AN EVALUATION OF FARMERS WILLINGNESS TO PAY FOR IRRIGATION WATER IN KERIO VALLEY BASIN KENYA

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DECLARATION AND APPROVAL

DECLARATION

I declare that, except where there is explicit reference to the contribution of others, this thesis is the result of my original work and has never, been submitted for any other degree at Egerton University or any other institution of higher learning.

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APPROVAL

This thesis has be submitted to the Graduate School with our approval as University Supervisors

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DEDICATION

I dedicate this work to my parents Mr David Tunduria and Mrs Pauline Tunduria, My Fiancée Celestine, brothers Elias, Eric, Josphat and Nelson and to my cousin Sally for their sincere support.

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ABSTRACT

Water is a critical resource whose availability and proper use is a key factor to Kenya's sustainable agricultural development. However, changing climatic conditions and growing population in arid and semi-arid lands have exerted pressure on the scarce water resources. Consequently, there have been renewed efforts to enhance capacity of smallholder irrigation farmers to own and manage irrigation schemes. The objective of this study was to evaluate the farmers' willingness to pay and to determine the average economic value of irrigation water used by major crops grown in the Kerio valley basin. A multistage sampling method was used to select a representative sample of 216 smallholder irrigation farmers. Data was obtained using a structured questionnaire administered to the farmers additional data on irrigation water requirements was obtained from the Food and Agriculture Organization Aquacrop model. The findings revealed significant differences in farmers occupation status, education level, total livestock ownership, membership in water users' association, access to training, distance to the market and distance to the water source between farmers willing to pay and those not willing to pay. The results of the probit regression model indicated that the education level of household head, membership in irrigation water users' association, farmers' participation in the construction and maintenance of the scheme and total income from irrigation positively influenced the farmers' decision on willingness to pay for irrigation water. However, distance to water source and access to extension services negatively influenced farmers' decision to pay for irrigation water. The Contingent valuation model results indicate that 91.4% of the smallholder farmers were willing to pay for irrigation water with a mean willingness to pay of KES 938 (USD 10.4) per Ha in a production season. This represents about 9.6% of the average total farm income. Factors that positively influenced the mean willingness to pay are; age of farmers, household size, distance to the water source and income obtained from irrigation farming. The residual imputation model results on the economic values of irrigation water for nine crops indicate that the overall mean value is KES 11.5 per cubic meter of water. The economic value of irrigation water for the crops; sorghum, green grams, maize, millet, cassava, cowpeas, mangoes, bananas and lemons were KES 25.2, 20.9, 14.9, 3.6, 4.3, 2.7, 16.9, 7.4 and 6.5 respectively. The study recommends the implementation of an all-inclusive bottom up approach, water management system that ensures equitable and affordable water distribution to the smallholder farmers.

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LIST OF ABBREVIATIONS

ADB	African Development Bank
AERC	African Economic Research Consortium
ASALs	Arid and Semi-Arid Lands
ASDS	Agricultural Sector Development Strategy
CVM	Contingent Valuation Method
FAO	Food and Agriculture Organization of the United Nations
FAO-COAG	Food and Agriculture Organization of the United Nations Committee on Agriculture
ICWE	International Conference on Water and Environment
IWRM	Integrated Water Resource Management
IWUA	Irrigation Water Users' Association
KNBS	Kenya National Bureau of Statistics
KVDA	Kerio Valley Development Authority
NIB	National Irrigation Board
OECD	Organization for Economic Co-operation and Development
GoK	Government of Kenya
SHDP	Smallholder Horticultural Development Project
WTP	Willingness to Pay
UNESCO-WWAP	United Nations Educational, Scientific and Cultural Organization World Water Assessment Programme
IFPRI	International Food Policy Research Institute
RIM	Residual Imputation Model

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Water is one of the most important natural resources and is a key component to prosperity and wealth Arbues *et al.,* (2003). However, globally water is becoming increasingly scarce, especially in developing countries (Amer, 2004). The growing population, rising incomes and urbanization are increasing the demand for fresh water. This upward trend in demand calls for efficient water allocation among competing uses. Irrigated agriculture is currently the biggest user of global water supply accounting for approximately 70 percent of fresh water abstraction in the world (FAO-COAG, 2007). In addition, it is projected that irrigated land in developing countries will increase by 27 percent in the next 20 years (World Bank, 2008).

Irrigated agriculture is the only option that can enhance food production in rain deficit regions. With climatic changes experienced in most regions of the World, irrigated agriculture is increasingly facing uncertainty about the quantity and regularity of water supply UNESCO-WWAP (2009). According to FAO (2007), climate change will account for 20 percent of global increases in water scarcity. In order to bridge the water deficit and adapt to climate change there is a need to implement decisions on conservation and allocation of water. The chosen approach must be compatible with the social objectives of economic efficiency, equity and sustainability.

Agriculture in Kenya is the basic and crucial sector to enhance food security. However, the sector has been facing numerous challenges in recent years including food insecurity, erratic weather conditions and rising population. Kenya is among the countries classified as water deficit in the world, with water resources unevenly distributed in space and time (ASDS, 2010-2030). Only 17 percent of the land area in Kenya is high potential area, receiving more than 700 mm of rainfall per year. Currently, irrigated land in Kenya is 1.8 percent of the total land cultivated compared to four percent of Sub-Saharan Africa (SSA) (World Bank, 2008). The remaining land is arid and semi-arid land and cannot support food crop production under normal rain fed agriculture. Food shortage is a recurrent problem, which rain fed crop production cannot solve alone, without emphasis on irrigation development. Over the years, empirical evidence has shown that irrigation increases the yield of most crops by 100 to 400 percent (FAO, 2009). As such, in order to develop a vibrant agricultural sector, irrigation development must be emphasised. The Government has acknowledged the relevance of irrigated agriculture and made its development a major aspect of Agricultural Sector Development Strategy (ASDS, 2030).

Irrigation in Kenya has a long history spanning over 400 years, and smallholder irrigation activities constitute a significant part of the total irrigation activities in Kenya (NIB, 2010). Irrigation farming occurs mainly in irrigation schemes, though individual farmers also practice it in isolation. Of the total irrigable land in Kenya, smallholder managed schemes account for 42 percent, while the government managed schemes account for 18 percent (RoK, 2010). Most of these irrigation schemes developed between the years 1960 and 1980 (Ngigi, 2002). Despite the strong gains made in the 1970’s, the rate of irrigation development has declined over the years. With the country being largely dependent on seasonal rainfall, the same has not been sufficient to sustain crop production. This has necessitated scaling up of irrigation development activities to contribute to the attainment of vision 2030’s objective of enhanced food security. Irrigation expansion and development will also boost food production in marginal lands and improve livelihoods in rural areas.

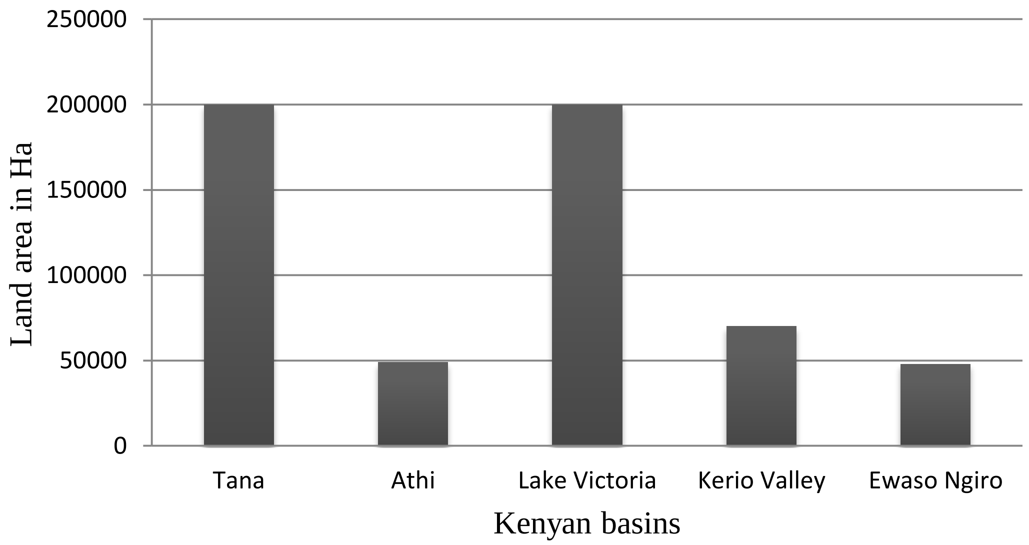

Figure 1: Irrigation potential in the Kenyan basins.

Source: National Irrigation Board (NIB), 2012.

Despite the importance of irrigation, only a small fraction (1.8 percent) of the crop area in Kenya is currently under irrigation yet there is an estimated potential area of about 1.3 million hectares as shown in Figure 1 (NIB, 2010).

Irrigation systems in Kenya are mainly traditional and modern. The traditional irrigation system is generally simple and labour intensive river diversions. This system requires frequent and seasonal maintenance characterized by the use of open furrows and subsistence food production (Ray, 1996). Despite the traditional system, bringing development in the past, it has been inefficient in terms of water use with a lot of water being wasted (Chepkonga *et al*., 2002). The modern irrigation systems use different technologies to distribute irrigation water, such as diesel generators, hydro power and solar pumps, which are more efficient in water use.

The Kerio Valley basin had a long history of traditional irrigation farming practise along the Kerio river dating back to 400 years ago (Kipkorir, 1983). It covers an area of 17,800 square Km with three irrigation schemes; Arror, Chepsigot and Tot (KVDA, 2005). The Government in partnership with the African Development Bank (ADB) through the Small Holder Horticultural Development Project (SHDP) recognized the need to upgrade to irrigation systems that are more efficient in water use. The transformation process of these systems is to involve the smallholder farmers and promote greater beneficiary participation through cost sharing to build self-sustaining systems. Under this new arrangement, irrigation water management is the responsibility of the irrigation water users associations in the respective schemes (SHDP, 2010).

The transition to new-piped irrigation technology system will bring changes in the management of irrigation water by the County. In the traditional furrow irrigation system, irrigation water management was the responsibility of clans' men and village headmen who considered water a gift from Mother Nature. State-controlled irrigation systems have been declining over the last 10 to 20 years due to over reliance on Government support and lack of sense of ownership by the farmers in Kenya. However, there have been changes in Government approach (Wallow, 2007). The current approach is to initiate and encourage formation of farmers' Irrigation Water Users Associations (IWUA's) to self-manage irrigation schemes and water systems upon termination of Government support. Under this arrangement, water users will have to pay a fee for irrigation water to enable them meet operational and maintenance costs. Payment for water services is an important tool that plays a significant role in water resource management. This is because it enables water users to use the water resource efficiently. In addition, it enhances sustainability of irrigation water since the water charges collected provide the financial requirements for operation and maintenance costs in these schemes (Bazza *et al.*, 2002).

1.2 Statement of the problem

Smallholder irrigation farmers in the Kerio valley basin, over the years, have relied on the traditional furrow irrigation system. Under this system, water is allowed to flow along the ground among the crops freely through furrows. The problem with this system is that, about half of the water ends up not getting to the crops. Moreover, water is freely abstracted which is not sustainable since there is no structure to support operation and maintenance functions**.** However, the current upgrading (changing to pressurized networks) will necessitate water users to pay a fee under the management of irrigation water users' association. Being a new system, there is little documentation on the reaction of smallholder users to the introduction of water pricing. Information on the average economic value of irrigation water used for production across major crops is also scarce. Hence, assessing the farmers' willingness to pay for irrigation water and estimation of the average economic value of irrigation water used in production across major crops would bridge this knowledge gap.

1.3 Objectives of study

1.3.1 General objective

The general objective of the study was to contribute to the sustainable management of irrigation water in community managed smallholder irrigation schemes, by establishing an effective water pricing mechanism.

1.3.2 Specific objectives

i. To describe the socio-economic and institutional attributes of smallholder irrigation farmers' in the Kerio valley basin
ii. To determine the socio-economic factors which influence the farmers' willingness to pay for irrigation water in the Kerio valley basin
iii. To assess how much farmers' are willing to pay for irrigation water in the Kerio valley basin
iv. To determine the average economic value of irrigation water used in production across major crops grown in the Kerio valley basin

1.4 Research questions

i. What are the socio-economic characteristics of smallholder irrigation farmers in the Kerio valley basin?

ii. What are the socio-economic factors that influence farmers' willingness to pay for irrigation water in the Kerio valley basin?

iii. How much are smallholder farmers' willing to pay for irrigation water in the Kerio valley basin?

iv. What is the average economic value of irrigation water used in production of the major crops in Kerio Valley basin?

1.5 Hypothesis

ii. Socio-economic and institutional factors do not significantly influence farmers' willingness to pay for irrigation water in Kerio Valley basin Kenya

iii Smallholder irrigation farmers are not willing to pay for irrigation water in Kerio Valley basin Kenya

1.6 Justification of the study

Changing climatic conditions and increasing water scarcity in semi-arid lands of Kenya is a major challenge to smallholder irrigation farmers. Various strategies have been implemented to expand smallholder irrigation in Kenya, with emphasis on development of smallholder irrigation projects in semi-arid lands (ASAL's). Improving access to irrigation water and modernization of irrigation systems is one of the approaches, aimed at enhancing food production and security. The bottom up management approach that emphasises community participation in planning, implementation, operation and maintenance of the irrigation schemes is also being emphasised. The approach is to have less government intervention and pursue a balanced policy that incorporates both public and beneficiary participation in building self-sustaining systems. This study aims to generate information on how to enhance sustainability in the management of irrigation schemes through payment of irrigation water as a mechanism to cover for the operation and maintenance costs.

Understanding how farmers perceive payment for irrigation water will help stakeholders to establish effective and efficient policies in the irrigation sub-sector. The contributions of this study will provide detailed information on pricing of irrigation water as a key instrument of improving water use efficiency.

1.7 Scope and limitation of the study

This study was done in the Kerio Valley basin, Elgeyo Marakwet County. It focused on the smallholder irrigation farmers, specifically Arror irrigation scheme due to time limitation to cover the whole river basin area. The study aimed at determining the economic value of irrigation water in small holder managed farms in the Kerio valley basin by eliciting farmers' willingness to pay (WTP) using the contingent valuation method and also determining the average economic value of irrigation water for the major crops grown in the basin. Since most smallholder farmers do not keep records, the study relied heavily on recall to capture the needed data.

1.8 Operational definition of terms

Crop water requirements - It is the quantity of water needed for normal growth and yield production, which is supplied through rain fed agriculture or irrigation

Food security - It is a state when all people at all times have both physical and economic access to sufficient food to meet their dietary needs for a productive and healthy life.

Integrated water resource management - Is a process, which promotes the co-ordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems.

Irrigation water users' association - An association of irrigation water users organized for facilitating the management and utilization of irrigation water

Surface irrigation - Are irrigation systems that supply irrigation water to the ground surface for crop use. The main methods include basin and furrow.

Water pricing - A charge levied on irrigation water users for water supplied based on operation and maintenance or other criteria.

Water productivity - Refers to the ratio between output (for example Yield) and total water used (m^3) or gross income (KES) and total water used (m^3).

Water scarcity - This is a situation whereby the quantity of water required by farmer for producing output exceeds available quantity.

Willingness to pay - is a monetary measure of the value an individual farmer would pay to have a specific change in quantity of water and service

CHAPTER TWO

LITERATURE REVIEW

2.1. Water as a resource

Water resources provide important benefits to mankind, both commodity benefits and environmental values. For physical, social and economic reasons, water is a classic non–marketed resource. In the past decades, increasing population, urbanization and industrial development have increased demand for water, resulting in considerable decrease in the renewable water resources. Market prices for water are seldom available or when observable are subject to biases Yokwe (2009). However, because of increasing scarcity of water, economic valuation plays an important role in public decision making on water policies Young (1996). Therefore, designing appropriate water pricing structures is a crucial issue for water utilities and local communities towards achieving an efficient allocation of the scarce water resources.

2.2 Economic value of water

Water is a natural asset, the value of which resides in its ability to create flows of goods and services over time Agudelo (2002). The concept of treating water as an economic good arises from the definition of economics, which is the study of how people and society choose to employ scarce resources and to distribute them for consumption now or in the future, among the various groups in society (Samuelson *et al.*, 1985). Water is an economic resource since it meets the basic needs of human beings and has many alternative uses in the society.

The concept of treating water as an economic good developed in the literature in the 20th century. It culminated in the 1990’s after the International Conference on Water and Environment in Dublin, Ireland (ICWE, 1992). In the conference report known as ‘the Dublin Statement,’ the fourth guiding principle states that, “water has economic value in all its uses and should be recognized as an economic good”. Later, on at the second World Water Forum held in The Hague in 2000, an agreement was reached that full resource value (economic, social, cultural and environmental) should be regarded in water management decisions. Therefore, the concept of treating water as an economic good is already accepted and enshrined in official international commitments throughout the world.

Water has different values to different users. The total economic value of water is the sum of use values and non-use values. Use value is the utility gained by an individual from direct or indirect use of water. Non-use value is the notion that people appreciate water even when they are actually not using it. The basis of the option value is how much individuals are willing to pay today for the option of preserving the water in the future. Bequest value is the value that others derive from water in the future (Munasinghe, 1993). While existence value means that, an individual places value on water and the functions, it supports (Marcouiller *et al.,* 1999).

2.3 Pricing of irrigation water

Irrigation is a vital component of crop production in many developing countries. Over the years, many researchers have examined economic valuation of water as an instrument for improving water allocation, reducing water consumption and management of irrigation systems (Dinar and Subramanian, 1998; Maestu, 2001, Boswotrh *et al.,* 2002; Dudu and Chumi, 2008; Ruto *et al*., 2012). Water pricing is an economic instrument used to improve water allocation and mitigate water scarcity situations (Bazza *et al.,* 2002). It is regarded a good tool to achieve efficiency in water use (Singh, 2007). Water prices denote any charge or levy that farmers have to pay in order to access water in their fields (OECD, 1999).

Water pricing plays two major roles, the financial role which is a mechanism for recovering operation and maintenance cost and the economic role signalling scarcity values and the opportunity cost of water, to guide in allocation decisions (Maher, 2009). ADB, in its water policy report of 2000, reaffirmed the need to promote efficiencies in water use by supporting demand management including water pricing. Jones (2003) stated that anything scarce and in demand commands a price. To achieve successful implementation of water pricing as an instrument is not an easy task. This is because water pricing has many constraints. One of these constraints is the cultural perception of water as a gift of nature, which is an impediment to the increasing need for the introduction of irrigation charge services (Abu Zeid, 1998; Perry, 2001).

Despite the success of the irrigation sector in contributing to falling food prices, food security and raising farm incomes the sector faces numerous challenges. Among these problems is the management of communal irrigation schemes, which has elicited growing frustration among the community, government and development agencies

(Rogers *et al*., 2002). The major reason is probably the low financial sustainability of the sector. These problems of low efficiency, poor management and financial un-sustainability are being addressed through a wide range of actions including rehabilitation, modernization and participatory management. The limited benefits obtained have shifted focus to economic-based intervention, particularly in the aftermath of The Hague and Dublin meetings. The pricing of water and establishment of water markets are among the measures that have received the greatest attention from academicians and development agencies.

According to studies conducted by Molle (2004) and Johansson *et al.,* (2002) water pricing could address the question of pricing as a signal to water users on the economic value of water hence regulate its use and avoid wastage. It also serves as a link between irrigation sustainability and cost-recovery from farmers. Two basic economic perspectives can describe irrigation sustainability; the first is that if the marginal cost of water is almost zero, it induces the farmer to use water beyond the levels defined as efficient by economic theory. The other concern is that economists view factor prices as being reflective of the scarcity of the resource. This guides in estimating prices to resources where no market exists, this serves as a way to avoid market distortions and outright subsidization (Dagne, 2008). In most countries that implement water-pricing policy, water users pay operation and maintenance costs (Dinar, 1997). In designing water pricing affordability, measured by the amount of water charges paid relative to households' income, should be an essential concern to ensure that the poor households can meet the costs (Hua-Wang *et al.,* 2009).

2.4 Willingness to pay for irrigation water

Willingness to pay (WTP) is an economic concept, which is used to determine the maximum amount a person would pay, or sacrifice in order to receive a good or to avoid something undesired (Young, 1996). This study elicits smallholder irrigation farmers' willingness to pay for improvements in the systems of irrigation. According to Freeman (1993), it is a measure of the maximum amount an individual is willing to forego in other goods and services in order to obtain some commodity or service. Willingness to pay is becoming increasingly popular and is one of the standard approaches used by researchers to place value on goods and services for which no market-based pricing mechanism exists (Koss *et al.,* 2001; Gil *et al.,* 2003). Past research has shown very high levels of

WTP for water in most developing countries (Griffin *et al.,* 1995; Raje *et al*., 2002; Altaf *et al.,* 2003; Rodriguez, 2003; Zekri and Dinar, 2003).

There are two main approaches used to analyse consumers' willingness to pay. The direct approach or stated preference technique, which allows respondents to express the value they place on non-marketed good or services. The other approach is the Contingent Valuation Method (CVM). This method is the most commonly used as it elicits information about respondents' preferences for a good or service (Carson *et al.,* 2001). Two underlying assumptions describe this approach. The first assumption is that people have hidden preferences for environmental goods. The second assumption is that people are capable of transforming these preferences into monetary values (Hoevenagel, 1994). The indirect approach or revealed preference involves observing consumer behaviour and modelling behaviour based on the approximate expenditure in terms of time and money to obtain the good or service (Cookson, 2000).

Some studies done to determine the economic value of irrigation water in developing countries include that of Speelman (2010) who carried out a study in Limpopo province, South Africa on the impacts of water rights system on smallholder irrigators' willingness to pay for water using contingent ranking. The results indicated that smallholders were prepared to pay considerably higher water prices if connected to improvements in their water rights system.

2.5 Determinants of farmers' willingness to pay for irrigation water

Contingent valuation method (CVM) has become a major tool for estimating the value of natural resources like water in developing countries (Whittington, 1998; Merret, 2002). Ruto *et al.* (2012) studied the economic value of guaranteed water supply under scarcity conditions using the contingent valuation method in the Guadalbullon river basin in Spain. The results indicate that the farmers were willing to pay 10 % to 20 % more on their current irrigators' annual payment.

Using the contingent valuation model Yokwe (2004) estimated the price for a unit of irrigation water which smallholder farmers were willing to pay in two irrigation schemes in South Africa. The results indicate that farmers were willing to pay an average of R0.19 per M^3 of water used. The study also employed a cross section regression model to investigate explanatory factors influencing willingness to pay. In this study, only credit affected farmers' willingness to pay positively and significantly.

A study done in Chalkidiki, Greece, using Contingent valuation model on farmers' willingness to pay for irrigation water and attitudes towards setting up an active water user's association showed that 65 percent of the respondents expressed a positive attitude regarding participation in the association. The family size of respondents and education level was significant in influencing farmers' willingness to pay for irrigation water. The effects of method of irrigation and farmers perceptions on the causes of water shortage were insignificant (Mallios *et al.*, 2001). The factors that influence farmers' ability to pay for irrigation facilities in Oshiri irrigation scheme in Nigeria under a public-private partnership was done using logistic regression (Bamidele *et al.,* 2010). The results showed that the major determinants of farmers' ability to pay include age of farmer, education level and household income as well as the size of the household.

Contingent valuation results from a study on farmers' willingness to pay for water services from community forests in western Nepal indicated that the mean WTP of users was USD 36.6 per year. Distance from household water source, daily water consumption and household income were significant in influencing their willingness to pay (Khanal *et al.,* 2010). The determination of farmers' willingness to pay for irrigation water under government managed small-scale irrigation projects in Bangladesh revealed that the estimated WTP for irrigation water was USD 23.85. The study argued that ground was water is highly under-priced while bid level, respondent's age, education level, respondent's age, family size and ownership of land have a significant influence on farmers' WTP for water (Sonia, 2006).

Aleeyar (2006) used a multiple regression model to identify the factors affecting farmers' willingness to pay for irrigation water in Sri Lanka. The results indicated that total farm income and land size affected their willingness to pay. Another contingent valuation survey carried out by Giorgis (2004) in Ethiopia in the form of open-ended WTP question revealed that access to credit creates an opportunity for respondents to invest in agricultural inputs, of which irrigation is one. Thus, those who tend to borrow were willing to pay more for irrigation water. Other variables that significantly influenced farmers' willingness to pay were respondents' education, quantity of fertilizer used in the preceding season, size of land, total household income, respondents' age and experience with irrigation.

Mbata (2006) used Contingent valuation survey to assess the factors affecting households' willingness to pay for private water connections in Kanye, Botswana using multiple linear regressions. Results showed that household income, household size, education of respondents and distance from the existing water source were significant determinants of household WTP for tap water.

2.6 Water productivity

Water productivity measured as the relationship between agricultural production and water consumption through evapotranspiration is an important component in crop production. Growing conditions, such as climate, agronomic practices, soil type and fertility affects it. Water productivity; is vital in assessing the performance of smallholder-irrigated agriculture (FAO, 2003). Different spatial scales such as plant, field, farm, scheme, sub-basin, and basin or regional scales define water productivity. Bos *et al.,* (2005) define water productivity at farm level in terms of economic benefit in relation to irrigation water supply. According to Cook *et al.* (2006), estimates of water productivity have two basic uses, firstly as a diagnostic tool to identify the level of water use efficiency of a system under study and secondly to provide insight into the opportunities for better management towards increased water productivity at the scale under consideration.

Researchers have developed several models to describe the relationship between crop production and water use. Hank (1974) linearly relates yields (Y_{act}) to transpiration (T_{act}) with maximum attainable yields (Y_{max}) under maximum transpiration (T_{max}). Doorenbos *et al* (1979) provides a simple method to assess the impact of crop water on yield reduction for more than 25 crops. Water stress is determined as the difference between actual evapotranspiration (ET_{act}) and the evapotranspiration when crop requirements are met (ET_{max}). This relates linearly to crop yield (Y_{act}) under certain conditions, and maximum yields (Y_{max}) under optimal conditions (Stewart *et al*., 1977). FAO introduced the Aqua crop toolbox in 2009, which simulates the yield response to water and is particularly suited to function under water scarcity condition (Steduto *et al*., 2009).

2.7 Residual imputation model

The residual imputation model, also known as a residual value method (RVM) is a technique used to value water productivity where water is used as an intermediate input into production. Crop production is a dynamic process in which decisions about inputs are made sequentially. Farmers require field level information on the soil-water plant relationship before making rational decisions on the best crops to grow given conditions of water scarcity. In valuing water, very few studies have employed the residual imputation technique. Some studies which have employed this technique include Yokwe (2005) and Ashfaq and Saima (2005).

Emad *et al.*, (2012) estimated the average economic value of irrigation water for twelve crops in Jordan. The results showed that the weighted average of water value used in field crops were JD 0.44 and JD 1.23 for vegetable crops and JD 0.23 for fruit trees. The overall weighted average water value in irrigation was estimated at JD 0.51. With regard to individual crops, cucumbers had the highest water values with about JD 6.05, followed by string beans with JD 2.64, and sweet pepper with JD 2.54. Average economic values of irrigation water for wheat, rice, sugarcane and cotton were determined by Muhammad *et al*., (2005) in Pakistan. The economic value of irrigation water for wheat, rice, sugarcane and cotton was Rs. 1.13, 0.63, 0.30 and 1.52, respectively. For the minor crops that is potato, onion, and sunflower, the economic value of irrigation water was Rs. 6.60, 13.10, and 0.53, respectively.

Yokwe (2005) investigated the productivity of water and value in two smallholder irrigation schemes (Zanyokwe and Thabina) in South Africa using the residual valuation method. In both schemes, water values estimated for vegetables (cabbage, tomatoes and butternut) were found to be greater than the water value for dry maize. Water productivity was also estimated at both the farm and scheme level by comparing the gross margins per m^3 of water, WTP per m^3 and accounting cost per m^3. From the results the active farmers in Zanyokwe scheme had lower WTP per m^3 (R0.084) of water which is less than the gross margin.

2.8 Theoretical framework

2.8.1 Consumers utility theory

At smallholder farm level, the decisions taken by irrigation water users' on willingness to pay for a resource depends on the expected level of satisfaction they would attain from utilizing the resource. However, their willingness to pay or not to pay at any time is a result of various factors such as the socio-economic characteristics of the farmers and the constraints they face. This study, expects that smallholder farmers would reasonably show their decisions to pay or not to pay for irrigation water in line with the objective of improving their yield or income and other benefits they derive from water supplied. The farmers would be willing to pay for the water they use if the utility they derive from irrigation water under the new system is higher than using irrigation in the old traditional system.

The farmers' decision behaviour is in the form of a utility function and the decision problem is, therefore a utility maximization problem. Assuming that, smallholders derive utility from using irrigation water in crop production and their resource endowment. The farmers' water use benefits under the new system is represented by *b*, where $b = 1$ if the farmer decides to use and pay for irrigation water under the new system and $b = 0$ if the farmer prefers the old system and not willing to pay for water. *X* represents the resource endowment of the farm household and the vector *Y* represents the other observable attributes of the farm household that may potentially affect the willingness to pay decision. The farmers' willingness to pay for irrigation water under the new system utility' is given as, $U_1 = U(1, X, Y)$ and if the farmer is not willing to pay for irrigation water use, the farmers' utility is represented as; $U_0 = U(0, X, Y)$. Therefore, farmers' would prefer the best option from the stated alternatives based on the assumption of rationality subject to socio-economic, demographic, institutional and other constraints. Based on the specification of the utility function and in line with a study by Wagayehu (2000) assuming additively separable utility function in the deterministic and stochastic components, the deterministic component is assumed to be linear in the explanatory variables. That is,

$$U_1 = U(1, X, Y) = S_1 = (1, X, Y) + \varepsilon_i \quad \text{……………………………………………….. (1)}$$

And

$$U_0 = U(0, X; Y) = S_1 = (0, X; Y) + \varepsilon_0 \quad \text{……………………………..………………….. (2)}$$

Where $U_t(.)$ is the utility for the use of irrigation water and $S_t(.)$ is the deterministic part of the utility, and ε_t is the stochastic component representing the utility known to the farmers but unobservable to the investigator. It is assumed that the farmers know their resource endowment, *X*, and the implicit cost involved in irrigation farming in terms of the use of their resources and can make a decision on whether to use or not. Farmers implicit cost of deciding and using irrigation water is represented by *I*. Therefore, a farmer would decide to pay for irrigation water under the new system if,

$U_1 = (.) \geq U_0 (.)$ ………………………………………………………………………….. (3)

$$S(1, X - 1; Y) + \varepsilon_1 \geq S(0, X; Y) + \varepsilon_0$$

The presence of random components permits making of probabilistic statements about the farmers' decision behaviour. If the farmer decides to pay for irrigation water under the new system, the probability distribution is:

$$P = \Pr\{ S(1, X - 1; Y) + \varepsilon_1 \geq S(0, X; Y) + \varepsilon_0 \} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

And if the farmer was not willing to pay for irrigation water under the new system,

$$P = \Pr\{ S(0, X - 1; Y) + \varepsilon_0 \geq S(0, X; Y) + \varepsilon_1 \} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

With the assumption that the deterministic component of the utility function is linear in the explanatory variables, the utility functions in one and two is,

$U_1 = \beta_1 + \mathrm{Y} + \varepsilon_1$ And $U_o = \beta_0 \mathrm{Y}_i + \varepsilon_0$

Where β_0, β_0 and $\varepsilon_1, \varepsilon_0$ are the vectors of response coefficients and random disturbances The probabilities in 4 and 5 are stated as:

$$P(WTP) = P_r\{(U_1(.) \geq U_0(.)\}$$

$$P(WTP) = P_r(\beta_1 \mathrm{Y}_i + \varepsilon_i) \geq U_0(\beta_0 \mathrm{Y}_i + \varepsilon_0)$$

$$P(WTP) = P_r(\beta_1 \mathrm{Y}_i - \beta_0 \mathrm{Y}_1) \geq \varepsilon_0 + \varepsilon_1)$$

$$P(WTP) = P_r(\mathrm{Y}(\beta_1 - \beta_0) \geq \varepsilon_0 - \varepsilon_1)$$

$$P(WTP) = P_r(\mathrm{Y}_{i\alpha} \geq V_i$$

$$P(WTP) = P(\mathrm{Y}_{i\alpha})$$

Where P is the probability function, $V_i = \varepsilon_o - \varepsilon_1$ is a random disturbance term

A = the number of vector parameters to be estimated

Y_i = is the number of explanatory variables

$P(Y_{i\alpha})$ =is the cumulative distribution function for V_i evaluated at $Y_{i\alpha}$

The probability that a farmer would be willing to pay for irrigation water under the new system is then a function of a vector of the explanatory variables, of unknown parameters and the disturbance term

2.8.2 Euler's theorem

Euler's theorem is a standard mathematical result that shows that if a production function involves constant returns to scale, the sum of the marginal products will actually add to the total product. Considering a production function f (x_1... x_n) suppose it is homogeneous of degree 1 (that is has "constant returns to scale"). Euler's theorem shows that if the price (in terms of units of output) of each input i is its "marginal product" f'_I (x_1... x_n), then the total cost, namely $\sum_{i=1}^{n} x_i f_i'(x_1 ... x_n)$ is equal to the total output, namely f (x_1... x_n).

$$\sum_i = 1^n x_i f_i'(x_1......, x_n) = kf(x_1, ..., x_n) \quad for\ all\ (x_1, ..., x_n) \quad \text{.............................(6)}$$

In this study the residual imputation model was applied to find out the average economic value of irrigation water used in production across major crops grown in Kerio valley basin. Considering a production function Y=f (x's) in which four factors of production namely; capital (k), labour (l), natural resources, such as land (r), and irrigation water (w) are employed in agricultural production.

$$y = f(k, l, r, w) \quad \text{...(7)}$$

Assuming known prices and constant technology where P_y is the price of output; P_x is the price of input under perfect information. In addition, we assume the farmers' objective is to maximize production, the production function becomes:

$$\pi = \sum_{j=1}^{n} P_{i^*} Y - \sum_{i=1}^{n} P_{x^*} X_i + P_w . Q_w \quad \text{... (8)}$$

To find the conditions for optimal profits, take the first derivative of π with respect to x and set that equal to zero

$$d\pi / dx = Py . df(X) / dx - Px = 0 \quad \text{……………………………………..………………(9)}$$

Therefore $P_y.d_y/dx=P_x$ or $P_y.MP_x$ which means $VMP_x = P_x$

If there is exchange of all the inputs, including water in a competitive market and subsequent employment in the production process, the value of water will be:

$$P_w . Q_w = P_y . Y - \sum_{i=1}^{n} Px_i . X_i \quad \text{…………………………………………………………...(10)}$$

The residual imputation model determines the incremental contribution of each input in production process through the assignment of appropriate prices to all inputs except water. The residual obtained by subtracting the non-water input costs equals the gross margin and is the maximum amount the farmer would pay for water and still cover the cost of production. The residual calculation is expressed as:

$$Pw^* = \frac{\left(\sum_{j=1}^{m} Y_j . P_j - \sum_{j=1}^{n} X_i . P_i\right)}{\sum Q_w} \quad \text{…………………………………………………(11)}$$

2.9 Conceptual framework

The framework depicts the assumption that farmers' perception about the performance and the attributes of the new system of irrigation significantly affects their probability of paying for irrigation water. Figure 2 shows factors that influence farmers' decision on whether to pay for irrigation water or not. The study conceptualized that, farmers form perceptions of payment for irrigation water under the influence of several variables, grouped into institutional factors, socio-economic factors and the attributes of the new irrigation system. The institutional factors include access to credit, access to extension service, membership in irrigation water users association, land tenure system, farmers' participation in construction and maintenance, distance from the market and distance from the water source. Socio-economic characteristics include: age of the farmer, education level, farm size, household size, income and the number of livestock owned while the attributes of the new system are water use efficiency, low maintenance cost and wider land coverage and water distribution. Therefore, if farmers are willing to pay for irrigation water they will derive benefits of improved management of water resources, reduction in water conflicts, reduced water wastage and increased land acreage under irrigation since the new system utilizes water more efficiently.

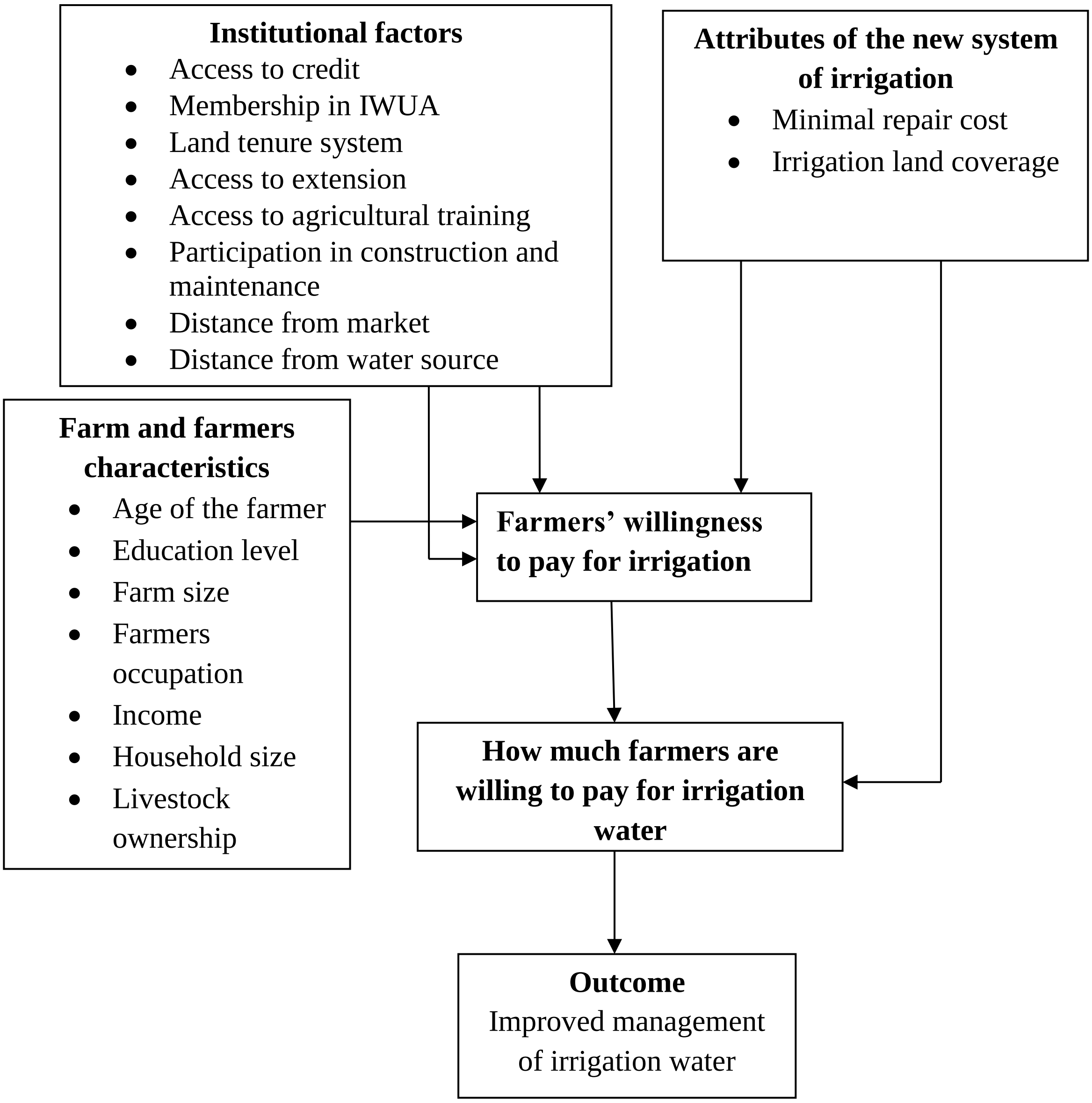

Figure 2: Relationship between the socio-economic factors and willingness to pay for irrigation water

Source: *Authors' Conceptualization*

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Study area

The study was undertaken, in Elgeyo Marakwet County consisting of Marakwet East, Marakwet West, Keiyo North and Keiyo South constituencies. The County is located between longitude 35° 20′ and 35° 45′ East Longitude and 0° 10′ and 0° 20′ North Latitude. It Borders, West Pokot County to the North, Baringo County to the East, Uasin-Gishu County to the West and Trans Nzoia County to the North West as illustrated in Figure 3. It covers a total land area of 3,030 Km^2 and a population of 369,998 (KNBS, 2009) with an altitude ranging from 1,000 meters in the Kerio valley to 3,350 meters above sea level in the highlands. The County receives a bimodal type of rainfall with long rains received in March through April and short rains starting from July to September. Mean annual rainfall ranges from 1000 mm for the highlands and between 200 mm to 800 mm in the dry low land. Temperatures in the Kerio valley basin vary from as low as 10 ° C in the highland areas of the Cherangany and Tugen Hills, with higher temperatures in the lower altitude areas of the valley floor that reach a maximum of 40 ° C. Evapotranspiration is high in these zones due to low humidity.

The County falls into three distinct topographical zones: The highland plateau (2500m-3500m) ideal for (forest, pyrethrum, tea, wool sheep, potatoes and dairy cattle); the Kerio Escarpment (1,200m-2,000m) and the Valley floor (300m-900m). Irrigation occurs along the 40 kilometres stretch of the escarpment containing three major irrigation schemes: Arror, Chepsigot and Tot. Irrigation under these schemes mostly occurs on small plots with the major crops grown being maize, millet, mangoes, sorghum, green grams, cassava and cowpeas. Untapped and underutilized crops, which have high potential for production potential, include sisal, cotton and pyrethrum. The main challenge in crop production is climate variation with occasional severe droughts and heavy floods. Natural resources like indigenous forests and minerals such as fluorspar endow the County while oil prospecting is currently underway.

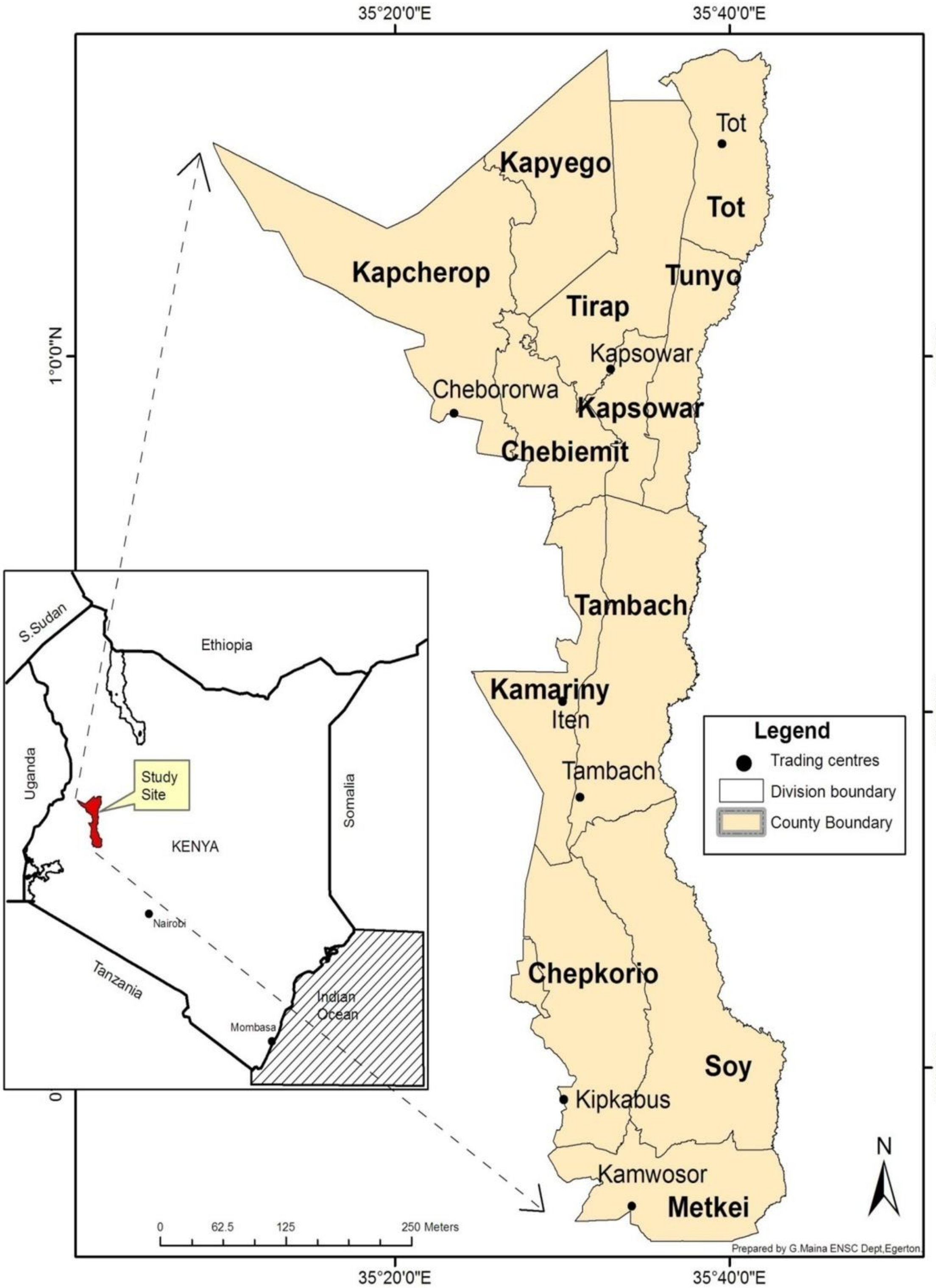

Figure 3: Map of Elgeyo Marakwet County

Source: (World Resource Institute, 2013)

3.2. 1 Population of study and sampling unit

The population in this study were the smallholder irrigation farmers in the whole of Kerio valley basin, while the sample unit for this study consisted of all smallholder irrigation farmers in the Kerio Valley basin in Elgeyo Marakwet County.

3.2.2 Sampling procedure

This study used multistage sampling procedure to select the sample for the study. In the first stage, the study purposively selected Elgeyo Marakwet County because of the large number of smallholder irrigation farmers and the irrigation schemes are currently undergoing a transition from traditional irrigation to modern systems. In the second stage, Arror irrigation scheme was selected purposively since it is the scheme that is currently undergoing upgrading and based on the availability of modern facilities. In the third stage, the study applied systematic sampling in choosing respondents from the source list obtained from irrigation water users' association and the Small Holder Horticultural Development Project in the County.

3.2.3 Sample size

The required sample size was determined using the proportionate to size sampling as specified by Groebner *et l.,* (2005):

$$n = \frac{(z^2 PQ)}{d^2} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \text{(12)}$$

Where n= is the sample size;

P=0.9 and is the proportion of the population of which in this case were smallholder irrigation farmers in the county. Since, approximately 90 percent of the farmers in the Kerio basin practice smallholder irrigation (SHDP, 2010).

d =0.04 is the significance level as this was enough to remove 90% bias in sampling.

Z = 1.96.

Q =1-P the weighting variable.

Based on the calculations the sample size calculated for the study was;

n= $[1.96^2 \times 0.9 \times 0.1] / [0.04^2] = 216.09 \approx 216$ respondents

3.3 Data collection

The study used primary data collected using a structured questionnaire and administered to the smallholder irrigation farmers in the Kerio basin. Secondary data on irrigation, crop-water use and requirements' were obtained from the FAO *CLIMWAT* and *CROPWAT* software 2013.

3.4 Data analysis

In analysing data, descriptive statistics including frequencies, percentages and means were used to describe the socioeconomic characteristics of the farmers willing to pay and those not willing to pay for irrigation water. A probit model was used to determine factors influencing farmers' willingness to pay while the contingent valuation model was used to analyse farmers mean willingness to pay. The study also used the residual imputation model to determine the average economic value of irrigation water used in production across major crops grown. A pre-test survey involving 30 farmers was undertaken to establish the starting bids for the contingent valuation model.

3.5 Analytical framework

3.5.1 Probit model

The decision taken by smallholder irrigation farmers' on whether to pay or not to pay for irrigation water depends on the unobservable utility index P_i influenced by the socioeconomic, institutional and attributes of the new system of irrigation. The larger the expected utilities index P_i, the higher the probability of paying for irrigation water. The index is expressed as;

$$P_i(0, 1) = \beta_1 + \beta_2 X_{i} \ldots\ldots \beta_n X_n \ldots + \varepsilon \quad \ldots\ldots \quad (13)$$

$$P_i(0,1) = \beta_0 + \beta_1 Edulevelhh + \beta_2 Agehh + \beta_3 Partc + \beta_4 Hhsize + \beta_5 Genderhh + \beta_6 Distmkt + \beta_7 Tlu\text{-}own + \beta_8 Crd\text{-}acc + \beta_9 Ext\text{-}ctc + \beta_{10} Income\text{-}irr + \beta_{11} Traing + \beta_{12} Memb\text{-}iwua + \beta_{13} Dist\text{-}ws + \varepsilon$$

To show the relationship between the utility index and the decision denoted by *Y* to pay or not to pay an assumption is made such that *Y*= 1 if the household is willing to pay and *Y*=0 if not willing to pay. Another assumption is the critical utility ρ* such that if the expected utility exceeds ρ * the then Y=1 otherwise Y=0 if the expected utility is less than the critical threshold, meaning that the farmer will not be willing to pay. Mathematically, this is expressed as:

$$Y=1 \text{ If } \rho^*>0 \text{ and } Y=0 \text{ if } \leq 0 \qquad (15)$$

The outcome equation of the profit model is estimated and presented as:

$$Y(0, 1) = \beta_0 + \beta_1 X_i \ldots \beta_n X_n \ldots + \varepsilon \qquad (16)$$

Where β_0 = constant, $Y(0, 1)$ = decision to pay or not, β = coefficient of determination, X_i= respective factors influencing the decision and ε = Error term

Hence the outcome equation is:

$$Willingness\ to\ pay\ (Y_i) = \beta_0+\beta_1 Edulevelhh+ \beta_2 Agehh +\beta_3 Partc+ \beta_4 Hhsize+ \beta_5 Genderhh+ \beta_6 Distmkt + \beta_7 Tlu\text{-}own+\beta_8 Crd\text{-}acc+ \beta_9 Ext\text{-}ctc+ \beta_{10} Income\text{-}irr+ \beta_{11} Traing+ \beta_{12} Memb\text{-}iwua+ \beta_{13} Dist\text{-}ws+ \varepsilon \qquad 17)$$

3.5.2 Double bounded contingent valuation model

The dependent variable for the Probit model analysis has a dichotomous nature, measuring the willingness to pay cash for irrigation water or not, where 1 is if the farmer is willing and 0 if not. However, the decision on willingness to pay is not sufficient. The total amount of cash that the farmer is willing to pay is very important. Since there is no market for irrigation water in the area, the study employed the double bounded contingent valuation method to collect information on the value of irrigation water. An opening question was posed to the respondent on whether he/she was willing to pay or not. If the respondent replied "no'' for the first bid, then further discussions on the payment were terminated. On the other hand, if the respondent's choice was ''yes'' then a second question was posed with a starting bid value. If the payment choice for KESs, was ''yes'' then the respondent faced another level of bid choice, which would be higher or lower amount, respectively. This second amount (bid) was based on the response of the first bid (if the response for the first is yes, then the following bid would be double the first one and half if otherwise).

The probabilities of the outcomes were represented by p (yy); p (nn); P (yn); and p (ny) for "yes", "yes'', "no", "no'', "yes", "no'' and "no", "yes' 'outcomes respectively. Following Hanemann *et al*. (1991), these likelihoods represented mathematically are:

The probability of " no, no" outcome is represented as:

$$P_{nn}(B_i^I, B_i^L) = P(B_i^I > Max.WTP \text{ and } B_i^L > \text{Max. WTP}) = G(B_i^L, \theta) \quad \text{……..……… (18)}$$

The probability of "yes, yes" will be:

$$P_{yy}(B_i^I, B_i^U) = P(B_i^I > Max.WTP \text{ and } B_i^U > \text{Max. WTP}) = 1 - G(B_i^U, \theta) \quad \text{…..…….. (19)}$$

When a "yes" is followed by "no" we have:

$$P_{yn}(B_i^I, B_i^U) = P(B_i^I < Max.WTP \leq B_i^U) = G(B_i^U, \theta) - G(B_i^I, \theta) \quad \text{……....………… (20)}$$

When a no is followed by a yes response the probability is :

$$P_{ny}(B_i^I, B_i^L) = P(B_i^I > Max.WTP \geq B_i^L) = G(B_i^I, \theta) - G(B_i^L, \theta) \quad \text{…………..………… (21)}$$

With a sample of N observations where B is:

$$L(\theta) = \sum_i^N d_i^{yy}.P_{yy}(B_i^I, B_i^U) + d_i^{nn}.P_{nn}(B_i^I, B_i^L) + d_i^{yn}.P_{yn}(B_i^I, B_i^U) + d_i^{ny}.P_{ny}(B_i^I, B_i^L) \quad \text{…. (22)}$$

Where $d_i^{yy}, d_i^{nn}, d_i^{yn}$ and d_i^{ny} are binary valued indicator variables, where $d_i^{yy} = 1$ for yes-yes response 0 otherwise, for no-no response, otherwise 0; $d_i^{ny} = 1$ for no –yes response, otherwise 0; and $d_i^{yn} = 1$ for yes no response 0 otherwise

Table 1: Description of variables and the expected signs used in the probit and contingent valuation model

Variable	Variable code	Type of variable	Unit of measurement	Expected sign
Dependent variables				
Willingness to pay for irrigation water	WTP	Dummy	1 for those willing to participate and 0 otherwise	
Independent variables				
Education level of household head	EDULHH	Continuous	Years	-
Age of household head	AGEHH	Continuous	Years	-
Participation in construction and maintenance	PARTC-MAI	Dummy	1 if participated, 0 otherwise	+
Distance from the market	DIST-MKT	Continuous	Kilometres	+ / -
Household family size	FAMSIZE	Continuous	Number of people in household	-
Livestock ownership	TLU	Continuous	Number of livestock owned	+ / -
Access to credit service	CRD-ACC	Dummy	1 if accessible,0 otherwise	+ / -
Access or contact with extension service	EXT-CTC	Dummy	1 if accessible,0 otherwise	+ / -
Income from irrigated farm	INCOME-IRR	Continuous	Kenya shillings	+
Access to training	TRAING	Dummy	1 if trained,0 otherwise	+
Membership in irrigation water users association	MEMB-IWUA	Dummy	1 if member,0 otherwise	+
Distance to the water source	DIST-WS	Continuous	Kilometres	+

3.5.3 Residual imputation model

This is the most common method applied to determine the shadow pricing of irrigation water and other producers' goods. The technique determines the contribution of each input to output in the production process. It assumes that if appropriate prices are assigned by market forces for all production inputs except one the remaining total value of product or residual which is water in this specific case, then its value can be imputed (Young 2005). The residual value of water is estimated even if water is a scarce resource and crops are irrigated with deficit or supplementary irrigation because water value is assigned the residual value once the remaining inputs get the opportunity or market cost.

The model expressed mathematically and by considering an agricultural production process in which four factors of production: capital (K), labour (L), natural resources, such as land (R), and irrigation water (W) produces a single product denoted Y.

$$Y = f(K, L, R, W) \quad \ldots\ldots (23)$$

If we consider technology as constant, but all other factors variable except water, the total production value is:

$$TVP_Y = (VMP_k Q_k) + (VMP_L Q_L) + (VMP_R Q_R) + (VMP_W Q_W) \quad \ldots\ldots (24)$$

Where *TVP* represents the total value of product *Y*, *VMP* represents value of marginal product of resource I, and Q is the quantity of resource i. Assuming competitive factor and product markets and treating, prices as known constants. The first postulate which asserts that ($VMP_i = P_i$) permits substituting into (2) and by rearranging

$$TVP_Y - P_k Q_k - P_L Q_L - P_R Q_R = P_W Q_W \quad \ldots\ldots (25)$$

Assuming that all variables in (1) are known except P_W, the expression can be solved for that unknown to impute shadow price of water P_W^* as follows:

$$P_W^* = (TVP_Y - P_K Q_K + P_L Q_L + P_R Q_R) / Q_W \quad \ldots\ldots (26)$$

The study undertook valuation of the residual value of water for nine major crops grown in the Kerio Valley basin. These crops together make up 90% of the total irrigated land area of the basin (KVDA, 2010). The crops included are maize, millet, cowpeas, green grams, cassava, bananas, mangoes, lemons and sorghum. Data available from FAO irrigation water use and crop water requirements for crops cultivated in different agro-ecological zones in Kenya guided the selection of these crops. FAO uses the Penman-Montheith methodology in calculating the crop water requirements. These data are available in the *CROPWAT* computer software, which uses data from *CLIMWAT* 2.0, which is a database of climatic data from weather stations globally. Farm budgets for each of these crops were developed. Gross margins calculations for each crop aided in imputing the value of water for these crops. All costs were on per acre basis, and converted to per hectare. These crop budgets were used to determine the price of water (KES/m^3). The costs of production were deducted from gross returns of each individual crop. These returns were further divided by the amount of water applied (m^3) in this case the irrigation crop water requirement.

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter discusses the empirical findings of the study. It starts by presenting the descriptive statistics for the socio-economic characteristics of the smallholder irrigation farmers based on their willingness to pay for irrigation water. It also presents the results of the probit model on the factors influencing the farmers' decision on willingness to pay for irrigation water. Lastly, it presents the results of the economic value of water based on farmers' mean willingness to pay and water productivity at the crop level.

4.1 Socio-economic characteristics of the smallholder irrigation farmers based on willingness to pay for irrigation water

4.1.1 Age and household size

The results presented in Table 2 provide a summary of the ages and household sizes of the farmers willing to pay and those not willing to pay for irrigation water. For farmers willing to pay, the youngest farmer was 20 years old while the oldest farmer was 75 years old. The mean age of all farmers was 40 years. In terms of the household size, composition, the mean household size was 6 members with the smallest household size being one member while the highest was composed of 15 members. However, farmers who were not willing to pay had a mean age of 42 years with the youngest farmer being 19 years old and the oldest being 68 years.

Table 2: Age and household size of the farmers given their willingness to pay

Characteristics	Willing to pay	Not willing to pay	Mean	*t-ratio*
Age (years)	40	42	40	-0.789
Household size (members)	6	5	6	1.084

The results in Table 2 indicate that the average age was higher for farmers not willing to pay for irrigation water (42 years) compared to farmers willing to pay (40 years).

However, the differences in the mean ages and household sizes between the two groups of farmers were not significant at the 5 % level of significance.

The household size distribution shown in Figure 4 illustrates the number of respondents sampled against the household size. The least number of household members being 1 and the highest being 15 members. Majority (36) of the respondents had six members in their household.

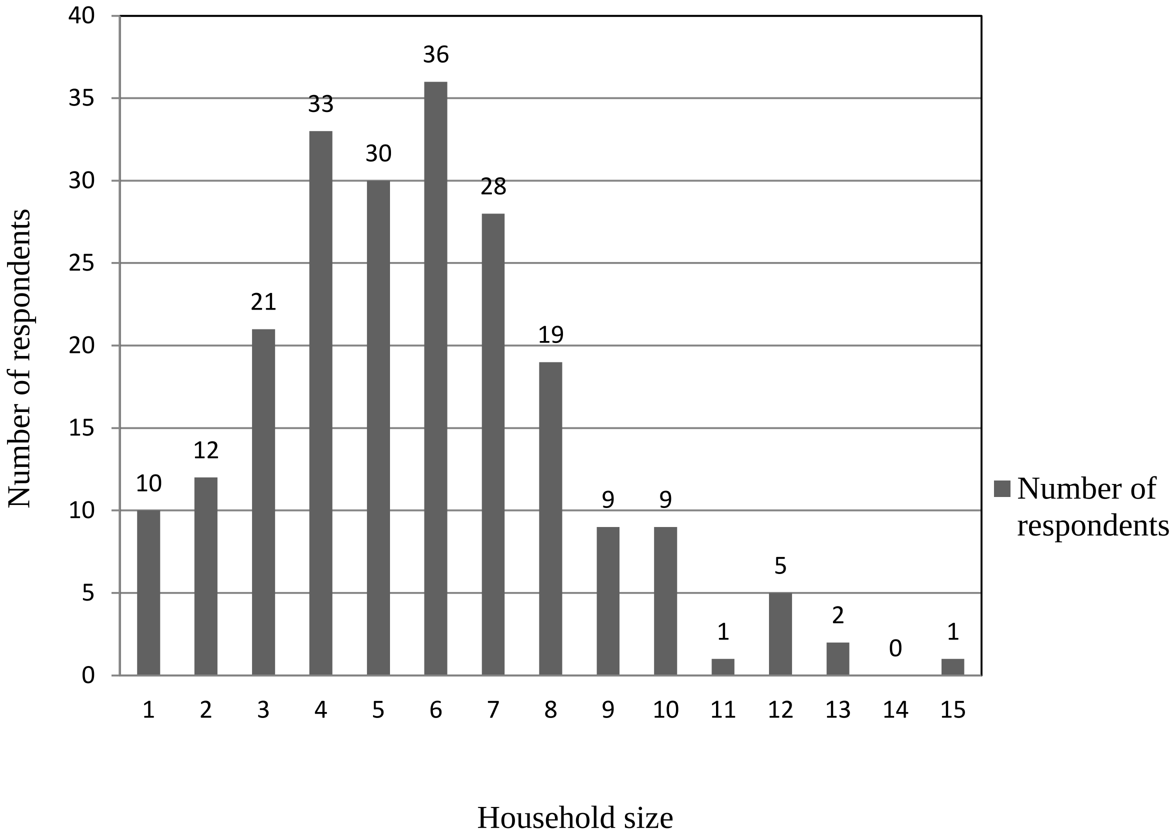

Figure 4: Household size distribution.

Results presented in Table 3 indicate that among farmers willing to pay for irrigation water, 65.4% were male and 34.5% female. On the other hand, farmers not willing to pay for irrigation water comprised of 73.7% male and 26.3% female. These results indicate that the majority of male-headed households were much more willing to pay for water compared to the female-headed households. There is however no statistically significant association between gender of the household and willingness to pay for irrigation water.

Table 3: Gender and occupation status of farmers given their willingness to pay

Characteristic of the farmer	Category	Willing to pay N=197		Not willing to pay N=19		Overall N=216		χ^2	*P value*
Gender		Freq.	%	Freq.	%	Freq.	%		0.001
	Male	129	65.5	14	73.7	143	66.2	0.470	
	Female	68	34.5	5	26.3	73	33.8		
Occupation status	Full-time farmers	117	59.4	7	36.8	124	57.4	17.615***	
	Salaried /employed	54	27.4	3	15.7	57	26.4		
	Retired	3	1.5	0	0	3	1.4		
	Casual labourers	23	11.7	9	47.3	32	14.8		

*, **, *** significant at 10, 5 and 1 percent level, respectively

Analysis of farmers' occupation status and participation in farm activities is presented in Table 3. The results indicate that 57.4% were full time farmers while 26.4%, 1.4% and 14.8% were employed, retired and casual labour respectively. In respect to the willingness to pay 59.4% of full time farmers were willing to pay for irrigation water. For employed farmers working off farm 27.4% were willing to pay. A closer look at the farmers working as casual labour in the scheme indicates that only 11.7% were willing to pay. There is however, a statistically strong positive association between farmers' occupation status and farm labour participation and farmers willingness' to pay for irrigation water.

4.1.3 Household heads' educational status

In terms of educational level, the majority (87%) of the farmers had accessed education as shown in Figure 5. The results show that 13% had not accessed formal education, 56% had accessed primary education, 18% secondary education and only 13% tertiary education.

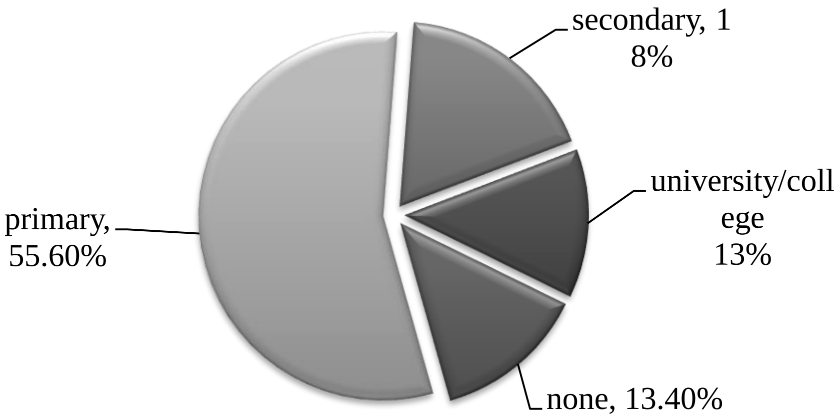

Figure 5: Education level of the farmers.

Concerning willingness to pay and education level the results in Table 4 indicate that 10.7% of farmers willing to pay for irrigation water had no formal education, while 57.8% went to primary school, 17.2% secondary school and 14.3% university. Among those not willing to pay 42.1% had no formal education, while 31.6% went to primary school, 26.3% secondary school, and no farmer who had attained tertiary education in the category. Results of *chi square* test indicate a significant positive association between farmers' access to education and farmers' willing to pay for irrigation water.

Table 4: Education level of farmers given their willingness to pay

Education level	Willing to pay N=197		Not willing to pay N=19		Overall N=216		χ^2	sig
	Freq.	%	Freq.	%	Freq.	%	18.405***	0.001
No education	21	10.7	8	42.1	29	13.4		
primary	114	57.8	6	31.6	120	55.6		
secondary	34	17.2	5	26.3	39	18		
Tertiary/college	28	14.3	0	0	28	13		
Total	197	100	19	100	216	100		

*, **, *** Significant at 1 percent level.

4.1.4 Land tenure and size

Land tenure plays an important role in agricultural production. Results presented in Figure 6 show that even though land ownership in the scheme is communally owned, due to insufficiency of own cultivatable land in the scheme, about 35 % of the farmers rented land from other farmers while 65 % farmed on their own portion of the communal land.

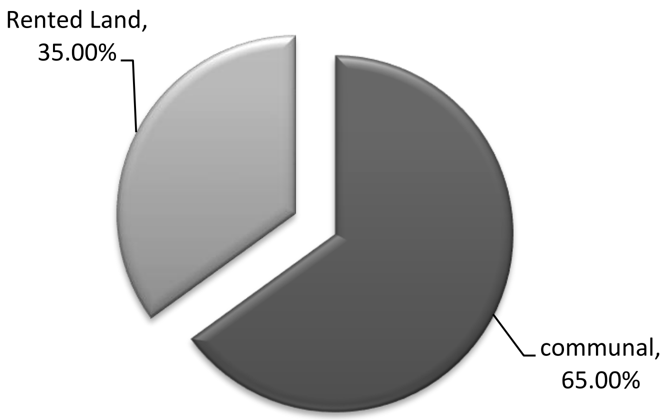

Figure 6: land tenure in the scheme

Analysis of landholding in the scheme presented in Table 5 show that the average size of total cultivated land owned by the farmers was 3.6 acres with farmers having the smallest size of land owning 0.5 acres and the largest owning 20 acres. Farmers willing to pay for irrigation water had a mean land size of 3.7 acres while non-willing farmers had a mean of 3.5 acres. There was no significant difference in land ownership between the two groups.

Table 5: Average land holding (acres)

Characteristics	Willing to pay	Not willing to pay	Overall mean	*t-ratio*	Sig.
Total land	3.7	3.5	3.6	1.06	0.214
Irrigated land	2.4	2.1	2.25	0.715	0.475

The total land utilized under irrigation had a mean of 2.25 acres with farmers willing to pay for water having a mean of 2.4 acres, while those not willing to pay have a mean of 2.1acres. The hypothesis is that farmers with larger total land area have higher demand for irrigation water. Hence, they were willing to pay for a secure and sufficient water supply. Total land area under irrigation had an overall mean of 2.5 acres. The differences between the means of the total land owned and land under irrigation in the scheme was not significant at 5 percent confidence level.

4.1.5 Farmers' total income and income from irrigation farming

The results in Figure 7 present an analysis of total household income and income obtained from irrigation farming. The overall mean household total income was KES 97,210. Farmers willing to pay for irrigation water had a total mean income of KES 92,127 while those not willing to pay had a mean of KES 98,068. The difference in means between these groups was not significant.

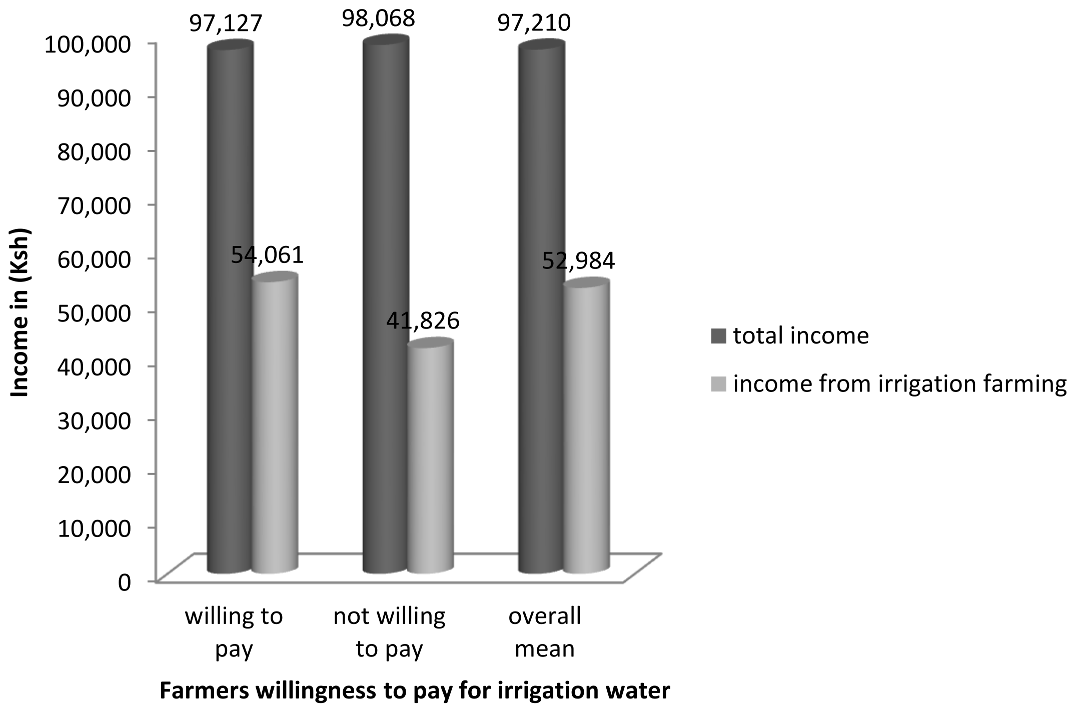

Figure 7: Farmers income given their willingness to pay

In terms of total mean income from irrigation farming, willing farmers had higher income with a mean of KES 54,061 compared to a mean of KES 41,826 for non-willing farmers. The difference between the means of the two groups was significant. Income plays a major role in influencing farmers' willingness to pay as it is hypothesized that the higher the amount of income per production season the more the farmer will be concerned about sustainability and is more likely to pay for irrigation water.

4.1.6 Livestock ownership

Livestock are important assets in most rural households in Kenya. They provide food, draft power and income. Moreover, livestock act as proxies of wealth and prestige. About 83% of the farmers in the scheme reared livestock, which constitute cattle, poultry, goats and sheep. The mean number of total livestock owned was 29. The willing farmers had a mean total livestock ownership of 28 and non-willing farmers had a mean of 31 livestock. As shown in Table 6, willing farmers had relatively lower total number of animals compared to the non-willing farmers. The mean difference of total livestock owned was significant at 5 percent confidence level.

Table 6: Mean livestock ownership in the scheme

Livestock	Willing to pay	Not willing to pay	Overall mean	t-value
Cattle	6	6	6	-0.076
Poultry	27	17	23	0.628
Goats	23	9	22	0.737
Sheep	7	5	7	0.887
Total livestock	28	31	29	3.04***

*, **, *** significant at 1 percent level

4.1.7 Farmers access to agricultural training, extension, credit and membership in irrigation water users association

Agricultural support services provided by various institutions are important sources of information on improved agricultural technologies and acquisition of farm inputs. These services include agricultural training, extension and provision of credit. The results presented in Table 7 indicate that 66 % of farmers had access to agricultural training. Majority of farmers who had access to training (70%) were willing to pay for irrigation water compared to 26% of the non-willing farmers who accessed training. There is, however a strong statistical association between access to agricultural training and willingness to pay for irrigation water. The probable reason for this is that farmers who have attended training courses on irrigation farming and water resource management have good knowledge on importance of paying for irrigation water hence; they would be willing to pay more.

Table 7: Farmers access to agricultural training, extension, credit and membership in irrigation water users association

Characteristic of the farmer	Category	Willing to pay N=197		Not willing to pay N=19		Overall N=216		χ^2
		Freq.	%	Freq.	%	Freq.	%	
Access to training	Yes	138	70	5	26	143	66	14.37***
	No	59	30	14	74	73	34	
Access to extension	Yes	160	81	16	84	175	81	0.470
	No	37	19	3	19	41	19	
Access to credit services	Yes	55	28	2	11	56	26	2.69
	No	142	72	17	89	160	74	
Membership in irrigation water users association	Yes	166	84	7	37	175	81	23.34***
	No	31	16	12	63	41	19	

*, **, *** significant at 1 percent level

Agricultural extension services, which include advisory and consultation on improved agricultural practices is important in enhancing agricultural production. The results in Table 7 indicate that 81% of willing farmers had access to extension services. In the category of farmers not willing to pay, 84% accessed the service. There was, however, no significant association between access to extension services and farmers willingness' to pay for irrigation water.

Frequency of contact with extension staff can gauge effectiveness of extension services delivered to the farmers. The results presented in Figure 8 indicate that out of the total number of farmers who had contact with the extension officers, 23% attested to having received the visit only once a year, 51% had received at least 4 times a year and 25% received at least once every month.

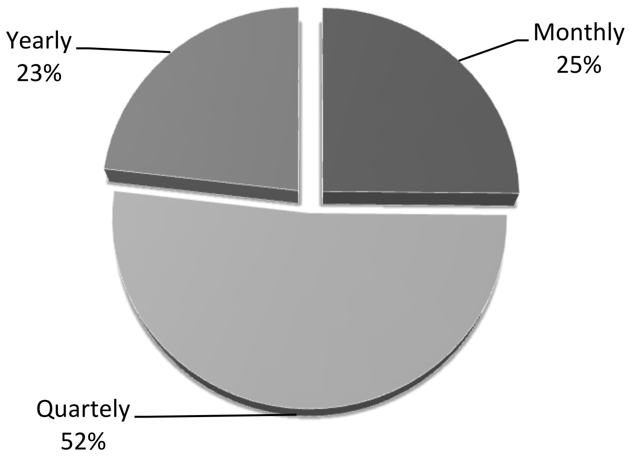

Figure 8: Farmers frequency of contact of extension service staff

The availability of sufficient credit to the smallholder farmers contributes positively in enhancing production and income. Access to credit enables farmers to overcome working capital constraints. The results in Table 7 indicate that 26% of farmers had access to credit. On the category of farmers, willing to pay for irrigation water 28% had accessed credit. These results indicate that most farmers in the scheme had no access to credit service. There is, however, no significant statistical association between access to credit services and farmers willingness to pay for irrigation water.

Water users' manage the majority of smallholder irrigation schemes in Kenya, since irrigation farming requires collective and coordinated action in case of any problems with the systems. The proportions of farmers who are members of the irrigation water users association and willing to pay for irrigation water were 84% as compared to 16% who were not willing to pay yet there are members of the association (Table 7). For farmers who were not willing to pay, 37.5% were members of the water users association while 63.5% were not members. From the results, it is apparent that the majority of the farmers in the scheme who are members of the water users association are willing to pay for irrigation water. There is a significant association between membership in the association and willingness to pay for irrigation water.

4.1.8 Mode of transport and distance to nearby market centre

The mode of transport has influence on marketing of agricultural products. It determines the marketing outlet chosen and the time the products reach the market. In Figure 9, results indicate that 59% of the farmers used human labour, 20% used motor vehicles, 15% used donkeys and oxen and 6 % used motorcycles to transport their produce to the market.

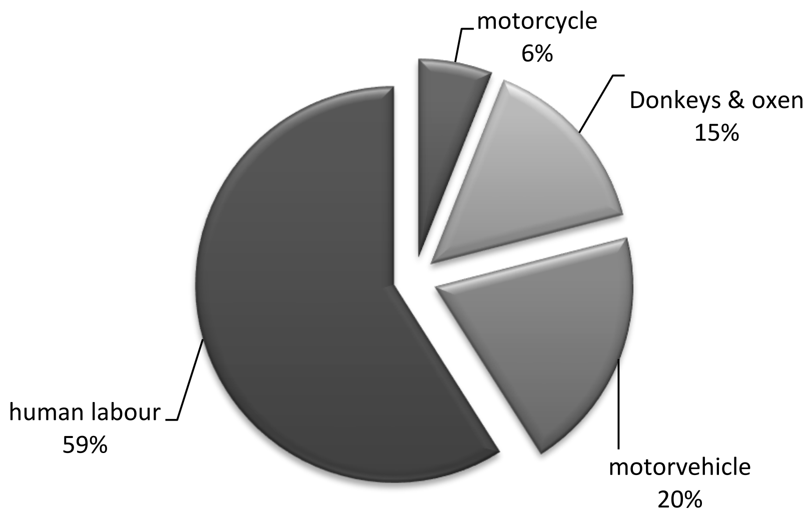

Figure 9: Major modes of transport used by farmers in the scheme

Farmers ease of access to the market centre contributes in increased agricultural income as it enables farmers reduce the transportation costs but also exploit market information. The results indicate that the average distance to the market for willing farmers was relatively shorter (4.51Km) than the non-willing farmers (9.5 km).

4.1.9 Irrigation development, operation and maintenance

There is an expected change in the manner of agricultural production in the basin with the introduction of the pressurised systems of irrigation. An analysis of the irrigation systems currently used by farmers in the scheme found out that few farmers had adopted the new system of irrigation though the process was still on going. From the results, 35% of farmers had adopted sprinkler irrigation, 0.9% used drip irrigation and the majority of the farmers (64.1%) were still using the traditional furrow systems as indicated in Table 8.

Perceptions and confidence in the new system of irrigation (pressurised systems) compared to the traditional furrow irrigation, showed that 98.6% of farmers perceived the new system as being better than the old one. Only 1.4% of the farmers had a contrary opinion. The results are in Table 8. Concerning the confidence of farmers in the news system, 99.5 % of farmers had confidence in the new system. They felt it would bring improvements in the manner in which their agricultural activities are undertaken while only 0.5% had no confidence in the new system bringing some changes

Table 8: Farmers perceptions on the new system of irrigation

Attribute		Frequency	Percentage
System of irrigation	Furrow irrigation	138	63.9
	Sprinkler irrigation	76	35.2
	Drip irrigation	2	0.9
Farmers' perception about new system	Better	213	98.6
	Worse	3	1.4
Farmers confidence in the new system	Yes	215	99.5
	No	1	0.5

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4.1.10 Water shortage, conflicts and preferred water allocation system.

Water scarcity due to changing climatic conditions creates water shortages and this has a direct impact on willingness' of farmers in valuing the resource. The results presented in Table 9 shows that 94% of farmers willing to pay and 90% of non-willing farmers reported having experienced water conflicts while utilizing the irrigation water. This indicates that both groups faced water conflicts in relative terms

Table 9: Preferred system of water allocation, water shortage and conflicts

Attribute		Willing to pay percent	Not willing to pay percent	Total percent
Conflict in water sharing	Yes	94	90	94
	No	6	10	6
Causes of water conflicts	Upstream diversion	76	78	72
	Water theft	6	10	8
	Increase in number of irrigation users	11	12	11
	Mis-utilization and wastage	7	6	6
Preferred system of water allocation	Based on the size of irrigated land	18	10	17
	Equally among the farmers	82	90	83

A further inquiry into the causes of water scarcity revealed that most of the farmers willing to pay believed that water scarcity was created by; upstream diversion by head users (76%), water theft (6%), increase in number of irrigation water users (11%) and mis-utilization and wastage (7%) respectively as shown in Table 9. The corresponding figures for non-willing farmers are 68%, 10%, 12% and 6% respectively. The results indicate that upstream diversion by head users was a major problem for both groups of farmers in the scheme.

To ensure that there is effective and equitable distribution of irrigation water in the scheme, the farmers were asked to give their opinion on their preferred system of water allocation. The results in Table 9 indicate that 83% of farmers preferred water allocation and distribution to be equal among the farmers while 17% preferred distribution based on the size of land owned by the farmers. Farmers willing to pay for irrigation water who preferred equal distribution of water accounted for 82% compared to 18% who preferred area based distribution. Among the farmers not willing to pay, 90% preferred equal distribution as opposed to 10% who preferred area based distribution.

4.2 Factors influencing farmers' willingness to pay for irrigation water

4.2.1 Farmers' response on willingness to pay decision

Farmers response on willingness to pay indicates that majority of the farmers (92%) were willing to pay some amount to cater for operational and maintenance costs as indicated in Figure 10.

Figure 10: Farmers response to willingness to pay for irrigation water

4.2.2 Factors influencing the farmers' decision on willingness to pay for irrigation water

Various demographic and socio-economic factors determine the smallholder irrigation farmers' decision to pay for irrigation water. The probit regression model results are presented in Table 10. Out of the total number of variables considered in the model, six variables significantly influenced the farmers' decision to pay for irrigation water. The variables are; the education level of the farmer, farmers' participation in the construction and maintenance of the irrigation scheme, access to extension, total income irrigation farming, membership in irrigation water users association and distance to the water source.

Table 10: Probit estimates for the factors influencing farmers' decision on willingness to pay decision for irrigation water

Variables	Dy/Dx	Coefficient	Std. Err.	Z
Education level	0.0297	2.88	1.34	2.14**
Age of farmer	-1.46e-09	-0.017	0.023	-0.74
Participation in construction	0.02	1.50	0.75	2.01**
Household size	.0000272	0.25	0.18	1.42
Gender of household head	-0.005	-0.74	0.71	-1.03
Distance to the market	-3.06e-08	-0.35	0.12	-2.76
Total livestock ownership	1.47e-09	0.008	0.015	0.54
Access to credit service	-0.004	-0.064	0.90	-0.07
Access to extension service	-0.001	-1.64	0.83	-1.97**
Total income from irrigated farm	0.182	5.80	1.53	3.79**
Access to agricultural training	0.0067	1.88	0.71	2.62
Membership in (IWUA)	0.16	1.72	0.81	2.10**
Distance to water source	0.04	-0.352	0.12	-2.88*
Constant		4.18	1.62	2.58
N		216		
LR χ^2		95.10		
Prob> χ^2		0.000		
Pseudo R^2		0.7707		
Log likelihood		-14.143		

*, **, *** significant at 10, 5 and 1 percent level, respectively

Education level of the household head had a positive and significant influence on farmers' decision on willingness to pay for irrigation water. An additional year of schooling increased the probability of farmers willing to pay for irrigation water by about 2.97%. The probable reason is educated farmers understand better issues of water scarcity. They could also perceive better the future risk of reduced water flows on crop production and hence may understand the importance of paying for irrigation water. This is consistent with the findings by Ndetewio *et al,* (2013) who found education as a significant positive factor in influencing farmers' willingness to pay decision for watershed and conservation in Lower Moshi irrigation scheme in Tanzania. However, the findings are contrary with those done of Baidoo *et al*. (2013) in the Upper East region of Ghana who found that surprisingly farmers with higher level of education were not willing to pay for improved access to irrigation water.

The farmers' participation in the construction and maintenance of the irrigation scheme had a positive and significant effect in influencing the farmers' willingness to pay decision. Farmers' participation in the construction and maintenance of the irrigation structures increased the probability of willing to pay for irrigation water by 2 %. Farmers' participation in formulation and project implementation process builds a sense of ownership. The reason is, as farmers perceive the existence of a furrow maintenance problem, then there is as a potential threat of production loss. This pushes them to seek for a sustainable solution of which financing the capacity of the irrigation scheme through water charging is appears a better option. Hence, the farmers will be willing actively participate in contributing water fees and maintenance of the irrigation systems. This finding is in line with IFPRI (2005) study on improved water supply in Ghanaian Volta Basin, in which farmers who were aware of problems in their irrigation water supply participated regularly in construction and maintenance and were more willing to pay for water supply improvements. Another study by Tsehayou (2013) on the challenges facing smallholder irrigation schemes in Amhara region, Ethiopia found that participation of water users in the management of the schemes had a positive impact on a sense of ownership and active involvement in matters regarding the scheme.

Unexpectedly the results show that access to extension service had a negative and significant influence on the farmers' willingness to pay for irrigation water. Access to extension service reduced the probability of farmers willing to pay by 1%. This is contrary to the expected theory. The probable reason might be that even farmers who have access to extension are better placed to have other sources of water and may have adopted more efficient technologies compared to those who have not accessed to the service. Nirere *et al.,* (2013) found contact with extension service providers significantly influenced farmers' willingness to pay for protection of the Nyaborongo river system in Rwanda. However, these results are contrary to a study done by Falola *et al.,* (2013) who found that access to extension services positively influenced farmers' willingness to take up agricultural insurance.

Total income from irrigation farming had a positive and significant influence on farmers' willingness to pay for irrigation water. A unit increase in farm income from irrigation increases the probability of farmers' willingness to pay for irrigation water by 18.2%. The interpretation of this is that if farmers earn more income from irrigation farming, they are most likely to pay for irrigation water. This is because they have more disposable income and more ability to deal with risk. Farmers with higher income may also command more financial capital to make better economic use of water allotted. On the contrary, farmers who earn low farm income from irrigation farming may face difficulty in paying for the irrigation water. Similar findings by Bamidele *et al*. 2012 indicate that total farm income had a significant effect on farmers' ability to pay for irrigation facilities in Nigeria. Another study by Tang *et al*. (2013) on the willingness to pay for irrigation water in North West China found that farmers' with higher incomes were much willing to pay for irrigation water.

Membership in irrigation water users' association increased the probability of farmers paying for irrigation water by 16%. Farmers who are members in the irrigation water users association are easily influenced by their acquaintances than those in isolation. They get to exchange ideas and learn about the benefits of new systems of irrigation and new farming methods in view of sustainable agricultural production. A study by Wegerich *et al*., (2000) on water users associations' sustainability in the management of irrigation water resources in Uzbekistan and Kyrgyzstan indicates that farmers were willing to pay full price for operational and maintenance costs and were willing to invest their labour and maintain the systems collectively. The results are consistent with those of Frija *et al*. (2008) in Tunisia, who showed that changes in institutional structures of irrigation water users association from individual to groups affect their willingness to pay for water and indicated that farmers were willing to pay more under the group. Amondo *et al*. (2013) found that membership in water users association had a significant influence on their willingness to pay.

Finally, distance to the water source significantly and negatively influenced the farmers' decision on willingness to pay for irrigation water. The results indicate that holding other factors constant a farmer's decision to pay for irrigation water decreases by 4% as the distance of the water source increases by 1 kilometre. These findings corroborate Wen *et al,* (2009) who found that the distance to the water source significantly reduces willingness to pay for securing water quality in the South to North water transfer project in China.

4.3 Estimation of farmers Mean willingness to pay for irrigation water

4.3.1 Farmers' response to different bid amounts.

The results in Table 11 show the distribution frequency of respondents willingness to pay at each bid amount. There were 197 farmers out of 216 who were willing to pay for the given bids, 19 respondents' were not willing to pay. Among the farmers who were offered the lowest bid of KES 375, the proportion of 34.5% accepted to pay the amount while those offered the highest bid of KES 1,500; about 50.2% were willing to pay. Only 15.3% of farmers' were willing to pay the average bid of KES 750 per production season.

Table 11: Farmers' response to different bid levels

Bid	Frequency	Percentage	Cumulative %
KES 375	68	34.5	34.5
KES 750	30	15.3	49.8
KES 1500	99	50.2	100
Total	**197**	**100**	

The double bounded dichotomous contingent valuation model was used to determine the farmers mean willingness to pay for irrigation water. Farmers' socio-economic characteristics were included in the model to determine the factors, which influence the mean willingness to pay for irrigation water. The results in Table 12 show that four factors, age of the farmer, household size, and distance to water source and income from irrigation significantly influenced the farmers mean willingness to pay. The constant, in this case- the mean Willingness to pay, amounted to approximately KES 968 per production season. This represents about 9.6% of the average total farm income.

Table 12: Factors influencing farmers' mean willingness to pay for irrigation water

Variable	**Coefficient**	**Std. Err.**	**z**
Age of farmer	-30.2755	6.0618	-4.99**
Household size	109.3838	33.7052	3.25*
Membership in IWUA	76.3842	238.9641	0.32
Access to credit	2.5983	174.4956	0.01
Access to extension	-423.3809	230.2513	-1.84
Access to training	-136.5829	186.0542	-0.73
Participation in construction	282.9909	220.9265	1.28
Distance to water source	-97.7158	38.6759	-2.53**
Distance to the market	-68.4304	28.5917	-2.39
Total livestock owned	0 .0151	2.5567	0.01
Income from irrigation	245.66	.00202	2.62*
Constant	938.4346	560.7905	1.67***
Number of observations	197		
F(14, 120)	15.78		
Prob >F	0.000		
R-squared	0.6461		
Adjusted R-squared	0.6081		

*, **, *** significant at 10, 5 and 1 percent level, respectively

The age of the farmer had a negative and significant influence on farmers' mean willingness to pay for irrigation water (Table 12). These results indicate that an increase in age of farmers by one year decreased the mean willingness to pay of farmers by KES 30.2. This finding is consistent with that of Allen *et al.*, (2013) who found that farmers' age negatively and significantly influenced farmers' willingness to pay for irrigation water in Wondo Genet District Ethiopia. The results further corroborate those of Abdelmoneim (1992) who estimated willingness to pay for water in Georgia and found that willingness to pay decreased as age increased. This implies that as a person becomes aged the interest to pay for irrigation water declines. The impact of farmers' age is a combination effect of farming experience and planning. Although long experience has a positive effect, younger farmers tend to have longer planning horizons and hence are likely to pay for the introduction of water charging and new technologies (Holden and Shiferaw, 2002). The plausible reason in this case is that older people are risk averse and tend not to change their way of doing things Ashenafi (2007).

Other studies conducted by Mallious *et al*. (2001), Paulos (2002) and Tiwari (2005), indicated that age has a negative effect on farmers' willingness to pay decision and older persons tend to pay less. The household size is significant and positively related to the mean willingness to pay for irrigation water. From the results (Table 12), the amount of money the farmers are willing to pay increases by KES 109.38 as households size increases by 1 member holding other factors constant. The probable reason for this is that, the larger the household size, the more the farm labour available in practising irrigation farming in the scheme. Larger households also face pressure in terms of food demand and income demand within the household, so they will be willing to pay for irrigation water since the intervention in water pricing will lead to improved water management, which in return enhance their income from irrigation and access to food. These results are consistent with a study done by Ratna (1999) who found that household size significantly influenced the pricing of rural drinking water in western India.

Distance to the water source is significant and negatively influences the amount of cash payment for irrigation water (Table 12). Keeping other factors constant, as the distance of the water source from the household increases by a kilometre, the mean willingness to pay reduces by KES 97.71. This might be because residents who are located around the head and main canals could easily access and use the water for irrigation while those at the other end have location disadvantage to do so. The results further showed that when the farmer is close to the head and main canal the amount of cash the household could pay for irrigation water may be higher per production season than the tail end farmers. These results are consistent with those of Rohith (2011) who found that distance of the farm from the main canal significantly influenced farmers' willingness to pay assured summer irrigation. A study by Pate *et al.* (1995) on the effects of distance on willingness to pay values for conservation wetlands programs in California indicates that distance affected the willingness to pay for three programs in the San Joaquin valley.

Farmers' income from irrigation had a positive and significant effect in influencing farmers' mean willingness to pay (Table 12). The higher the farm income from irrigation farming, the more likely the farmers were willing to pay. This is in line with prior expectation that the higher the income from farming, the higher the chance that the farmer will pay for irrigation water. On the other hand, poverty reduces a household's willingness to pay and ability to invest in agricultural technologies. This is consistent with studies done by Mwaura *et al.* (2010) and Agyekum *et al.*, (2014).

4.4 Average economic value of irrigation water used in production across major crops grown

Table 13: Summary of crop budgets

Crop	Total sales TVP (KES/Ha)	Total variable cost KES/ha	Gross margin (KES/Ha)
Maize	110,484	21,040	89,444
Millet	74,649	10,388	64,261
Cowpeas	16,945	2,461	14,484
Green grams	108,779	12,991	95,788
Cassava	52,350	18,700	33,650
Bananas	120,000	35,747	84,253
Mangoes	185,000	26,318	158,682
Lemons	141,368	93,277	48,091
Sorghum	74,981	15,035	59,946

Farm enterprise budgets for each of the crop enterprises from the 216 sampled farmers were undertaken. This involved quantifying all the costs involved in production. Farm costs, which include land rent, labour, seed, fertilizer, pesticides, were all added up to arrive at the total cost for each crop. Table 13 presents findings of the crop budgets in the scheme. The results indicate that mango production enterprise had the highest gross margin of KES 158,632 followed by green grams KES 95,788, maize KES 89,944, bananas KES 84,253, millet KES 64,261, sorghum KES 59,946, lemons KES 48,091, cassava KES 33,650 and cowpeas KES 14,434 respectively in decreasing order. Prices were determined by the farm gate price or first point of sale transactions where farmers participate in their capacity as sellers of their own products.

Table 14: Water productivity ratios and residual value of irrigation water

Crop	Average total sales (KES/Ha)	Gross margin (KES/Ha)	Average water consumption m^3	Sales /water KES/m^3	Gross margin/water m^3	Residual value KES/m^3
Maize	110,484	89,944	5,650	19.6	15.9	14.9
Millet	74,649	64,261	2,440	30.6	26.3	3.6
Cowpeas	16,945	14,484	4,582	3.7	3.1	2.7
Green grams	108,779	95,788	1,115	97.6	88.6	20.9
Cassava	52,350	33,650	3,730	14.0	9.0	4.3
Banana	120,000	84,253	6,215	19.3	13.6	7.4
Mangoes	185,000	158,652	3,415	54.1	46.5	16.9
Lemons	141,368	48,091	4,600	30.7	10.4	6.5
sorghum	74,981	59,946	982	76.3	61.0	25.2
Residual value						11.5

An analysis of water productivity in terms of gross margins per quantity of water used expressed per M^3 indicated that green grams had the highest water productivity at KES 88.6 per M^3, followed by sorghum KES 61.0, mangoes KES 46.5, millet KES 26.3, maize KES 15.9, lemons KES 10.4, cassava KES 9.0 and cowpeas KES 3.1 respectively (Table 14). These results take into account the water use by the crops contrary to the previous results on gross margins that indicated that mango enterprise was the most profitable, in terms of water use sorghum is the most productive.

An analysis of the residual value of water indicates that the overall mean value is KES11.5 per meter cubic of water. The economic value of irrigation water for field food crops; sorghum, green grams, maize, millet, cassava and cowpeas are KES, 25.2, 20.9, 14.9, 3.6, 4.3, 2.7 respectively per M^3 (Table 14). As for the fruit trees; mangoes, bananas and lemons, the economic value of irrigation water is KES, 16.9, 7.4, 6.5 per M^3 respectively. In general, sorghum and green grams have the highest values for the ratios of apparent productivity, residual value while cowpeas and lemons have the lowest. The results showed that at crop level, water values estimated for field crops are higher generally compared to fruit trees. This means that there is greater potential in field crops than fruit trees.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

This study aimed at determining the economic value of irrigation water in small holder managed farms in the Kerio valley basin. This was done by eliciting farmers' willingness to pay (WTP) using the contingent valuation method and also determining the average economic value of irrigation water for the major crops grown in the basin using the residual imputation approach. Different socio-economic characteristics of farmers residing in the scheme were analysed. The findings revealed significant differences in farmers occupation status, education level, total livestock ownership, membership in water users' association, access to training and distance to the market between willing to pay for irrigation water and those not willing to pay. In conclusion, farmers willing to pay had a comparative advantage over those not willing to pay for irrigation water. As hypothesised education level of household head, membership in irrigation water users' association, farmers' participation in the construction and maintenance of the scheme and total income from irrigation positively influenced the farmers' decision on willingness to pay for irrigation water. However, distance to water source and access to extension services negatively influenced farmers' decision to pay for irrigation water.

An assessment of how much smallholder farmers were willing to pay for irrigation water and the factors influencing the mean willingness to pay for irrigation water indicates that 91.4% of the smallholder farmers were willing to pay for irrigation water with a mean WTP of KES 938 per production season. This represents about 9.6% of the average total farm income. The factors that influenced the mean willingness to pay were; age of the farmer, household size, distance to the water source and income from irrigation farming. Lastly, results on the average economic value of irrigation water used in production across major nine crops grown in the Kerio valley basin indicate that the overall mean value is KES 11.5 per meter cubic of water. The economic value of irrigation water for field food crops; sorghum, green grams, maize, millet, cassava and cowpeas are KES, 25.2, 20.9, 14.9, 3.6, 4.3, 2.7 respectively. Similarly, for the fruit trees; mangoes, bananas and lemons, the economic value of irrigation water is KES, 16.9, 7.4, 6.5 respectively. Sorghum and green grams had the highest values for the ratios of apparent productivity/

residual value while, cowpeas, and lemons had the lowest for the ratios of apparent productivity/residual value.

5.2 Recommendations

Based on the results of the study, improving accessibility and provision of adequate irrigation water to smallholder farmers is needed. Modern and efficient water saving delivery systems in semi-arid lands is necessary given the changing climatic conditions and incidences of water scarcity. This study makes the following recommendations concerning the management of smallholder irrigation schemes in the Kerio valley basin. Education level was one of the factors, which significantly influenced farmers' willingness to pay. More capacity building initiatives such as training and field days will enhance the farmers' willingness to pay. The results also showed that farmers who regularly participated in the construction and maintenance of the scheme were more willing to pay for irrigation water than those who did not. Therefore, these findings imply that improvement of irrigation systems in terms of developing physical infrastructure and efficient distribution of water can enhance farmers' participation in the scheme. Moreover, farmers training and guidance provided through the irrigation water users association can contribute to enhance farmers participation.

The level of income obtained from irrigation farming significantly influenced the farmers mean willingness to pay. Hence pricing of irrigation water in the scheme should follow a policy of differential pricing based on income levels of farmers, rather than the administering of flat rates that has the potential of misusing or overexploiting water (for those who can afford it) as well as discouraging especially the poor farmers from its since they cannot afford. Though it must be acknowledged that identifying households according to income levels may be a major challenge, differential pricing has the potential of ensuring that most households, if not all, have the ability to pay to for irrigation water. Hence establishing a feasible water charging system in the schemes such as the volumetric basis of water charging this will be helpful.

Membership in irrigation water users association significantly influenced the farmers' decision on willingness to pay water charges. The water users associations should be strengthened through training of technical staff such as plumbers who will ensure water systems are properly maintained. On the other hand, adequate extension support should be delivered more specifically on irrigation farming so that farmers would be able to make efficient use of their irrigated land. Implementing an irrigation water management system that would ensure equitable water distribution and effective enforcement of existing rules and regulations would further enhance not only the farmers' willingness to pay but also the intensity of payment they would commit

The results of factors influencing the cash payment intensity showed that the level of payment committed by farmers near the water source was higher compared to those who are far. The less value attached to irrigation water by farmers who are far away may be due to its insufficiency and poor management users have benefited less and lost sense of ownership to commit resources. Crop water productivity indicates that sorghum and green grams give high returns while utilizing less water. Therefore, farmers should be encouraged to grow more of sorghum and green grams in the river basin.

5.3 Areas of further research

This study highlights the need to improve water productivity in the smallholder irrigation context. The study recommends the following studies to enrich the results of future research on smallholder irrigation farming and water demand studies. There is need for research to establish the daily minimum water requirements farmers need for basic household activities. This would be helpful in water pricing where certain basic minimum considered essential could be supplied freely, after which consumption is priced. Further investigations are needed to establish whether interventions in upgrading the traditional systems of water supply have improved or worsed the welfare of the farmers. There is neede to give policy-makers the required feedback to improve on policy formulation and implementation strategies where necessary.

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Appendix: 1

FARM/HOUSEHOLD QUESTIONNAIRE

This study was conducted to assess farmers' willingness to pay for irrigation water in Kerio valley Basin. The information provided will assist the policy makers, farmers and irrigation water users associations in designing policies and programmes that will enhance efficient and sustainable management of irrigation water in the County. All information will be treated as confidential

Date of data collection……………………….

Questionnaire Number……………………….

Farmer's Name……………………. ……………………Village……………………...

Enumerator's Name…………………….. …………………..

1.0 Household socio-demographic information

1.1 Gender of the Farmer ………. (*Male=1, female=0*)

1.2 Age of farmer ………………..years

1.3 Marital status……………….. *(Married=1, Single=2, Divorced=3, Widowed=4*)

1.4 Household family size (*number of people living and eating together*) ……..............

1.5 What is the education level of the household head............................? *(Non =1, primary=2, secondary=3, college=4, university=5)*

1.6 Main occupation of the household head ………………..? *(1=fulltime farmer, 2= salaried employee, 3=self-employed off-farm, 4=casual labourer, 5=retired)*

1.7 Farm labour participation…………….? (*1=full time, 2=part time, 3=Not a worker*)

2.0 Farm characteristics

2.1 How long have you been farming on your own..................years?

2.2 How many Acres in total land holding do you own in the scheme...............Acres?

2.3 How many Acres of cultivated land are under irrigation…………….Acres?

2.4 Land tenure system...…………. *(1=individual, 2=Leasehold, 3=communal)*

2.5 Do you pay any fees for land……………….? (1=yes, 2=No)

2.6 If yes how much per Acre…………………………

2.7 Do you hire people to work on your farm………..?(1=yes, 2=No)

2.8 If yes How much do you pay per day KES…………………………………………

Crop	Area planted (Acres)	Quantity harvested	Quantity sold	Price/unit	Quantity consumed (specified unit)	Market outlet 1.local market 2. shop 3 Middle men 4.Others (specify)
Maize						
sorghum						
millet						
cowpeas						
green grams						
cassava						
bananas						
mangoes						
lemons						

2.9 Please, Indicate the size and allotment of your land for the various crops you grow including rented plots.

 # market price per unit will be checked with an extension officer

2.10 Have you ever faced food shortages in the past 5 years……………...? *(Yes=1, No=0)*

2.11 If yes, how did you overcome……………? *(1=Buying 2 borrowing 3 Aid 4 others, specify……………..)*

2.12 What are the major agricultural problems you face in your farm in increasing order (1 for major and 9 for least)……………………………………………………………………?

(1=Small farm, 2=crop pests and diseases, 3=animal disease, 5=shortage of input, 6=lack of technical support, 7=shortage of input, 8=Lack of technical support, 9=others specify………………………….)

Expenditure/production costs

Crop	Inputs 1.fertilizers 2.seeds 3.herbicides 4.pesticides 5.labour 6.tillage	Suppliers 1.local shop 2.store in town 3.coop 4.individual (friends, neighbours)	Quantity purchased and used	Cost per unit	Marketing cost Transport packaging And other costs
maize					
sorghum					
millet					
cowpeas					
green grams					
cassava					
bananas					
mangoes					
lemons					

#input price per unit will be checked with extension officer

2.13 What major problem do you experience in input supply………………………………………………………………………………
……………………………

3.0 Access to road and major institutional infrastructures

3.1 Do you own any large equipment (e.g tractor, pickup, implements)…… *(1 yes, 2= no)*

3.2 Which mode do you use to transport agricultural produce to the market place..........? *(1=Pack animals, 2=motorcycle, =3=motor vehicle, 4=others (specify)……………………*

3.2 What is the approximate distance from your farm to the nearest market……………km

4.0 Access to credit services

4.1 Do you access credit/loan…………………..? *(1= Yes, 0 =No)*

4.2 If yes which is the major source from which you borrow money*…………….? (1= Cooperatives, 2=Microfinance institutions 3=bank, 4=merchants, 5=friends 6= money lenders, 7=Agricultural Finance Corporation 8=others specify……….*

4.3 For what purposes do you use the credit............? *(1=to buy farm inputs, 2=for trade, 3=livestock rearing, 4=consumption, 5 others, specify……………)*

4.4 Do you repay back your loan on time………….? *(Yes=1, No =0)*

4.5 If No, what is the major challenge……….? *(1=Due to insufficient return, 2=due to crop failure and unfavourable weather,3=Due to price failure 4=Others, specify…………………………..)*

4.6 Is the credit facility adequate in meeting your needs……………? *(1=Yes, 0=No)*

4.7 Have you faced a problem of getting a loan………………? *(1=Yes, 2= No)*

4.8 If yes, which is the major problem………….? *(1=Administrative problem 2=collateral 3=others, specify………………………….)*

5.0 Access to Extension Services

5.0 Do you have access to Irrigation extension service in your area…….? (*Yes=1, No =0)*

5.1 Are there any Government or Non-Governmental Organizations supporting irrigation development in your area……………*? (Yes=1, No=0)*

5.2 Have you ever been supported by any of these organizations to improve your irrigation activities……………….? (*Yes=1, No=0)*

5.4 If yes, mention the type of support you received so far…………? (*1=Extension 2=training 3=maintenance, 4=experience sharing)*

5.5 How frequently do you usually discuss agricultural matters with the extension staff………………..? *(1=monthly 2=quarterly 3=yearly)*

5.6 From whom do you get most frequent advice…………..? *(1=Development agents, 2=agricultural officers, 3=irrigation water users association)*

5.7 Have you ever had vocational training in Agriculture so far…………? *(Yes=1,No=0)*

6.0 Irrigation development, operation and maintenance

6.1 Have you participated in the construction and maintenance at Arror irrigation scheme...................? *(Yes=1, No=0)*

6.2 If yes, what and how much was your contribution…………….? *(1 labour for………days,2=cash KES………….3= Material……………..units)*

6.3 Do you experience problems or conflicts about water sharing *…………?(1=yes,2=no)*

6.4 If yes, what are the causes for scarcity……..? *(1 =Upstream diversion 2= unfavourable weather, 3=water theft)*

6.5 How do you perceive the level of income (Profitability) you have generated from irrigated farming…………………..? *(1=High 2=medium 3=low)*

6.7 Are you a member of an irrigation water user association…………? *(Yes=1, No=0)*

6.8 Do you have any responsibility in the association…………………? *(Yes=1, No=0)*

6.9 Do you think the existence of this users' institution is useful………? *(Yes=1, No=0)*

6.10 What is the system of water allocation among users……………..? *(1=proportion to the size of irrigated land, 2=equal distribution among members of association 3=equal distribution among all users 4 based of crop type)*

6.11 Which system of irrigation do you use in your farm…………..? *(1=Traditional furrow irrigation, 2= sprinkler irrigation 3=drip irrigation 4= others specify…………*

6.12 How do you perceive maintenance of the new system of irrigation compared to the old system is it better or worst……………...*? (Better=1, worse=No)*

6.13 What is the approximate distance of your farm from the water source intake…………km

7.0 Willingness to pay for irrigation water

7.1 In the frame of an improved water supply, would you be willing to pay some amount to cover the cost of operation and maintenance in the irrigation scheme………? (*Yes=1, No=0)*

7.2 If Yes to 8.1 would you be willing to pay X……….. KES/ha/yr for supply and service

7.3 If Yes to the First bid ask the respondent if He/she would you be willing to pay BX………… KES /ha/yr? Where BX>X.

7.4 If no to the first bid, ask the respondent if he/she will be willing to pay BC………. KES/ha/yr where BC<X

7.5 If No to the second lower bid, ask the respondent the maximum amount he/she would be willing to pay KES……………………………………….

8.0 Income Sources

sources of income	in kind (cash equivalent)	in cash	total
farm income			
Income from crop irrigation farming			
Rented out land			
Farm labour			
Income from livestock sales and sale of the products			

nonfarm income			
Wage from employment of family members			
Income from remittances			
Casual village labour			
Business income from trade (shops, butchery. etc.)			
Craft works			
Total income			

9.0 Livestock Ownership

9.1 Do you own any livestock …………….*(1=Yes, 0=No)*

If yes, tell me the type and number of livestock owned

Livestock type	Number owned	Number sold	Gross income
Oxen			
Cows			
donkeys			
poultry			
goats			
sheep			
Total			

10.0 General opinion

10.1 Do you have trust or confidence on the new system of irrigation compared to the traditional furrow system...? (*Yes=1, No=0)*

As farmer in the scheme, has your situation improved over the last 2 years.................? (*1=yes.2=no)*

If yes why………………………………………………………………………………………

10.2 How do you value water as a resource? Do you think it is a free and everlasting good*? ……………………………………… (Yes =1, No=0)*

Thank the interviewee for sparing his time.

Appendix 2

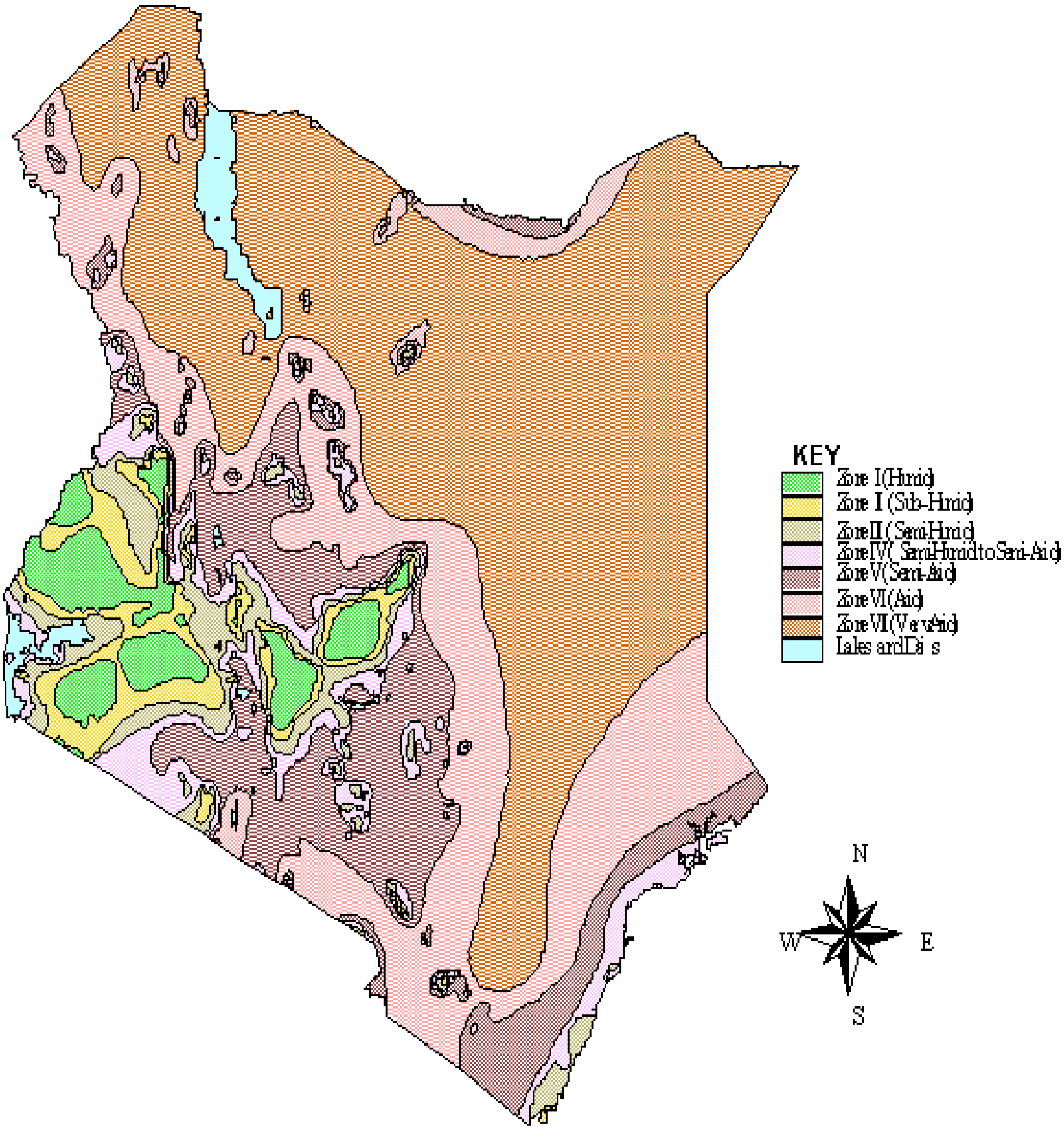
FAO data on *CROPWAT* model analysis of water use in Kerio valley basin agro-ecological zone IV

Crop name	Etm (mm)	Ectrop (mm)	ky	Ya	Ym	Area cropping intensity	Ectrop actual (mm)	Crop water use (m^3)	irrigation water requirement
maize	476.2	319	1.25	2881	9,000	20,900	128.5	5,650	39.9
sorghum	526	326.5	0.9	1853	5,000	3,653	98.2	2,440	8.4
millet	460.4	244	1	1433	3,000	30,000	116.6	4,582	4.9
cowpeas	509.8	321.2	1.15	550	800	1,533	85.8	1,115	21.9
green grams	396.9	250.1	1.15	971	2,500	12,400	117	3,730	17.5
cassava	458	366.4	1.1	1085	2,000	500	214.1	6,215	0.2
bananas	942	820.3	1.35	7931	60,000	1,637	193	3,415	9.0
mangoes	1,618	1,570	0.8	11750	35,000	380	266.4	4,600	69.6
lemons	1,650	1,200	0.9	1245	40,000	350	325	982	50.4

Notes: ETm (Maximum crop evapotranspiration), ETcrop (Crop evapotranspiration), Ky (Yield reduction factor), Ya (Actual crop yield in Kg/ha), Ym (Maximum crop yield in Kg/ha), IWR (Irrigation water requirement), FWS (Field water supply in l/s/ha), ETcrop actual (Actual crop evapotranspiration)
Source; FAO 2009

Appendix 3

Figure; Agro-ecological zones of Kenya



Source; FAO, 2006

Appendix 4

Crop budget for the major crops grown in Arror irrigation scheme

Crop	Yield unit	Price (KES)	Total Revenue KES/Ha	Production cost KES/ha	GM (KES)	Water used (M^3/ha)	GM Per m^3	Residual value KES/ m^3
maize	bag	2,400	110,484	25,540	84,944	5,650	15	14.8
sorghum	bag	3,200	74,649	15,388	59,261	2,440	24.3	4.3
millet	bag	4,800	16,945	4,461	12,034	4,582	2.62	0.3
cowpeas	bundle	3,000	108,779	17,491	91,288	1,115	81.8	20.8
green grams	bag	10,000	52,350	23,200	29,150	3,730	7.8	1.2
cassava	box	500	257,488	106,971	150,517	6,215	24.2	1.3
bananas	bunch	300	295,643	251,958	43,685	3,415	12.8	0.9
mangoes	net	350	141,368	98,277	43,091	4,600	9.5	0.4
lemons	net	200	74,981	19,535	55,446	982	56.4	11.2