BAHIR DAR UNIVERSITY

COLLEGE OF AGRICULTURE AND ENVIRONMENTAL SCIENCE

GRADUATE PROGRAM

ANALYSIS OF FARMERS' WILLINGNESS TO PAY FOR IMPROVED IRRIGATION WATER USE SYSTEM IN GUMARA IRRIGATION SCHEME, SOUTH GONDER ZONE, AMHARA REGION OF ETHIOPIA

MSc. Thesis

By

Aklok Getnet

July 2020

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Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science (MSc.) in Agricultural Economics

Major advisor: Ermias Tesfaye (PhD)

Co- advisor: Zewudu Berhanie (PhD)

July 2020

Bahir Dar

THESIS APPROVAL SHEET

As member of the Board of Examiners of the Master of Sciences (M.Sc.) thesis open defense examination, we have read and evaluated this thesis prepared by **Aklok Getnet Derbew** titled **"Farmers' Willingness to pay for Improved irrigation water use system in Gumara irrigation scheme, South Gonder Zone, Amhara region".** We hereby certify that the thesis is accepted for fulfilling the requirements for the award of the degree of Master of Sciences (M.Sc.) in **Agricultural Economics.**

Board of Examiners

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Internal Examiner	Signature	Date
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External Examiner	Signature	Date

DEDICATION

Dedicated to my mother Alemitu Baye and my father Getnet Derbew

DECLARATION

This is to certify that this thesis entitled "**Farmers' Willingness to Pay for Improved Irrigation Water Use System in Gumara Irrigation Schemes, South Gonder Zone, Amhara Region**" submitted in partial fulfillment of the requirements for the award of the degree of Master of Science in "**Agricultural Economics**" to the Graduate Program of College of Agriculture and Environmental Sciences, Bahir Dar University by Mr. **Aklok Getnet** (ID. No. 1100537) is an authentic work carried out by him under our guidance. The matter embodied in this project work has not been submitted earlier for the award of any degree or diploma to the best of our knowledge and belief.

Name of the Student

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Signature & date ____________________

Name of the advisors

1) ____________________________________ (Major advisor)

Signature & date_________________________

2) ____________________________________ (Co-advisor)

Signature & date_______________________

BIOGRAPHIC SKETCH

The author Aklok Getnet Derbew was born in Amstya Kebele, Ebinat District, South Gonder zone, Amhara National Regional state on 28 April 1994. He attended his elementary education at Feres Mesk primary and junior secondary school. And he completed his high and preparatory education at Ebinat Comprehensive secondary and preparatory school in May 2014.

He joined Bahir Dar University in September 2014 and while he was attending his Bachelor of Science Degree in Agricultural Economics, he has gotten a one-year internship from Arava International Center of Agricultural Training (AICAT) an agricultural college found in Israel in October 2015. After a year's stay from the internship, he has returned to Bahir Dar University with a diploma in General Agriculture in September 2016. He then completed his Bachelor of Science Degree in Agricultural Economics with a very great distinction in June 2018.

As soon as he graduated, the Amhara National Regional State Government gave him an in-country scholarship in Bahir Dar University to pursue his MSc. Degree in Agricultural Economics.

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ACRONYMS /ABBREVIATIONS

CV	Contingent Valuation
CVM	Contingent Valuation Method
DBDC	Double Bounded Dichotomous Choice
ETB	Ethiopian Birr
FAO	Food and Agriculture Organization
FIEO	Fogera Woreda Irrigation Engineering Office
HH	Household
IFAD	International Fund for Agricultural Development
IFC	International Finance Corporation
JKIO	Jigna Kebele Irrigation Office
KMKIO	Kuhar Michael Kebele Irrigation Office
MoWR	Ministry of Water Resources
MWTP	Maximum Willingness to Pay
NOAA	National Oceanic and Atmospheric Administration
OE	Open-Ended
PWTP	Probability of willingness to pay
SBDC	Single Bounded Dichotomous Choice
SHKIO	Shina Kebele Irrigation Office
SUBPM	Seemingly Unrelated Bivariate Probit Model

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ABSTRACT

This study aims to analyze farmers' willingness to pay /WTP/ for improved irrigation water use systems in Gumara irrigation schemes using double bounded dichotomous choice followed by open ended questions. The study assesses the status of households' WTP, identified factors affecting households WTP, maximum willingness to pay /MWTP/, and quantified households' mean and aggregate WTP for improved irrigation water use. For this purpose, a total of 300 HHs were selected using systematic random sampling. Seemingly unrelated bivariate probit model /SUBPM/ was applied to identify factors affecting HHs' WTP and to estimate households' mean WTP from double bounded dichotomous choice, On the other hand, the Tobit model was utilized to identify factors affecting WTP from open-ended questions. Besides some descriptive statistics such as mean, minima, maxima, and percent were used to characterize the sample HH. The result revealed that 98.26% of HHs supported the idea of improving irrigation water use activities of constructing water storage, allocation, and distribution service. Seemingly unrelated bivariate probit model /SUBPM/ result revealed that bid values, men-headed household, irrigating farm size, extension service significantly affected households' WTP in both initial and followed up bid values whereas the age of the household head, the total annual income level of the household, credit utilization of the household, distance from the water source and dissatisfaction with the current irrigation water use system were found to have a significant influence on the probability of willingness to pay in the first bid response. The mean and aggregate WTP of the household was ETB3802.8 per year per person per hectare, ETB 6644257.2 per year respectively. On the other hand, the Tobit model result indicated level of education, initial bid values, extension contact, farm distance from the irrigation water source, irrigated farm size of household, men-headed household, age of household head were the factors that influence the households' MWTP. The Mean and aggregate WTP was also derived from OE question be ETB 3704 per year per person per hectare, ETB 6,472,327.68 per year respectively. Therefore, policymakers should be informed that HHs have a high WTP for improved irrigation water use and consider the important variables identified above in designing policies related to improvement in irrigation water use.

Keywords: *Aggregate willingness to pay, double bounded dichotomous choice, MWTP, and SUBPM.*

Chapter 1. INTRODUCTION

This chapter presents the general background information, statement of the problem, general and specific objectives, research questions, scope and limitations of the study, significance, and organization of the thesis consecutively.

1.1. Background

Water is central to sustainable development and achieving the broader development goals on poverty reduction by providing a vital role for the agricultural sector since it has an indispensable and significant role for irrigation. When water is used effectively and safely, its productivity in irrigation-based agricultural production would be optimum (FAO, 2019). Therefore, the future use and quality of water resources are influenced by the effective use, financing, and management of water in addition to the most important factor of population growth. As a result, one of the significant factors of water use efficiency will be water users' activity and their demand for financing the irrigation water acquisition, distribution systems, and sustainable management of water sources such as rivers, streams ponds or lakes (Aydogdu, 2016).

Globally, demand for irrigation farming has been growing due to the ever-growing land shortage and the prerequisite to make the best use of the return from the limited land available to grow food (Moyo F.*et al*., 2015). This entails irrigation, to be one of the measures required to bring about sustainable food production in the face of changing climatic conditions such as drought, (Kljajic N. *et al*., 2013). Besides, irrigation benefits the poor through increasing production, productivity, and lowering the risk of crop failure. According to Kinfe Asayehegn *et al*. (2011) irrigation also enables smallholders to adopt more diversified cropping patterns, and to shift from staple crop production to market-oriented crops.

In Africa, irrigation development is the lowest since the availability of surface water varies tremendously. The continent has less available surface water per unit area and higher evaporation than most other regions of the world (Asit., 2018). Besides, insecure access of land, unsuccessful institute, uncomplimentary strategies, and high cost of development are the other factors which make irrigation system in Africa is the lowest in the region of the world (Ofosu E. A. *et al*., 2014). Thus, given this unexploited potential of poorly developed irrigation systems, it is an opportunity for donors and African governments and institutions to make it an explicit priority investment focus which would help a shift in the current state of subsistent agriculture.

Despite the cases in most of SSA, Ethiopia is blessed with abundant water resources usually referred to as “the water tower of Africa”with12 major river basins and 22 natural and artificial lakes (ADF, 2005). The geographical location of the country creates a favorable climate with a relatively high amount of rainfall when compared with countries in the sub-Saharan African region. According to MoWR (2002) annual surface runoff is estimated to be about 122 billion m^3 of water. Due to this development in the Ethiopian irrigation system has shown great advancements to assure Ethiopian livelihoods (Tadese Tolera *et al*., 2017). Consequently, the Ethiopian government and people believe that irrigation can play a significant role in food security enhancement and economic growth. This shows more investments in irrigation have principal importance for the development of the country. However, several factors such as lack of water control infrastructure, lack of technical experts to support irrigation development, and governments’ less priority to irrigation agriculture reduce the productive use of water in irrigation (Dessalegn Worku, 2018). The practical experience of payment for irrigation water in Ethiopia is low. According to Mekonen Ayana *et al.* (2015), Awash River Basin is the only basin in Ethiopia where irrigation water pricing is practiced. Therefore this low experience of payments for irrigation water use could be one reason for the less productive use of water in irrigation.

Amhara National Regional State is one of the water potential regions of the country for small-scale irrigation characterized by a low level of investment in small-scale irrigation infrastructure and it desires to increase productivity and resilience of small farm enterprises by increasing areas under sustainable agricultural water management (MoAR, 2016). However, this is to be achieved if there is an irrigation scheme participatory planning and small-scale irrigation infrastructure development. Irrigation scheme participatory planning helps to organize water users association to act as the representative of the potential irrigation farmers. Besides small-scale irrigation infrastructure development helps to ensure adequate access to irrigation water (MoAR, 2016).

The Ethiopian government has focused on the designing and a measure of different activities to improve the irrigation system through mainly focused on the supply side and seems to disregard the effective demand of the irrigation users (Tadese Tolera *et al.*, 2017). However, the important requirement for success in the improvement of irrigation water use system is sufficient knowledge about farmers' demand or willingness to pay for improved irrigation water (Hudu Z. *et al.*, 2014). As a result, implementation of such policy decisions should focus on the demand as opposed supply-side thereby regulating the pricing mechanisms and considering the willingness to pay of the irrigation water users. Consequently, the need of analyzing farmers' willingness to pay for improved irrigation water use is timely research to improve irrigation systems.

1.2. Statements of the Problem

Water is becoming increasingly scarce in many parts of the world. Water scarcity is one of the greatest challenges of our time and these matters most severely affect water-scarce regions, as well as areas where a lack of infrastructure or capacity prevents sufficient access to water. There is an urgent need to address water scarcity (FAO, 2019). Water scarcity originates from low availability of the resource in time and space. But, quite often, it gets to alarming levels because of intense water uses. Competition and conflicts among uses and users of water arise mostly at local and regional levels. As a result; the issue of how irrigation water is allocated among users is raising on most countries' policy agenda (OECD, 2015). Irrigation water and its management are becoming progressively important. In Principle, water valuing policies ensure the potential to alleviate water inadequacy. It is believed that water pricing can play a major role in using irrigation water economically. Pricing of irrigation water supports the achievement of economic objectives; specifically, it is full cost recovery for irrigation water services (OECD, 2010).

However, undervaluing of irrigation water and lack of cost recovery for irrigation water service leads to some undesirable outcomes such as excessive use of the resource, resource pollution, mi sallocation of the resource, and unsustainable irrigation water service (Meseret Birhane, 2016). All these outcomes also lead to unsustainable irrigation water for farms. When water charges are low, people tend to use water carelessly. Therefore, better water allocation could be achieved if the economic value of water is known by use, region, and season (Omondi S., 2014). It happens if there is the decision of conservation and allocation of water through an idea of setting water prices at the appropriate level for providing water users with the correct economic incentives. Therefore, the pricing of water at the right level is an efficient instrument to improve the sustainable use of water resources (Daniela B.*et al.*, 2019).Exact estimations of the economic value of irrigation water also vital for Wise allocation of limited water resource through locations, uses, users, and periods (OECD, 2015)

The Ethiopian water policy highlights the importance of irrigation water fees for the sustainable development of the sector. The policy urges the advertising of site detailed tariff settings in all irrigation schemes depend on the nature of the project, location, the users, the cost, and other characteristics of the schemes (MoWR, 2001b). The water development strategy has also strengthened the setting of site-specific irrigation water users' fees based on cropping patterns, farm-level profit, scheme effectiveness, etc. Furthers, the strategy recognizes the powerful energy of the willingness to pay off the irrigation users for the financial sustainability of the scheme (MoWR, 2001a). Therefore, the effectiveness and successes of irrigation water charge for the sustainable development of the sector are highly factored on several site-specific factors. Therefore, the introduction of irrigation water fee analyses of users' willingness to pay has paramount significance.

Gumara irrigation scheme is irrigation water sourced from Gumara River which is a favorable river for irrigation purposes. According to the Fogera irrigation engineering office (FIEO[1], 2020), the irrigation in Gumara plays a central role in pushing the production to an extent that helps to support local livelihoods and alleviate poverty, as well as to mitigate the short supply of food elsewhere in the country. However, the provision of water to crop is inadequate. The water supply is not year-round because the schemes face several water use problems such as inadequate acquisition which leads to insufficient supply of water, unfair allocation; which leads to conflicts between users, and the absence of a well-designed distribution service (line canal) which leads to higher water wastage. Besides, there is a serious shortage of fuel for pumping the water to farmlands. Overalls these challenges create a serious problem at the time of the dry season at which more water for irrigation is needed by all members of users. Farmers are irrigating the same types of vegetables across the schemes and their demand for irrigation is the same across seasons and kebeles, this makes the problem sever (FIEO, 2020). Besides, from the observation, it could understand the described problems are due to the unavailability of any committed body to organize the farmers to state their willingness to pay to recommend for any

[1]*Fogera* Irrigation Engineering office, 2020

responsible body to take an intervention for the improvement of the irrigation water use to solve the described challenges.

It is possible to end these problems by improving the existing irrigation water use system. These include improving the acquisition system by creating and operating physical structures such as small dams, improving the distribution system through constructing the properly lined canal, and improving the allocation system through designing legal frameworks like the schedule for users. By considering these cases there is a hypothetical program designed to provide an improved irrigation water use system. This could be done if and only if the irrigation users are willing to participate in maintaining the improved service for their future use. As a result, understanding the users' willingness to pay plays a great role to realize this improvement practice.

Studies like Getachew Ewonetu (2013) and Yilkal Gebeyehu (2018) was conducted to evaluate the irrigation potential and to identify the major challenges that hinder the sustainability of the irrigation water in Gumara irrigation schemes. However, there have no studies attempted to quantify the farmers' willingness to pay for improving the sustainability of the irrigation water in Gumara irrigation schemes. As a result, the researcher is motivated to investigate farmers' willingness to pay for improved irrigation water use to sustain the supply of irrigation water use.

1.3. Objectives

1.3.1. General objective

The general objective of the study was to analyze farmers' willingness to pay for improved irrigation water use systems in Gumara irrigation schemes.

1.3.2. Specific Objectives

- To assess the status of farmers' willingness to pay for improved irrigation water use in Gumara irrigation schemes.
- To identify the socio-economic determinants of farmers' willingness to pay for improved irrigation water use in Gumara irrigation schemes.
- To identify the socio-economic determinants of farmers' maximum willingness to pay for improved irrigation water use in Gumara irrigation schemes.

- To estimate the mean level of farmers' willingness to pay for improved irrigation water use in Gumara irrigation schemes.
- To estimate the aggregate level of farmers' willingness to pay for improved irrigation water use in Gumara irrigation schemes.

1.4. Research questions

This research answered the following research questions:

- What is the current status of farmers' willingness to pay for improved irrigation water use in Gumara irrigation schemes?
- What are the factors that influence farmers' willingness to pay for improved irrigation water use in Gumara irrigation schemes?
- What are the factors that influence farmers' maximum willingness to pay for the improved irrigation water use in Gumara irrigation schemes?
- How much the mean level of farmers' willingness to pay for improved irrigation water use in Gumara irrigation schemes could be in ETB?
- How much the aggregate level of farmers' willingness to pay for improved irrigation water use in Gumara irrigation schemes could be in ETB?

1.5. Significance of the Study

The information obtained from this research is expected to be an input for policymakers (higher level or local level administrators) to design irrigation water use strategies and programs. Particularly having the information of factors that influence both farmers' probability and maximum willingness to pay for improved irrigation water use could help in reviewing and improving policy and strategies which has been designed to conserve irrigation water specifically, in *Fogera* and *Dera* plains. Likewise, estimating the economic value of the commanded irrigation schemes most importantly help for project designer and planer specifically for projects that are interested to invest irrigation water use improvement at Gumara irrigation schemes to ensure the financial sustainability of it through predicting how much users will be able and willing to pay for irrigation water for the future. Moreover, the study expected to contribute to the existing empirical evidence of CV studies that use a double bounded followed by open-ended questions, and the result of this research will serve as a benchmark and a source of information to other researches which will be conducted in the study area on related issues.

1.6. Scope and Limitation of the Study

The scope of the study was restricted to the analysis of the demand-side for the provision of improved irrigation water from a cross-section data of Gumara irrigation kebeles. Besides, the sample used for this study was limited in both area coverage and size. Geographically the sample coverage of the study was limited with three irrigation kebeles only and the sample was limited with 300 households. Moreover, the CVM in which this study was used may pose limitations.

1.7. Organization of the Study

The thesis is organized into five chapters. The next chapter presents a review of the related theoretical and empirical literature. Whereas chapter three outlines the research methodology tracked, chapter four presents the result and discussion parts of the study and finally, chapter five provides a conclusion and recommendation of the study.

Chapter 2. LITERATURE REVIEW

This chapter is all about theoretical and empirical literature reviews, which are related to households' WTP and factors that determine households' WTP for improved irrigation water use, starting with the basic concept of Economic Importance of Irrigation schemes Development, and Economic Valuation method of Environmental Resource. It gives the foundation for designing the conceptual framework to do this research as well as it helps the researcher to enrich the thesis with literature-based evidence.

2.1. Definition and Basic Concepts

Willingness to pay: refers to the economic value of a good to an individual under a given condition (Young R.A., 2005). It could be the maximum amount of money the individual would be willing to give for a change in the quality of goods or services such as environmental amenity. The consumers' willingness to pay is becoming increasingly popular and is one of the standard approaches that are used by market researchers and economists to place a value on goods and services for which no market-based pricing mechanism exists (Chandrasekaran K.S. *et al*., 2009). Willingness to pay survey is very important in that it can be used to answer the question of ''how much can be charged?''. It helps to estimate the number of clients who will pay a given price, the amount of revenue that will be generated by that price about what is required to accomplish a given task and the characteristics of an individual who will pay or will not pay that price (Foreit K. G. and Foreit J. R., 2004).

Irrigation: different studies defined irrigation as follow; is the artificial application of water to the crop for food and fiber production over a coming deficiency in rainfall and help in creating stabilized agriculture (FAO, 1994). Irrigation development could be defined as a sense of agricultural development in which technology intervenes to provide control for the soil moisture regimes in the crop root zone to achieve a high standard of continuous cropping (EVDSA, 1996). Therefore, a working definition of irrigation for this study can be ''the practice of applying water to the soil to supplement the natural rainfall and provide moisture for plant growth ''.

Irrigation water use: An activity that refers to the provision of water to crop in an adequate and timely manner includes acquisition, allocation, distribution & drainage (Byrnes K.R., 1992). According to Byrnes K.R. (1992), these irrigation water use activities are defined;

The acquisition is one of the other irrigation water use activities concerning the acquisition of water from the sources, either by creating and operating physical structures such as dams or weirs or wells or by action to obtain some share of existing supply.

Allocation refers to the assignment of the right to users thereby determining who shall have access to irrigation water by scheduling.

Distribution refers to the physical process of taking the water from a source and dividing it among users at certain places, in certain amounts, and at certain times. On the other hand, drainage is important where excess water must be removed.

2.2. Economic Importance of Irrigation Schemes Development

The dependency on rain feed agriculture leads to less productivity in agriculture since rainfall is erratic due to climate change. Thus the transformation of the agricultural sector from rain feed agricultural system to irrigation-based agriculture is decisive. Irrigation has a multidimensional role in contributing to food security, self-sufficiency, food production, and export (Yenesew Mengiste, 2015). It can also provide surplus agricultural production by improving the economic, social well-being, and livelihood diversification of farmers. For negotiating the worlds increasing demand for food in the short run and long run, irrigation has an enormous role.

As far as irrigation meets the short-run demands of food it is one of the options which increases production, facilities diversification, reduces multidimensional risk, and creates employment opportunities. Besides, the role of irrigation development is growing food adequacy level of households (helps to produce sufficient amount of food consumption), increasing income level, asset building such as house construction for rent, saving account, and creation of employment opportunity. Therefore, it is a significant indicator of economic development and brings sustainable agriculture development (Tesfa Worku, 2011).

Developing countries may require large water storage facilities, further irrigation development, and charges in the operation of existing schemes (Molden D.Q., 2007). Therefore these are the most possible measures for reducing poverty, to keep up with global demand, to adapt to the effect of urbanization, to meet the shifting demand from staple crops to fruits, vegetables, and livestock products, and to respond to climate change. Irrigation is critical to poverty mitigation through increased productivity in rural areas; as a result, it improves food security and rural livelihoods (Belay Mehretie and Bewket Woldeamlak, 2013). According to Hamda Tulu (2014) irrigation has its impact to have high crop income, the large size of livestock, as a result, access to irrigation increase the opportunity for crop intensity and diversification which increases cropping income. Generally, irrigation has a significant and positive contribution to households' income. Irrigation also has a positive role on hold earning from livestock.

Although irrigation is important in the Ethiopian economy the use of irrigation technology currently not widespread and the country intensively depends on rainfall agricultural production. Besides a lack of irrigation water infrastructure leads to a serious constraint to irrigation development. However (FAO and IFC, 2015) reported Ethiopia could offer ample score for growth in agricultural production through irrigation developments because the country is endowed with a substantial amount of water. Therefore, it needs improvement in the irrigation sector of Ethiopia by overcoming the constraints of irrigation infrastructures.

2.3. Review of Methodological Frameworks

2.3.1. Economic Valuation of Environmental Resource

Nearly everybody would approve that the environment has remarkable value to humanity, from the natural resources that provide the basic material inputs for our economy to the ecological services that provide us with clean air and water, arable soil, flood protection, and aesthetic enjoyment. Some of these values are expressed through market transactions. Using market data, economists can estimate the benefits consumers and producers obtain from marketed goods and services. But many of the benefits we obtain from nature are not necessarily derived from market transactions.

Therefore 'how can we analyze tradeoffs between the market benefits of goods and services versus the nonmarket benefits of ecological services and environmental amenities' is the main issue in this regard. Many economists such as: (Jonathan M. and Brian R., 2015) believe that to make a valid comparison we need to first quantify all these benefits using a common metric. The standard metric normally used by economists is some monetary unit, such as dollars. Thus the central challenge for nonmarket valuation becomes expressing various benefits and costs in dollar terms.

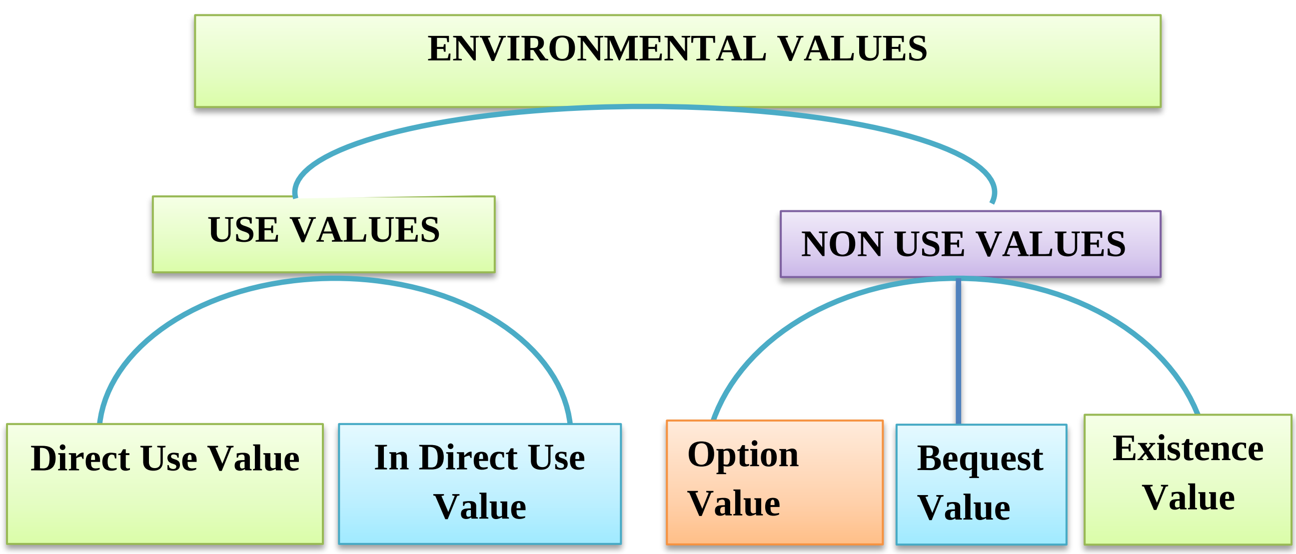
First, it needs to consider the benefits that we receive from natural resources and the environment (Perman R.M.*et al*., 2003). Marketed goods and services provide benefits to consumers as defined by the difference between their maximum willingness to pay and price, which is consumer surplus. The same notion can be applied to nonmarket goods and services. The economic value that people obtain from a specific resource is defined as their maximum willingness to pay (WTP) for it. For many nonmarket goods, there is not a direct "price" that must be paid to receive benefits. Clean air, for example, is something for which most people would be willing to pay. While they cannot necessarily express the valuation of clean air in markets, they can express their support in other ways, such as by voting or donations.

If a specific policy would damage or destroy a certain environmental resource or decrease environmental quality we can ask how much people would be willing to accept in compensation for these changes. This is the willingness to accept (WTA) approach to environmental valuation. Both WTP and WTA are theoretically correct measures of economic value. They can be applied to any potential policy situation. We will consider various economic techniques used to estimate WTP or WTA shortly, but first, we turn to the different types of economic value (Jonathan M. and Brian R., 2015).

2.3.2. Types of Values that We Place on the Environment

Economists develop classification schemes to describes various types of values that we place on the environment. These values are classified as use and nonuse values (Akram A. *et al*., 20011) Use values are tangible benefits that can be physically observed. They are further classified as direct use value and indirect use value (Latinopoulos P., 2005). Direct use value is obtained when we make a deliberate to use the environmental resource. These values may derive from the financial benefits that we could obtain by extracting or harvesting a resource, such as the profits from drilling for oil. They may also derive from the well-being that we obtain by interacting with a natural environment, such as fishing or going for a hike or fishing. Indirect-use values are tangible benefits obtained from nature without any effort on our part. Also referred to as ecosystem services, they include flood prevention, the mitigation of soil erosion, pollution assimilation, and pollination by bees. While these benefits may not be as apparent as direct use benefits, they are still real economic benefits and should be included in economic analysis (Jonathan M. and Brian R., 2015).

Nonuse values are derived from the intangible well-being benefits that we obtain from the environment. While these benefits are psychological, they are nonetheless "economic" as long as people are willing to pay for them and they are further classified into option value, bequest value, and existence value (Hussen A.M., 2000; Jonathan M. and Brian R., 2015). Option value refers to the amount that people are willing to pay to preserve a resource because they wish to use it in the future. On the other hand bequest value is the value that one places on a resource because he or she wishes it to be available for future generations. Finally, existence value is the benefit that an individual obtains from knowing that a natural resource exists, assuming that he or she will never physically use or visit the resource separate from any bequest value.



Source author's design, 2020

Figure 2. 1Types of environmental values

Table 2. 1. Definitions of environmental values

Variables	Description
Use value	The value that people place on the use of a good or service.
Nonuse value	Values that people obtain without actually using a resource
Direct use value	The value one obtains by directly using a natural resource
Indirect use value	Ecosystem benefits that are not valued in markets,
Option value	The value that people place on the maintenance of future options
Bequest value	On the knowledge that a resource will be available for future generations.
Existence value	The value people place on a resource that they do not intend to ever use

Source author's design, 2020

2.3.3. Types of Valuation Method

Typically, the researcher's goal is to estimate the total willingness to pay for the goods or services in question. This is the area under the demand curve up to the quantity consumed. For a market good, this calculation is relatively straight- forward. However, nonmarket goods and services require the estimation of willingness to pay either through examining behavior, drawing inferences from the demand for related goods or through responses to surveys.

Valuation methods can be classified as either stated preference or revealed preference method (Ward F. and Michelson A., 2002; Tietenberg T. and Lewis L., 2018). Revealed preference methods are based on actual observable choices that allow resource values to be directly inferred from those choices, on the other hand, stated preference method that can be used when the value is not directly observable, such as the value of conserving environmental resource (Tietenberg T. and lewis L., 2018).

Revealed preference method

Revealed preference methods are those that are based on actual observable choices that allow resource values to be directly inferred from those choices. These methods are observable. They involve actual behavior and indirect because they infer a value rather than estimate it directly resource (Tietenberg T. and lewis L., 2018). The revealed preference indirect approach methods infer the value of environmental goods by studying their actual or revealed behaviors in closely related markets through the application of some model of relationships between marketable goods and environmental services (Bockstael I.*et al*., 2005). Some of the revealed preference methods that are in use about environmental resource valuation are hedonic pricing method (HPM) and the travel cost method (TCM).

A Hedonic pricing method

The hedonic pricing method is the most commonly used revealed preference valuation technique. It is derived from the characteristics theory of value and seeks to explain the value of commodities as a bundle of valuable characteristics (Young R.A., 2005). HPM relies on market evidence related to property values to determine the value that people assign to improvements in access to public and quasi-public goods (e.g., police and fire protection, local parks) and environmental quality. It is assumed that individuals choose the number of public goods and environmental quality they want by the choices they make concerning residential purchases. People choose to live in areas that have cleaner air or less crime, they choose to live near airports or along highways, and they choose to live on quiet or on busy streets. The choice is determined by what they are willing and able to pay for housing. HPM exploits these choices by estimating implicit prices for house characteristics that differentiate closely related housing classes (Van Kooten G., 2016).

B Travel cost method

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

Stated preference method

Stated preference methods use survey techniques to elicit willingness to pay for a marginal improvement or for avoiding a marginal loss. The most direct approach, called contingent valuation, provides a means of deriving values that cannot be obtained in more traditional ways. The simplest version of this approach merely asks respondents what value they would place on an environmental change or on preserving the resource in its current state. Alternative versions ask a “yes” or “no” question such as whether or not the respondent would pay $X to prevent the change or preserve the species. The answers reveal either an upper bound (in the case of a “yes” answer) or a lower bound (in the case of a “no” answer). This survey approach creates a hypothet ical market and asks respondents to consider a willingness-to-pay question contingent on the existence of this market (Tietenberg T. and Lewis L., 2018). Some of the stated preference methods that are frequently used in the valuation of an environmental resource are contingent choice modeling and contingent valuation approach

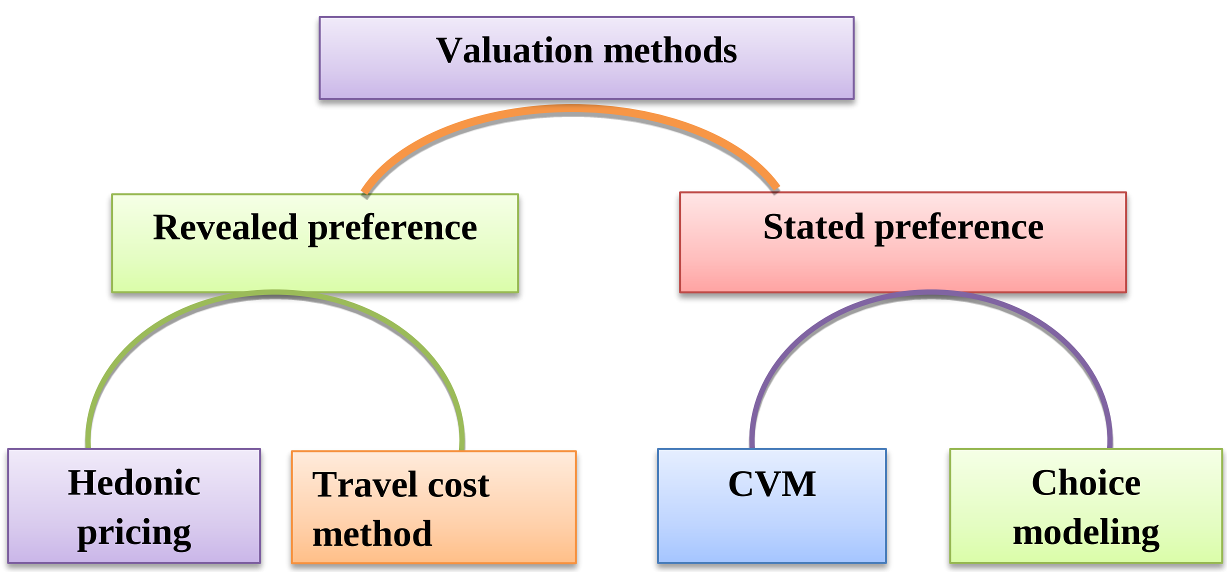
A Choice modeling

Indirect hypothetical stated preference methods include several attribute-based methods. Attribute-based methods, such as choice experiments, are useful when project options have multiple levels of different attributes. Like contingent valuation, choice experiments are also survey-based, but instead of asking respondents to state a willingness to pay, they are asked to choose among alternate bundles of goods. Each bundle has a set of attributes and the levels of each attribute vary across bundles. Since one of the attributes in each bundle is a price measure, willingness to pay can be identified (Tietenberg T. and Lewis L., 2018).

B Contingent valuation method

Contingent valuation, the most direct approach, provides a means of deriving values that cannot be obtained in more traditional ways. CVM is a recognized and widely used non-market valuation technique (Adem Kedir, 2011).In developing countries, contingent valuation surveys were originally applied in water supply and other environmental benefits estimation, and are much easier and very straight forward to conduct because the respondents take it more serious than in the industrialized countries (Alhassan M. *et al*., 2013). CVM is a demand-side approach with hypothetical markets that allow individuals to state their willingness to pay for changes in the quantity or quality of environmental goods and services and the objective of CVM is to measure consumer surplus for the environmental attributes (Ellingson L. and Seid l A., 2007). There are two advantages to this method. First, CVM can assess an individual’s WTP in the present conditions and also values their WTP with hypothetical changes. Second, CVM can value trips with multi destinations by asking hypothetical questions for each specified destination. Specifically, CVM was seen both as an alternative method of valuation TCM and HPM and as being able to quantify some types of benefits, such as non-use or passive-use benefits, which lie outside the scope of TCM and HPM studies (Ian J.et al., 2001). Given this, and the fact that indirect methods cannot address non- use/existence values, the study employed the CVM in the context of trying to ascertain non-use/existence values.

Following Perman R. M.*et al*. (2003) the steps involved in applying the CVM can be stated as follows. The first step is the creating of a survey instrument for the elicitation of individuals' WTP/WTA. This can be broken down into designing the hypothetical scenario, deciding whether to ask about WTP /WTA and creating a scenario about the means of payment or compensation. The second step is using the survey instrument with a sample of the population of interest. This step is followed by the analysis of the responses to the survey that can be seen as using the sample data on WTP/WTA to estimate average WTP/WTA for the population and assessing the survey results to judge the accuracy of this estimate. Fourthly, computing total WTP/WTA for the population of interest is followed. The last, but not least step in CVM is conducting sensitivity analysis



Source author's design, 2020

Figure 2.2.Valuation method

Table 2.2.Valuing methods of environmental resource

Methods	Revealed preference	Stated preference
Direct	Market Price Simulated Markets	Contingent Valuation
Indirect	Travel cost, hedonic pricing	Choice modeling (attributed based)

Source author's design, 2020

2.3.4. Ways of Asking CV Question

There are different ways to ask willingness to pay questions in contingent valuation surveys, which are known as elicitation methods (Ahmed S. U. and Gotoh K., 2006). Presently four ways of asking are commonly used in CVM studies. These are open-ended, bidding game, Payment Card, and dichotomous choice (Chanel O.*et al*., 2015)

Open-Ended: it is a way of asking CV questions in which the respondent is asked to provide the interviewer with a point estimate of his or her WTP. It is a question like "how much you will pay? Due to, respondents' difficulty in answering the payment question, the open-ended question leads to extreme response or results in many missing values

Bidding Game: it is a way of asking CV questions in which individuals are iteratively asked whether they would be willing to pay a certain amount or not. The amounts are raised (lowered) depending on whether the respondent was (was not) willing to pay the previously offered amount. The bidding stops when the iterations have converged to a point estimate of WTP. The final amount is interpreted as the respondent's WTP. This approach, however, has its disadvantages. The first disadvantage of the bidding game approach is that it results in a starting point bias as the final value is systematically related to the initial bid value. Annoying or tiring respondents which cause them to answer yes or no to a stated amount in hopes of terminating the interview is another disadvantage of the bidding game approach.

Single-bounded question: it is a dichotomous or discrete choice way of asking CV questions in which the respondent gives a "Yes" or "No" response to a proposed bid. Such a method is easy to implement and much more familiar to the respondents because of the similarity to the market condition. Thus, it minimizes non-responses and decreases outliers. However, the large sample size may be required to get a sufficient level of accuracy in WTP estimation. Thus, it increases the cost of the survey.

Double-bounded question: is an extension of the single-bounded discreet choice. Accordingly, a second bid is introduced conditional to the answer given to the first bid. Thus, in this method more statistical efficiency can be achieved than that of SBDC as additional information can be elicited on each respondent's WTP. However, similar to the single-bounded method, the double-bonded question method may require a large sample size to reduce the risk of feeble information on the WTP distribution.

Payment Cards: it is the way of asking CV question in which individuals are asked to choose a WTP point estimate (or a range of estimates) from a list of values predetermined by the surveyors, and shown to the respondent on a card. The final amount chosen by the respondent can be interpreted as the respondent's WTP. This approach is also criticized on the ground that the respondents might limit their announced WTP to the values listed on the card.

Generally, Dichotomous choice contingent valuation questions have gained popularity over the last several years. This is due primarily to their purported advantages in avoiding many of the biases known to be inherent in other formats used in the contingent valuation method (Cameron T. and Quiggin J., 1994). However, all these methods of asking questions have their relative advantages and disadvantages and none is free from criticisms (Ahmed S. U. and Gotoh K., 2006).

2.3.5. Limitation of contingent valuation

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

Strategic bias: This occurs when a respondent does not state his/her true preference of the good or service, i.e., he behaves strategically with the hope to "free ride" (Tietenberg T., 2003).

Starting point bias: This occurs when the respondent's WTP amount is influenced by a value introduced by the scenario. The bidding game elicitation techniques pose the most obvious threat of this kind since it directly confronts the respondent with a proposed amount that the respondent is asked to accept or reject. Thus, the choice of a low (high) starting point leads to a low (high) mean WTP (Bateman I. and Turner R., 1993). While the use of starting points may reduce non-response and variance in the open-ended questionnaire, "bidding hints" might lead respondents to take cognitive shortcuts to arrive at a decision rather than thinking seriously about their true WTP (Mitchell R. and Carson R., 1989).

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

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

Nevertheless, when surveys are properly planned and executed, most of the CVM problems can be eliminated, thus offering the best hope for estimating environmental benefits (Whittington D. *et al*., 1993). According to Hoevenagel R. (1994), the application of CVM is better compared with other valuation methods in its completeness, the ability to measure a wide range of goods, and the capacity to measure non-use value. Moreover, according to FAO (2004), careful use of CVM can elicit both use and non-use values for an amenity. Also, CVM focuses on ex-ante (forecasted) behaviors before some change occurs whereas others such as; the travel cost and hedonic pricing methods produce values ex-post. Thus, estimates of changes in the welfare of interest to the policymaker are theoretically better approached using CVM than using the observed-indirect methods

2.3.6. Types of water pricing method

Several water pricing methods are implemented throughout the world (Tsur Y. and Dinar A., 1997). There are two reasons: First Costs of supplying irrigation water vary widely, reflecting different combinations of water sources, suppliers, distribution systems, and other factors such as field proximity to water, and topography. Secondly, efficient water allocation can be achieved by the marginal cost pricing rule, but its implementation is a costly operation that requires metering, monitoring, fee collection, and other administrative tasks. Thus, the most implemented water pricing methods are presented as follows (Fragoso R. and Marques C., 2013).

Volumetric water pricing: Water is charged by direct measurement of water volume consumption (the charge is based on the amount of water delivered). The economic optimal pricing rule requires that price should be set equal to the marginal cost of providing the water, and it requires accurate measurement of water through meters. The advantage of this pricing method is that it encourages farmers to limit their water use. Also, it is easy to understand in the sense that you pay for the quantity of water delivered to your farm. However, it has several disadvantages. First, the implementation costs can be high because meters are required, and they have to be honestly read and reported. Second, marginal cost pricing does not allow full cost recovery in the case of decreasing average costs (for example, large canal systems). Once the infrastructure is in place, the marginal project costs will be lower than average costs, thus pricing based on the marginal cost will not achieve full cost recovery. In contrast, for the case of pump irrigation using groundwater, the marginal project costs are likely to be higher than average project costs, particularly when marginal costs include the marginal user cost. Thus, for some groundwater projects, marginal cost pricing could result in over-collection as well as high water charges relative to farm income.

Output/input: According to FAO (2004) output pricing, where the water fee is levied on each unit of output produced by the user; and input pricing, where a farmer pays for irrigation water indirectly through higher prices for inputs purchased from the government or water agency. Both input and output pricing avoid the need to measure the volume of water diverted or consumed. However, there is no evidence found for the application of these two methods in practice; because of distortion effects on the price of crops.

Area-based pricing: Water is charged by irrigated area and fees usually vary according to the kind and extent of irrigation crop, irrigation method, and season of the year. The disadvantage of this pricing method is that, once the irrigated area decision is made, the water charge will not affect farmers' water consumption, because the marginal cost of applying additional quantities of water per hectare is zero. Thus, the water demand is usually higher than it would be under a price or charge that varied by the quantity of water used, and it is likely to lead to overuse of water by farmers near the head of the canal. The advantage is that it is simple to calculate, easy for farmers to understand, and the implementation costs are lower than for volumetric pricing because water deliveries do not have to be measured. Although it gives farmers no incentive to reduce water use per hectare, it is one of the most widely used water pricing methods around the world due to the simplicity of its implementation (Chazovachii B., 2012).

Block-rate: Under this pricing method, different volumetric rates vary according to certain threshold values of water consumption. Block pricing involves varying the water price when water use for a set time exceeds a set volume (for example, 5,000 m3 per hectare per season). If high water charges are a concern, an increasing block charge can be used. The price of the first block can be set below O&M costs. The second and later blocks are raised to higher rates that cover O&M costs and reflect the marginal cost of operations.

Two-part tariff: A two-part charge is a combination of volumetric pricing and fixed annual charge for the right to access water which can be charged by irrigation area (based on the size of the area irrigated). For the block pricing methods described above, the two objectives full cost recovery and reduced water uses are often in conflict. The advantage of a two-part charge is that it can reconcile the conflict.

Water markets: Their participants may trade water rights at a particular price during specific periods or trade water quantities at the spot price or for future delivery, and water is charged on a volumetric or flow basis. There are several kinds of water markets, from sanctioned markets for water rights in Chile (Fragoso R. and Marques C., 2013) to spontaneous spot markets in Brazil

Each water pricing method is associated with different levels of welfare and net benefits, and the choice depends particularly on the implementation cost, which varies from region to region due to climate issues, demography, social structure, water rights, water facilities, history, and economic conditions. The preferred pricing method should be the one that achieves the highest benefit. Volumetric methods are efficient (Fragoso R. and Marques C., 2013). However, Tsur Y. and Dinar A. (1997) compared volumetric pricing with area-based pricing, and they conclude that area based pricing was better resulted due to the low implementation of water proceeds. As a result, in this study per area pricing(area-based pricing) method was employed.

2.4. Theoretical Framework

The theoretical foundations of CVM are in the random utility theory (Kanyoka P.*et al.*, 2008). The respondent households are initially asked whether or not they would be willing to pay a specific amount for improved irrigation water supply service. When a respondent is asked one dichotomous choice question, the response is usually "yes" or "no", depending on the individual's WTP the proposed bid value. It is assumed that respondents know which choice maximizes their utility. The utility that individual i will realize after choosing an alternative j can be expressed as follow

$$\mathrm{Uij} = \mathrm{Vij} + \varepsilon\mathrm{ij} ------------------------------ (1)$$

Where:

- uij represent the indirect utility, i individual receives on choosing alternative j
- vij represent the deterministic utility, i individual receives on choosing alternative j
- εijrepresents the random component of the utility function.

The random component is assumed to be identically, independently distributed with zero means. The marginal utility of payment depends on an expected improvement in the irrigation water supply. Assume pi be a specific amount that a respondent is willing to pay to get the improved irrigation water supply k. That is, an individual will choose alternative k over alternative j if utility from k is greater than from j (Cornes R., 1992).

$$\mathrm{Uik}\left\lfloor\frac{\mathrm{y}-\mathrm{pi}}{\mathrm{xi}}\right\rfloor > Uij\left\lfloor\frac{\mathrm{y}}{\mathrm{xi}}\right\rfloor ---------------------------(2)$$

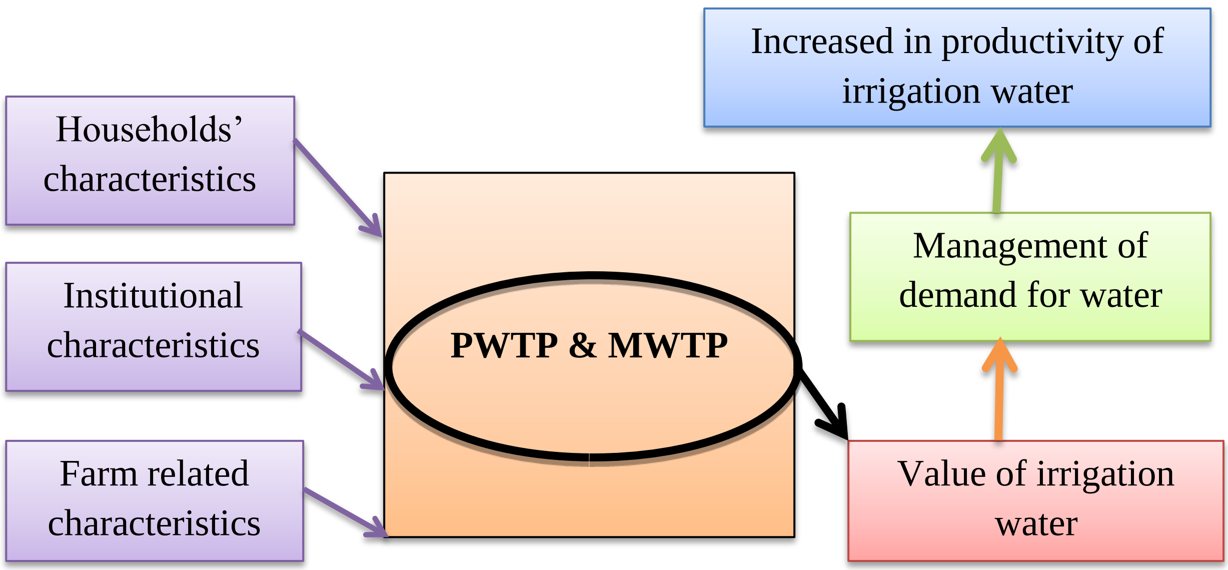
Where:

- y income & xi is represented as a vector of socio-economic characteristics of individual i.

An individual will be willing to pay an amount of pi, if the utility gained from the situation with improved irrigation water supply is larger than the utility with the current irrigation water supply system, taking into account the change in income.

2.5. Conceptual Framework

The conceptual framework of this study is based on the assumption that WTP (PWTP&MWTP) is influenced by several socio-economic factors such as households' characteristics, institutional characteristics, and farm-related characteristics. Besides as a study by Omondi S. (2014) reported, quantifying farmers' WTP help to manage the water demand, as a result, it increases the efficiency and productivity of the irrigation water.



Source author's design, 2020

Figure 2.3.Conceptual frameworks of households' WTP

2.6. Review of Empirical WTP Studies

There are different studies in environmental valuation through both WTP and WTA approach using the contingent valuation method. However, this subsection favored reviewing several previous studies where the contingent valuation method has been used to determine WTP for a specific improvement or conservation of environmental resources especially, water in Ethiopia and out said of Ethiopia.

Analyzing farmers' WTP for improved irrigation water use is an important requirement for successive irrigation water management and sustainable financing of the irrigation schemes. This information is important for adequate implementation of water pricing policies, for accurate cost-benefit analysis of investments in water supply or water market infrastructure, and also for determining optimal distribution of the scarce resource between users (Hudu Z. et al .,2014).

In this regard, Tadese Tolera *et al*. (2019) conducted a study on the determinants of farmers' WTP for improved irrigation water use in the case of Woliso district, Ethiopia. Accordingly, the study explored as 92.43% of 251 respondents were demanded to invest in the improved irrigation scheme. Beside this assessment was made using CVM with Double bounded dichotomies choice followed by open-ended elicitation formats to identify socio-economic determinants of farmers' WTP. Under their assessment the authors found, Education Level of the Household Head, Family size, Irrigable Land Size, Total Annual Income, Experience in Irrigated Farming, Dissatisfaction, Credit Utilization and, initial bid to have a significant effect on farmers' willingness to pay for improved irrigation water.

From the detailed discussion of the study education level of the household head, was significantly and positively influences the farmers' probability and maximum willingness to pay for improved irrigation water use. The researchers explained that more literate individuals are more concerned about water resource since education provides knowledge and enable households to have information and awareness about the opportunity from improved irrigation water than less or non-educated households. Similarly, the irrigable land size was reported as one of the positively determinant factors for farmers' probability and maximum willingness to pay for improved irrigation water use at Woliso district Ethiopia. The possible explanation from the report was more irrigable land increase the opportunity to get income from crop production. Furthermore, total annual income; experience from irrigated farming, dissatisfaction, and credit utilization was the other factors that influence the farmers' probability and maximum willingness to pay for improved irrigation water use positively. On the other hand, the initial bid was influenced by the households' probability and maximum willingness to pay negatively. These detail discussion about the determinant of farmers' probability and maximum willingness to pay was based on the result obtained from Tobit Model regression.

On the other hand, farmers' willingness to pay status was found in the Agarfa district, bale zone, Oromia national regional state to have about 80% of the 124 respondents (Meseret Birhane and Endrias Geta, 2016). This study informed households' willingness to pay status is different across the study area and contingent valuation surveys have been widely applicable methods in valuing use and non-use values of environmental goods and services like water resources. From this CV study assessment identified, sex of the household head, education level of the household head, family size, and perceived trend in rain-fed agricultural productivity, initial bid, credit utilization, and total annual income determined farmers' probability and maximum willingness to pay for improved irrigation water-use facilities. The finding from Tobit econometric model revealed the sex of the household head, educational level of the household head, credit utilization, total annual income, and perceived trend in rain-fed agriculture, were found to be positively and significantly related to the probability and maximum households' WTP whereas household family size, and the bid value offered were found to be negatively and significantly influence on the probability and maximum households' WTP for improved irrigation water use. Their study recommends that the decision-makers and the policymakers should consider the above significant factors in taking up the decisions related to irrigation water use. Generally, this finding shows analyzing the households' demand for sustaining the improved irrigation water use services is paramount importance for adequate implementation of water pricing policies.

Having sufficient knowledge about farmers' demand or willingness to pay is important for conserving other environmental resources (Birara Endalew and Beneberu Assefa, 2019). Birara Endalew and Beneberu Assefa (2019) assess the willingness to pay decisions of the respondents for the conservation of church forests (which is a part of an environmental resource like irrigation water) in northwestern Ethiopia. For this purpose, double-bounded CVM followed by open-ended questions was employed. The assessment indicated that 248 (87.3%) of sample respondents were willing to pay for conservation practice. Apart from this, the study aimed at the objective to estimate the households' mean willingness to pay and to analyze the factor influencing the households' maximum willingness to pay for the conservation of the church forest. For this purpose Tobit model was found to be an appropriate econometric model to analyze the factor influencing the households' maximum willingness to pay for the conservation of church forests. Accordingly, the finding demonstrated that the income of the household was one of the other factors that had a statistically and positively significant influence on households' willingness to pay for conservation of church forests. The possible explanation from the report was "having more income increases the purchasing power of sample respondents". Whereas the result from the CV survey revealed a mean willingness to pay in terms of cash and labor are 178 ETB and. (1787.75 ETB) man-days, respectively. The forest policy of Ethiopia, particularly the

South Gondar zone should design strategies to diversify income sources of the households to realize the conservation of church forests. This study recommends that the forest policy of Ethiopia, particularly the South Gondar zone should design strategies to diversify income sources of the households to realize the conservation of church forests. Generally, this finding informed that having the information of factors that influence house holding willingness to pay for conserving environmental resource could help in reviewing and improving policy and strategies which has been implemented by the responsible bodies.

Understanding households' mean as well as aggregate willingness to pay for improved irrigation water use system is worthwhile for proposing and implementing a project that allows participation of the users' contribution toward the improvement of irrigation water use to get a better supply of irrigation water. Mattering this, Tadese Tolera *et al*. (2017) carried out an estimation of farmers' mean level of willingness to pay for improved irrigation water use at South Shoa Zone Oromia Ethiopia. The study used a double bounded dichotomous choice method eliciting a contingent valuation method to elicit the respondents of the sample household. After eliciting the response from the double bounded contingent valuation method the author employed a seemingly unrelated bivariate probit model to display the coefficient of bid values and its corresponding constants outcome. Then after employed the method introduced by (Krinsky I. and Robb A., 1986) to estimate the mean. Consequently, the estimated mean willingness to pay for the improved irrigation water use was Birr 575.23 per 0.25 hectares per year. On the other hand, mean estimation was made on the open-ended questions it was estimated to be 562 per 0.25 hectare per year. The report suggested that "as a matter of fact that, households become free riders in the open-ended questions" the mean willingness to pay in double bounded dichotomous choice format is higher than that of open-ended CVM questions. This finding mainly could an empirical evident for methodological frameworks of estimating farmers' mean willingness to pay. Besides, it showed estimating the mean willingness to pay in open-ended CV question is undermined the true value of environmental resources, especially for water resources. Also, a similar study was undertaken earlier (Ayana Anteneh, 2016).

Ayana Anteneh (2016) estimated the economic value of improved irrigation water by eliciting the sample households' WTP using DBDC followed by open-ended CVM in Bahir Dar Zuria Woreda, Ethiopia. The study utilized the bivariate probit model to estimate the mean WTP from the DBDC format. Consequently, the mean WTP from the bivariate probit model was found to be ETB 674.5 per year per timed per household. The study also estimated the mean willingness to pay from open-ended elicitation format, as a result, it was estimated to be ETB 579 per year per timed per household. Under this study identifying determinant factors that influence households' willingness to pay for improved irrigation water use system was also made. This was carried out based on two separate methods of econometric model analysis. i.e. the bivariate probit model was employed to estimate the determinant factors which influence farmers' probability of willingness to pay for improved irrigation water use. On the other hand, the Tobit model was the other econometric model employed for identifying determinant factors that influence farmers, MWTP for improved irrigation water use. Consequently, the result of the bivariate probit model revealed in both Bid levels price was found to be the negative significance determinant for the probability of households' WTP but the income was influenced positively. Furthermore, the report from the Tobit model showed that households' annual income had a positive and significant influence on households' maximum willingness to pay. This paper is empirical evidence that identifying farmers' probability of willingness to pay and MWTP should be analyzed in different models. This result also been in agreement with the other findings which are stated farmers mean willingness to pay from the open-ended question is less than from DBDC format.

Some other studies show different socio-economic determinant factors that determine farmers, WTP for improvements of irrigation differently across different study sites. For instance, Mekonnen Ayana *et al* (2015) conducted a study to identify determinant factors for farmers' WTP for the conservation of irrigation water in the Awash River Basin of Ethiopia. For the analysis, the logit model was undertaken. The finding showed the controversial influence of education level on households' WTP. This result showed the education level of the household had a negative significant influence on the probability of households' willingness to pay for conservation of irrigation water use. It was explained "educated respondents had the fear of increased price if they identify themselves willing to pay. Whereas, a study conducted in Gondar town, Ethiopia using the contingent valuation survey by Yibeltal Wale (2015) found parameters of education level to be positively statistically significant with farmers' willingness to pay for watershed protection.

Similar study Tesfahun Alemayehu (2014) identified the factors that influence households' probability of willingness to pay for improved irrigation water at Koga district in Ethiopia. Using the binary probit the finding showed that" sex "of household head was the main determinant factor which influences positively the households' PWTP toward the hypothetical project the dissection suggested male households are more likely WTP for improved irrigation water services than female households. Similarly, the level of education and household annual income was the other explanatory variables that positively and significantly influence the probability of households' WTP. On the other hand, the study reported bid values as it was a significant influence on the probability of households' willingness to pay negatively. Also, a similar study by Mekonnen Ayana *et al* (2015) suggested that households with access to credit were more willing to pay for irrigation water than those households with no access. Similarly, Irrigators with longer irrigation experiences were also more WTP than those relatively short periods of experience.

Alem Mezgebo *et al*. (2013) conducted a study on "Values of Irrigation Water in Wondo Genet District, Ethiopia" using a CVM of stated preference valuation technique. Using the probit model the study identified as "Age" of the household head had a negative and significant effect on households' PWTP in ETB. The report suggested that old people faced labor shortage to encroach the irrigation water resource and old people demanded fewer water resources than the young people similarly the bid values had a negative sign as the economic theory predicts. The negative sign indicated that as the bid prices increase the proportion of respondents who answer yes in the choice question decreases. Furthermore, the finding revealed annual income and education level of household head were the other determinant factor that had a positive and significant influence on households' PWTP toward the irrigation water.

Using probit model Nega Assefa (2012) suggested; the estimated coefficient of the proposed bid value was statistically significant and affected households' PWTP for irrigation water negatively. Whereas, irrigation farming experience, was found to have a highly statistically significant influence on households' PWTP positively. The author suggested that households with longer irrigation farming experience could easily realize the benefit of irrigation and hence is more likely to attach high value for irrigation agriculture than those who have no or shorter years of irrigation farming experience. Furthermore, households' annual income and market access were the other explanatory variables that influence the probability of households' willingness to pay.

Kinds of literature also showed there is a mean estimated value difference of irrigation water in different time horizons and across different study areas. Mekonnen Ayana *et al.* (2015) conducted a study in the Awash River Basin of Ethiopia. From his analysis the estimated mean willingness to pay for irrigation improvement found to be Birr 88 per hectare per year per person whereas, the mean willingness to pay for irrigation water in the case of the Koga irrigation project in Ethiopia was found to be 128.88 Birr per hectare per year per person (Tesfahun Alemayehu, 2014). The method of how the studies were analyzed to estimate the mean farmers, willingness to pay for irrigation water is different and it might be expected to lead different amounts of values. Also, Nega Assefa (2012) estimated the farmers' mean willingness to pay for the irrigation water in south Gonder Ethiopia and the result was Birr 614 per annual per timad per household. But it was Birr 417 from the open-ended question. The aggregate demand from close-ended and open-ended was estimated as birr 35,513,760 and 24,147,622 respectively.

Although a lot of studies have done on WTP for irrigation water throughout the country, Practical experience of payment for water in Ethiopia is low (Mekonen Ayana et al., 2015). According to Mekonen Ayana *et al.* (2015), Awash River Basin is the only basin in Ethiopia where irrigation water pricing is practiced. Awash Basin Authority, which was legally established in 1998 as Awash Bain River Basin Administration Agency has been responsible for integrated management of the waters of the basin. It is reestablished and named as ABA in 2000. Any significant water diversion from the river for irrigation purposes requires the approval of the authority. The ABA collects water charges on a volumetric basis from all legal water users who are developing greater than 2 ha of land. The payment is categorized into water charge (3 Birr1 per 1000 m3 of water), operational service payment (84.10 Birr) per hectare of land served per year. The charge rate for irrigation water was set in 1994 by the then Ethiopian Water Resources Development Authority and never modified since then. Charging water use is legalized with the Ethiopian water management proclamation number 115/2005. As stated in the same proclamation, charge for water use is to be determined by the council of ministers. The country has established river basin councils and authorities for all 12 major river basins with the proclamation number 534/2007. This proclamation also stipulates the legality of charging users for water.

There are also some other studies reviewed on socio-economic determinants of farmers' willingness to pay for irrigation water improvement out said of Ethiopia. For instance, Hudu Z.*et al*. (2014) assessed Factors affecting Farmers' WTP for improved irrigation service in Bontanga Irrigation Scheme, Northern Ghana. In their assessment found age and income to have a significant influence on farmers' willingness to pay. Also, the study found that the mean WTP for improved irrigation service delivery per ha per season was GHS 22.92 ($10.51). The study recommends that any proposed increase in Irrigation Service Charges (ISCs) should be taken into consideration the mean WTP of 22.92GHS.

Njoko L. (2014) in the assessment of WTP for irrigation water in rural areas of Kwazulu, South Africa found accessed to extension contact to have a significant effect on farmers' WTP positively. The finding was generated from a binary probit model through the CVM. Also, Karthikeyan C. *et al*. (2010) using a logit model; in their assessments of WTP for irrigation in India found the family labor force and irrigating farm size to have a negative influence on farmers' WTP. Others like Ibrahim A. and Robert H. (2010) attempted to quantify the economic value of domestic water in Ramallah Palestine. The study applied a Tobit model to identify the factors that influence MWTP. The mean WTP was calculated from the open-ended question format which was estimated to be NIS 627(the currency of Palestine) per year. Besides the Tobit model result revealed that household income and age of household were a significantly positive determinant factor for domestic water users' WTP.

Generally, the empirical literature revealed CVM is a widely accepted method for valuing environmental resources. Besides, the author noted that understanding households' WTP is paramount importance to sustain the improvement or quality of the given environmental resource. However, the following issues are some points observed in the overall literature;

- Most findings of the studies revealed that HHs' status and level of WTP for improvement of irrigation water were varied in time, area, and methodology used.

- Of the WTP studies reviewed, a combination of socioeconomic variables could determine HHS' probability and MWTP. However the sign of the variable of influence and level of significance of each determinant variable are different across location, time, and methodology used.
- Most of the existed literature valued water using a single bounded discreet model but, a single bounded dichotomous choice approach yields inefficient welfare measures due to limited information obtained from each respondent. So more studies should be used double bounded dichotomous choice approach.
- Except few, all previous studies were conducted using CVM in the valuation of irrigation water improvement to identify only the households' PWTP but none has been focused on the estimation of improved irrigation water use to analyze both the PWTP and amount of money the households could pay.
- Identifying the determinant factors of WTP is a Comprehensive issue of identifying determinant factors for PWTP &MWTP for the improvement of a specific environmental resource. However, the previous studies were not considered for both PWTP &MWTP rather most studies inclined to assess the determinate factors on the PWTP only.

As a result, this paper attempted to cover such undermined issues in the previous studies through conducting a study aiming at identifying factors which influence both the probability of willingness to pay and maximum willingness to pay for improved irrigation water use system through applying bivariate probit model and Tobit model using DBDC followed by OE elicitation method respectively. Besides this, it tried to quantify the mean and aggregate willingness to pay using both DBDC and OE formats of CVM.

Chapter 3. RESEARCH METHODOLOGY

3.1. Description of the study area

The study was conducted in the Gumara irrigation scheme which is located in *Fogera* and *Dera* districts. The irrigation schemes are bounded with *Fogera* and *Dera* districts of South Gonder zone ANRS Ethiopia. The name Gumara irrigation scheme is originated from Gumara River which is located in South Gonder which extends from mount Guna from the east to Lake Tana in the west.

Fogera is a district in the Amhara National Regional State and found in South Gondar administrative zone bordering with Lake Tana, the source of Blue Nile. It is situated at 110 58 N latitude and 370 41 E longitude. The district has a total land area of 117,414 hectares. The land use pattern of the district includes 51,662 hectares of cultivated land, 25,831 hectares of pasture land, and 16,434 ha for other purposes, and the water bodies‟ account for 23,483 hectares (Getaneh Kebed, 2011).IPMS (2005) indicate that flat land accounts for 76%, mountain and hills 11%, and valley bottom 13%. The high proportion of plain topography creates an opportunity for irrigation. The altitude ranges from 1774 to 2410 masl. The mean annual rainfall is 1215 mm and ranges from 1100 to 1340 mm (MOA, 2005).

Dera district which is another location of the irrigation scheme is also located in the south Gonder zone and is bordered to the south by the Abay River which separates it from the west Gojam administrative zone. To the west, it is bordered by Lake Tana, to the north by *Fogera*, and to the east by *Estie* district. Dera district covers a total area of 158,948 ha, of which 35% is plain, 20% is mountainous, 18% is gorges and 27% is undulating. The altitude of the woreda ranges from 1,500 m to 2,600 m above sea level while the annual average rainfall is 1,250 mm. As to the agro-ecology, 85% is Woyn dega while 15% is dega (Dera woreda agricultural office, 2019).

Generally, *Dera* and *fogera* are the most agricultural productive districts in the south Gonder Zone of the Amhara region and they are characterized by the high proportion of plain topography that gets them the opportunity for irrigation.

3.1.1. Description of selected kebeles

Kuhar Michael Kebele

Kuhar Michael kebele is located 17 Kilometer south-east of the woreda's town (woreta) and 39 Kilometer north of Bahir Dar. The main Asphalt road pass from Addis Ababa to Gonder passes through this kebele. Gumara town, which is known as an onion and tomato market, is found in this Kebele. According to the *Fogera* district office of agriculture (2020), the number of population and households in the Kebele were estimated 7888.4 and 1834respectively. The landscape is characterized by both plain and upland. Kuhar Michael is endowed with perennial rivers and streams. Gumara River, one of the largest tributaries of Lake Tana, passes through this kebele. Farmers in this kebele use the Gumara River for all of their water needs. Gumara River is used for drinking purposes. Both people and livestock use it for drinking, washing, and other activities. Irrigation is the other important use of the Gumara River. Motorized pumps are widely used to draw the water from the river for irrigation. Traditional irrigation water distribution and allocation are practiced in this kebele. According to the Kuhar Michael irrigation office (2020), 372.5heactar of land is irrigated by using this river for irrigation.

Shina Kebele

Shina is located 13 km south-west of the woreda's town (Werota town). It is found towards Lake Tana. According to the *Fogera* district office of Agriculture 2010, the number of population and households in the Kebele were estimated 13067.6 and 2618.75 respectively. The landscape of the kebele is plain. The total surface area of the kebele is 3,400 hectares Motor and treadle water pumps are the common irrigation systems. Traditional river diversion and shallow wells are also used for irrigation, drinking, washing and other household consumption in the kebele. Gumara River has great economic importance to the district traverse this kebele. This River is mainly used in the kebele for irrigation during the dry season using water pumps. The small-scale irrigation methods used in the kebele are motorized pumps and wells. According to the Shina Kebele irrigation office (2020), the 439-hectare farm is irrigated by the Gumara River.

Jigna Kebele

Jigna is found in *Dera* district and is bordered to the north by the Gumara River which separates it from the *Fogera* district generally and from Shina and Kuhar Michael kebeles particularly. Gumara River is mainly used in this kebele for irrigation during the dry season using water pumps. The total irrigated land which is irrigated with the Gumara River is estimated to be 1008 hectares (Jigna kebele irrigation office 2020). The topography of the kebele is plain and some while gently sloping. The annual maximum and minimum rainfall of the kebele is 1,200 to 1,000 mm, respectively, while maximum and minimum temperatures range from 36oC to 24oC(MollaTafereetal.,2014). The land fertility of this kebele category into two as those lands which are found in plain areas is fertile due to sedimentation from upper catchments, while gently sloping land is relatively infertile according to the farmers in the kebele. Water resources have become a major source of conflict in the kebele, as water shortages are becoming more serious each year, especially for the production of irrigated crops. According to the Jigna Kebele irrigation office (2020), the 630-hectare farm is irrigated by the Gumara River.

Common characteristics of selected Kebeles

The selected kebeles have some common characteristics. The agro-climatic ecology of the three kebeles is similar. In each kebele, the *belg* and *meher* are two cropping seasons. The *belg* cropping season is a very short rainy period whereas *meher* season is the long rainy period. Farmers depend on *meher* season for rain-fed crop production. The onset, duration, and quantity of the rainfall are variable. Agriculture is the major occupation of the people in each kebele. The agriculture in all kebele is a mixed crop-livestock farming system. Crop production is rain-fed during the rainy season, supplemented for some households by small-scale irrigation in the dry season. The dominant crops grown in the study area are rice, teff (Eragrostis), wheat, barley, maize, beans, peas, chickpeas, and lentils. In irrigated agriculture production they commonly produced vegetables such as onion, tomato, potato, pepper, and cabbage. Furthermore, there is little irrigation water use improvement in all irrigation kebeles.

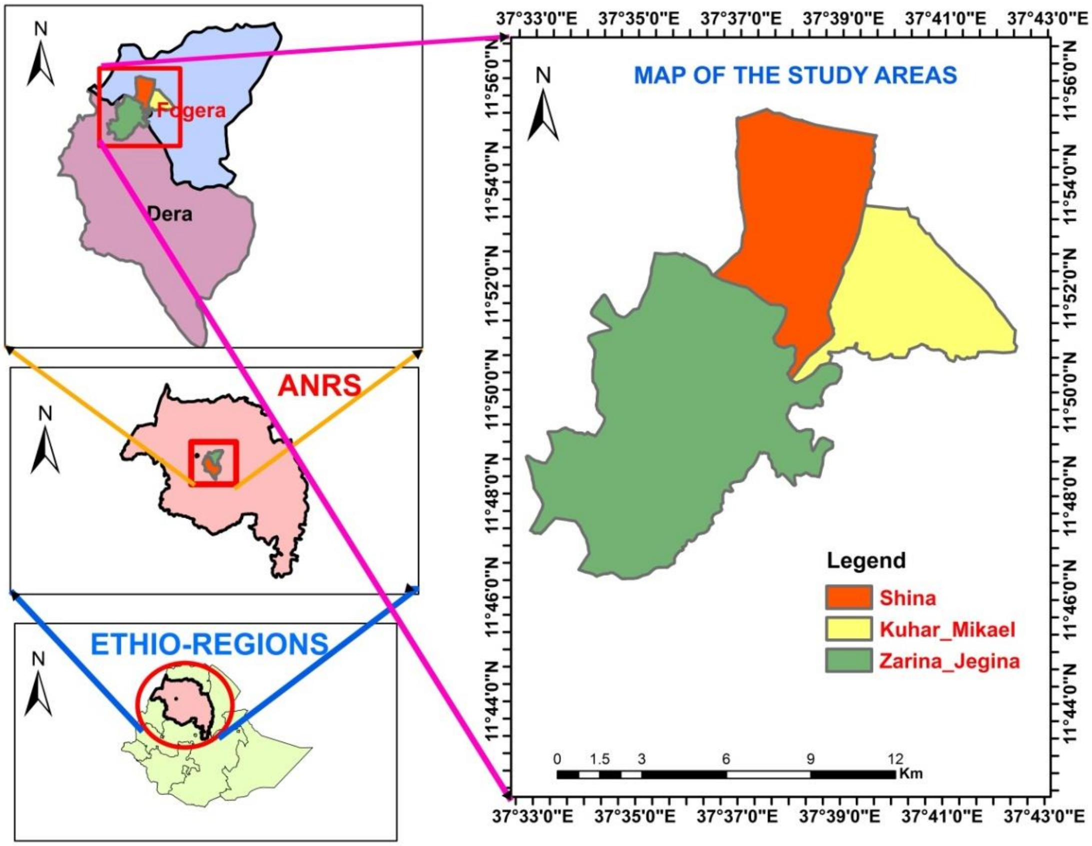


Figure 3.1.Map of the study areas

3.2. Data Type, Source and Methods of Data Collection

The study used both primary and secondary data. Primary data were collected from sampled household heads in the study area through a structured questionnaire using face to face interview. Secondary data were gathered from each selected kebeles' irrigation office. Secondary data was also gathered from the *Fogera* irrigation engineering office and Dera irrigation office.

The questionnaire was administered into two main sections. The first section provides several socioeconomic characteristics of households. The second section contains the contingent valuation scenario and the question of households' probability and maximum willingness to pay for the provision of improved irrigation water use. The questionnaire was translated into the Amharic language to ease the data collection process and reduce errors.

The data were collected by well trained and experienced enumerators. Before starting the actual survey, training about the objective of the study and how to manage the CV survey data was given to enumerators. Besides, a pre-test survey was undertaken to check the performance of the enumerators' understanding of the questionnaires and customization of the questionnaire into the local context.

Focus group discussion and the key informant interview were held to decide on the initial bid values during the first draft questionnaire preparation. A pilot survey was also conducted on 18 randomly selected households before the actual survey was started to check the validity of the questionnaire. Accordingly, the pilot survey was conducted with due supervision of the researcher, and the necessary adjustment to the draft questionnaire was made by the researcher. After the necessary adjustment was made to the draft questionnaire the final questionnaire was developed. Accordingly three most frequently stated values were approved as a starting bid values for the double bounded dichotomies choice format. These values were ETB 500, 600, and 700 per year per 0.25 hectares of irrigable land.

Using CVM and following Mitchel R. and Carson R. (1989) households were fairly assigned to one of the three assigned initial bid values to minimize the starting point bias. Sets of followed up bids were determined by making doubled the initial bid if the first response is "Yes" and halved if the second response is "No "following (Cameron T. and Quiggin J., 1994). As a result (500, 250, 1000), (600,300, 1200) and (700, 350, 1400) were the sets of bid values for this study. After the respondent answers the yes /no question in double bounded question they were asked their maximum willingness to pay using the open-ended questions to state the maximum amount they are able and willing to pay. Finally, the actual survey was conducted between Februarys and March 2020. Furthermore, the Contingent valuation method of survey data was summarized with the following figure.

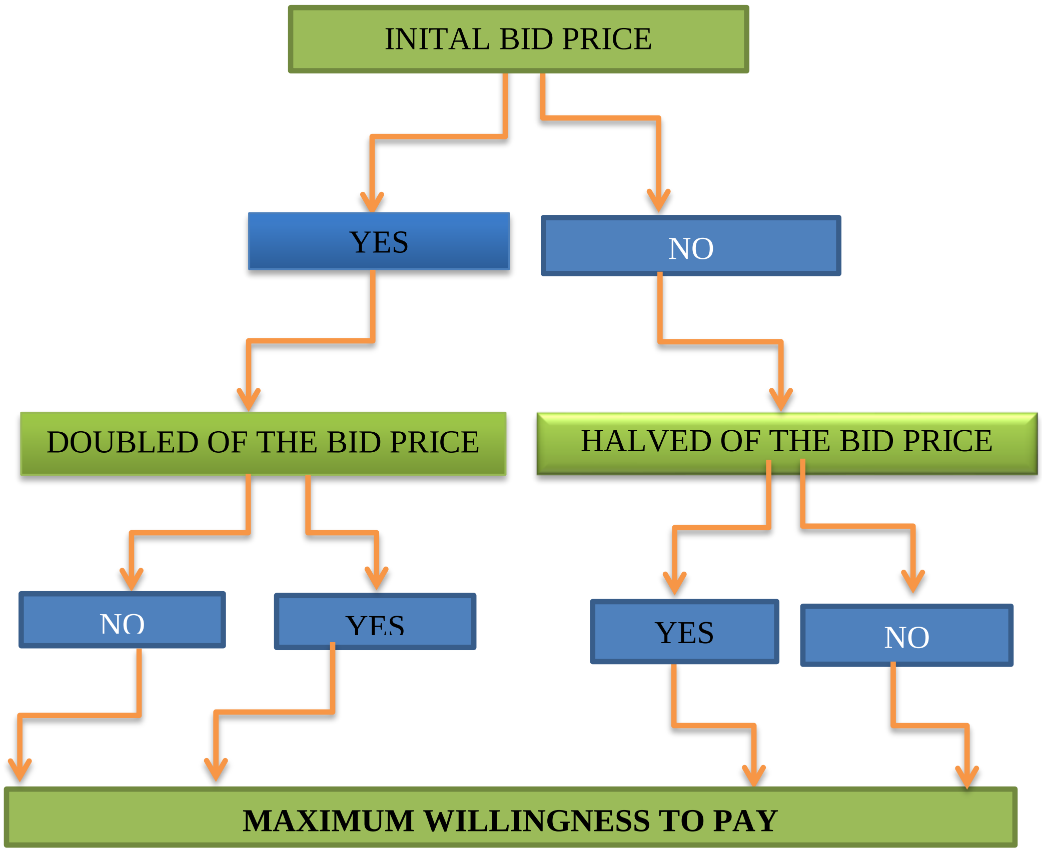


Figure 3.2.Summary of CV elicitation format

Source own design, 2020

3.3. Sampling Technique and Sample Size

For quantitative research, the probability sampling technique is more representative than the non-probability sampling technique. Accordingly, a systematic random sampling technique was used to select the sample households of the study. The study was conducted in three potential Kebeles under the command area of Gumara irrigation schemes, which have a high irrigation potential in Dera and Fogera districts of Amhara Regional State. Kebeles which had more or less improvement in irrigation water use are not considered for selecting these kebeles because the selected kebeles need to have the same existing irrigation water use system. The three potential kebeles are Kuhar Michael, Shina, and Jigna Kebeles and then individual respondents were selected from each kebeles by applying a systematic random sampling technique. Thus, 300 households were selected based on probability proportionate to population seize technique.

Therefore, the total sample size was distributed to each selected kebeles based on the proportion of Gumara river irrigation beneficiaries in each kebeles as shown in table 3.1.

In this study, the sample size was determined following Yamane T. (1967)

Yamane T. (1967): $n = \frac{N}{1+N(e)^2}$ ---------------------------------(3)

Where n is the sample size, N is the population (total irrigation water user households by using Gumara river), and e is the level of precision (0.05) for this study. N=1171 according to (Shina, Kuhar Michael, and Jigna kebeles irrigation office, 2019). Therefore the required sample size becomes≈ 300

Table 3.1.Sample size distribution

Name of selected kebeles	Number of the user population	Number of user sample farmers
Jigna kebele	630	161
Kuhar Michael	248	64
Shina kebele	293	75
Total	1171	300

Source Jigna, Kuhar Michael and Shina kebeles irrigation office, 2019

3.4. Method of Data Analysis

The data were analyzed using both descriptive statistics and econometrics models.

3.4.1. Brief description of the scenario presented for respondents

The irrigation improvement scenario is presented for the respondents during data collection period in such a way:“ By considering the existing unsustainable irrigation water problem there is a program intended to make a change in irrigation water use system through the mechanisms of constructing a small dam, and canal that can cover more than 1820 hectares of farmland to overcome existing storage and distribution challenges in the irrigation scheme. Besides, it is also intended to establish legal frameworks to give fair irrigation water allocation services between irrigation users. However, once the project improved the irrigation water use system mentioned above, money is required for maintaining the service provided for the future use of irrigation.

This money should be covered by the beneficiary households in the command area. So you will be charged a yearly irrigation water fee based on the hectare of land irrigated. Thus, to maximize the benefits from the improved service, 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 canals as well as to sustain the implementation of legal frameworks of irrigation schedule". After this scenario presented, the irrigation water was valued by the contingent valuation method.

The contingent valuation method is a valuation based on a survey that offers the respondents a chance to make an economic decision on non-market goods. That is, the valuation is contingent upon the simulated market presented to the respondent (Adem Kedir, 2011). World Bank (2002) states that contingent valuation is a method of estimating the value that a person places on a good, habitually one that is not sold in markets, such as environmental quality or good health. In natural resources, contingent valuation studies generally derive through the elicitation of respondents' willingness to pay to prevent injuries to natural resources or to restore injured natural resources (Abdul Rahim, 2005). Those elicitation approaches of respondent's willingness to pay are open-ended, biding game, dichotomous choice, and payment card method.

These approaches, however, have its' own advantage and disadvantages. Several studies such as Angella N.*et al*. (2014); Tesfahun Alemayehu (2014); Meseret Birhane and Endrias Geta (2016) conducted a study regarding irrigation improvement focused on open-ended follow-up question to analyze both probability and maximum willingness to pay. However, open-ended contingent valuation questions are doubtful to provide the most reliable valuations because responses to open-ended questions are unreliable and biased (Arrow K.*et al*., 1993). As a result, the researcher is motivated to investigate farmers' willingness to pay for improved irrigation water use using DBDC followed by open-ended questions to analyze the probability of willingness to pay and amount of WTP respectively.

3.4.2. Descriptive analysis

Descriptive statistics including percentage, frequency, mean, minima, and maxima were computed to presents the socio-economic characteristics and willingness to pay status of sample households.

3.4.3. Econometric model specification

The ultimate goal of estimating the econometric model from the DBDC format of CVM was to calculate the household's WTP for providing the irrigation service described in the scenario and to answer the question what are the factors that influence the households' PWTP in two different bid levels. On the other hand, the goal of estimating the economic model from the open-ended format was to answer what are the factors that influence the households' MWTP for improved irrigation water use. Binary probit and bivariate probit model are appropriate models for analyzing the influence of factors on discrete dependent variables.

A. Bivariate probit model

The binary probit econometric model is efficient and unbiased to estimate the coefficient of independent variables for the single bounded dichotomous choice model. Whereas, the bivariate probit econometric model is efficient and unbiased to estimate the coefficient of independent variables for the double bounded dichotomous choice model. Therefore, the bivariate probit model is a joint model for two binary outcomes with correlated error terms, in the same way for seemingly unrelated bivariate probit regression model /SUBPM/ (Greene W., 2003). SUBPM takes two independent binary probit models into account and estimates them together by considering their non-zero correlation of error terms between two equations. However binary probit regression model can produce unbiased, but inefficient estimators for exogenous variables because it assumes the error terms are not correlated with each other, also it ignores the unobservable heterogeneity between the two equations. Hence, an alternative approach to control for unobservable heterogeneity is to consider a SUBPM, as it provides a way of dealing with two separate binary dependent variables (Greene W., 2008).

The other comparative advantage of the SUBPM is to calculate the mean level of farmers' willingness to pay for improved irrigation water use. Therefore, in this study, a SUBPM was employed to estimate the coefficient of independent variables for the double bounded dichotomous choice to identify factors that influence PWTP and to quantify their mean WTP in two bid levels jointly. The Marginal effects and predicted values for farmers' PWTP in the two separate binary outcomes could be estimated similarly to those for the binary probit models. Marginal effects for the joint probability, say P (y_1=1 and y_2=1) are also available

The most general econometric model for the double bounded CV Data comes from Haab C. and McConnell (2002), formulations

$$WTPij = \mu i + \varepsilon ij ------------------------------ ---4$$

Where:

- $WTPij =$ is the jth respondents WTP
- $i = 1,2$ represents first and second answers.
- $\mu 1, \mu 2 =$ is the mean value for the first and second response and
- $\varepsilon ij =$ un observable random component

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

Haab C. and McConnell (2002):

A. $pr(yes, no) = (WTP1i \geq t^1, WTP2i < t^2) = \; pr(\mu 1 + \varepsilon 1i < t^1, \mu 2 + \varepsilon 2i < t^2),$

B. $pr(yes, yes) = (WTP1i > t^{1,}, WTP2i \geq t^2) = \; pr(\mu 1 + \varepsilon 1i > t^1, \mu 2 + \varepsilon 2i \geq t^2)$

C. $pr\,(no, no) = (WTP1i < t^1, WTP2i < t^2) \quad = \quad pr(\mu 1 + \varepsilon 1i < t^1, \mu 2 + \epsilon 2i < t^{2)}$

D. $pr(no, yes) = (WTPli < t^1, WTP2i \geq t^2) \; = \qquad pr(\mu 1 + \varepsilon 1i < t^1 \mu 2 + \varepsilon 2i \geq t^2 --- 5$

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

$$Li\left(\frac{\mu}{t}\right) = * \; pr(\, \mu 1 + \varepsilon 1i \geq t^1, \mu 2 + \varepsilon 2i < t^2)\; YN,$$

$$* \; pr(\mu 1 + \varepsilon 1i > t^1, \mu 2 + \varepsilon 2i \geq t^2) YY,$$

$$* \; pr(\mu 1 + \varepsilon 1i < t^1, \mu 2 + \varepsilon 2i < t^2) NN,$$

$$* \; pr(\mu 1 + \varepsilon 1i < t^1, \mu 2 + \varepsilon 2i \geq t^2) NY. ------------------6$$

where:

- t^1First bid price
- t^2second bid price
- $YN = 1$for yes, no answer, 0 otherwise
- $YY = 1$ for yes, yes answer, 0 otherwise
- $NN = 1$ for no, no answer, 0 otherwise
- $NY = 1$ for no, yes answer, 0 otherwise

This formulation is referred to as the Bivariate Discrete Choice Model. Assuming normally distributed error terms with mean 0 and respective variances $\sigma 1^2$ and $\sigma 2^2$, then WTP1j and

WTP2j have a bivariate normal distribution with means μ1 and μ2, variances $\sigma1^2$ and $\sigma2^2$ and correlation coefficient ρ.

Given the dichotomous responses to each question, the normally distributed model is represented as a bivariate probit model. The i^{th} contribution to the bivariate probit likelihood is given as;

$$L\left(\frac{\mu}{t}\right) = \varphi\varepsilon1\varepsilon2\left(d1i^{(t^{1-\mu})/\sigma1}\right),\left(d2i^{(t^{1-\mu/\sigma2)}}\right), d1id2i\rho ----------------- 7$$

where:

- $\varphi\varepsilon1\varepsilon2$ = the bivariate normal cumulative distribution function with zero means
- $d1i = 2y1i - 1$ and $d2i = 2y2i - 1$
- ,$y1i = 1$if the response to the first equation is yes and 0, otherwise
- $y2i = 1$ if the response to the second equation is yes and 0, otherwise
- ρ = coorlation coefficient &
- σ = standard deviation of the error

Then after running a regression of dependent variable of two equations (yes/no indicators), on a constant and on Independent variables consisting of the bid levels, the mean WTP value was calculated Following the approach developed by(Krinsky I. and Robb A.,1986). Therefore, the mean WTP value of improved irrigation water can be calculated as follows as:

$$\text{Mean WTP} = {x'\beta'}/{\mu o'} --------------------------8$$

where:

- x' = raw vector of a sample mean including 1, for the constant term,
- $\beta'^{(k-1\times1)}$ = estimated coefficients
- $\mu o'$ = coefficent on the bid variable
- $x' = 1\&\beta$ *is the coefficient in the constant term*

Whereas, the mean WTP from open-ended contingent valuation response could be estimated following to Habb C. and McConnell (2002) as:

$$\text{mean WTP} = \sum_{i=0}^{n} {yi}/{n} ------------------------ 9$$

Where:

- n, is the sample size and y, is the MWT pay reported by households.

B. Tobit Model

One of the specific objectives of the study was to identify the factors that influence the households' MWTP in the improvement of irrigation water use. Using contingent valuation method DBDC followed by the open-ended question was used to produce the dependent variable (households' MWTP) having continuous values including zero.

The Tobit model is more importantly appropriate if the dependent variable takes value below the lower limit and above the upper limit for some part of the observation and positive continuous values for the rest of observation (Verbeek M., 2004). However, OLS estimates become biased and inefficient because of the number of zero values in the dependent variables (Wilson C.and Tisdell C., 2002). As it is clearly stated above the nature of the dependent variable in this study needs to censor zero from below or left since there is true zero MWTP from the survey result. Thus, the Tobit model was used to analyze the explanatory variables which explained the MWTP among sample households. Following Verbeek M. (2004) the model specified as:

$$y* = xi\beta + \varepsilon i, \quad i = 1,2,3, - - - - - - - N$$

$$y = y*, \text{if } y* > 0, y = 0, if\ y* \leq 0 - 10$$

Where:

- y= the maximum willingness to pay of i^t respondents
- Xi=the vector of independent variables
- β=vector of coefficients
- εi is the error term where εi ~ (0, δ2
- y*= the latent variable which is not observable when it is ≤ 0 but it observed when >0.

According to Johnston P. and Dinardo J. (1997) interpreting the coefficient of a Tobit in the same way as interpreted in the non-censored linear model is not sensible. Therefore, one has to submit a post estimation of the Tobit model to predict the effect of change in the exogenous variables.

$$\frac{\partial \epsilon(y)}{\partial xi} = f(t)\beta' - 11$$

where:

- $\frac{\beta xi}{\delta}$ is denoted by t $- 12$

The change in the amount of WTP concerning a change in the explanatory variable among

Individuals who are willing to pay are:

- $(\partial y/y * \neq 0) = \beta'[1 - t\frac{f(t)}{F(t)} - (\frac{f(t)}{F(t)})^2]$ --------------------13

Where:

- F (t) is the cumulative normal distribution of T,
- f (t) is the value of derivative of the normal curve at a given point)
- t is the T score for the area under a normal curve, and
- β' is the vector of the Tobit maximum likelihood estimate.

3.5. Definition of Variables and Hypotheses

Under this subsection, variables are explained and the relationship between independent variables to the dependent variables is hypothesized.

3.5.1. Dependent variables

Willingness to pay (WTP): is the farmers' probability of willingness to pay for maintaining of improved irrigation water use system. This variable is a dummy variable that takes the value of 1 if the respondent is willing to pay the offered bid values 0 otherwise. The variable is dummy variable

Maximum willingness to pay (MWTP): is the maximum willingness to pay that the respondent will be asked to state their maximum values for improved irrigation water use in ETB. The variable is continuous

3.5.2. Independent variables

Bid values: bid value is one of the important determinant variables that determine the households' probability and maximum willingness to pay for improved irrigation water use. It is the offered bid price to the respondents. Economic theory states the higher is the bid price (value) the less likely households would be willing to pay for the improvement of environmental goods or services. Yibeltal Wale (2015) has shown that bid value had a negative significance influence on households' probability of WTP. This is in agreement with the result obtained latter (Ayana Anteneh, 2016). Yibeltal Wale (2015) has also shown that bid value had a positive significant influence on the MWTP for the improvement of irrigation. This is in disagreement with the result obtained latter (Meseret Birhane and Endrias Geta, 2016). Therefore, this variable was expected to have a negative influence on farmers' PWTP for improved irrigation water use. However, it is difficult to hypothesize the direction of bid values on MWTP for improved irrigation water use systems.

Gender: It is the state of either the household head is being male or female. The variable in this study is a dummy variable which takes 1 if the household head is male and 0 if female. A study by Tesfahun Alemayehu (2014) reported that men headed households are more likely WTP for the improved irrigation water service than women-headed Households. This is in agreement with results obtained later (Meseret Birhane and Endrias Geta, 2016). Meseret Birhane and Endrias Geta (2016) also showed that men headed households are more amounts willing to pay than women-headed households. Therefore, it was hypothesized that men headed households would have a positive significant influence on farmers' probability and maximum willingness to pay for improved irrigation water use.

Age of the household head: age is another important explanatory variable that explains the households 'probability and maximum willingness to pay for improved irrigation water use. It is a continuous variable that measures the age of the household head in a number of the year at the time of the interview. Ibrahim A. and Robert H. (2010) showed that the age of household head affected households' PWTP for the improvement of irrigation water positively. This is in disagreement with the result obtained later (Alem Mezgebo *et al*., 2013). Therefore, it is difficult to hypothesize the direction of the age of the household head on the probability of households' willingness to pay as well as maximum willingness to pay for improved irrigation water use systems.

Education level of household head: education level is the number of years of schooling household head has attained. The variable in this study is treated as a continuous variable. Tesfahun Alemayehu (2014); Yibeltal wale (2015) and Meseret Birhane and Endrias Geta (2016) have shown that the education level of the household head determines households' probability of willingness to pay for improved irrigation water use positively. This is in agreement with the result obtained latter (Tadese Tolera *et al*., 2019). Also, Tadese Tolera *et al*. (2019) reported that the education level of the household head determines households' MWTP for improved irrigation water use positively. On the other hand, Mekonnen Ayana *et al*. (2015) showed that the controversial influence of education level on households' PWTP. This result showed the education level of the household head had a negative significant influence on the probability of households' WTP for the conservation of irrigation water. However, as the majority of the report revealed its positive sign, households with more years of schooling are expected to more likely willing to pay for improved irrigation water use. As a result, it is hypothesized that the education level of the household head would have a positive effect on the households' probability of willingness to pay and maximum willingness to pay.

Family labor force: it is the members of the family that are engaged in work. So, the Family labor force is a continuous variable measured in adult equivalent in this study. Family labor force influences households' probability of willingness to pay for irrigation water improvement negatively (Karthikeyan C.*et al*. 210). Thus, it is hypothesized that families with large Family labor force would have a negative influence on households' probability of willingness to pay and maximum willingness to pay for improved irrigation water use.

Experience in irrigated farming: it is the number of years since the household head has started irrigating practice. So this variable is a continuous variable for this study. Farmers who had more experience in irrigated farming knew the importance of irrigation and they are more amounts willing to pay for irrigation water than those with relatively shorter or non-experienced farmers (Chandrakanth M. G. and Rohith B. K., 2011). While the other study by Nega Asefa (2012) and Mekonen Ayana *et al*. (2015) have suggested that more experienced farmers in irrigation practice are more likely willing to pay than less experienced. This is in agreement with the results obtained latter (Tadese Tolera *et al*., 2019). Tadese Tolera *et al* (2019) also showed that more experienced farmers in irrigation practice are more level of willing than less experienced farmers. Thus, experience in irrigated farming was expected to influence households' probability and maximum willingness to pay for improved irrigation water use positively.

Total annual income: it is a continuous variable and indicates households' previous total annual income measured in ETB. Ayana Anteneh (2016) has shown that total annual income has a positive impact on the households' probability and maximum willingness to pay for the improvement of irrigation water. This is in agreement with the result obtained (Meseret Birhane and Endrias Geta, 2016). Therefore, households' total annual income was expected to influence both the probability and maximum households' willingness to pay for improved irrigation water use positively.

Credit utilization: it is another dummy variable that influences farmers' willingness to pay for improved irrigation water use. This dummy variable refers to whether or not the farmers received credit. Consequently, if a farmer took credit it takes 1 and 0 otherwise. Tadese Tolera *et al*. (2019) reported that credit utilization has a positive influence on the probability and maximum willingness to pay of users for improved irrigation water use. Therefore, credit utilization was expected to influence the households' probability and maximum willingness to pay for improved irrigation water use positively.

Distance of Output market: This is a continuous variable that measures the distance of the farm of the household in an hour's walks on foot to the nearest market center. Molla Tafere (2005) stated if the market place is located far away from the farm, the commodity may perish, especially for perishable commodities, before reaching the market and reported the negative relationship between the probability of WTP for irrigation water and distance to the output market center.
Therefore, this variable expected to influence farmers' probability of WTP and maximum willing ness to pay for improved irrigation water use negatively.

Perceived trend in rain feed agricultural productivity: this variable is one of the other explanatory variables which determined farmers' willingness to pay for improved irrigation water use and which states the farmers' perception toward rein feed productivity trends since five years have gone. It is a dummy variable and takes 1 if the household head believes that there has been a decrease in crop yields per hectare of land during the past five years, 0 otherwise. For the interest of this study, the five-year time horizon would provide an adequate period to realize whether the crop productivity reduction is caused by a change in rainfall if there is any change in rain feed agricultural productivity. Meseret Birhane and Endrias Geta (2016) Suggested a Perceived trend in rain feed agricultural productivity positively affected the households' probability and 'maximum willingness to pay. Thus, the Perceived trend in rain feed agricultural productivity was expected to determine farmers 'probability and maximum WTP positively.

Farm distance from irrigation water source: it is a continuous variable that refers to the distance of the farm of the household measured in hours walk on foot from the nearest irrigation water source. A study by Chandrakanth, M. G. and Rohith B. K. (2011) forwarded that households' probability of willingness to pay increases when the distance from main water Source increases. However, Alhassan M. (2012) reports a negative impact of distance from the main water source on farmers' probability of willingness to pay for improved irrigation water use. Therefore it is difficult to hypothesize whether this variable influences the farmers 'probability and maximum willingness to pay for improved irrigation water use positively or negatively.

Contact with development agents: this variable is one of the important dummy explanatory variables that explain the farmers' probability and maximum willingness to pay for improved irrigation water use. It refers to whether the farmers (household head) have had development contact to get information or advice from a development agent related to irrigation farming at least one times since one year has gone. Then it is a dummy variable for this study which takes 1 if a farmer has had development contact0 otherwise. Njoko L. (2014) suggested extension contact has a positive role in farmers' willingness to pay for improvement in irrigation technology. Therefore, contact with development agents was expected to influence the farmers' willingness to pay for improved irrigation water use positively.

Dissatisfaction: it is a dummy variable which states whether the household head is dissatisfied or satisfied in the existing irrigation water use system. It takes 1 if the household head is dissatisfied with the existing irrigation water use system, 0 otherwise. Ayana Anteneh (2016) has shown that farmers who are not satisfied with the existed irrigation water use system found to be more likely and level of willingness to pay if there is an improvement as compared to those satisfied with the existing irrigation water use. This is in agreement with the result obtained later (Tadese Tolera *et al.*, 2019). Therefore, dissatisfaction was expected to influence the farmers' probability and maximum willingness to pay for improved irrigation water use positively.

Irrigated farm size: it is the amount of irrigated land that households have during the survey year measured in a hectare. So this variable is continuous. Alem Mezgebo *et al.* (2013) have shown that irrigated farm size determines households' PWTP for improved irrigation water positively. This is in agreement with the result obtained latter (Tadese Tolera *et al*., 2019). Tadese Tolera *et al*. (2019) also suggested that irrigated farm size determines households' MWTP for improved irrigation water use positively. Thus, this variable was expected to influence the farmers' PWTP and MWTP for improved irrigation water use positively.

Table 3.2.Summary of variables and their expected sign

Dependent variables			Variable description
willingness to pay (WTP)			Dummy, 1 if yes, 0 otherwise
Maximum willingness to pay (MWTP)			Continuous ,in ETB
Explanatory Variables	Exp sign of WTP	Exp sign of MWP	Variable description
Gender	+	+	Dummy , 1 if male,0 otherwise
Age of household head	+/-	+/-	Continuous , in year
Education level of household head	+	+	Continuous ,in class year
Family labor force of household	-	-	Continuous, in proportion number
Irrigating farm size of household	+	+	Continuous, in hectare
Total annual income of household	+	+	Continuous, in Birr
Irrigating experience of household head	+	+	Continuous ,in year
Credit utilization of household	+	+	Dummy ,1 if utilized 0 otherwise
Contact with development agents	+	+	Dummy, 1 if contacted 0 otherwise
Farm Distance from irrigation water source	+/-	+/-	Continuous, in Minutes of walk
Farm Distance from output market	-	-	Continuous ,in hours of walking
perceived trend of rain fed agricultural productivity	+	+	Dummy ,1 if decrease 0 otherwise
Dissatisfaction of household	+	+	Dummy,1 if dissatisfied 0 otherwise
Bid values	-	-	Categorical , in ETB

Source own data, 2020

Chapter 4. RESULTS AND DISCUSSIONS

This chapter presents the finding of the study and deals with an appropriate level of discussion. It is divided into four main sections. The first section presents several socio-economic characteristics of sample households. The second section is about sample households' WTP status. The third section presents about determinants of households' WTP and finally, the fourth section deals with the estimation of mean and aggregate households' WTP.

4.1. Socio-economic Characteristics of sample households

In this study, a total of 300 households were interviewed in 3 kebeles of the Gumara irrigation scheme. But 288 households were used for analysis purposes since 12 observations were eliminated as invalid responses. Those protests attached the scenario with political issues and they gave wrong responses when they asked to state their WTP. based on the criteria of the report of the NOAA panel on a contingent valuation by Arrow K *.et al*. (1993) which suggested that a respondent willing to pay the stated amount might answer in the undesirable, if the respondent believes the proposed scenarios distributed the load unfairly, misgiving on the feasibility of the planned action and refusal to accept the hypothetical choice problem. Therefore, the result and discussion are made based on 288 respondents who gave a valid response.

4.1.1. Household characteristics

Relating to the sex of the household head (SEX), the descriptive statistics revealed in Table 4.1 that among 288 sampled households, about 89% were men headed households about 11% were women-headed households. Age of the household head, the average age of the sampled respondents was 45.3 years with the minimum age of 22 years and a maximum of 75 years old. Regarding the education level of household head, the average attainment of household head was 4 grades with a minimum of 0 and a maximum of 12 class years. The survey result presented in table 4.2 revealed that the average family labor force of the total sampled household was about 3.6 adult equivalents with a minimum of 0.8 adult equivalents and a maximum of 5.4 adult equivalents. In table 4.2 is also demonstrated that the average households' yearly income is about ETB 51,416. The total annual income level ranges from a minimum of ETB 3500 to a maximum of ETB100000. From the total income of the household, the average households' yearly income from irrigated farming is about ETB 43, 832. The income level of the household from irrigated farming ranges from a minimum of ETB 3010 to a maximum of ETB 84500. Experience of irrigation practices is another continuous variable of households' attribute and the mean experience of sample households in irrigation practices was about 11 years with the ranges from a minimum of 2 years to a maximum of 15 years.

Table 4.1. Household characteristics for a dummy variable

Explanatory variable	Categories	Freq.	%	Obs.
Men-headed household	Male	256	89.32	288
	Female	32	10.68	

Source, author's survey data, 2020

Table 4.2. Household characteristics for continuous variables

Explanatory Variables	Obs.	Mean	Std. Dev.	Min	Max
Age of household head	288	45.34722	14.07165	22	75
Education level of household head	288	4.440972	4.759365	0	12
Family labor force	288	3.6	1.539957	0.8	5.4
Total annual income of household	288	51416.67	28792.42	3500	100000
Income from irrigated farming	288	43, 8632	24473.56	3010	84500
Irrigating experience of household head	288	10.78819	5.086047	2	15

Source, author's survey data, 2020

4.1.2. Institutional characteristics of sample households

Regarding credit utilization of the household head (CRDT), out of the total sampled households, about 36% were utilized credit and about 64% were not utilized credit in the last year. Concerning development agent contact (EXTENSION), about 66% of households accessed a development agent contact at least once in a year and 34% of households did not get development agents' service at all in the last year.

Table 4.3. Institutional characteristics of sample households

Explanatory variables	Categories	Freq.	%	Obs.
Credit utilization of household	Yes	103	35.76	288
	No	185	64.24	
Extension service	Yes	190	65.97	288
	No	98	34.03	

Source, author's survey data, 2020

4.1.3. Farm-related characteristics of sample households

The survey result also is shown in Table 4.4 that from the total sampled household about 92% of households are dissatisfied and 3% are satisfied with the current irrigation water use system. Table 4.4 is also demonstrated that 86% of household heads perceived that the trend of rain-fed agricultural productivity over the last five years decreases and about 13.54% of household heads are perceived as constant or increase. Relating to the irrigated land ownership, the average irrigated landholding size of the sampled household during last year was about 3 timad (0.75 ha) with the minimum 1 timad (0.25 ha) and a maximum 7 timad (1.75 ha). Concerning the farm distance from the irrigation water source, the mean distance from the farm to the river was about 13 minutes with a minimum of 2 minutes to a maximum of 32 minutes.

Table 4.4. Farm-related characteristics of sample households for dummy variables

Explanatory variables	Categories	Freq.	%	Obs.
The perceived trend of rain-fed Agricultural	Decreased	249	86.45	288
productivity	No decreased	39	13.54	
Households' dissatisfaction with the current	Yes	280	97.22	
irrigation water use system	No	8	2.78	288

Source: author's survey data 2020

Table 4.5. Farm-related characteristics of sample households for continuous variables

Explanatory Variables	Obs.	Mean	Std. Dev.	Min	Max
Irrigating farm size of household	288	3.416667	2.249274	0.25	1.75
Farm distance from water source	288	13.20486	7.798622	2	32

Source: author's survey data, 2020

4.2. Households' Willingness to Pay

4.2.1. Households' willingness to pay status for improved irrigation water use.

To measure WTP of the households for the provision of improved irrigation water use in Gumara irrigation schemes this study conducted key informant interviews to decide either the schemes are labor-intensive or capital intensive. Consequently, from the qualitative data obtained from the *Fogera* irrigation office, FGD, and key informant interview the study area was face to labor shortage (there is no cheap access of labor) then the researcher decided to use money as a payment vehicle to elicit farmers' willingness to pay for maintaining an improved irrigation water use system in the Gumara irrigation scheme. Before the elicitation questions, individuals were asked if they would pay money for the proposed program. So, yes or no question was designed to assess the WTP status of the respondents. Accordingly out of the total 288 random selected households, 283 (98.26%) of the respondent were willing to pay money (they said yes) for the proposed project and the reaming 5 (1.74%) of them were not willing to pay for the given scenario. Those, unwilling household heads reported that they couldn't afford to pay for the proposed improvement. This implies that the given scenario is supported by about 98 percent of households. Those who did not show a willingness to pay as the economic reason could be treated as having true zero willingness to pay (Ayana Anteneh, 2016; Birara Endalew and Beneberu Asefa, 2019).

Table 4.6. Households' willingness to pay for the proposed scenario statistics

Willingness to pay any amount of money	Freq.	Percent	Cum.
Willing	283	98.26	98.26
Unwilling	5	1.74	100.00
Total	288	100.00	

Source: author's survey data, 2020

4.2.2. Households' willingness to pay in the initial bid values

In the CV survey, the households were asked their willingness to pay by giving those three fairly assigned initial bid values (500, 600, and 700). Consequently, given the fairly assigned initial bid values, out of the total 288 household heads, about 69% of them were willing to pay in the initial bid values, and the reaming about 31% of them were not willing to pay in the initial bid values.

Table 4.7. Households' willingness to pay in the initial bid values

Willingness to pay in initial bid values	Freq.	Percent	Cum.
Yes	199	69.10	69.10
No	89	30.9	100.00
Total	288	100.00	

Source author's survey data, 2020

4.2.3. Households' willingness to pay in the second (follow up) bid values

The second bid values were doubled of the initial bid values for those households who were willing to pay in the given initial bid values and halved for those who are not willing to pay in the initial bid values. Thus based on the survey data, out of 288 sampled household heads, 54.51% of the respondent was willing to pay in the second bid values and the remaining 45.49% of the respondent was not willing to pay in second bid values.

Table 4.8. Households' willingness to pay in the second bid values

Willingness to pay in second bid values	Freq.	Percent	Cum.
Yes	157	54.51	54.51
No	131	45.49	100.00
Total	288	100.00	

Source: author's survey data, 2020

4.2.4. Joint responses of households' WTP

Households were also categorized based on their joint responses to the first and the second bids as we discussed in methodology part (chapter 3) if a household responds "Yes 'to the first bid he/she could be asked an increased amount of the first bid and the discounted amount for those who respond" No' to the first bid. Accordingly, the joint responses of respondents are Yes-Yes, Yes-No, No-Yes, and No-No. Therefore, the descriptive statistics revealed in table 4.9 that among 288 sampled households, 117 (40.62) households were willing to pay in both in the first bid and second bid values (Yes-Yes). Whereas for respondents who were willing to pay in the first bid and not willing to pay in the follow-up bid values were 82 (28.47%). The percentage of households who were not willing to pay in first bid level and willing in the second bid levels(No-Yes) was found to be 40(13.8%) and the remaining 49 (17.11%) responded No-No(who are not willing at both level of bids)

Table 4.9. Joint responses of households' WTP

Joint responses	Freq.	Percent	Cum.
Yes-yes	126	43.75	43.75
Yes-No	72	26.04	69.79
No –Yes	27	9.37	79.16
No-No	63	20.84	100
Total	288	100.00	

Source: author's survey data, 2020

4.2.5. Households' maximum willingness to pay for improved irrigation water use

This study used double bounded CVM followed by open-ended question hence, efficiency in the elicitation of willingness to pay increases if the repeated question is used (Hoyas and Mariel, 2010). Accordingly, the result of the CV survey revealed that the mean maximum willingness of sampled households was about 926.7 ETB with the ranges from 0 to 3000 ETB annually per timad (0.25hectar) of irrigable land toward the improvement of the irrigation water use.

Table 4.10. Households' maximum willingness to pay

Variable	Obs.	Mean	Std. Dev.	Min	Max
Maximum willingness to pay	288	926.059	639.842	0	3000

Source: author's survey data, 2020

4.3. Determinants of Households' WTP for Improved Irrigation Water Use

In this section of study econometric method of data analysis was used to estimate the coefficient of the hypothesized independent variables that affect households' probability of willingness to pay at two different bid levels, to estimate the coefficient of the hypothesized independent variables that affect households' maximum willingness to pay and to estimate the mean level of households' willingness to pay for improved irrigation water use. For this econometric method of analysis seemingly unrelated bivariate probit and Tobit model was employed according to the nature of the dependent variable as we discussed earlier in methodology.

As Greene (2008) cross-sectional data may encounter the problem of heteroscedasticity, the researcher checked hetero scedasticity see (appendix table 2). As a result, the econometric models which are used in this study are corrected from heteroscedasticity problem through using the robust command in STATA version 15.

4.3.1. Determinants of households' PWTP for improved irrigation water use

The objective of the double bounded dichotomous choice format was to identify farmers' probability of willingness' to pay for improved irrigation water use after the estimation of a seemingly unrelated bivariate probit model. A pretest of analysis was done to chick SUBP Misappropriate or not. To do so a SUBPM was run to check whether the correlation between two error terms (rho) is different from zero and whether the test of significance (Prob> chi2) is low bellow the acceptable limit to reject the null hypothesis which is rho=0.

As a result of the SUBPM as shown in Table 4.11, the value of rho is about 0.66 with a positive sign implying there is a positive correlation between the error terms of the dependent variables with a significance level of 0.0015. Which means it is at an acceptable limit to reject the null hypothesis (rho=0). Therefore, SUBPM is found to be appropriate.

From SUBPM, men-headed household (SEX), irrigating farm size (IFS), extension contact (EXTENSION), and bid values were statistically significant in determining the probability of willingness to pay in both initial bid and follow up bid responses toward the improvement of irrigation water use. The result also revealed that age of the household head (AGE), the total annual income level of the household (INCOME), credit utilization of the household (CRDT), distance from the irrigation water source (DISOURCE) and dissatisfaction with the existing irrigation water use (DISSATISFY) to have a significant influence on the probability of willingness to pay in the first bid response (WTPB1). Whereas, the education level of household head (MLEDU) and family labor force (WAGEFS) were found to have a significant influence on the probability of households' WTP in the followed-up bid response (WTPB2).

Discussions on determinants of HHs' PWTP for improved irrigation water use

Irrigating farm size (IFS): the irrigation farm size had a positive influence on the probability of households' willingness to pay in initial bid values as well as in followed up bid values at 10% and5%significant level respectively. This would mean that households who had large size irrigated farms would be more likely willing to pay in the proposed program. This result was found as per the prior expectation of the study and it is in agreement with the previous result obtained (Nega Assefa, 2012; Alem Mezgebo *et al*., 2013; Tadese Tolera *et al*., 2019). This could be due to the expectation that households who have large irrigated farms would get a higher return from an improved irrigation system. The marginal effect of bivariate probit regression indicated that holding the influences of other factors constant, as the irrigated land size of household increase by one timad (0.25ha), the probability of household willingness to pay in the proposed bids for the improved irrigation water use is increase on average, by about 5.3%.

Contact with development agents (EXTENSION): contact with development agents influence d households' willingness to pay in both the initial and the follow-up bid response positively at a 1% level of significance on the probability. This is consistent with the prior expectation and results obtained earlier (Njoko L., 2014). The positive effect could be due to the reason of improved awareness they get from development contact. The awareness might have supported households to convince on the benefit that they will drive from the improved irrigation system. Based on the calculated marginal effect, a household that has had contact with development agent since one year has gone is more likely willing to pay in the given bids on average about 43.4% holding the influences of other variables constant.

Bid value: as a result of bivariate probit model regression implied the bid value was found to have a negative and significant influence on the probability of households' willingness to pay in both bid responses (B1, influence WTPB1, and B2, influence WTPB2) at 1% level of significance. The negative sign of initial bid values tells us the higher the bid amount is the lesser the probability of willingness to pay in that bid. This is consistent with the hypothesis and results obtained (Yibeltal Wale, 2015; Ayana Anteneh, 2016). The result also lines with the theory of demand. The possible clarification behind the result could be due to the law of demand. The marginal effect of the bivariate probit model indicated that as the starting bid prices increase by 100 ETB per year the probability of households' willingness to pay decreases on average, by about 0.02%.

Men headed household (SEX): About sex of the household head, the maleness of the household head positively and significantly affected the probability of willingness to pay in first and followed up bid response at 1% and 5% level of significance respectively. This would tell us men headed households are more likely willing than women-headed households. This result was found as per the prior expectation of the study and it is in agreement with the previous result obtained (Tesfahun Alemayehu, 2014; Meseret Birhane and Endrias Geta, 2016). This is because; most probably men have more economic decision power than women. The marginal effect after bivariate probit regression output indicated, keeping the influence of other factors constant, and men headed households have on average about 32% more probability of willingness to pay in the proposed bid for improved irrigation water use than women-headed households.

Age of household head (AGE): age had a negative and statistically significant effect on households' probability of willingness to pay specifically, in the initial bid values toward the proposed program at less than 5% level of significance. The negative relation of age with the probability of households' willingness to pay in the proposed bid values is that the older the household head is, the lesser the probability of the households' willingness to pay in the proposed bid values. This is in disagreement with results obtained earlier (Ibrahim A. and Robert H., 2010) and in agreement with results obtained later (Alem Mezgebo et al., 2013). This might due to older people facing a labor shortage to engage more in irrigation water resources. From the marginal effect as the age of household increase by one year the probability of households' willingness to pay in a given bid value goes down on average, by about 0.3%.

Total annual income of the household (INCOME): this variable was found to have a statistically positive significant influence on the probability of households' willingness to pay in the dichotomous response, in the initial bid values particularly at 1% level of significance. This would mean that households with higher total annual income were more likely willing to pay for improved irrigation water use system than that of households with lower income. This result was found as per the prior hypothesis of the study and in agreement with the results obtained (Ayana Anteneh, 2016). The possible explanation for the result obtained in this study could be that those households that have higher income levels have a higher demand for most commodities or services according to the basic economic theory. Keeping the influence of other explanatory variables constant, one birr increase in the total annual income, the probability of households' willingness to pay increase on average by about 0.001%.

Utilization of credit (CRDT): The bivariate probit model revealed that credit utilization positively and significantly influences the probability of households' willingness to pay in the proposed bid value toward the given scenario at less than 5% level of significance. This implies that households who received the credit could be more likely willing to pay in the given bid level than those who did not receive credit. This result was found as per the prior expectation of the study and it is in agreement with the previous result obtained (Tadese Tolera *et al*., 2019). The possible reason could be household who received credit might have an opportunity to overcome the financial constraint and enables the farmer's inclination toward purchasing productive service or good for enhancing farm production. From the marginal effect of the bivariate probit model, the relation is interpreted as farmers who received credit had on average about 6.6% more probability of willingness to pay in the proposed bids than those farmers who did not receive credit keeping the influence of other explanatory variables constant.

Farm distance from the irrigation water source (DISOURCE): It had a statistically significant and positive effect on the probability of household willingness to pay in proposed bid values specifically in the initial bid values (WTPB1) at less than 1% significance level. This tells us the distance the water source from the farm is, the households are more likely willing to pay in a given bid for improved irrigation water use. This study was in agreement with results obtained earlier (Chandrakanth M. G. and Rohith B. K.,2011) and in disagreement with the results obtained latter (Alhassan M., 2012). The possible explanation might be farmers whose farm are far from the irrigation water source might receive a little water because of their distance from the water source and they may more likely willing whereas, farmers whose farm are near to the irrigation water source might receive plenty of water because of the farm proximity to the water source and enables them lesser willingness to pay for the improvement of irrigation water use. The marginal effect result indicated that as the distance of farm is increase by one minute the probability of willingness to pay in a given bid values for the provision of improved irrigation water use increase on average by about 0.1% keeping the other influencing factors constant.

Education (MLEDU): this explanatory variable was found to have a significant positive influence on the probability of households' willingness to pay in second bid values at less than 5% level of significance. This tells us households with more years of schooling are more probably willing to pay for improved irrigation water use than household heads with lower years of schooling at a given bid price. This result was found as per the prior hypothesis of the study and consistent with results obtained (Tesfahun Alemayehu, 2014; Yibeltal wale, 2015; Meseret Birhane and Endrias Geta, 2016; Tadese Tolera *et al*., 2019). The possible reason could be the higher the academic level of individuals could enable households more concerned about resource improvement than that lower academic level. The marginal effect after this model showed that keeping the influence of the other factors constant, as year of schooling increase by one year, the probability of households' willingness to pay in a bid price increase on average by about 2.1%.

Dissatisfaction with existing irrigation water use: this explanatory variable was found to have positive statistical influence at a 5% level of significance. This would mean that Households who are dissatisfied with the existing irrigation water use system were more likely willing to pay for improved irrigation water use systems. This result is consistent with the hypothesis and the finding of (Tadese Tolera *et al*., 2019). The possible reason could be due to the existing challenges of the current irrigation water use system that should be addressed. The marginal effect after bivariate probit regression output indicated, keeping the influence of other factors constant, households who are dissatisfied with the existing irrigation water use are 35.6% more likely to willing to pay for improved irrigation water use than those satisfied households.

Table 4.11. The estimated coefficient of the bivariate probit model

Explanatory variables	WTPB1		WTPB2		dy/dx
	Coef.	Robust Std. Err	Coef.	Robust Std. Err	
Men headed household	1.170388	.4544416***	.7887913	.3662606**	.320
Age of household head	-.0231935	.009289**	-.00652	.0065196	-.003
Education level of household head	.0019241	.0345717	.056161	.0223101**	.021
Family labor force of household	.0902435	.1033234	.1908559	.065311***	.074
Irrigated farm size of household	.1636535	.0948406*	.1290348	.0535491**	.052
Total annual income of household	.0000197	6.53e-06***	4.91e-06	4.48e-06	2.37e
Irrigating experience of HH head	.0009255	.0279159	-.01853	.0205766	-.006
Credit utilization of household	.6137633	.2465132**	.1385599	.177219	.066
Extension contact of HH head	.8047887	.2771524***	1.158176	.239655***	.4341
Farm distance from water source	.0881848	.024757***	.0125511	.0163278	.007
Trend of rain feed A/productivity	.4566076	.3590951	.4063045	.2550684	.1649
Dissatisfaction	1.03971	.4145015**	.9645326	.5910984	.3569
Initial bid value	-.0053108	.0014465***	-------	--------	-.001
Followed up bid value	-------------	-----------	-.00170	.000289***	-.006
Cons	-.8072134	1.094979	- 2.354842	.770704	
Rho.668162					
Wald test of rho=0: chi2(1) = 10.101		Prob> chi2 = 0.0015			

Source Authors' Survey, 2020

Note: ***, ** &* represent statistically Significant at 1 percent, 5 percent and10 percent level of significance, respectively, WTPB1, WTPB2 represents the willingness to pay at initial and followed up bid values respectively. Whereas, (dy/dx) represent marginal effects of independent variables on households'' probability of willing to pay at offered bid values.

4.3.2. Determinants of households' MWTP for improved irrigation water use

The Tobit model was used to estimate the coefficient of determinant variables for the open-ended questions to identify the factors that affect farmers' maximum willingness to pay for the provision of improved irrigation water use.

The result of Tobit model showed that Men-headed household(SEX), age of household head (AGE), the maximum level of education (MLEDU), irrigated farm size of household (IFS), extension contact (EXTENSION), farm distance from the irrigation water source (DISOURCE) and initial bid values (B1) to have statistically significant.

Discussion on determinants of HHs' MWTP for improved irrigation water use

Men-headed household (SEX): based on the Tobit model result revealed men headed household was found to have positively and statistically significant influence on households' maximum willingness to pay at less than 5% significance level. This tells us men headed household was found to be more amount ETB willing than women headed household. This result was found consistent with the prior expectation and results obtained earlier (Meseret Birhane and Endrias Geta, 2016). This difference might emanate from the better financial position of men headed households than women-headed households. The marginal effect after Tobit regression showed that keeping the influence of other factors constant, men headed households would pay on average about ETB 167.8 more than women-headed households for improved irrigation water use.

Age of household head (AGE): age of the household head was found to have a negative and significant influence on households' maximum willingness to pay at a 5% level of significance. This means older household heads were less willing than the younger household head. This may be older household head people might give less attention to the technology of irrigation water improvement than the younger household head. Also, older people faced a labor shortage to engage more in irrigation water resources then older people might less quantity demanded than younger people. The marginal effect result revealed keeping the influence of other explanatory variables constant, a one year increase in age, the average maximum willingness to pay off household head goes down by ETB 3.03.

Level of education (MLEDU): the Tobit model result demonstrated, level of education had statistically and positively related to farmers' maximum willingness to pay for improved irrigation water at less than 1% significance level. The result of the model implied that more educated farmers (who had more schooling years) were more willing to pay than respondents who are lesser educated. This result was found as per the prior expectation of the study and it is in agreement with the previous result obtained (Tadese Tolera *et al*., 2019). This can be attributed to farmers with higher education levels having a better understanding of the benefit of improvement in irrigation water use. The other possible clarification might be increasing the academic level is believed to increase farmers' .ability to obtain, analyze, and assimilate information related to resource improvement and management. According to The marginal effect of the Tobit model indicated, as the year of schooling increased by one year, the households' average maximum willingness to pay for improved irrigation water use may increase by aboutETB17.63.

Irrigating farm size (IFS): the Tobit model was also indicated irrigating farm size of the household was statistically significant for households' maximum willingness to pay for improved irrigation water use at less than 1%levelofsignificance with a positive coefficient. This would mean that households that had large size irrigated farms would be willing to pay the maximum amount of birr than a household that had less irrigated farm size if, the scenario of improving irrigation water use is implemented in the study area. This is in agreement with the hypothesis of the study and the results obtained earlier (Tadese Tolera *et al*., 2019). The possible explanation might be as the irrigable land size of a household in timad increases, the opportunity to engage more in the irrigation water results in receiving more income from the irrigation than who irrigated less. Therefore having large irrigating farm sizes would lead to higher quantity demand for improved irrigation water. The marginal effect result indicated that keeping the influence of other explanatory variables constant, as the irrigated land size of household increase by one timad (0.25ha), the average maximum amount of respondents' willingness to pay for improved irrigation water use could be increased by about ETB 97.63.

Contact with development agents (EXTENSION): the Tobit result also revealed, extension contact for irrigation farming device positively and significantly influence the households' maximum willingness to pay toward the scenario of improving irrigation water use at less than

1% level of significance. This positive significance result is consisting of the research hypothesis and report by (Njoko L., 2014). The positive effect of the extension contact on households' maximum WTP could be those who had any extension or development contact might have timely information related to better agricultural technology. This improves their knowledge and awareness of the need to pay to sustainable resource use, as a result, the households' become more quantity demanded toward improvement. As the marginal effect result showed, keeping the influence of other explanatory variables constant households who had contact with development agents for irrigation farming advice would pay on average ETB 285 more than who did not contact with development agent for irrigation farming advice.

Farm distance from the irrigation water source (DISOURCE): farm distance from the irrigation source had a statistically significant and positive effect on households' maximum willingness to pay at less than 10% significance level. This tells us the far distance the farm from a water source; the households would pay a maximum amount than the household whose farm is proximate to the water source. The possible explanation might be, farmers whose farm is near to the irrigation water source might receive plenty of water because of the farm proximity to the water source and this enables them lesser in quantity demand for the improvement of irrigation water use. The marginal effect after probit showed, keeping the influence of other factors constant as the distance of farm is increased by one minute the maximum amount of respondents' willingness to pay for improved irrigation water use could be increased on average by about ETB 8.35

Bid values: as a result of the Tobit model regression implied the initial bid value was found to have a negative and significant effect on farmers' maximum willingness to pay for improved irrigation water use at less than 1% level of significance. The negative sign of initial bid values tells us the higher the bid amount is the lesser the quantity of willingness to pay. This is in disagreement with results obtained earlier (Yibeltal Wale, 2015) and in agreement with the result obtained latter (Meseret Birhane and Endrias Geta, 2016). The possible explanation behind the result is due to the law of demand. The marginal effect of the Tobit model indicated that as the starting bid prices increase by 100 ETB per year the households' average maximum willingness to pay would decrease by ETB1.44 keeping the influence of other explanatory variables constant.

Table 4.12. Estimated coefficients of Tobit model

Maximum willingness to pay	Coef.	Robust Std. Err.	(dy/dx)
Gender	182.6616	83.00339**	167.8195
Age of household head	-3.205312	1.406939**	-3.03109
Education level of household head	18.64893	6.977179***	17.63528
Family labor force of household	18.98097	17.02011	17.94928
Irrigating farm size of household	103.2475	17.17752***	97.63558
Total annual income of household	.0011041	.0012338	.0010441
Irrigating experience of household head	2.07056	5.795332	1.958016
Credit utilization of household	18.67963	49.2429	17.67826
Extension service	319.8804	64.65528***	295.6358
Farm distance from the water source	8.830817	4.796676*	8.350823
Perceived trend of rain fed agro productivity	49.8277	70.48537	46.84262
Dissatisfaction of household	-13.02292	84.60801	-12.33779
Bid value ,(initial bid values)	-1.523371	.3159213***	-1.440569

Source Authors' Survey, 2020

Note: ***, ** &* represent statistically Significant at 1 percent, 5 percent and10 percent level of significance, respectively. (dy/dx) refers marginal effect.

4.4. Estimated Households' WTP for Improved Irrigation Water Use

4.4.1. The estimated mean level of farmers' willingness to pay

As we discussed in methodology, one objective of seemingly unrelated bivariate probit model was to estimate the mean level of farmers' willingness to pay from the double bounded dichotomous choice format. Therefore, the mean WTP estimation in double bounded dichotomous choice was made based on willingness to pay in first and second bid values through the following (Krinsky I. and Robb A., 1986) procedure. Accordingly, the first procedure was calculating the mean of equation one and mean of equation two from seemingly unrelated bivariate probit model which is displayed in table 4.13

Equation one is the equation of farmers' probability of willingness to pay response in the initial bid values whereas, farmers' probability of willingness to pay response in followed up bid values is equation two. And then mean of equation one was calculated by dividing the coefficient of the constant term to the coefficient of initial bid values (B1) in the farmers' probability of willingness to pay in initial bid values. And also the mean of equation two was calculated by dividing coefficients of the constant term by coefficient of followed up bid values (B2) in the farmers' probability of willingness to pay in followed up bid values. Finally, the mean level of farmers' willingness to pay was found to be ETB (950.7) per year per timad (0.25ha).

Therefore, birr 950.7per year per timad (0.25ha) was the estimated user farmers' mean willingness to pay if improved irrigation water is implemented in the study area. Whereas, the descriptive statistics from open-ended questions indicated in table 4.10 the mean level of user farmers' willingness to pay was found to be ETB 926.1 per year per 0.25ha which is less than the mean WTP from the double bounded dichotomous choice format. This comparison result is consistent with the finding of (Tadese Tolera *et al*., 2017) who suggested a possible reason that households become a free rider in the open-ended questions. Generally, the calculated mean farmers' willingness to pay from open-ended questions would tell us estimating the mean level of farmers' willingness to pay from this elicitation technique would lead to under evaluating the value of the natural resource.

Table 4.13. Parameter estimates of a seemingly unrelated bivariate probit model

WTPB1	Coef	Robust Std. Err	Z	P>|z|	[95% Conf. Interval]	
B1	-.0023819	.0009627	-2.47	.013	-.0042688	-.0004949
_cons	1.941436	.5918425	3.28	0.001	.7814456	3.101425
WTB2	Coef.	Robust Std. Err	Z	P>|z|	[95% Conf. Interval]	
B2	-.0005104	.0003871	-1.32	0.187	-.001269	.0002482
_cons	.5545097	.3694068	1.50	0.133	-.1695142	1.278534
Rho	.6942757	.1851148			.1544699	.9148696

Wald test of rho=0: chi2(1) = 5.7393 Prob> chi2 = 0.0166

Source author's survey data, 2020

4.4.2. Estimated aggregate farmers' willingness to pay

The aggregate farmers' willingness to pay for improved irrigation water use could be estimated by taking the total number of beneficiary households less the protest zero bidders and their total irrigable land sizes in the command area. According to KMKIO (2019); SHKIO (2019) and JKIO (2019) the total number of irrigated land is estimated to be 372.5, 439.5, and 1008 hectares respectively and the total beneficiary households are estimated to be 248,293 and 630 respectively. Therefore, the estimation was done as shown in the Table (4.14). As a result, Aggregate willingness to pay has found to be ETB 6,644,257.16 and 6,472,327.68 from double bounded and open-ended questions respectively.

Table 4.14. Estimation of aggregate willingness to pay

Commanded area	Number of user population	Total irrigating area in hectare
Kuhar Michael kebele	248	372.5
Shina kebele	293	439.5
Jigna kebele	630	1008
Total user population	1171	1820
No, of protested users	46[2]	72.8

Source author's survey data, 2020

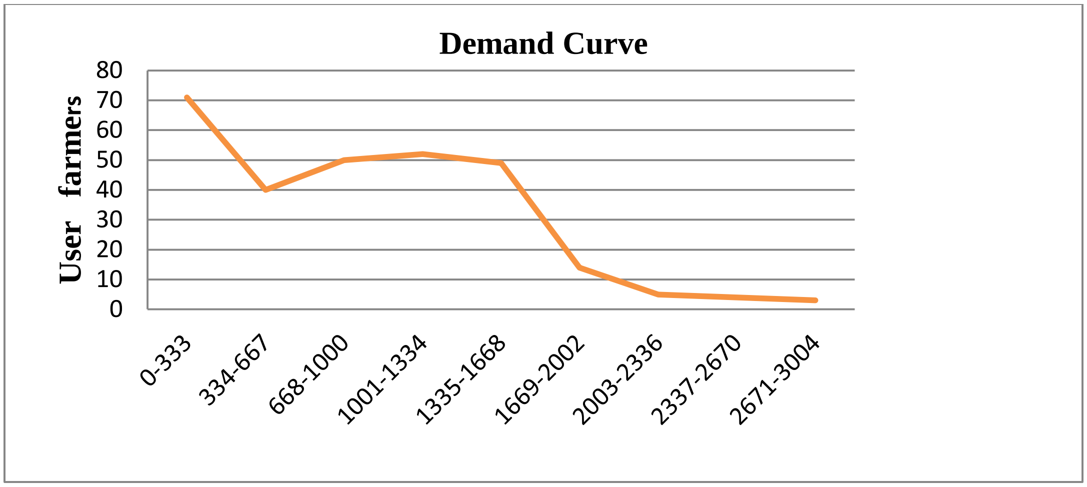
4.4.3. Estimated households' demand curve for improved irrigation water use.

The sampled household demand toward the scenario of improving irrigation water use at different price levels could be observed through driving demand curve as shown in fig 4.1. The demand curve is derived with the mid-point value of maximum willingness to pay along the X-axis and the number of sampled irrigation water user farmers that are willing to pay per 0.25 hectare per year along the Y-axis. Moreover, the figure was formulated following some appropriate mathematical equations to get constant (K)[3] and width (W)[4] to set the stated level of maximum willingness to pay class along the "X" axis.

[2] If 12 protest households get from 300 households then how much protests would be in 1171? then it would be 46

[3] k=1+3.322 log288 =9, where:288 is sample size /n

[4] $W = \frac{x\,max - x\,min}{k}$, where: x max and x min are MWTP then W=333.3



Source author’s survey data, 2020

Figure 4.1. Sample households demand curve

As shown in figure 4.1 even if the demand curve is not downward everywhere it has a downward sloping in the long term perspective. It is in line with the economic theory of demand. The downward sloping of the demand curve implies an increase in the price of the improved irrigation water decreases the quantity demand for the improved irrigation water, other things remain constant.

Chapter 5. CONCLUSIONS AND RECOMMENDATIONS

In this section, conclusions, and recommendations are explained based on the result of the study. This study was investigated to analyze farmers' WTP for improved irrigation water use in the Gumara irrigation scheme. The analysis was done at a household[5] level by using cross-sectional data of 288 sampled households in the study area

5.1. Conclusions

From the result of this study, the researcher concluded that there are a high degree and level of WTP in the Gumara irrigation scheme for improved irrigation water use to provide sustainable irrigation water. The estimated total WTP from this study can be considered as the societal benefits of recovering the cost of sustaining water service and can be used in future cost-benefit analysis for policy formulation. However, the estimated mean WTP from open-ended elicitation format was less than the double bounded elicitation format that might be due to a human being may want a free service from government or the benefit of improved irrigation water use at the expense of others.

from the empirical finding of the study, the author could able to know the maleness of household head and access with extension service would increase the farmers' probability and amount of WTP for improved irrigation water use. From the finding, it was evident that the increment of the education level of household head increases their WTP towards the maintain practice of improved irrigation water use. It is also understood as the ages of the respondents and initial bid price become increase, their probability and level of WTP go to decrease.

The finding also was evident that credit utilization of household and the increment of total annual incomes of the household, increase their probability of WTP for improved irrigation water use. Besides, the increment of the irrigated land size of the respondents increases their MWTP towards the maintain practice of improved irrigation water use.

[5]**Household**: Constitute a person or group of person irrespective of whether related or not who normally live

5.2. Recommendations

Depending on the findings of this study the following recommendations are forwarded

As far as households in Gumara irrigation scheme have high degree and level of households' willingness to pay, the governmental or non-governmental projects should consider as it is room to introduce improvement project in the area, as a result, it is worthwhile for projects for proposing and implementing a project relating to improvement of irrigation water use there.

Men headed households’ are more likely willing and more level of willing than women-headed households. Indicates most probably men-headed households had more economic position and economic decision power than women-headed households concerning willingness to pay for irrigation improvement. Then the government should empower the economic decision and position of women-headed households through improving the irrigation systems.

The finding also demonstrated that household heads that had more schooling years were more level of willing to pay than those who had lesser schooling years. Indicates farmers with higher education levels have a better understanding of the benefit of improvement in irrigation water use. Therefore, the policymaker should make capacity building for household heads that had a lower level of education about the benefit of improvement in irrigation water use systems for accessing sustainable irrigation water.

Interventions that promote farmers’ access to extension contact are recommended, based on the positive relationship between having had access to extension contact and willingness to pay. These may include the establishment of a development team that can visit farmers from their irrigation farm to observe the status of irrigated farming systems to give valuable advice related to the teams would be observed.

As far as the finding concerned older household head is less probable and level of willingness to pay for improved irrigation water use. This might indicates older people faced labor shortage to engage more in irrigation water resources. Thus, local administrators should make an intervention that promotes the offering of older farmers. This may include the establishment of a Youth voluntary association that can address the labor shortage problem of elders in time of agricultural activity undertaken seasons.

As bid price increase the households’ demand for improved irrigation water use is decreasing in the Gumara irrigation scheme. This implies the commodity that farmers will drive from the improved service could be a normal good. Thus, any concerned body should consider the law of demand to analyze the households’ willingness to pay for improved irrigation water.

The government should consider designing income-generating programs through improving the existing irrigation water use of the Gumara irrigation scheme since the income level of the households was positively related to the level of WTP for irrigation water use.

From the finding, the positive significance of credit utilization indicates credit is room to overcome farmers’ financial constraints and it empowers their economic decision power to contribute a certain bid price of money for irrigation water service. Therefore any governmental or non-governmental irrigation improvement project should consider the need to promote farmers' credit utilization up to the affordable rate.

Furthermore, the finding showed that having large irrigating farm size would lead to higher quantity demand for improved irrigation water use. This indicates households that have large irrigating farm needs a high amount of supply of irrigation water. Therefore, a higher supply of irrigation water that enhances crop productivity should take into account while designing and planning for improved irrigation water use in the study area. Besides this, the government should give training to farmers about proper farm management.

- This study was done in the Gumara irrigation scheme ANRS and it may not be representative of the whole parts of the region. Therefore, extending the study to other parts of the region is highly recommended for future study.

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7. APPENDICES

Appendix table 1.Fair distribution of initial bid values

Initial bid values	Frequency	Percent	Cumulative percent
500	93	32.29	32.29
600	99	34.38	66.67
700	96	33.33	100.00
Total	100	100.00	

Appendix table 2. Test for heteroscedasticity with hettest

Breusch-Pagan / Cook-Weisberg test for heteroscedasticity
Ho: Constant variance
Variables: fitted values of MWTP
chi2 (1) = 38.03
Prob> chi2 = 0.0000

NB: the appendix table 2revealed it is heteroscedasticity**.** However**,** the econometric models which are used in this study are corrected from heteroscedasticity through using the robust command in STATA version 15.

Appendix table 3. Conversion for adult equivalent

Labor class	Age class in year	Conversion factors
Children	Less than 7	0
Children	7-14	0.4
Adult male	15-64	1
Adult female	15-64	0.8
Old male/female	≥ 65	0.5

Source: Stork H. et al. (1991)

Appendix 4. Survey questionnaire

BAHIR DAR UNIVERSITY

COLLEGE OF AGRICULTURE AND ENVIRONMENTAL SCIENCE

Survey questionnaire on analysis of farmers' willingness to pay for improved irrigation water use system in Gumara irrigation scheme

The Survey was conducted With the Advance of Online Kobo Tool Box In two Main Parts.

General Information

Hello, how are you. I am Mr…………… This interview is used for the research of Mr. Aklok Getnet who is currently studying his MSc at Bahir Dar University. This research is a partial fulfillment for the awarded of MSc in Agricultural Economics. He is conducting a survey which focuses on your Willingness to pay for improved irrigation water use in Gumara Irrigation Schemes Now you are randomly selected and asked to give information about your socio economic characteristics as well as your support (willingness to pay) for improved irrigation water used.. The result of this study will help different stakeholders and policy makers to make appropriate measures on irrigation development and improvement of irrigation water use for sustainable use of irrigation water for irrigation farm in the future. Whatever information you provide will be kept strictly confidential. Therefore, you are kindly requested to provide genuine responses.

Part one several Socio-economic Characteristics

A. Household's characteristics

1. Respondents' Name____________
2. Respondents' Code No, ___________
3. Enumeration Kebele, Jigna ◯ , Kuhar ◯, Shina ◯
4. Enumerator village: _________________
5. Sex of household head. Female ◯, Male ◯
6. Age of the household head __________
7. Education level of household head 0= illiterate, 14= diploma 16= degree

8. Family labor force in total ________
    a. Name ______________________Sex___________age_____________
    b. Name _______________________Sex___________age_____________
    c. Name _______________________Sex___________age___________
    d. Name _______________________ Sex ___________age_____________
    e. Name ________________________Sex___________age___________
    f. Name ________________________Sex___________age___________
    g. Name ________________________Sex___________age__________
    h. Name _________________________Sex___________age_________
9. In what income source did you get your yearly income last year?
   From rain-fed farming ⬭ from irrigated farming ⬭

From Livestock and their output ⬭ others ⬭

10. If rain-fed farming were your income source, how much income did you get from rain-fed farming during last year in Ethiopian birr? _______
11. If irrigated farming were your income source, how much income did you get from irrigated farming during last year in Ethiopian birr? _______
12. If livestock and their output were your income source, how much income did you get from livestock and their output sold during last year in Ethiopian birr? _______
13. If your income was emanated from other specified sources how much income did you get from those income sources?
14. Total annual income in year 2011ec in Ethiopian birr._________________________
15. How long have you been in farming in years? __________________
16. Do you have irrigated farming experience? Yes ⬭ , No ⬭
17. How many years of irrigating experience do you have? ___________

B. Institutional characteristics

1. Did you get credit for the irrigation facility in the last year? Yes ⬭,No ⬭
2. If yes, was the credit adequate to your demand? Yes ⬭,No ⬭
3. If no question #1. No, what was the reason? No access ⬭ collateral ⬭

I have sufficient capital , If other ____________

4. Did you have contact with the extension agent for irrigation farming advice in last year? Yes No
5. If yes to question #2, how many times per year did you contact have with extension agents? _

C. Farm-related (size, distance, and input supply) characteristics

1. How many timad of Total land size did you have? __________
2. How many timad of Total irrigated land size did you have? __________
3. How many timad of Total rented in irrigated farm did you have? _____
4. How many Total rented out irrigated farm did you have of household____
5. How many kilometers do you normally travel to reach the nearest market from your farm? __________________ in Kilometer
6. How many hours do you normally travel to reach the nearest irrigation water source from your farm? __________________in Minute
7. Did you have a labor shortage to hire when you are demanded for crop and livestock farming in last year? Yes , No
8. If yes to question # 3, did you try to solve the problem? Yes No,
9. If yes to question # 4, how did you solve the shortage? support , communal labor , other , specify ______________
10. Did you encounter the problem of water scarcity for farming due to variability of rain fall? Yes No
11. If yes to question # 6, did you try to solve the problem? Yes , No
12. If yes to question # 7, how did you solve the problem?

By rainwater harvesting, u[illegible]vity irrigation

Pumped ground water , pumping from the River other specify_

13. Are you dissatisfied with the current irrigation water use system? Yes No,
14. If yes question # 1 above, what kind of challenges and problems you have faced/observed in the existing irrigation schemes?

    ____

15. What are the major types of crops you produce or grow under irrigated? __________, _____________________________, ________________

16. Why you prefer to produce the crop you mentioned above as your major choice? ____________________,_________________, ________________________

17. Which types of crop you produce is high sources of your income? _________, ____________________, ________________________________.

18. Did you get enough water for your irrigational and livestock from this irrigations?

Yes ◯ No ◯

19. If No to question # 6 what do you do?

Use only part of the irrigation farm ◯ Use crops that require less water ◯

Produce partially ◯ specify if other, __________________

20. How can you explain the trends in your agricultural output over the last four year per timad of land in rain-fed agriculture? Decreasing ◯ , not decreasing ◯

21. If decreasing question # 8 what do you think the causes? low fertility of the soil ◯

Lack of improved seed ◯ , lack of fertilizer ◯ rain fall variability ◯

Thank you!!

Part Two the CV Scenario and Question

Scenario

Irrigation in Gumara kebeles plays a central role in pushing the production to an extent that helps to support local livelihoods and alleviate poverty, as well as to mitigate the short supply of food elsewhere in the country. However, the irrigation water source (Gumara River) faces water scarcity to provide water to crop inadequate ad year-round manner since it has been several water use problems such as acquisition, allocation, and conflict management problems. These results inconsistent supply of water, reduction of irrigation agricultural production, and productivity and it will increase the time and money spent to bring irrigation water from a distance or to use underground water. Constructing small dam and irrigation canals as well as participating in managing conflicts within irrigation water users are required to alleviate such problems as well as to get year-round irrigation water supply. Considering these there is a proposed program intended to construct dam, canals, and establish legal frameworks.

The construction of irrigation dam and canals among other things means providing adequate water which is safe for crop production and improving cropping for the dry season. The construction of the irrigation dam will benefit the farm households by enabling them to produce permanent crops, to produce three times a year, and for a livestock water supply, because there is a year round irrigation water, the construction of canals will improve the distribution of irrigation system as well as the program designto establish legal frameworks to improve the allocation of irrigation water between farmer. To sustainably deliver this irrigation water from the improved service for farm households itrequires money for the maintenance and management cost.This cost should be covered by the beneficiary households in the command area. So you will be charged yearly irrigation water based on the hectare 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 canals as well as to implement the legal framework of irrigation schedule.

1. Are you willing to pay some money in the proposed program to get year-round water supply?
   Yes ◯, No ◯
2. If No to question #1 what is your reason?
   It is the responsibility of the government to provide ◯
   I am satisfied with existing irrigation water supply ◯
   Irrigation water should be freely provided ◯
   I don't have enough money ◯
   Other ◯ specify____________________
3. Are you willingness to pay Birr "X" (500, 600, and 700) per timad (0.25 hectare) of irrigable land per year? Based on the fairly assigned initial bid Yes ◯No ◯
4. If Yes to question #3 are you willingness to pay Birr twice of "X"? Based on fairly assigned initial bid Yes ◯, No ◯
5. If No to question # 3 are you willingness to pay Birr half of "X" Based on fairly assigned initial bid Yes ◯, No ◯

6. What is your maximum willingness to pay for one timad (0.25 hectare) of irrigable land per year in Birr(Ethiopian currency) ________________
7. In what form the money should be collected

   On cash ⬭

   With social association ikub, idir, and etc ⬭

   On tax ⬭

   With water bill ⬭

   On labor ⬭

Thank you!!

Focus Group Discussion Checklist

Name of sampled Keble _____________

FGD member: Male: ___________ female: _____________ total _________

Date: _______________

1. What kind of irrigation waterdistribution methods are practiced in the area? How much it is effective and efficient? How much (on average) one incurs a cost for irrigating timad of farm per year?
2. What is the existing problem in water distribution in the area? Is there any dispute (conflict) among water users in the area?
3. What is/are the existing rules and regulations practiced on water usage in the area?
4. Do you think that water is free good?
5. What do you comment if the district office set up a legal framework governing the distribution of the water?
6. Since developing or constructing an irrigation scheme requires a lot of finance, it is important to consider which sources of financing are available. Who do you think the source of finance?
7. If the government constructs a scheme how can you maintain the sustainability of the resource? How the cost of maintenance and operation will be covered? And who should be responsible?
8. What do you comment if the government construct irrigation scheme in the area and impose a charge on water users that covers the initial investment cost and/or operation and maintenance costs?
9. If the government imposes payment for irrigation water use, would you be willing to pay? If yes how many ETB would you pay per timad per year?

Thank you!!

Key Informant Interview Checklist

Name of respondent: _________

Name of organization ________

Position: ___________________

1. What is the irrigation potential of the water resource in terms of hectare and number of user households?

2. How many hectares of land in your kebele currently irrigated by using Gumara River? _______________

3. What is the prevailing (current) management system of the water resource in the area? ______________________________

4. What is/are the potential challenges in using the water resource? Are there formal or informal rules and regulations for managing the water resource in the area?

____

____

5. Which kebeles is/are the most user of irrigation using Gumara River? ____________

6. What is/are the roles of your office in managing and controlling the water resource?

7. Did the office educate farmers in relation to the water resource? If yes, in what area(s)?____

____

8. Did any measurement have implemented by farmers or Governments to store the run of water from Gumara River? If yes what was ______________________

Thank you!!