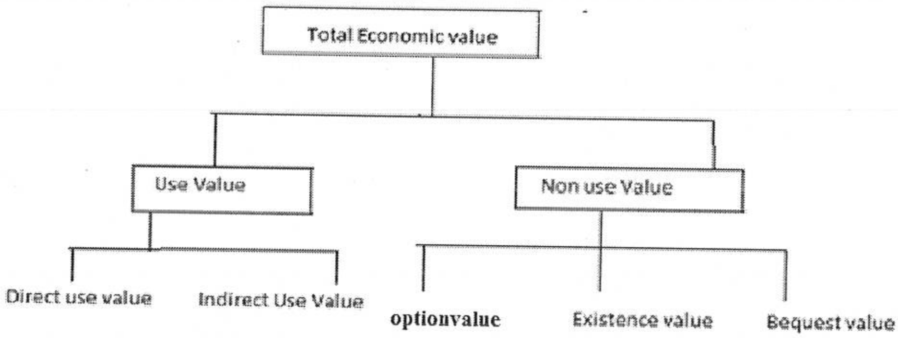
In the environmental and resource economics literature, nonuse values are hypothesized as having three separable components, namely option, bequest and existence values or demands.

Option value- refers to individuals' willingness to pay to retain the option of possible future use. It shows peoples willingness to pay to preserve an environmental resource to guarantee for future use but not actually using it currently.

Bequest value- refers to the satisfaction that people gain from the knowledge that a natural resource endowment is being preserved for future generations. Bequest demand exists to the extent that the present generation is willing to pay for preserving natural resources for the use of future generations.

Existence value- refers to the satisfaction that some people derive from the preservation of natural resources so that there remains a habitat for fish, plants, wildlife, and so on. In other words, it refers to what people are willing to pay (demand) for preserving the ecological integrity of the natural environment (Ahmed Hassen, 2004, P.157).

Figure 2.1 Categorization of value of environmental resources



Source: Ahmed Hassen (2004)

Thus the calculation of the total economic value of an environmental resource should contain all the above components of value. Since non use values are derived from motivations other than direct personal use, they are obviously less tangible than the use values. The estimated non use values can be quite large so ignoring either one or more components of the value will under estimate the total value of the resource or leads to resource misallocations (Tietenberg, 2003, p.37 and Freeman, 1999, p. 141)

2.1.3 Environmental valuation techniques

There are two broad valuation techniques: direct (stated preference) valuation techniques and indirect (revealed preference) valuation techniques.

2.1.3.1 Revealed preference methods (indirect valuation methods)

Hedonic pricing method (HPM)

The hedonic pricing method is an indirect valuation method that is used to estimate economic values for environmental services that directly affect market prices. It is most commonly applied to "*variations in housing prices that reflect the value of local environmental attributes. It can be used to estimate economic benefits or costs associated with environmental quality, including air pollution, water pollution, or noise*." (Letson et al., 2002, P. 39).

The hedonic price approach is based on the theory that value of a commodity is a bundle of valuable characteristics, one or more of which may be environmental. The basic premise of the hedonic pricing method is that the price of a marketed good is related to its characteristics, or the services it provides. "*It assumes that goods and services are defined by the attributes embodied in them, and the values of these goods and services are the sum of the values of the attributes which they contain.*" When goods or services contain an environmental characteristic, the market value of the environmental characteristic is 'embedded' in the market price of the good or service which contains the characteristic (Abila et. al, no date, p. 66).

The hedonic pricing method uses the prices of traded commodities to determine the value of environmental characteristics that are thought to affect the price of the item. The main disadvantage of this valuation method (HPM) it cannot be used to estimate non use values of an environmental resource. In this regard the method has limited importance.

Travel cost method (TCM)

Travel cost methods have been used extensively to estimate the value of recreation. Using these methods, researchers can calculate the economic costs necessary to reach a recreational site as an estimate of user willingness to pay for recreation. That economic cost may include entry fees, monetary costs of travel, and foregone earnings. In effect, these travel expenses represent the "price" of the recreational experience and are an indirect but observable indicator of user value. By comparing the number of visits that individuals make at different levels of travel cost, economists are able to estimate economic value for site attributes, such as improved environmental quality (Letson et. al, 2002, p. 45).

The travel cost method uses costs, such as travel costs, entrance fees and time, incurred in visiting a particular site for recreation or other purposes as a proxy of the value of that site for the purpose (Graves et. al, 2009, p. 34). The travel cost method (TCM) is used to estimate economic use values associated with ecosystems or sites that are used for recreation. The method involves using travel costs as a proxy for the price of visiting outdoor recreational sites. The basic premise of this method is that the time and travel cost expenses that people incur to visit a site represent the 'price' of access to the site. Thus, peoples' willingness to pay to visit the site can be estimated based on the number of trips that they make at different travel costs. This is analogous to estimating peoples' willingness to pay for a marketed good based on the quantity demanded at different prices (Abila et. al, no date, p. 62).

The main benefit of travel cost approaches is their reliance on observable market behavior. Individuals routinely spend their money and time to attend recreational sites, and easily obtained visitation records offer much of the data needed to deduce economic values. The main disadvantage of this method is it cannot be used to estimate non use values.

2.1.3.2 Stated preference methods (direct valuation methods)

Two main stated preference methods are the contingent valuation method (CVM) and the choice experiment method (CEM). Both methods depend on a hypothetical market which is presented to the respondent in a questionnaire. A main advantage of stated preference methods over the revealed preference method is that we can ask respondents for their WTP regardless of whether they make use of the hypothetical commodity or not. In other words we can obtain use and non-use values whereas the revealed preference method only addresses the use value of the resource (Abila et al., no date, p. 72). In the next section a detailed description of the two stated preference methods (CVM and CEM) is provided.

Contingent valuation method (CVM)

The contingent valuation method is the earliest technique of the stated preference method of non-market valuation approaches. The CVM involves asking people directly what they would be willing to pay or willing to accept compensation for change in preferences. This method is called contingent valuation because the valuation is contingent on the hypothetical scenario put to respondents. The contingent valuation method has two major advantages over the indirect valuation methods. First, CVM deals with both the use and non use values of the environmental resource while the indirect methods deal only with the use value. Second, survey responses to willingness to pay or willingness to accept hypothetical questions go directly to the monetary measures of utility change (Perman et al., 2003, p. 420).

The CVM has proven the most popular of the available methods for monetary valuation of the environment. According to Spash (2008, p. 4) this is because of the following three main reasons. The first thing is its simplicity. Secondly the application of CVM seems unlimited in the sense that questions could apparently be asked concerning the provision of any environmental goods and services. The last and obvious reason is the CVM deals with both the use and non use values of these environmental goods and services.

Main steps in CVM

The major steps involved in a CVM exercise are described below. The first step is the design of a survey instrument for the elicitations of individuals WTP/WTA. The instrument includes a detailed description of the good being valued and the hypothetical circumstance under which the good is made available to the respondent, i.e., designing the hypothetical scenario, deciding whether to ask respondents WTP or WTA questions and creating a scenario about the means of payment or compensation.

The next step is defining the population of interest and administering the survey instrument to a sample. Different methods of survey administration can be used such as telephone, face-to-face, ordinary mail and e-mail etc. The third step is analyzing the survey responses like estimating the average WTP/WTA for the population and assessing the survey result to ascertain the accuracy of these estimates. The fourth step of the CVM exercise is estimating and aggregating WTP/WTA for the population. Conducting sensitivity analysis is the final step (Perman et al., 2003, p. 421, Carson and Hanemann, 2005 p. 897-903 and Hanley et al., 1997, p. 384).

Elicitation formats and related biases in CVM analysis

The main value elicitation formats used in CV studies are briefly described below.

Open ended format- using this format respondents are simply asked to state their maximum WTP or minimum WTA for any proposed environmental change. A major problem associated with this elicitation format is it is exposed to strategic bias and loose answers or do not know answers. To deal with such problems economists proposed the following elicitation formats even if they are not also free of bias.

Payment card approach –in this format respondents are asked to choose WTP/WTA estimate or a range of estimates from a range of values shown to respondents on a card (Mitchell and Carson, 1981).

Bidding game format- in this format respondents are asked a series of questions whether they are willing to pay a certain amount say $X. If he/she refuses a proposed amount then another offer with lower value will be proposed for the respondent, lower than $X amount, and the procedure continues until the respondent says yes. The last amount can be taken as his/her maximum WTP. And if he/she accepts to pay the proposed amount then he/she will be asked to pay a larger value until he/she says no to the proposed WTP amount. Likewise the last offer will be taken as the maximum willingness to pay for the respondent (Carson and Hanemann, 2005, P. 870). In this elicitation format the starting point has a sizable influence on the final willingness to pay estimate. In this sense this format is exposed to starting point bias, i.e. if we start at inappropriate amount we will arrive at inappropriate WTP estimates.

Dichotomous or discrete choice format- respondents are asked simply whether he/she is WTP the assigned value for the environmental improvement. This format has yes or no responses. Compared to open ended this format provides limited information about the respondents WTP (Carson and Hanemann, 2005, p. 871). Hanemann, Loomis and Kanninen (1991) show the gain in efficiency of the double bounded dichotomous choice model over the single bounded elicitation format by asking respondents a second binary question based on the response of the first offer. If the first response is 'yes' the second bid is some amount higher than the first bid. In the same manner if the first response is 'no' the second bid will be some amount lower than the second bid.

Even though CVM is a good method in non market valuation for environmental goods, it suffers from potential biases. Of these biases the following can be mentioned:

A. Starting point bias - The starting point can influence the respondent's answer about WTP. For example if we start with inappropriate price (bid value) we may obtain inappropriate responses in the final bid. Most of the time this bias arises in the biding game because the value selected has an impact on the final bid. To overcome this problem the payment card approach is advised even if this one is also not free of bias (Gundimeda, no date, p. 12)
B. (Payment) Vehicle bias – this type of bias arises if the WTP/WTA varies depending on the mode of payment. The response of respondents on their WTP estimates may be different if the mode of payment available to them is different.

For instance if an individual is asked how much he/she is willing to pay for an environmental improvement, WTP may be different depending on the mode of payment which could be in the form of tax, labor hour, user fees etc. This difference in WTP dependent on the mode of payment is called (payment) vehicle bias.

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

D. Strategic bias – sometimes especially in the case of public goods respondents under estimate their WTP to free ride if they know that bids are actually going to be collected. Even if respondents know the intention of the analyst because of human behavior and to be free riders respondents may not give their true WTP. Referendum format may reduce strategic bias.

E. Compliance bias – this may happen when respondents decide not to fulfill the interest of the researcher, especially when they have been called upon frequently to answer questions without any benefit. They just provide responses which may be too low or too high which may actually affect the true value of the environmental resource. In order to minimize such kind of bias different incentive mechanisms have to be arranged for respondents.

Many other biases exist in CVM analyses which are not mentioned here. So, researchers have to give emphasis on the best way to minimize these biases by using different elicitation formats and by attempting to create a common understanding on the good or service going to be valued between respondents and the researcher.

Choice experiment method (CEM)

The pioneer of this method is said to be Lancaster (1966) and the econometric model used for analysis is mainly due to McFaden (1974). The basic idea of this method is individual consumers derive utility/satisfaction from goods through the attributes the goods provide. The CEM is based on the idea that any environmental good can be described in terms of its attributes and the levels it take. For example irrigation water can be described in terms of the quality of water, the stock of fish, the size of cropping/grazing land/and its aquatic species etc. Respondents are presented with various alternative descriptions of a good, differentiated by their attributes and levels and are asked to rank the various alternatives to choose their most preferred attribute (Hanley et al., 2001, p. 436).

Stages in choice experiment exercise

Any choice modeling exercise requires the following basic steps.

Table 2.1: Stages of a choice modeling exercise

Stages	***Description***
Selection of attributes	*Identification of relevant attributes of the good to be valued. Literature reviews and focus groups are used to select attributes that are relevant to people while expert consultations help to identify the attributes that will be impacted by the policy. A monetary cost is typically one of the attributes to allow the estimation of WTP.*
Assignment of levels	*The attribute level should be feasible, realistic, non-linearly spaced and span the range of respondents' preference maps. Focus groups, pilot survey, literature reviews and consultations with experts are instrumental in selecting appropriate attribute levels. A base line 'status quo' level is usually included.*
Choice of experimental design	*Statistical design theory is used to combine the levels of the attributes into a number of alternative scenarios or profiles to be presented to respondents.* *Complete factorial designs allow the estimation of the full effects of the attributes upon choices: that includes the effects of each of the individual attributes presented (main effects) and the extent to which behavior is connected with variations in the combination of different attributes offered (interactions). These designs often originate an impractically large number of combinations to be evaluated. For example 27 options would be generated by a full factorial design of 3 attributes with 3 levels each.* *Fractional factorial designs are able to reduce the number of scenario combinations presented with a concomitant loss in estimating power (i.e. some or all of the interactions will not be detected). For example, the 27 options can be reduced to 9 using a fractional factorial. These designs are available through specialized software.*

Construction of the choice sets	*The profiles identified by the experimental design are then grouped in to choice sets to be presented to respondents. Profiles can be presented individually, in pair or in groups. For example, the 9 options identified by the fractional factorial design can be grouped into 3 sets of four- way comparisons.*
Measurement of preferences	*Choice of a survey procedure to measure individual preferences: ratings, rankings or choices.*
Estimation procedures	*OLS regression or maximum likelihood estimation procedures (logit, probit, ordered logit, conditional logit, nested logit, panel data models etc). Variables that do not vary across alternatives have to be interacted with choice specific attributes.*

Source: Hanley et al., 2001, p. 437

Comparison of CEM and CVM

The following advantages of CEM over CVM can be mentioned:

- ✓ It is easier to estimate the value of the individual attributes that make up an environmental good because in the CVM the value of individual characteristics of the good will not be estimated. Estimation in CVM is made for the environmental good or services as a whole.
- ✓ CE provides the opportunity to identify marginal values of attributes that maybe difficult to identify using revealed preference data because of co-linearity or lack of variation.
- ✓ Because of this, CE may offer advantages over CVM in terms of benefits transfer, if environmental goods can indeed be decomposed into measurable attributes with money values which can be estimated; and if socioeconomic variable are included in the CE models used.

- ✓ CE also avoids the "yea-saying" problem of dichotomous choice design in CVM, since respondents are not faced with the stark "all or nothing" choice in that design of CV. They may choose one of two environmental alternatives, or the status quo, in each choice pair, of which they receive many. There are thus repeated opportunities for them to express their environmental preferences within a CE design
- ✓ The repeated sampling approach of CE allows for internal consistency tests in the sense that models can be fitted on sub-sets of the data (Hanley et al., 1998, p. 416; Alpizar et al., 2001, p. 4).

Note that disadvantages of the choice experiment method include its complexity in the experimental design of the data compared to the CVM and its difficulty in the selection of attributes and its levels (Hanley et al., 1998, p. 426).

2.2 Empirical literature review

2.2.1 Studies on valuation of irrigation water using CVM or CEM or both

Tsegabirhan W/Giorgis (1999) conducted a CVM study in Wikro, Tigray, Ethiopia for 82 randomly selected farmers using both OLS and ordered probit regression models. A contingent valuation method is used to elicit the valuation of small farmers' small scale irrigation schemes. The survey results are for the main irrigation seasons and the whole year, which depends on the 0.25 hectares of irrigable land. The average WTP for the main irrigation is birr 369 and for the supplementary irrigation is birr 217 which implies the average WTP for the whole year is birr 586. The variables identified in the study to determine WTP of the peasant are age, credit, education, experience with irrigation, total area cultivated, number of oxen owned by a house hold, family size, total revenue and quantity of fertilizers. The elicitation format used in the study is open ended elicitation approach which is vulnerable to different biases. The study also recommends the following variables to be included for further studies like existence of market outlets, agro-climatic factors and the type of irrigation technology used by framers this study includes some of the suggested variables for analysis.

Using a CVM study Jonse Bane (2005) tried to obtain the valuation of peasants for non agricultural uses of irrigation water using 260 randomly selected households in two peasant associations in Bure district of west Gojam, Ethiopia using probit and bivariate probit models. The study employed double-bounded referendum style elicitation format with open ended follow up questions. The study identified the following determinants of WTP: income, age, sex age, family size, irrigation water management, choices of water use rights, quantity of irrigation water consumption, distance from current sources (in meters), wealth, land tenure, Peasant Associations (Sites), quality of water, location and starting point bid. The study also finds that using double bounded value elicitation technique does not improve statistical efficiency over single bounded format. The study therefore used the single bounded elicitation format to calculate values of households' WTP for domestic uses of irrigation water.

Habtamu Tilahun (2009) employed CVM to analyze irrigation beneficiary households' willingness to pay for watershed management to value irrigation water to enhance agricultural productivity using 210 randomly selected household heads in the Koga Watershed of the Upper Blue Nile Basin in Ethiopia. The study also analyzed the magnitude and determinants of labor supply behavior of farm households for the routine management and maintenance of irrigation infrastructure in the Upper Blue Nile basin of Ethiopia. For the total irrigable land area it is estimated that households could contribute an estimated 468,784 person labor days per year and the aggregate expected WTP for the total of 7,000 hectares of irrigable land was 964,320 birr per year[3]. The logit model analysis based on single dichotomous elicitation format shows that households' willingness to contribute labor was influenced by education, age of the household head, expectations about yields in irrigated agriculture, wealth of the household, involvement in off-farm activities, time taken to walk to the nearest market, the household's dependency ratio and randomly assigned bid working days. The study proposes the following policy implication "Any plan for generation of financial resources from irrigation beneficiary households should also consider factors that influence the productivity of this system."

Sonia Akter (no date) applied a contingent valuation technique (CVM) to value the economic benefit of government managed small scale irrigation project (GMSSIP) in Bangladesh using single bounded closed ended WTP questions. The estimated WTP for use of irrigation water from government managed small scale irrigation project equals to Taka 1670 (US$ 23.85) per 0.25hectars of land per cropping season, which is 12 percent of the average agricultural income of households per cropping season. Furthermore, the logit study reveals that bid level, respondents' age, education, family size, number of income sources, ownership of farm land, management system of current irrigation scheme and decision to change cropping patterns if a government managed irrigation

[3] 1 US $ equal to birr 9.65

scheme is provided, have significant influence on farmers' WTP for GMSSIP. It may be difficult to find the maximum willingness to pay of respondents as the study restricted to close ended WTP questions only.

Karthikeyan et al. (2009) used contingent valuation method in the form of close ended questions to determine the factors contributing to WTP for irrigation water in south India in the dry and wet seasons. Logit model results reveal that the mean WTP of farmers for irrigation water was INR (Indian currency) 218./Ha/Year and family size, age of the respondent, educational level of the head of the household, family labour force, area under cultivation, and water requirement at farm level as the main determinants of farmers' WTP for irrigation water.

Using logistic regression Latinopoulos (2005) used contingent valuation method and hedonic pricing method (HPM) to determine the factors contributing to WTP for irrigation water in Greece agricultural areas. The study result shows the value of irrigation water, as estimated either directly or indirectly by water users, is low because it relates to its use component and ignores the non use value of water. The paper put the following concluding remark.

> *As a general rule, one can propose that properly designed water management policies that aim at environmental and economic goals should also take into account the social impacts to the main stakeholders, i.e. the farmers. Within this sense, the provision of water services can be best implemented by combining a water pricing structure that ensures equity at low price levels with a more strict*

and efficient administrative system that will safeguard the sustainability of water resources.

Using logistic regression model Bamidele et.al (2010) investigated factors influencing farmers' ability to pay for irrigation facilities by taking Oshin Irrigation scheme in Kwara state in Nigeria. The study used a one stage sampling procedure for selecting 60randemly farmers. The study is based on cross sectional farm data which was sourced mainly from primary source. The primary data sources comprised the use of well structured questionnaires to solicit response from farm household. The study result reveals that the age of farmers, the type of education acquired by the farmers, household income and the size of the farmers' household were revealed to determine farmers' ability to pay for irrigation facilities. The result indicates that farmers are able to pay a mean sum of N1077.64 (in Nigerian domestic currency) per hectare which is below the N1000 per hectare charged at the Oshin irrigation site. The main problem of this study is the study sample is too small and it does not explicitly put the elicitation format to survey farmers WTP for irrigation water service in Nigeria.

2.2.2 Studies on valuation of water using CVM or CEM or both

Using CVM Dunfa Lemessa (1998) examined respondents WTP for improved rural water supply in the Ada'a Liben district as a case study in Ethiopia based on data collected from 228 households. The ordered probit model result indicates the coefficients of income, time, and status of water quality; education and credit availability were positive and statistically significant. Whereas the coefficients of women, children, domestic animals, sex of the respondent and corrugated iron sheet roof house were statistically insignificant.

Using Probit and Tobit regression models Medhin Fissha (2006) conducted a CVM study in Addis Ababa for 250 randomly selected households. The study estimated WTP for sampled households for improved water supply services. Results of the study revealed that respondents' WTP is affected by a number of explanatory variables including sanitation facility, water related disease and socio –economic variables like income, age, sex, marital status, education level and family size of the respondent etc. Many of the variables had the expected sign and significance except the variables Years of stay in the area and marital status of the respondent have negative sign and are insignificant.
The mean WTP for private connection is found to be 0.2 birr per Baldi and 0.1579 birr per Baldi from closed ended and open-ended question respectively, which are well above the current subsidized tariff.

Fissiha Aberra (1997) used a CV survey to estimate households' willingness to pay for piped water supply using 266 respondents in Meki town, Ethiopia. This study revealed that more than 50% of the selected households are willing to pay almost twice the existing tariff rates for improved water services.

Using a CVM study Gossaye Fanta (2007) tried to obtain households WTP for improved water service in Debre Zeit town, Ethiopia based on 234 randomly selected sampled households from all kebeles of Debre Zeit town. The survey result shows that 99.57% of the survey respondents use pipe water. However, only 10.26% of the respondents were satisfied with the status quo level. Using dichotomous choice and open ended elicitation formats the study result reveals that mean willingness to pay for one bucket or for 20 liter of improved water service are 10.2367 and 12.4786 cents respectively. The total willingness to pay for one bucket or 20 liters of improved water services is 262,781.45 cents or Birr 2,627.82 per day or Birr 959,159.30 per year. The Probit and OLS econometric models show that age, household size, reliability dummy and the income variables influences households' willingness to pay for the improved water services in the Debre Zeit town. Except the existence of significance between the probit and OLS estimation results are more or less the same.

The study indicates all of the respondents were expressed their willingness to pay above the existing tariff structure and recommends the provision of improved water would increase the revenue of the study area.

Hala Abou-Ali (no date) used both CVM and CEM to analyse the impact of better water quality on health improvements in Cairo, Egypt. 1500 randomly sampled households in metropolitan Cairo were used to administer the survey. The valuation format used is dichotomous choice. The study result shows no considerable difference is found between the estimated values of the changes in health risk derived from both methods. However, it still could be concluded that households living in Metropolitan Cairo have positive WTP for reducing health risks owing to water quality.

Mahumani (2009) estimated the economic value of ground water by determining the utility value of ground water using contingent valuation method. The elicitation format used for contingent valuation of the ground water is open ended approach which is exposed to strategic bias and loose answers. The result of the study shows the overall mean WTP for satisfactory household ground water for the study area is R 2.28 (in domestic currency) per kiloliter of ground water.

Applying the Tobit and ordinary least squares (OLS) econometric models Ibrahim and Robert (2010) tried to measure the total economic value of domestic water in Ramallah, Palestine. The total number of sampled households in the study is about 525 and the elicitation format used to model WTP for respondents is dichotomous choice with follow up open ended questions. The study result shows the mean WTP for the total economic value of improved domestic water in Ramallah is about NIS 627(in domestic currency) per annum.

The results revealed that the variables age, water consumption, the use of water filters and income have significant impact on WTP. Water consumption has a negative effect on households WTP which is theoretically consistent while the other explanatory variables have a positive impact on WTP as expected. The variable gender, urban respondents, employment status, gainfully employed and education has positive but insignificant impact on WTP. This is inconsistent compared with results of many other studies.

We may note that water valuation studies conducted in Ethiopia are not on irrigation rather on the provision of potable water supply for urban people except a few. In this regard this research will have its own significant contribution on irrigation water.

CHAPTER THREE: DATA AND METHODOLOGY

As noted above, the study basically employed two standard valuation techniques for environmental resources, CVM and CEM, to estimate the benefit of Ribb Irrigation and Drainage project in South Gonder. The data and methodology used for this study are discussed in this chapter.

3.1 Data source and type

The data sources for this study were based on primary data collected from 300 randomly selected farm households in the command area, the area located behind the dam on each side of the Ribb River that should be irrigated by water. The sample survey is limited to only 300 farm house holds even though CVM studies require larger sample size due to large variance in the WTP response (Green and Tunstall, 1991). This is because of time and financial constraint.

The survey was administered using a face to face (in-person) interview. Based on their educational qualification and work experience six enumerators were selected and all of them were development agent workers in the command area. The survey is conducted for more than two weeks in April. Interviewers were supervised by the researcher. Before the main survey interviewers were trained carefully on how they approach the problem to the respondents, explain the whole scenario and the attributes and their levels to be used in the survey. A pilot study was made for one day by the interviewers. This pre test has a significant contribution in the modification of the final questionnaire.

3.1.1 Value elicitation format for CVM

Every elicitation format has its own advantages and disadvantages. For example an advantage of the open ended elicitation format, where respondents are asked to state their maximum WTP for the proposed environmental change, is that simple descriptive statistics can be used for analysis like mean, median, mode etc. However it is exposed to strategic bias[4]. The bidding game format suffers from starting point bias. The other two elicitation formats, the payment card and the dichotomous choice, also suffer from starting point bias.

In this study the single-bounded dichotomous choice approach with an open-ended follow-up question is applied. The main advantage of this elicitation format is to avoid strategic bias. In the single bounded dichotomous choice approach respondents will be asked a simple yes or no question for a given price set to determine their maximum willingness to pay for the particular environmental resource (Mitchell and Carson, 1989).

Studies like Jonse Bane(2005) used the double bounded CV elicitation format but the study also finds that double bounded value elicitation technique does not improve statistical efficiency over single bounded format. The study therefore used the single bounded elicitation format to calculate values of households' WTP for domestic uses of irrigation water. The study identified small sample as the main reason for the loss of efficiency of the double bounded elicitation format.

[4] Strategic bias occurs when respondents provide a response which is not his/her true WTP like to free ride.

The open ended elicitation format that followed from the discrete choice format helps to identify whether there is inconsistency between the closed ended elicitation and the maximum willingness to pay while at the same time it helps to correct starting point bias.

3.2 Econometric models for CVM

Given the binary nature of the data a probit model is used to estimate farm households' WTP for the provision of irrigation water.

The main objective of estimating econometric model in WTP survey is to calculate mean WTP and to allow inclusion of respondents' socio-economic factors into WTP functions. Incorporation of respondents' characteristics into the CV model helps the researcher to gain information on validity and reliability of the CV results (Habb and McConnell, 2002).

The basic model to analyze dichotomous responses based on the random utility theory is developed by Hanemann (1984). The central theme of this theory is that although the individual knows his/her utility certainly, it has some components which are unobservable from the view of the researcher. As a result, the researcher can only make probability statement about respondent's 'yes' or 'no' responses to the proposed scenario. The indirect utility for the jth respondent can be specified as follows

$$U_{ij}=U_i(y_j,X_j,\varepsilon_{ij})$$

Where Y_j = jth respondent's income

i =1 denotes the final state and i =0 the status quo (or the initial state)

X_j = vector of household characteristics and attributes of a given choice

ε_{ij} = random component of the given indirect utility

If a payment (also called the bid value, β_i^*) is introduced due to changes in measurable attributes like quality or quantity of environmental goods, the consumer accepts the proposed bid if and only if $U_{1j}(Y_j - \beta_i^*, X_j, \varepsilon_{1j}) > U_{0j}(Y_j, X_j, \varepsilon_{0j})$

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

$$P(yes) = [U_{1j}(Y_j - \beta_i^*, X_j, \varepsilon_{1j}) > U_{0j}(Y_j, X_j, \varepsilon_{0j})]$$

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

$U_{ij} = U_i(y_j, X_j) + \varepsilon_{ij}$ Given the additive specification of the utility function the probability statement for respondent j becomes:

$$P(yes) = [U_{1j}(Y_j - \beta_i^*, X_j) + \varepsilon_{1j} > U_{0j}(Y_j, X_j) + \varepsilon_{0j}]$$

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

The probit model now can be defined as:

$$Y_i^* = \beta' X_i + \varepsilon_i$$

Where

- β' is vector of parameters of the model

- X_i is vector of explanatory variables

- ε_i (the error term) and is assumed to have random normal distribution with mean zero and common variance δ^2 (Greene, 2003).

- Y_i^*=unobservable households' actual WTP for the provision of irrigation water supply. Y_i^* is simply a latent variable. What we observe is a dummy variable WTP_i, which is defined as:

$$Y_i = WTP_i = 1 - if, Y_i^* \geq \beta_i^*$$

$$Y_i = WTP_i = 0 - if, Y_i^* < \beta_i^*$$

In the single bounded elicitation format the j[th] respondent is asked if he/she is willing to pay the proposed bid value, to get say a given improvement in environmental quality, quantity or both.

Thus, for example, the probability that a household is willing to pay to assure the sustainability of a year-round irrigation water supply is given by:

$$\Pr(Y_i = 1/X_i) = \Pr(Y_i^* \geq \beta_i^* / X_i)$$

$$= \Pr(X_i\beta' + \varepsilon_i \geq \beta_i^* / X_i)$$

$$= \Pr(\varepsilon_i \geq -X_i\beta' + \beta_i^* / X_i)$$

If we assume the distribution is symmetric

$$\Pr(Y_i=1/X_i)=\Pr(\varepsilon_i \geq -X_i\beta' + \beta_i^* / X_i)$$

$= F(X_i, \beta')$ Where F is a cumulative distribution function (Cdf). Depending on the assumption on the distribution of the error term we can estimate the probability either using logit or probit model. In this case the main assumption is the error has mean zero and constant variance δ^2 to have a probit model (Greene, 2003).

Note that the probability that the household is not willing to pay for the proposed bid is given by: $\Pr(Y_i=0/X_i)=\Pr(Y_i^* < \beta_i^* / X_i) = 1-\Pr(Y_i=1/X_i)=1-F(X_i, \beta')$

The standard approach to estimating binary choice models according to Greene (2003) is the MLE (maximum likelihood estimation).

The resulting log-likelihood function for the responses to a CV survey using the single–bounded format for a sample of n observations is.

$$\ln L(Y,X,\beta)=\sum_{i=1}^{n} \{y_i \ln F(X_i'\beta)+(1-y_i)\ln[1-F(X_i'\beta)]\}$$

Or $\ln L(y,x,\beta)=\sum_{i=1}^{n} \{y_i \ln P_i+(1-y_i)\ln(1-P_i)\}$

Where: P_i is the probability of the respondents to choose the environmental improvement and $(1-P_i)$ is the respondents' probability of choosing no for the proposed bid.

Where $y_i=1$ if the i^th^ response is yes and zero otherwise.

Based on the above justification, we specify the probit model for households' preferences for the irrigation water services as follows:

$$WTP_i = \beta_0 + \beta_1 BIDV + \beta_2 EDU + \beta_3 AGE + \beta_4 EXP + \beta_5 NOX + \beta_6 FHHS + \beta_7 INC + \beta_8 LANDSize + \beta_9 CIS + \beta_{10} OFA + \beta_{11} MARK + \beta_{12} DR + \beta_{13} CR + \beta_{14} HHS + \beta_{15} FERT + \beta_{16} LANDC + \varepsilon_i$$

Where WTP is response to the bid price =1 if the response is yes, = 0 if the response is no, β_i is regression parameters, ε_i is the error term and the explanatory variables will be defined under the variable description sections (3.6) latter. The regression parameters will be estimated by Maximum likelihood technique.

One of the main objectives of estimating empirical WTP model based on the CV survey response is to derive mean of the WTP distribution (Hanemann, Loomis and Kanninen, 1991).

Mean WTP (μ) using the model for the single–bounded probit model format is defined as follows $\mu = \frac{-\alpha}{\beta}$ (Carlsson, no date, P.29)

Where α = is the intercept (constant) term and

β= is the coefficient of the bid proposed to the respondent

An alternative method of estimation the mean WTP (μ) where there are socio economic characteristics of the respondent is included for close ended format is defined as

$$\mu = \frac{-[\alpha + \sum_{i=1}^{m} \beta_i \mu_i]}{\beta}$$ where β_i-are the coefficient of the i^{th} explanatory variable

μ_i - are the mean of the i^{th} explanatory variable. α = is the intercept (constant) term and β= is the coefficient of the bid proposed to the respondent

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

$$\text{Mean } WTP = \sum_{i=1}^{n} \frac{y_i}{n}$$

Where n is the sample size and each y is reported willingness to pay amount by surveyed households (Habb and McConnell, 2002, p.128).

3.3 Design of the choice experiment

The modeling of a choice exercise passes different steps starting from the focus group discussions, identification of relevant attribute and levels to the estimation procedures. The major steps involved in the design of the choice experiment are defining attribute and attribute levels, experimental design and development of the questionnaire. In the following sections a brief discussion of these steps is provided.

3.3.1 Defining attributes and levels

To select the relevant attributes and levels that will be included in a choice set requires discussion with informed groups. The task of this discussion is to determine the number of relevant attributes and levels included in the choice set. The selection of attributes is made based on their policy relevance and their effect on the choice of respondents. In consultation with development agents, experts from agricultural and rural office in the area and by reviewing different previous studies the following three attributes are identified: irrigation water availability, fish abundance, and productivity in addition to a monetary attribute. The selected attributes and their levels for this study are reported in the following table.

Table 3.1: Description of attributes and their levels for irrigation water provision

Attributes	Description	Levels
Irrigation water availability	The irrigation water availability in the command area allows improved cropping in the dry season. In addition to this the irrigation water availability improves wet season agriculture and provides other different purpose for farmers like, livestock watering, drinking water, washing, bathing etc. The availability of irrigation water also has the advantage of bringing agricultural yield stability by providing stable yield from one year to another. So irrigation dam helps for farmers to produce crops in all seasons of the year.	A. **one crop season** B. two crop seasons C. three crop seasons D. all four seasons
Migratory fish(catfish and tilapia fish) abundance	As a result of channelization of the main river Ribb different fish species like cat fish and tilapia fish in the area (behind the dam) will be lost. In addition to this because of the change in the hydrology of wet lands and the reduced flooded area the stock of migratory fish species will decline. The program will improve the condition and abundance of migratory fish in the area by initiating wetland restoration and conservation projects, supporting kebeles fishery management programs, re-draw project boundaries to exclude the two main wetlands (*shesher and welela*) in the area and by ensuring the drainage structure which allows fish pass.	A. **low** B. medium C. high
Productivity	Average production harvested per 0.25ha from planting a particular crop type like rice.	A.**700 Kg** B .1400 Kg C.2000 Kg D. 2800 Kg
Annual payment in birr	The amount of money collected from each household respondents per 0.25ha of land(a proxy for WTP for the provision of irrigation water)	A. **0 birr** currently B. 100 birr C. 300 birr D. 600 birr

Note: the bold levels indicate the base line (status quo) level

3.3.2 Experimental design

Once attributes and levels have been determined, experimental design procedures are used to construct the choice sets that will be presented to the respondents. The most common approach in economic applications has been to use orthogonal design, in which the levels of the attributes of the different alternatives are uncorrelated in the choice sets. In this survey we have 4 attributes one attribute with three levels and the remaining with four levels each. These attributes with their respective levels result in a full factorial design 192 combinations $(4^3 * 3)$ which is large.

But literatures show when the choice set designed using the full factorial design are too large there will be tradeoff between the quality of response and the complexity of the choice sets. In the case of our survey the primary respondents are farmers and it is difficult for them to compare different sets. In other words, our respondents will not carry out a large number of choices. In order to solve this problem the literature suggests the use of fractional factorial design. The choice sets are constructed based on the OPTEX procedure of SAS. After reducing the number of combinations either by reducing identical combinations or by reducing combinations that looked similar 6 choice sets are identified. A sample choice set is attached in the following table:

Table 3.2 Sample choice set

Attributes	**Plan 1**	**Plan 2**	**Status quo**
Migratory fish abundance	High	Medium	Low
Irrigation water availability	Three crop seasons	Four crop seasons	one crop season
Productivity	1400 kg	2800 kg	700 Kg
Annual payment in birr	600 birr	100 birr	0 birr currently
Please tick(√) only one			

3.3.3 Questionnaire development

The questionnaire consisted of four parts. The first part of the questionnaire consists of the socio-economic characteristics of household respondents. In this section of the questionnaire information regarding the socio-economic characteristics (age, education, occupation, sex, income, and other wealth indicators etc...) is collected.

The second section of the questionnaire seeks to generate data on households' actual experience on credit access, land certification; fertilizer used and market access to their agricultural products. The third section is on contingent valuation (CV) which included the scenario for the respondent and question on household's willingness to pay for year round irrigation water. The single bounded elicitation format with an open ended follow up question was used.

The final sections of the questionnaire are the choice experiment and follow up questions or debriefing questions. The follow up questions are targeted to identify irregularity of responses such as protests. The follow up questions also help to check if a respondent faced some problems while choosing alternatives in the choice set like: confusion, ability to understand the questions etc. The full questionnaire is attached in the appendix.

3.4 Econometric models for CEM

3.4.1 Multinomial logit model

The choice experiment model is based on the works of Lancaster (1966) on model of consumer choice and the econometric model is based on random utility theory (McFadden, 1974). The basic idea of this method is individual consumers derive utility/satisfaction not from the goods themselves but from the attributes they provide. In the random utility theory, the utility of an alternative i for an individual t (U_{it}) is assumed to depend on environmental attributes of alternative (Z_i) and the socio-economic characteristics of the individual (S_t).We assumes that there is a function containing attributes of alternatives and characteristics of individuals that describes an individual's utility valuation for each alternative given by:

$$U_{it}=V(Z_i,S_t)+\varepsilon_{it}$$

$$U_{it}=V_{it}+\varepsilon_{it} \quad \text{......} \quad 1$$

Where U_{it} - is the true utility of alternative i for the individual t.

V_{it} - is the vector of deterministic or observable portion of the utility that an individual t has from choosing an alternative i and

ε_{it} - is the vector of random or unobservable portion of the utility an individual t has for alternative i (Adamowicz and Boxall, 2001).

In this model the probability that a particular respondent prefers option i in the choice set to any alternative option j, can be expressed as the probability that the utility associated with option i exceeds those associated with all other options. This can be given as

$$prob(i/c)=prob\{U_{it}>U_{jt}\} \text{ For all } i, j \in C, i \neq j$$

$$prob(i/c)=prob\{V_{it}+\varepsilon_{it}>V_{jt}+\varepsilon_{jt}\} \text{ For all } i, j \in C, i \neq j \quad \text{......} \quad 2$$

In words the probability of a particular respondent selecting alternative i from the choice set C is equal to the probability that the systematic and random components of alternative i for the individual t are greater than the systematic and random components of option j for individual t in the choice set C (Nam DO and Bennett, 2007).

To estimate the choice probabilities we use assumptions on the distribution of the error terms. To estimate the model using multinomial logit model (MNL) the basic assumption on the distribution of the error term is that the error terms has extreme value (Gumbel) distribution and the error components are independently and identically distributed across individuals and alternatives (McFadden, 1974).

Hence the probability of choosing alternative i (i= 1, 2, 3...J) from a set of J alternatives chosen by individual t is given as:

$$Prob(i/j) = \frac{\exp V_i}{\sum_{j \in C} \exp V_j}, V_i \neq V_j; j \in C \ldots\ldots\ldots\ldots\ldots\ldots\ldots 3$$

Here V_i and V_j are the indirect utility functions assumed to be linear in parameters (Hensher et al., 2007.P. 340).

There are three main properties of the multinomial logit model (MNL). The first one is ***the equivalent differences property (EDP)*** which means the choice probabilities of the alternatives depend only on the differences in the systematic utilities of different alternatives and not their actual values. This means that the choice probability equations are unchanged if the same incremental value of say ΔV is added to the utility of each alternative.

The second property is ***the sigmoid or s-shaped property*** which limits the probability range between 0 (when the utility of the alternative is very low, relative to other alternatives) and 1 (when the utility of the alternative is very high relative to other utilities). And, the third is ***independence of irrelevant alternatives (IIA)*** which means that for any respondent the ratio of probabilities of choosing two alternatives is independent of the attributes of any other alternative (McFadden, 1974).

The general estimation model of the indirect utility function can be expressed as:

$$V_{it} = ASC_i + \beta_1 Z_1 + \beta_2 Z_2 + ... + \beta_n Z_n + \gamma_1 S_1 + \gamma_2 S_2 + ... + \gamma_m S_m \text{..................} 4$$

Where n is the number of attributes considered and m is the number of social and economic characteristics of the respondent. ASC_i is the alternative specific constant for option i which captures the effects on utility of any attributes not included in choice specific attributes. The vectors of coefficients β_1 to β_n and γ_1 to γ_m be attached to the vector of attributes (Z) and vector of socio-economic characteristics of the respondents (S) that affect utility respectively (Birol et al., 2006).

The basic model

In the MNL model two models were estimated. The first model includes only attributes to determine preference of respondents for the three plans[5]. The second model incorporates in addition to attributes the socioeconomic characteristics of respondents. The choice experiment was designed with the assumption that the observable utility function would follow a strictly additive form. For each plan there is a utility function specified as a function of the attributes (eqn 5). The first indirect utility function is the utility associated with the current situation and the other two equations will be from the two improvement plans for irrigation water.

Model 1

$$V_i = ASC + \alpha_1 fish + \alpha_2 irrw + \alpha_3 prod + \alpha_4 payment \text{.................} 5$$

[5] The plans were discussed in the experimental design (section 3.5.2)

For i =1, 2, 3 and where ASC =0 for the status quo and 1 for alternative1 and alternative 2 and the $\alpha's$ are coefficients of the attributes. The alternative specific constants for option/plan 1 and 2 (improvements options) is constrained to be equal (Bennett et al., 2001) fish, irrw, prod and payment are the identified attributes (fish abundance, irrigation water availability, productivity and annul payment) respectively. Because a generic format and an experimental design that was close to orthogonal were used to develop the choice sets and hence we included one common alternative specific intercept for the two alternatives that imply changes.

Model 2: extended MNL model

This model is an extension of model one and it includes socio-economic variables interacted with the alternative specific constant to incorporate observed heterogeneity of respondents in to the analysis. The model is specified as follows.

$$V_i = ASC + \alpha_1 fish + \alpha_2 irrw + \alpha_3 prod + \alpha_4 payment + \gamma_1 (ASC * HHS) + \gamma_2 (ASC * EDU) + \gamma_3 (ASC * INC) + \gamma_4 (ASC * AGE) + \gamma_5 (ASC * SEX) \quad \text{.................6}$$

For i =1, 2, 3 and where ASC =0 for the status quo and 1 for alternative1 and alternative 2 and the α's are coefficients of the attributes and $\gamma's$ are coefficients of interacted socioeconomic characteristics of respondents. The need for interaction of socioeconomic characteristics of respondents is required because if they are used as an independent variable in the model 'hessian singularities' arise as they do not vary across alternatives (Bennett et al., 2001). So they need to be interacted either with ASC or the attributes. But in the later case multicollinearity among explanatory variables may arise. Thus, in this study they are interacted with ASC.

3.4.2 Random parameter logit model (RPL)

One of the basic assumptions/property of MNL model is the IIA. This assumption has its own advantages and disadvantages. The advantage of this assumption is it simplifies the estimation of the parameters of MNL. The disadvantage of IIA assumption is it may not properly reflect the behavioral relationships among groups of alternatives. This may result in erroneous predictions of choice probabilities. So if the IIA assumption is violated the results of MNL model will be biased.

To avoid the problem associated with the MNL model. More complex statistical models that relax these assumptions are necessary. This includes the multinomial probit model, the nested logit model and the random parameter logit model (Alpizar et al., 2001). The main advantages of RPL model: First, RPL is not subjected to the IIA assumption. Second, it accommodates correlations among panel observations. Thirdly, the procedure explicitly incorporates and accounts for heterogeneity in tastes across respondents by allowing the model parameters to vary randomly over individuals (Adamowicz and Boxall, 2001).

The random utility functions for the random parameter logit models take the following form:

$$U_{it} = V_{it} + \varepsilon_{it} = Z_i(B + \eta_t) + \varepsilon_{it} \text{..........................} 7$$

Where U_{it} is the total utility for respondent t from choosing alternative i in the choice set

It is assumed that the utility function consists of both systematic components (V_{it}) and stochastic component (ε_{it}). The indirect utility is assumed to be a function of the choice attributes Z with parameters B (and socioeconomic and environmental attitudinal variables, if included in the model), which due to preference heterogeneity may vary across respondents by a random component η_t.

The probability that an individual t chooses alternative i from each choice set is then presented as:

$$P_{it} = \frac{e^{Z_{it}(B+\eta_t)}}{\sum e^{Z_{jt}(B+\eta_t)}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 8$$

3.5. Part worth (implicit price) or marginal willingness to pay

The β coefficients estimated in the MNL model can be used to estimate the rate at which respondents are willing to trade-off one attribute for another. This trade off is known as the part worth, which represents the marginal rate of substitution between the monetary attribute and the non marketed environmental attribute and it is determined by using the following formula (Nam DO and Bennett, 2007).

$$part-worth = -\frac{\beta_{\text{Non- marketed attribute}}}{\beta_{\text{Monetary attribute}}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 9$$

The calculation of part worth is also used to determine the marginal rate of substitution between attributes both monetary and non monetary attributes. For instance if we divide the coefficient of one non marketed attribute with another non marketed attribute it shows how respondents are willing to sacrifice one attribute to accept one more unit of the other attribute. Based on this trade off made by respondents we can determine the relative importance of attributes for policy purpose and resource allocation.

Compensating surplus welfare measures can be obtained for different irrigation water scenarios associated with multiple changes in attributes as follows (Birol et al., 2006).

$$CS = \frac{-(V_0 - V_1)}{\beta_{monetary attribute}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots 10$$

Where CS= compensating surplus, V_0 = the indirect utility from the status quo, V_1 =the indirect utility from the improvements and $\beta_{\text{monetary attribute}}$ the coefficient of the monetary attribute from the MNL model.

3.6 Definition of variables and their expected signs

ASC (alternative specific constant) - taking the value of one for plans/alternatives one and two and a value of zero for the status quo option (plan3).

Irrigation water availability – the level of irrigation water made available for farmers in the command area that helps farmers to produce crops in different seasons of the year.

Migratory fish (catfish and tilapia fish) abundance –this is the level of cat fish and tilapia fish to be enhanced by the program intervention.

Productivity – Average production harvested per 0.25ha from planting a particular crop type like rice.

Annual payment in birr - The amount of money collected from each household respondent per 0.25ha of land. The sign of the attributes except the monetary attribute is positive

EDU (house hold level of education)-the hypothesis here is respondents with higher education are more aware of the benefit of irrigation water supply. So a positive relationship is expected between the level of respondents' education and their willingness to pay for environmental improvements. A dummy variable 1 is specified for those who attended formal education and 0 otherwise.

BIDV (bid value) - This is a randomly assigned price (in birr) for irrigation beneficiary households potentially reflecting a household's maximum willingness to pay to get year round irrigation water per 0.25 ha of irrigable land. In this study 7(seven) prices were identified in the focus group discussion which were **50,100,200,300,400,500,600**. As theory suggests bid value and willingness to pay has a negative relationship if the good or service going to be valued is a normal good.

EXP (farmers practical irrigation experience) - Practical irrigation farming experience of a household is an essential element in the valuation of irrigation water. It is hypothesized that those households who have longer experience (in years) are more likely to realize the benefits of irrigation farming and hence are likely to value irrigation water provision highly.

OX (the number of oxen) - the number of oxen a particular farmer holds are one measure of wealth in the area. Thus it is expected that farmers with more oxen will value irrigation water more.

INC (farm + off-farm income) - this is the average income of the respondent; both farm and off-farm income measured in thousands of birr per year. Economic theory shows for normal goods and services the income of the individual and the quantity demanded have a positive relationship. Therefore as income increases the probability of farmers willing to pay for sustainable irrigation water supply will be high if irrigation water is a normal good.

Landsize (area of land a household possesses) - this is the size of potentially irrigable land a particular respondent possesses measured in *hectares*. An increase in the size of land a household possesses has a positive effect on farmer's willingness to pay by providing an opportunity to generate cash either from land rent or the sale of crops.

CIS (number of corrugated iron sheet used for roof work) - is measured by the number of corrugated iron sheet used in making the roof. A positive effect is expected because farm households having a home with corrugated iron sheet is one measure of wealth in the command area.

OFA (off- farm activities) –this is a dummy variable OFA=1 if the respondent participates in off farm business and 0 otherwise. Participation of households in off-farm activities may have different effects depending on their returns. If households believe that irrigation agriculture has a lower expected return than the off-farm business, they may not place a high value on the sustainability of irrigation agriculture.

MARK (respondents market access) - Access to markets is measured as the time required walking to the nearest market. As the time to travel to gain market access increases, this may decrease the probability that a household would be willing to pay for a sustainable irrigation water supply. So a negative relationship is expected.

DR (dependency ratio) – This is the ratio of dependent household members to the number of economically active family members. This variable is expected to have a negative effect on farmers' willingness to pay.

LANDC (land certification) – this is a dummy variable 1 if the respondent has land certificate and 0 otherwise. Land certificate has a positive effect on farmers willingness to pay for irrigation water this is because if the respondent has the right to use the land without any reduction in its size he/she will invest in the land to increase its productivity hence they will be more willing to pay for irrigation water.

FHHs (female headed households) – This is a dummy variable where 1= the presence of a female-headed household, and 0 otherwise. The assumption is female headed households more often have access to different packages of agricultural training relative to their small number in the study area. This may contribute toward a positive attitude towards the sustainability of irrigation agriculture.

CR (credit availability) – is the amount of credit obtained from formal institutions in the preceding year. Access to credit creates an opportunity for farm households to invest on new technology that enhances productivity. One of these is irrigation water hence a positive relationship between credit availability and willingness to pay for irrigation water is expected.

HHS (household size) - this is the family size measured as the total number of people in the respondent's household. A negative relationship is expected between family size and the probability of choosing an improved environment due to the fact that households' expenditure for consumption will be high.

FERT (fertilizer used) - this is the quantity of fertilizer used in kilograms during the preceding crop year. A positive relationship is expected because fertilizer is expected to increase agricultural yield.

Age (age of the respondent) - this variable is households age measured in years. A positive relationship is expected between household respondents' age and environmental improvement.

CHAPTER FOUR: ANALYSIS OF THE SURVEY DATA

This section of the study addresses the following main issues: The first section provides descriptive statistics of the socio-economic survey results. The second section presents multivariate analysis and discussion of the CVM data. The final section of the chapter presents analysis and discussion of from the choice experiment data.

4.1 Descriptive analyses of the survey data

4.1.1 Socio-economic characteristics of the surveyed households

This study is conducted based on a sample of 300 farm household respondents in the command area. The mean household size of respondents was 5 with a minimum of 1 and a maximum of 11. The average household size for willing and non willing households is 4.91 and 4.31 respectively. The average dependency ratios for willing and non willing households were about 0.89 and 0.97 respectively. This means in each household member on average there is one economically inactive individual dependent on an economically active member of the family.

As shown in Table 4.1 out of the total respondents 255 (85%) were engaged in fishing activity. There is no significant difference between willing and non willing households. The data on age tells a wide range of responses starting from 17 to 90 years and the average is found to be 40.94 years. The respective average age for willing and non-willing households is 40.9 and 41.42 years. The age difference is not significant.

Of the sample of 300 respondents 93.67% were found to be willing to pay the proposed bid price for the supply of year round irrigation water for irrigation agriculture and other purposes, the remaining 6.33% not accepting the proposed bid price(see Table 4.1)

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

N=300					Willing N=281			Non willing N =19			Mean diff
Variable .	Mean	Std. Dev.	Min	Max	mean	min	max	mean	min	max	t-test
fishing	0.85	0.35	0	1	0.86	0	1	0.73	0	1	-1.54
Age	40.94	15.09	17	90	40.9	17	85	41.42	20	90	0.14
Fhhs	0.067	0.25	0	1	0.05	0	1	0.21	0	1	2.62
Hhs	4.877	2.12	1	11	4.91	1	11	4.31	1	10	-1.19
Dr	0.905	0.72	0	5	0.89	0	5	0.97	0	2.5	0.43
edu	0.443	0.49	0	1	0.45	0	1	0.26	0	1	-1.64
nox	1.69	1.02	0	8	1.72	0	8	1.15	0	3	-2.37
cis	39.767	23.76	0	144	40.63	0	144	26.94	0	76	-2.45
ofa	0.057	0.23	0	1	0.05	0	1	0.105	0	1	0.95
inc	31349.04	16510.14	7295	120000	32143.88	7623	120000	19593.74	7295	41215	-3.25
cr	786.587	1258.83	0	4800	783.188	0	4800	836.84	0	3500	0.18
fert	15.07	31.33	0	250	15.55	0	250	7.89	0	50	-1.03
mark	1.34	0.81	.14	5	1.33	0.14	5	1.413	0.15	2.5	0.43
landc	0.813	0.39	0	1	0.82	0	1	0.68	0	1	-1.49
landsize	1.058	0.62	0	3	1.07	0	3	0.84	0	2	-1.57
exp	4.236	3.87	0	25	4.38	0	25	2.1	0	10	-2.49
bidv	306.8	190.35	50	600	304.09	50	600	347.36	100	600	0.95
mwtp	419.65	295.41	40	2000	435.83	50	2000	180.26	40	500	-3.73

Source: Computed from the survey data

Note: diff= mean (non wiling) –mean (willing), H0: diff=0 HA: diff> <=0

Of the total number of household heads, only about 20(6.7%) were female while the remaining 93.3% were male headed households. The respective averages for willing and non willing female headed households are 14.5(5%) and 3.99 (21%) and the group difference is found to be significant.

The average educational attainment of household respondents was 1.21 years with the minimum educational achievement 0 years and the maximum achievement was 10 years. Out of the total number of household respondents 132(44%) are attending formal education. The group comparison in terms of education between those willing to accept the proposed bid price and refused to accept the proposed bid price shows the mean educational attainment for willing and non willing households is 1.95 and 1.21 years respectively. Out of 281 households willing to pay the proposed bid price in the closed ended question 126 (44%) were attending formal education while from those who are not willing to pay for the supply of irrigation water 26% were attending formal education.

The observed average household yearly income is birr 31,349.04. The income level ranges from a minimum of birr 7,295 to a maximum of birr 120,000 per month. Income was found to be significantly different between willing and non-willing respondents 32,143.88 and 19,593.74 respectively.

The survey data also shows 5.7% of the households are engaged in off farm activity to earn additional income. It was also noted 5% and 10% of the willing and non wiling households were engaged in off arm activity to enhance their income.

The total number of oxen owned by the sampled households constitutes 507 with an average of 1.69 heads of oxen per household. The average number of oxen possessed was about 1.72 and 1.15 for willing and non willing households respectively and the difference is statistically significant. The minimum ownership of oxen is zero while the maximum is eight. The average number of corrugated iron sheet used to make the roof is reported about 39.76. For willing and non willing households the average number of corrugated iron sheet used was about 40.63 and 26.94 respectively and the difference is statistically significant.

The survey result also shows the average quantity of fertilizer used in last crop year was about 15.07 Kilograms per household with a minimum of zero and a maximum of 250 kilograms respectively. The average fertilizer application between willing and non willing households was 15.5 and 7.89 kilograms respectively.

The average credit households obtained from formal lending institutions in the previous crop season is about birr 786.5. The respective averages for willing and non willing households was found to be birr 836.84 and 783.18 respectively. The credit levels range from 0 birr to 4800 in the last year crop season.

The mean land holdings by household respondents were 1.058 hectare. The land holding ranges from a minimum of zero hectares to a maximum of three hectares.

We also find that young households are equally willing to pay for the supply of irrigation water by the irrigation water users association. But practical irrigation farming experience significantly varies between willing and non willing households, with average years of experience 4.38 and 2.1 respectively. This suggests experience contributes to willingness to pay for the supply of irrigation water.

The average maximum willingness to pay for the total sampled households was about 419.65 birr per year. The maximum willingness to pay ranges from 40 birr to 2000 birr. The mean difference is significant between the willing and non willing households (based on the closed ended value elicitation questions) and it was about 435.8 birr and 180.26 respectively. One of the reasons for the use of open ended follow up question is to check the inconsistencies and to check starting point bias. These were checked using the null hypothesis that the mean difference is zero which was rejected as it is insignificant at 5% level of significance in the two groups. The result would imply no starting point bias in the initial bid prices.

4.2 Multivariate Analysis of Determinants of Households' WTP

In addition to the descriptive analysis, econometric analysis is used to present the major determinants of willingness to pay responses and determine the mean willingness to pay of household respondents. The heteroscedastic probit model is estimated to identify those factors that determine households' willingness to pay for the supply of year round irrigation water.

4.2.1 The probit model estimation results

Prior to the estimation of the conventional probit model the existence of heteroscedasticity is checked since it is an important statistical problem to deal with in estimation. One way of dealing with this is checking whether each explanatory variable is responsible for the existence of heteroscedasticity or not. The probit model face these problem because the likelihood ratio test shows for instance female headed households (fhhs) are responsible for the rise/fall in the error variance (see appendix 2). Then to correct the heteroscedasticity problem we estimate the robust standard errors.

The study also tests the joint significance of explanatory variables by using Wald test. The Wald test rejects the null hypotheses of all slope coefficients are equal to zero. The Wald test which takes a chi-squared ($\chi2$) distribution with 16 degrees of freedom (df) is about *51.6*. From $\chi2$ distribution table with 16 df the critical value is 7.96 at 5% level of significance. The null hypothesis of all slope coefficients of explanatory variable except the intercept are equal to zero is rejected (see Table 4.2 below). So the model has some explanatory power.

The other problem in econometric analysis is the existence of multicollinearity among explanatory variables which lead to imprecise coefficient estimates. To check for the existence of multicollinearity among explanatory variables the VIF is calculated (see appendix 3). The VIF is found less than 3 and the variables responsible for the existence of multicollinearity are land size, nox , inc, hhs, cis and age since their VIF is above the mean variance inflation factor (Zerayhu, 2011). But in this study even if there is multicollinearity it is not a severe problem because of the existence of small variance inflation factor.

Table 4.2: Probit model estimation results of households' WTP for irrigation water (with robust standard errors)

wtpi	Coef.	Robust Std. Err.	z	P>z	[95% Conf. Interval]	
bidv	-.003***	0.001	-3.02	0.003	-0.004	-0.0009
edu	0.34	0.29	1.17	0.243	-0.23	0.9128
age	-0.01	0.01	-0.72	0.474	-0.028	0.0132
exp	0.16***	0.047	3.26	0.001	0.062	0.2489
nox	0.07	0.154	0.43	0.668	-0.235	0.3669
inc	0.0001***	0.00002	2.76	0.006	0.00001	0.0000
landsize	0.11	0.29	0.37	0.714	-0.47	0.6933
cis	0.006	0.007	0.86	0.392	-0.008	0.0198
ofa	-0.98**	0.485	-2.02	0.044	-1.93	-0.026
mark	-0.28**	0.12	-2.30	0.021	-0.51	-0.041
dr	-0.06	0.169	-0.33	0.742	-0.39	0.2764
cr	0.0001	0.0001	0.66	0.511	-0.0006	0.0002
hhs	-0.08	0.094	-0.82	0.410	-0.26	0.1064
fert	-0.001	0.004	-0.28	0.783	-0.009	0.0070
landc	0.34	0.35	0.96	0.337	-0.35	1.0307
fhhs	-0.49	0.45	-1.10	0.272	-1.37	0.3879
_cons	1.14	0.53	2.15	0.031	0.103	2.1746

Number of observations	*300*
Log pseudo likelihood	*-51.0*
Wald chi2(16)	*51.6*
Pseudo R2	*0.28*
Prob > chi2	*0.00*

*** And ** indicate significant level at 1%, and 5% respectively

The heteroscedastic probit model more or less provides the expected sign of explanatory variables except for female headed households, the quantity of fertilizer(fert) used in the previous crop season and age with a negative impact on the probability of willingness to pay for irrigation water supply. Among the important variables bid value, irrigation farming experience, income of the household, participating in off farm activity, and households market access has a significant impact on the probability of households WTP for irrigation water supply.

In the heteroscedastic probit model estimation the magnitude of coefficients of explanatory variables is not important except the sign and the magnitudes of p-values to determine its significance. So as to analyse the effect of each independent variable on the probability of households WTP for irrigation water supply we need to estimate the marginal effects. The interpretation of the marginal effects for continuous and discrete variables is different and it is appropriate to determine the baseline outcome for the explanatory variables. For continuous variables the interpretation of marginal effects is for a unit increase/decrease in the independent variable from the baseline outcome may increase/decrease the probability of the occurrence of an event by the magnitude of the marginal change holding other variables constant. On the other hand for discrete explanatory variable (that takes 0 or 1) the interpretation of marginal effects is the probability of the occurrence of an event is expected to change based on the magnitude of the indicated change holding other variables constant when the explanatory variable change from zero to one. The marginal effects of the probit model estimation results are reported in Table 4.3.

Table 4.3: Marginal effects of the probit model (with robust standard errors)

wtpi	dF/dx	Robust Std. Err.	z	P>z	x-bar	[95% C.I.]	
bidv	-0.0001	0.00004	-3.02***	0.003	306.8	-0.0002	-0.000023
edu*	0.013	0.011	1.17	0.243	0.44	-0.0088	0.034
age	-0.0003	0.0004	-0.72	0.474	40.94	-0.0011	0.0005
exp	0.006	0.003	3.26***	0.001	4.2	-0.0005	0.012
nox	0.003	0.006	0.43	0.668	1.69	-0.0092	0.014
inc	1.75	7.10	2.76***	0.006	31349	3.6e-07	3.1
landsize	0.004	0.011	0.37	0.714	1.06	-0.0171	0.025
cis	0.0002	0.0003	0.86	0.392	39.77	-0.0003	0.0007
ofa*	-0.093	0.08	-2.02**	0.044	0.057	-0.2495	0.064
mark	-0.01	0.007	-2.30**	0.021	1.34	-0.023	0.0027
dr	-0.002	0.006	-0.33	0.742	0.9	-0.0149	0.0107
cr	2.41	3.98	0.66	0.511	786.6	-5.4	0.00001
hhs	-0.003	0.003	-0.82	0.410	4.87	-0.009	0.0036
fert	-0.00004	0.0002	-0.28	0.783	15.07	-0.0003	0.0002
landc*	0.016	0.02	0.96	0.337	0.8	-0.024	0.0564
fhhs*	-0.029	0.04	-1.10	0.272	0.06	-0.104	0.045
Number of observations			*300*				
Log pseudo likelihood			*-51.00*				
Wald chi2(16)			*51.6*				
Pseudo R2			*0.279*				
Prob > chi2			*0.00*				

**** And ** indicate significant level at 1% and 5% respectively*

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

The estimated coefficient of the proposed bid value is statistically significant and has the expected sign in affecting the probability of household's willingness to pay for irrigation water supply at 1% level of significance. In particular, the results indicate that a one unit increase in the proposed bid value from the baseline of 306.833 birr decreases the probability of household WTP for irrigation water supply by 0.01% holding other factors constant.

Practical irrigation farming experience is found statistically significant at 1% level of significance with the expected positive sign. The results suggest a one year increase in irrigation farming experience of household respondents increases the probability of household WTP for irrigation water supply by 0.6 % holding other factors constant. A possible explanation is that households with longer irrigation farming experience can easily realize the benefit from it and hence are more likely to attach high value for irrigation agriculture than those who have no or shorter years of irrigation farming experience.

Households' average yearly income has a positive sign and is statistically significant at 1% level of significance which is consistent with economic theory. The marginal effects show that a one birr increase in the income of the household increases the likelihood of WTP for sustainable irrigation water supply by 175%, keeping other factors constant.

The dummy variable off-farm activity has a negative and statistically significant effect (at 5%) level suggesting that households involved in off-farm activity are less willing to pay for the sustainability of irrigation. This may be the case when the benefit households realized from irrigation agriculture is less than the benefit they realized from off farm activity.

Market access is found statistically significant at 5% level of significance with a negative sign, which is consistent with prior expectation. The survey result shows as the time required to reach the nearest market rises by an hour the probably of households willing to pay for the sustainability of irrigation water falls by 1% holding other factors influencing WTP constant.

4.2.2 Calculating Mean WTP: Single-Bounded Model Estimates Results

One of the main objectives of estimating empirical WTP model based on the CV survey response is to derive central value (or mean) of the WTP distribution (Hanemann, Loomis and Kanninen, 1991). One objective of estimating the probit model is to calculate the mean willingness to pay for irrigation water supply by running a regression of the binary choice variable on the bid values.

However estimation of the probability of households' willingness to pay for irrigation water supply on the bid value is found insignificant so the study used an alternative estimation by taking significant socio-economic variables as follow.

$$\mu = meanWTP = \frac{-[\alpha + \sum_{i=1}^{m} \beta_i \mu_i]}{\beta}$$

Where β_i -are the coefficient of the ith explanatory variable

μ_i - are the mean of the ith explanatory variable. α = is the intercept (constant) term and β= is the coefficient of the bid proposed to the respondent

Table 4.4: Probit estimates used to calculate the mean WTP for single bounded format

wtpi	Coef.	Robust Std. Err.	z	P>z	[95% Conf.	Interval]
bidv	-0.003	0.0007	-3.09	0.002	-0.004	-0.0008
exp	0.154	0.05	2.76	0.006	0.044	0.26
inc	0.00005	0.00001	3.28	0.001	0.00002	0.00008
ofa	-1.017	0.4865	-2.09	0.037	-1.97	-0.063
mark	-0.23	0.13	-1.77	0.076	-0.48	0.024
_cons	0.88	0.373	2.37	0.018	0.15	1.613
Number of Obs					*300*	
Wald chi2(5)					*37.07*	
Pseudo R2					*0.2383*	
Log pseudo likelihood					*-53.938376*	
Prob > chi2					*0.0000*	

Source: From the survey response

Using the estimates in Table 4.4 and the above equation the mean willingness to pay from single bounded elicitation were found to be birr 614.

To determine the mean willingness to pay from the open ended follow up questions we simply averaged the maximum willingness to pay figures across respondents as follows:

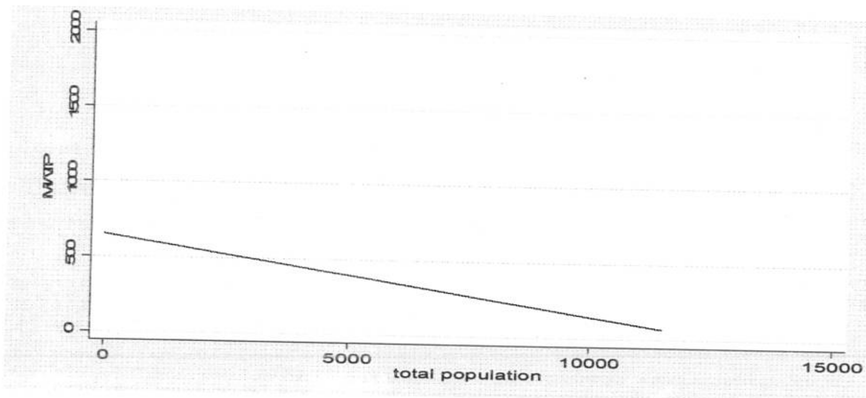
$$\text{Mean } WTP = \sum_{i=1}^{n} \frac{y_i}{n}$$

Where n is the sample size and each y is a reported willingness to pay amount by surveyed households (Habb and McConnell, 2002). The mean willingness to pay estimated from the sampled households were reported as is birr 417.49 per 0.25 ha (*Kadda)* of irrigable land. Clearly the mean willingness to pay estimate from the single bounded elicitation is much higher than the open ended elicitation which is in line with results from other studies.

4.2.3 Estimating total WTP

The aggregate willingness to pay for year round supply of irrigation water can be estimated by taking the total number of beneficiary households in the command area. Based on environmental and social impact assessment report made on the project (RIDP) the total number of beneficiary households is estimated about 11,500 and the total irrigable area is about 14,460 ha (MoWE, 2010). Based on this figures the expected aggregate willingness to pay for irrigation water supply using the close ended and open ended is estimated birr 35,513,760 and 24,147,622 respectively.

Figure 4.1 Aggregate demands for irrigation water



The negatively sloped aggregate demand curves for the supply of irrigation water ascertains the law of demand if the good is assumed a normal good. As the price of irrigation water rises the number of household respondents willing to pay for the supply of irrigation water declines.

4.3 Econometric results of the choice experiment

For analysis purpose the data is coded as follows: migratory fish (cat and Tilapia) abundance is coded as 2 for high abundance, 1 for medium abundance and zero for the status quo. Irrigation water availability is coded as 3 for all four seasons, 2 for three crop seasons, 1 for two crop seasons and 0 for status quo. For the other two attributes, annual payment and production, their levels were used directly. The ASC were equal to 1 for the alternatives with improvement in the attributes, for alternative 1 and 2 and 0 for the status quo.

4.3.1 Estimation and discussion of results

The multinomial logit model is estimated based on 1800 observations elicited from 300 farm household respondents. Each respondent for this study were provided six choice sets. Table 4.5 shows the basic model of multinomial logit model which were specified in such a way that the probability of selecting a particular alternative is a function of the identified attributes and the alternative specific constant.

Table 4.5 Results of the multinomial logit model (only attributes included)

Variables	Coefficients	Std. error	P-value
ASC	9.29 ***	0.42	0.0000
FISH	3.74***	0.32	0.0000
IRRW	4.109***	0.229	0.0000
Prod	0.006***	0.0003	0.0000
Payment	-0.005**	0.001	0.0000
Log-likelihood		-2408.522	
Pseudo R-squared		0.2992732	
Number of observations		1800	
Prob[ChiSqd > value]		0.000	

*** Significance at 1% level

The estimated coefficients of attributes (migratory fish abundance, irrigation water availability and productivity) from the multinomial logit model have a positive sign and all of them are statistically significant at 1% level. This indicates all the attributes are found significant in the determination of households' choice for irrigation water. The positive coefficient estimate indicates the improvement of these attributes will increase the utility of the respondent. That means the probability of choosing the improved alternative rises with an improvement in any of the attributes.

The other attribute that determines the utility of respondents is the monetary attribute (annual payment in birr). The estimated coefficient of this attribute has a negative sign and statistically significant at 1% level of significance consistent with prior expectation.

The result reveals respondents will choose alternatives with lower price. The probability of choosing improved plans declines with a rise in the price of any of the attributes. In other words higher price of attributes reduce the utility households derive from a particular plan.

The coefficient of ASC (alternative specific constant) is positive and statistically significant at one percent level of significance. The positive and significant sign on the ASC coefficients implies that a positive utility impact occurs in any move away from the status quo (Birol et al., 2006).

Table 4.6 shows the result from an extended model of multinomial logit model specified in such a way that the probability of choosing a particular alternative is a function of an alternative specific constant, all the attributes and interacted socio economic variables with the alternative specific constant. This enables to capture the influence of observable characteristics of respondents on the probability to choose the improvement alternatives (either paln1 or plan 2).

Table 4.6 Results of the multinomial logit model (attributes and socioeconomic characteristics included)

Variables	Coefficients	Std. error	P-value
ASC	9.28***	0.46	0.00
fish	3.74***	0.32	0.00
IRRW	4.11***	0.23	0.00
Prod	0.006***	0.0003	0.00
Payment	-0.005***	0.001	0.00
ASC_AGE	-0.001	0.003	0.67
ASC_SEX	-0.036	0.136	0.79
ASC_HHS	0.01	0.018	0.59
ASC_EDU	0.001	0.014	0.93
ASC_INC	0.13	0.24	0.59
Log-likelihood		*-2408.041*	
Pseudo R-squared		*0.2994129*	
Number of observations		*1800*	
Prob[ChiSqd > value]		*0.000*	

*** Significance at 1% level

The interaction of socio economic characteristics of the respondent with ASC didn't provide any significant result. The variables income and education are positive but insignificant. Which means the inclusion of these variables was insignificant in affecting the probability of choosing the improved alternatives. The household size is positive inconsistent with prior expectation but has a statistically insignificant effect on the choice of improved alternatives.

Age and sex of the respondent have a negative sign but are insignificant. The probability of choosing improved plans is higher for young's than old aged respondents but still both variables are insignificant.

With respect to attributes both models are providing similar positive results and statistically significant at 1% level of significance. The monetary attribute too is significant at 1% and negative. Other statistical summary indicates the inclusion of socioeconomic variables improves relatively the explanatory power of the model because the extended model has higher log likelihood ratio and *Pseudo R-squared*. The magnitude of attributes in both models is also similar.

Among the properties of multinomial logit model the independence of irrelevant alternatives (IIA) has been mentioned. This property of the multinomial logit model means for any respondent the ratio of probabilities of choosing two alternatives is independent of the attributes of any other alternatives (McFadden, 1974). To avoid the problem associated with the MNL model. More complex statistical models that relax these assumptions are necessary like the random parameter logit model (RPL) which incorporates unobserved heterogeneity of preferences and tastes of respondents in the model by allowing the model parameters to vary randomly over individuals (Adamowicz and Boxall, 2001).

The test to identify the existence of IIA assumption in the MNL model using Hausman test was not successful because the difference matrix is not positive definite. An alternative model that does not require this test, RPL model is estimated and the result is reported in Table 4.7.

Table 4.7 Results of the RPL model (with attributes only)

Variables	Coefficients	Std. error	P-value
FISH	1.495***	0.278	0.00
IRRW	1.57***	0.23	0.00
Prod	3.498***	0.121	0.00
Payment	-0.008***	0.001	0.00
Log-likelihood		-1150.029	
Pseudo R-squared		0.4184434	
Number of observations		1800	
Prob[ChiSqd > value]		0.0000	

*** Significance at 1% level

Like the MNL model the estimated coefficients of attributes (migratory fish abundance, irrigation water availability and productivity) from the RPL model have a positive sign and all of them are statistically significant at 1% level of significance. This indicates all the attributes are found significant in the determination of households' choice of irrigation water. The only difference observed in this estimation as a result of incorporating unobserved preference of respondents is a change in the magnitude of coefficients of attributes. Compared to the multinomial logit model estimation the RPL model has a higher overall fit with Pseudo R-squared of 0.4184434 higher than 0.2992732 .

4.3.2 Estimation of the marginal willingness to pay (part worth)

The β coefficients estimated in the MNL model can be used to estimate the rate at which respondents are willing to trade-off one attribute for another. This trade off is known as the part worth, which represents the marginal rate of substitution between the monetary attribute and the non marketed environmental attribute (Nam DO and Bennett, 2007).

Based on equation (9) in chapter three the marginal willingness to pay for each attribute is summarized in Table 4.8.

Table 4.8 Implicit price of attributes for irrigation water

Attributes	Implicit price Birr/0.25 hectare/annum
Migratory Fish abundance	748
Irrigation water availability	822
Productivity	1.2
Total	1571.2

Respondents are on average willing to pay birr 748 annually for any improvement of fish (tilapia and cat) abundance in the area form the current status. The implicit price indicates also respondents are on average willing to pay 822 birr per annum per 0.25 hectares of land for any improvement in either quantity or quality or both for the attribute irrigation water availability to have multi season cropping, keeping other things constant. The marginal willingness to pay for productivity is very low 1.2 birr/annum for 0.25 hectares of land. The highest preference is given for irrigation water and the lowest preference is given for productivity in terms of marginal willingness to pay for irrigation water.

The calculation of part worth is also used to determine the marginal rate of substitution between attributes both monetary and non monetary attributes. For instance if we divide the coefficient of one non marketed attribute with another non marketed attribute it shows how respondents are willing to sacrifice one attribute to accept one more unit of the other attribute. Respondents are willing to sacrifice 1.099 cropping seasons for one unit improvement in the attribute of fish abundance. In the same way respondents are also willing to sacrifice 619.9 units of fish stock to increase productivity by one kilogram.

4.3.3 Estimation of welfare measures

The other purpose of the choice experiment is to estimate the welfare of respondents from an environmental improvement provided that respondents have the right to derive utility from the current situation. Based on the estimates of the choice experiment result we can derive compensating welfare measures obtained for different irrigation water scenarios associated with multiple changes in attributes (Birol et al., 2006).

The attribute levels that characterize alternative irrigation water improvement scenarios are listed below, along with the current situation/status quo attribute levels:

Current situation (status quo) scenario

- Fish(cat and tilapia) stock abundance is low
- Irrigation water availability helps farmers to produce only in one crop season.
- The average productivity of crops like rice is 700 Kg per year

Improvement scenario 1 (high impact improvement scenario)

- Fish(cat and tilapia) stock abundance is high
- Irrigation water availability helps farmers to produce in all crop seasons.
- The average productivity of crops like rice is 2800 Kg per year

Improvement scenario 2(medium impact improvement scenario)

- Fish(cat and tilapia) stock abundance is high
- Irrigation water availability helps farmers to produce only in three crop seasons.
- The average productivity of crops like rice is 2000 Kg per year

Improvement scenario 3(low impact improvement scenario)

- Fish(cat and tilapia) stock abundance is medium
- Irrigation water availability helps farmers to produce only in two crop seasons.
- The average productivity of crops like rice is 1400 Kg per year

Table 4.9 Estimates of compensating surplus (CS)

Alternative improvement scenario	WTP (birr per year) using basic model
Improvement scenario 1	5610
Improvement scenario 2	4090
Improvement scenario 3	2514

Estimates of compensating surplus (CS) are calculated using equation 10 in chapter three. To use this equation to estimate compensating surplus, it is first necessary to calculate the utility associated with the current option and the improvement scenarios. Estimates of willingness to pay for the three scenarios are presented in Table 4.9. These are the marginal estimates, showing willingness to pay for a change from the current situation. Based on these the mean WTP for improvement scenario 3 is 2514 birr per year, for medium impact improvement scenario the mean WTP is 4090 birr per year which is higher than the low impact improvement scenario. And the mean WTP for high impact improvement scenario is about 5610 birr per year which is higher than all the other improvement scenarios.

4.4 Analyses of the results of the follow up questions

All respondents are provided the follow up questions which best describes them while choosing alternatives in each choice set. A summary of the results is provided in Table 4.10. The first most chosen attribute is irrigation water availability. About 40.6 percent of the respondents chose the alternative with higher level of irrigation water. The second most chosen attribute is migratory fish abundance. About 26.5 percent of the respondents chose the alternative with the higher level of fish stock and lastly 22.4 percent of the respondents found enhancement of productivity is important and choose a plan that gives them higher productivity.

Table 4.10 Results of follow up questions

Follow up questions	% of responses
1. I find the irrigation water availability is important and choose exclusively this attribute in the alternatives.	40.6
2. I exclusively choose the cheapest alternative.	10.5
3. I find fish stock enhancement is important and choose such attribute in the alternatives.	26.5
4. I find productivity is important and choose such attribute in the alternatives.	22.4
5. I wish I could pay/contribute more for the program, but I cannot afford it.	0
6. I don't think farm households should have to pay or contribute money to environmental quality improvement and conservation of natural resources	0
Total	100

Source: Computed from the survey data

On the other hand the remaining 10.5 percent of the respondents are willing to pay but exclusively chose the cheapest alternative regardless of the levels of the non monetary attributes.

CHAPTER FIFE: CONCLUSION AND RECOMMENDATION

5.1 Conclusions

The purposes of this study were to contribute to the agricultural water policy in order to enhance efficiency and to promote sustainability in water use. The study attempts to determine the price of irrigation water by eliciting farmers' willingness to pay (WTP) on Ribb irrigation project using choice experiment method (CEM) and contingent valuation method (CVM).

The survey responses of 300 randomly selected farm households in the study area were analyzed for this study. The sample households were asked a closed ended question with follow up open ended question to elicit households' willingness to pay for irrigation water for the CV analysis. Six choice sets were also provided to each respondent for the choice experiment part to determine their WTP for irrigation water provision.

The contingent valuation method used a probit model to estimate the key factors that determine households' willingness to pay for irrigation water. The important variables identified in this study to determine household's WTP for irrigation water are, bid value, irrigation farming experience, income of the household (Inc), participating in off farm activity, and households market access.

Regarding the sign and the significance of these variables, bid value, irrigation farming experience, income of the household (Inc), participating in off farm activity, and households market access has a significant impact on the probability of households WTP for irrigation water supply.

The mean WTP from the open ended and close ended survey responses is different. The mean willingness to pay for 0.25 Ha of land from the single bounded elicitation survey responses is about birr 614, much higher than the mean willingness to pay result from follow up open ended elicitation survey response of birr 417.49 per 0.25 ha (*Kadda)* of irrigable land. The expected aggregate willingness to pay for irrigation water supply for the close and open ended questions were estimated to be birr 35,513,760 and 24,147,622 respectively.

To analyze the survey response for choice experiment, the multinomial logit model and the random parameter logit model were used. The result showed that the estimated coefficients of attributes (migratory fish abundance, irrigation water availability and productivity) from both models have a positive sign and all of them are statistically significant at 1% level of significance. This indicates all the attributes were found significant in the determination of households' choice of irrigation water. The result also showed that the attribute availability of irrigation water had a greater impact on the utility of households than the other attributes. The mean willingness to pay for fish abundance, irrigation water availability and productivity were 748, 822 and 1.2 birr respectively.

The welfare measures from different improvement scenarios including the status quo showed that higher welfare can be derived from high impact improvement scenario. These were reflected by higher mean WTP for high impact improvement scenario which is about 5610, higher than all the other improvement scenarios.

The follow up questions of the choice experiment showed a larger percentage of respondents chose irrigation water availability (about 40.6 percent of the respondents chose an alternative with higher level of irrigation water).

5.2 Recommendations

The result from the two stated preference techniques indicates farm households are willing to pay for irrigation water supply. This result has strong policy implications in that if government designed and implements a proper pricing of irrigation water in the area it will avoid inefficient water use practices and there would be efficient and sustainable utilization of environmental resources. It also inculcates sense of responsibility among irrigation water users.

An important policy implication from the strong and positive relationship between explanatory variables and willingness to pay for improved irrigation water supply suggests the need to consider all the important variables in designing policies related to irrigation water provision for farm households. That is the provision of complementary endeavors/services is found important to boost the value attached by farm households to irrigation water like market expansion, and designing of income generating programs. All these services will enable farm households to pay higher price for irrigation water.

The estimated aggregate willingness to pay for irrigation water is a large amount of money. This revenue collected from households may assist in financing other projects that assist the development of the country as well as sustainable use of Rib irrigation system.

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Appendixes

Appendix 1: Questionnaire

Contingent valuation and choice experiment questionnaire on farmer's willingness to pay (WTP) for irrigation water the case of RIDP (Ribb irrigation and drainage project)

Interviewee name ______________________

Place of interview ______________________ (write kebeles)

Date of interview______________________

Length of interview ______________________ (minutes)

Farmers code ______________________

Supervisor______________________

INTRODUCTION TO THE RESPONDENT

How are you, I am ______________________. I am assisting an ongoing research by Nega Assefa for the partial fulfillment of his Msc in Economics at Addis Ababa University. The questionnaire is designed to obtain information on Ribb Irrigation and drainage project (RIDP), and farmers' willingness to pay for irrigation water service by taking randomly selected farmers in the command area. So your view could be used as an important input to officials and policy makers in their attempt to provide irrigation water and to commercialize agriculture in the area. The interview will take a few minutes and the answer will be completely confidential and strictly for academic purpose only. Your name will never be associated with your answers. There are no correct or wrong answers. Thus please answer the questions honestly and as truthfully as you can.

THANK YOU IN ADVANCE

I. Socio economic characteristics of the respondent

1. Gender? 1. Male 2. Female
2. Age? __________years
3. Marital status (please tick one) 1. Single 2. Married 3. Separated/divorced 4.other(specify)______________

4. Are you the head of this house hold? 1. Yes 2. No
5. If no to question 4 who is the head of the house hold? 1. Female headed 2. Male headed
6. House hold size ___________ (No. of family members)

   No. of adults (15-65 years) ____________

   No. of children (those less than 15 years) ________

   No of elders (those higher than 65 years) _________
7. Do you attend formal education? 1. Yes 2. no
8. If yes to question 7, Years of formal education ____________ (in years completed)
9. Occupation: 1.fisherman 2. Farmer 3. Student 4. Trade 5. Other (___________)
10. What is your average yearly income (farm income)? _______ in birr (use the following table)

Crop type	Output in Kg	Average price in Kg	Revenue
Rice			
Wheat			
Teff			
Finger millet			
Sorghum			
Maize			
Pea			
Horse bean			
Barely			
Noug			
Tomato			
Potato			
Carrot			
Onion			
Garlic			
Cabbage			
Paper			
Other income			
Total			

11. How many oxen do you have? ____________

12. If the material you used to construct the roof of your home is corrugated iron sheet how many sheets you used (if not write 0)? ________________

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

14. If yes, how much money do you earn from this activity per year (including other member of the family)? __________birr

II. Credit, fertilizers, land certification and market access situation of farm house holds

1. Do you have formal or informal credit access whenever you want to borrow? 1. Yes 2. No
2. If your answer to question 1 above is no, what is the reason? Because
   1. Lending institutions or individuals know the money will not be used for the planed objective
   2. No formal and informal lending institution in the area
   3. High lending interest rate
   4. Lack of collateral to get credit
   5. Other (specify) ____________________
3. If your answer to question 1 above is yes, how much have you borrowed for agricultural production in the preceding agricultural season (2003 E.C)? __________ Birr.
4. Have you used fertilizers (not homemade like compost) for crop cultivation in the preceding year (2003 E.C)? 1. Yes 2. No
5. If No what is the reason? ________________________
6. If yes, how many kilograms of fertilizers have you used in 2003? ____Kg
7. How much time do you take to travel the nearest market to sell your agricultural Products? __________ Hours.
8. Do you have land certificate (tenure security)? 1. Yes 2.no
9. How many *kadda* (0.25 ha) of Land do you have? ______________

10. How many *kadas* of Land did you cultivate (own and rent) in 2003?__________

III. Contingent valuation questions

1. What benefit do you think you can get from irrigation? You can indicate more than one.
    1. Increased agricultural yield from a given size of land in a given crop season
    2. Additional crop seasons
    3. cultivation of high water demanding crops like rice
    4. For domestic water supply
    5. For livestock water supply
    6. Enables cultivation of permanent crops
    7. Increase in water supply for different purpose
    8. Others, specify ____________________
    9. ______________________________

2. In general do you say irrigation is advantageous to you? 1. Yes 2. NO
3. If No, why not? ______________________________
4. Do you have an irrigable land? 1. Yes 2. NO
5. If yes, to question 4 what size? ______________(in terms of hectares)
6. Do you have practical irrigation farming experience before? 1. Yes 2. No
7. If you have practical irrigation farming experience how many years do you have? __________ years
8. If NO, what are the main reasons(multiple answer is possible) b/c
    1. You have no irrigable land
    2. Shortage of water supply
    3. No capacity to pay for water pump
    4. Your land is too far from the water source
    5. Others, please specify______________________
    6. ______________________________________

Willingness to pay (WTP) questions

Background information

In this section of the questionnaire, I would like to ask you how much it is worth to you in money terms, the provision of irrigation water.

The construction of irrigation dam among other things means providing adequate water which is safe for crop production and improving cropping for the dry season. Drainage and flood protection measures will also improve the condition for wet season agriculture. The irrigation water dam is used to provide reliable water at any time throughout the year for agricultural as well as for non-agricultural uses and it will reduce the time and money spent to bring irrigation water from a distance or to use underground water. The construction of the irrigation dam will benefit the farm house holds by enabling them to produce permanent crops, three times a year, to provide year round irrigation water, reduce the regular flooding in the area, for domestic water supply and for livestock water supply etc.

Now, the government of Ethiopia is constructing the Rib Irrigation and Drainage Project (RIDP) using a fund obtained from an international organization (World Bank). This irrigation and drainage project will provide you as much irrigation water as you want throughout the year and will reduce the regular flooding. To provide/deliver this year round water for diffident uses, different drainage and channels will be constructed. To sustainably deliver this irrigation water for farm households it requires money for the maintenance and operation cost. This cost should be covered by the beneficiary households in the command area. So you will be charged a yearly irrigation water fee using irrigation water users' association (IWUAs) based on the hectare of land irrigated. Here, you are not asked to pay the cost of construction of the dam and different waterway but you are required to contribute money for the use of irrigation water based on the size of land irrigated.

Thus, to maximize the benefits from irrigation water, irrigation beneficiary households in the command area have to contribute money for the use of irrigation water to maintain the sustainable use of the irrigation dam and channels.

9. Do you want to have an irrigation system to get year round water supply using irrigation water users association? 1. Yes 2. No
10. If you have an irrigable land, would you be willing to support the rules and regulations of the IWUAs that require collecting money from each irrigation water user's _____________ birr/household/year/0.25Ha of land to get year round irrigation water supply? 1. Yes 2. No
11. What is the maximum amount you would be willing to pay for one *kadda* (0.25Ha) of irrigable land for such a project per year? _______________ Birr.
12. If your answer is yes to question 10 and if the respondent WTP in question 10 is greater than in question 11, then ask; You said that you are willing to pay _________ Birr (in Q.10) but when I ask you your maximum amount willingness to pay in (Q.11) you said _________Birr, which is less than the amount you already agreed to pay previously. Why? ____________________

13. **(To interviewer)** if the maximum amount that they would like to pay for the irrigation water is zero, ask them why they do not want to pay?
    1. Irrigation water should be provided free of charge
    2. I am satisfied with the existing irrigation service
    3. I do not have enough money
    4. I know that the money will not be used properly
    5. It is the responsibility of the government to provide
    6. Other reasons, specify_______________________
14. What do you recommend to make irrigation water sustainable throughout the year? (multiple answers are possible)
    1. Government has to cover all the costs incurred to provide water
    2. The people have to take the ownership to manage it properly after finalization
    3. Beneficiary Households has to contribute money for the proper maintenance of the dam
    4. Irrigation water should be provided free of charge
    5. Other(specify)______________

IV Choice experiment questions

1. Are you involved in fishing activities in the area? 1. YES 2. NO
2. If you are involved, for what purpose you are involved?
   1. Commercial
   2. Home consumption
   3. Both
   4. Others __________________________(specify)
3. If the purpose of fishing is for commercial purpose who are your customers? (multiple answers possible)
   1. Individuals
   2. Hotels
   3. Whole sellers
4. Which fish species is more abundant in your catch?
   1. Tilapia (QOROSO locally)
   2. Catfish (Ambaza locally)
   3. Bilicha (local name)
   4. Other ______________________________ (specify)

Interviewer***: please read the choice scenario to your respondents and make sure that the respondents give attention to your description before you go to the questions.***

Scenario of the choice Experiment

The aim of this experiment is to investigate farm house holds choices for various measures affecting the provision of irrigation water in terms of **Irrigation water availability, Migratory fish (catfish and tilapia fish) abundance, and productivity**. Now we ask you to consider these attributes or issues and the cost of carrying out various measures in the choice questions that follow. But for the questions that follow there no ***wrong*** or ***correct*** answers are expected. What is required is the priority that you place for different options provided and asked you to choose your preferred option. Please! Be careful in considering the attributes: **Irrigation water availability, Migratory fish (Catfish and Tilapia fish) abundance, and productivity**.

Assume that the levels of this attributes are independent of each other. Please mark the preferred plan/ alternative as if it is the only choice you make and if you face any difficulty in understanding the options, don't hesitate to ask for further clarifications. In case you change your mind, feel free to go back and change your previous choice(s).

Suppose the government has an intention to take measures that could mitigate the problems in the area and designed a program for the development, conservation and sustainable use of the irrigation water (RIDP) and its surrounding. In order to accomplish this, suppose the government has designed a plan in the following areas to improve the environmental quality at the same time the life of the project area.

1. **Irrigation water availability**: The irrigation water availability in the command area allows improved cropping in the dry season. In addition to this the irrigation water availability improves wet season agriculture and provides other different purpose for farmers like, livestock watering, drinking water, washing, bathing etc. The availability of irrigation water also has the advantage of bringing agricultural yield stability by providing stable yield from one year to another. To make available this water the government has designed and undertakes construction of Dams and drainages in the area.
2. **Migratory fish (Catfish and Tilapia fish) abundance**: As a result of channelization of the main river Ribb different fish species like cat fish and tilapia fish in the area (behind the dam) will be lost. In addition to this because of the change in the hydrology of wet lands and the reduced flooded area the stock of migratory fish species will decline.

The program will improve the condition and abundance of migratory fish in the area by initiating wet land restoration and conservation projects, supporting kebeles fishery management programs, re-draw project boundaries to exclude the two main wetlands (*shesher and welela*) in the area and by ensuring the drainage structure which allows fish pass. Consequently, the society as a whole will be benefited from such programs

3. **Productivity:** the plan of the government here is to increase the average production harvested per 0.25 Ha of land from planting a particular agricultural crop like rice in the area. To do this the government has designed different packages for farmers' one of this is the provision of irrigation water in addition to other services like extension services, provision of new technology in the form of improved seed, new working style and new idea etc.
4. **Annual payment in birr**: for the implementation of the program it requires money. The government authority designed a strategy for the implementation of the program. Irrigation water users association is organized in the area that performs this task. They collect an amount of money from each household respondent per 0.25ha of land (a proxy for WTP for the provision of irrigation water).

   Interviewer: After this present the choice set for them and help in case they face problems/ have doubts.

For each choice set from the three alternatives below, mark the alternative you prefer.

Choice 1

Attributes	**plan 1**	**plan 2**	**status quo**
Migratory fish abundance	High	High	**Low**
Irrigation water availability	All four seasons	Three crop season	**one crop**
Productivity	2000 Kg	1400 Kg	**700 Kg**
Annual payment in birr	300 birr	600 birr	**0 birr** currently
Please tick(√) only one			

Choice 2

Attributes	**plan 1**	**plan 2**	**status quo**
Migratory fish abundance	High	Medium	Low
Irrigation water availability	All four seasons	All four season	**one crop season**
Productivity	2000 kg	2800 kg	**700 Kg**
Annual payment in birr	300 birr	100 birr	**0 birr** currently
Please tick(√) only one			

Choice 3

Attributes	**plan 1**	**plan 2**	**status quo**
Migratory fish abundance	High	Medium	**Low**
Irrigation water availability	All four seasons	Two crop seasons	**one crop season**
Productivity	2000 kg	1400 kg	**700 Kg**
Annual payment in birr	300 birr	300 birr	**0 birr** currently
Please tick(√) only one			

Choice 4

Attributes	**plan 1**	**plan 2**	**status quo**
Migratory fish abundance	High	Medium	**Low**
Irrigation water availability	Three crop seasons	Four crop seasons	**one crop season**
Productivity	1400 kg	2800 kg	**700 Kg**
Annual payment in birr	600 birr	100 birr	**0 birr** currently
Please tick(√) only one			

Choice 5

Attributes	**plan 1**	**plan 2**	**status quo**
Migratory fish abundance	High	Medium	**low**
Irrigation water availability	Three crop seasons	Two crop seasons	**one crop season**
Productivity	1400 kg	1400 kg	**700 Kg**
Annual payment in birr	600 birr	300 birr	**0 birr** currently
Please tick(√) only one			

Choice 6

Attributes	**plan 1**	**plan 2**	**status quo**
Migratory fisha bundance	Medium	Medium	**low**
Irrigation water availability	Four crop seasons	Two crop seasons	**one crop season**
Productivity	2800 kg	1400 kg	**700 Kg**
Annual payment in birr	100 birr	300 birr	**0 birr currently**
Please tick(√) only one			

Follow up questions

Which of the following statements describes best how you reasoned while choosing between the alternatives in the above choice set? Mark one or more statements.

7. I find the irrigation water availability o is important and choose exclusively such attribute in the alternatives
8. I exclusively choose the cheapest alternative.
9. I find fish stock enhancement is important and choose such attribute in the alternatives
10. I find productivity is important and choose such attribute in the alternatives
11. I wish I could pay/contribute more for the program, but I cannot afford it.
12. I don't think farm households should have to pay or contribute money to environmental quality improvement and conservation of natural resources

Thank you for your cooperation!

Appendix 2: Heteroscedasticity test

wtpi	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
bidv	-0.00218	0.000701	-3.11	0.002	-0.00356	-0.00081
edu	0.247873	0.234335	1.06	0.29	-0.21142	0.707162
age	-0.00707	0.006203	-1.14	0.254	-0.01923	0.005088
exp	0.13366	0.049055	2.72	0.006	0.037513	0.229806
nox	0.082437	0.152347	0.54	0.588	-0.21616	0.381031
inc	0.000039	1.45E-05	2.7	0.007	1.07E-05	6.74E-05
landsize	0.259484	0.213428	1.22	0.224	-0.15883	0.677795
cis	0.005362	0.003616	1.48	0.138	-0.00173	0.012449
ofa	-0.96008	0.55108	-1.74	0.081	-2.04018	0.120013
mark	-0.23428	0.110156	-2.13	0.033	-0.45018	-0.01838
dr	-0.00149	0.084021	-0.02	0.986	-0.16617	0.163187
cr	-9.64E-06	7.35E-05	-0.13	0.896	-0.00015	0.000134
hhs	-0.05508	0.076561	-0.72	0.472	-0.20514	0.094976
fert	-0.00082	0.005759	-0.14	0.887	-0.0121	0.01047
landc	0.099718	0.223147	0.45	0.655	-0.33764	0.537079
fhhs	-1.17166	0.240888	-4.86	0	-1.64379	-0.69953
_cons	1.105279	0.521166	2.12	0.034	0.083813	2.126745
lnsigma2	-16.4815	642.9899	-0.03	0.98	-1276.72	1243.756
Number of obs			300			
Zero outcomes			19			
Nonzero outcomes			281			
Log likelihood			-44.50495			
Prob > chi2			0.0000			
Wald chi2(16)			105.17			

Likelihood-ratio test of lnsigma2=0: chi2 (1) = 12.99 Prob > chi2 = 0.0003

Declaration

I the under signed, declare that this thesis is my original work and has not been presented in other Universities; all sources of materials used have been duly acknowledged.

Name: Nega Assefa

Signature: ________________________

Date of submission: June 2012

This thesis has been submitted for examination with the approval of university advisor

Name: Dr. Alemu Mekonnen

Signature: ________________________

Date of submission: June 2012

JUNE, 2012

ADDIS ABABA