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Tegemeo Institute

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Abstract

This paper evaluated farmers willingness to pay for irrigated maize production using field level data collected through a cross sectional survey. The results showed that 78% of the farmers were willing to pay more than the men willingness to pay of 3,082. This was above the average payment that farmers were making. It was also noted that willingness to pay increased with increase in irrigation rates. Labour, tail end farms, and enforcement of scheme level rules and regulations will enhance willingness to pay. Efficient factor use is an important factor influencing the amount paid for irrigation. Although the economic value of water was found to be greater than the willingness to pay implying that irrigated maize production is sustainable, irrigation services in Kenya are highly subsidized by the government. We therefore recommend farmer training, empowering water user associations to help enforce irrigation management processes as a way of enhancing farmers' willingness to pay. On sustainability of irrigated maize production, we recommend that market forces be allowed to establish the price of irrigation services.

Keywords: Willingness to pay, Irrigation, maize, food security, sustainability

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List of Acronyms

ASAL	Arid And Semi-Arid Lands
CAN	Calcium Ammonium Nitrate
DAP	Di Ammonium Phosphate
EVW	Economic Value Of Water
FAO	Food And Agricultural Organization
FPI	Financial Performance Index
GM	Gross Margin
GMI	Gross Margin Index
IWMI	International Water Management Institute
KES	Kenya Shillings
MFC	Marginal Factor Cost
MVP	Marginal Value Product
NGO	Non-Governmental Organization
NIB	National Irrigation Board
NPK	Nitrogen, Phosphate and Potassium
O & MI	Operations And Management Index
O+M	Operations And Management Cost
RI	Replicability Index
W/O	Without
WC	Working Capital
WTP	Willingness To Pay.

1.0 Introduction

The current trends in irrigation development and use all over the world point to the fact that the primary task of agricultural policies is the promotion of irrigated crop production whether through subsidies or price support (Biswas and Venkatalacham, 2015, Mesa-Jurado et al, 2011). This is because water is a major constraining factor to food production and in developing countries. Its scarcity is a major cause of food shortages and irrigation is a major consumer of water globally. While heavy runoff is witnessed during the rainy seasons, water as a commodity has value and needs to be priced if it is to be used efficiently. There is a lot of literature on irrigation studies, however, there has been scanty of information on its correct value (Tang, Nanga and Liu, 2012). The main sources of irrigation water are the lakes, ground water and rivers. However, the effects of climate change and human interference with the ecosystem in some water catchment areas in Kenya have reduced available water for food production either as rains or river water for irrigation. The changing patterns of climate have also affected investment in water use for agricultural purposes, especially in the arid areas leading to a slowdown in economic development in this country (ROK, 2014).

Low investment in agriculture and effects of changing climate has led to a decline in food production (ROK, 2014). To ensure food self-sufficiency, the government has to explore alternative ways of increasing food production. Irrigation has been identified as one of the strategies that could solve this problem. This is because it has the potential to increase food production by up to 140% (IWMI, 2010). This motivated the government of Kenya proposed development of the Galana Kulalu food security project with maize being production under 500, 000 acres of land. This project targeted the production of 40 million bags of maize annually.

Kenya is a water deficit country and has an irrigation potential of about 1.3 million hectares of land. Of this, 125,000 hectares are currently under irrigation, with smallholders farmers, accounting for 43%, public irrigation schemes has 18%, while the private large scale farms own 39% (ROK, 2014). Examples of public irrigation schemes are Bunyala and Ahero. Private irrigation is mainly carried out for high value crops such as flowers.

However, government involvement in the provision of irrigation services through the National Irrigation Board (NIB) has distorted the pricing of irrigation water. The amount of water provided through flood method cannot be not easily quantified and water payments include all other irrigation services offered to the farmers. The opportunity cost of water is therefore difficult to estimate. As a result, it becomes difficult to formulate suitable water pricing policies and design other institutional reforms to meet the increased water requirements of the farmers, and to recover the cost of operations and maintenance (O&M) (ROK, 2015). Thus, estimating the economic value that farmers place on incremental changes in irrigation water becomes vital in the process of deciding the economic viability of new irrigation projects (Biswas and Ventachalam, 2015).

Overtime, there has been poor collection of dues for irrigation services in Kenya. This coupled with inability to recover the O&M cost from the farmers has made difficult for services to be offered efficiently in irrigation schemes making them perform below their full capacity. Their viability and sustainability especially in terms of crop production have thus been doubted. Due to this, the choice of whether to practice irrigation farming or not depends on the benefit and cost tradeoffs that farmers get. The benefits that farmers get or perceive to get are based on their experience and exposure to irrigation (Adesina and Baidu-Forson, 1995; Knowler and Bradshow, 2007). If farmers get positive benefits to their investment in irrigation farming, they become motivated to continue with investments by meeting all their obligations to irrigation service providers. When returns are low, most farmers may not be willing to pay for services that are not beneficial. To provide an insight toward understanding the contribution of farmers to irrigation development in Kenya, we carried out a study on farmers' willingness to pay for irrigated maize production.

1.1 Research Questions

Farmer participation in irrigation is very important since they generate revenues which go towards paying for irrigation services. There are irrigation studies done in Kenya and this is going to be part of the contribution. To inform policy makers and other stakeholders on farmers' participation, their willingness to pay and sustainability of irrigation, we selected maize as a study crop in smallholder irrigation farmers. The main research questions that were addressed include:

1. What are the farmers perceptions about services offered for irrigated maize production?
2. Is irrigated maize production profitable in Kenya?
3. Are farmers willing to pay for irrigation services?

4. How can the available water be used sustainably in irrigated maize production in Kenya?

1.2 Theory of willingness to pay

In many studies, irrigation water has been regarded as a nonmarket good and thus carries no market price (Tang, Nan, and Liu, 20121). Thus, non-market methods can be used in valuing it. Willingness to pay (WTP) estimates the maximum amount a person is willing to pay in order to obtain a certain good or condition (Harun et al, 2015). The theoretical basis of WTP is equivalent to the Compensating Variation Method (CVM). The CVM approach is a measure of how much a consumer's income needs to increase or decrease in order to keep utility constant in the case of a price change of goods, a change in product quality or if new products are introduced. This can also be interpreted to imply that the utility received from a purchase of a commodity should be equal to the utility given up on money, and thereby keep the utility level constant. The respondents' stated utility is based on their preferences and can therefore be expected to differ between individuals. Studies on WTP can give an estimation of the firms' marginal revenue products, i.e. the demand for an input. The result exposes the difference between an input's market price and the buyers stated value of the input. A market price that is significantly higher than the stated WTP value could indicate that the economic rent is larger than the buyers 'surplus, which means that the sellers have market power. Firms will only purchase an input if the market price is equal or lower than their willingness to pay.

A market price that is too high will lead to fewer buyers. If the supply curve is located entirely above the demand curve these will not intersect at any point and there will be a non-existing market for the input (Gravelle & Rees, 1992). On the other hand, if the stated WTP is higher than the market price there might be revenues to earn for the seller.

2.0 Methodology

The study adopted a mixed method cross section correlational research design in which quantitative and qualitative method were collected using key informant interviews, focus group discussions and respondent interviews using a structured questionnaire. The study area covered both small and large irrigation schemes in the country. They were selected purposively with the aim of ensuring different irrigation water availability in order to estimate the relationship between increased water availability and WTP values. Since water availability was different along the distribution canals within the schemes, we selected households at different points along the main canals and feeder canals in order to provide different water availability regimes. The agency implementing irrigation in Kenya, NIB, provided a list of farming households in their areas of jurisdiction from which 10 were selected randomly. The list had farmers who were receiving irrigation services from the government agency. The selection process was repeated in all the eight schemes that were visited.

Questionnaires were used to collect information about the households. The information collected captured socio-economic demographics of the irrigation farmers, the sources and types of institutional support they access; and their perception of maize production under irrigation, maize production activities and inputs used as well as their willingness to pay for irrigation water (Adesina and Baidu-Forson, 1995, Agbamu, 1995, Burton, Rigby, and Young, 1999). Focus group discussions were also used to generate information needed for evaluating the perception of farmers about adoption of irrigation Bunyala, Nandi, Mwea, Pekerra, Hola, Galana/Kulalu, Hola, Lower Kuja and Bura.

Table 1: Participants in irrigated maize production

Irrigation Scheme	Survey respondents	Focus Group Discussion	Key informant interviews
Lower Kuja /Nyatike	10	17	3
Bunyala	10	21	2

Nandi	10	33	1
PerKerra	10	16	4
Mwea	10	-	1
Bura	10	13	3
Hola	10	23	1
Galana Kulalau	10	10	4
Total	**80**	**123**	**19**

Source: Field data 2015

At least 13 participants took part in each of the focus group discussions. The objective of these focus group discussions was to collect in-depth qualitative information about the irrigated maize production in Kenya. The information regards to the community's expectations, planned activities, contributions towards setting up the scheme, scheme and plot level factors affecting irrigated maize production as well as perceptions of the levels of maize production under irrigation. A checklist with key questions was drawn up to guide the discussions. Male and female participants were combined during the discussions as the proposed irrigation scheme was expected to benefit them equally with no special bias to gender. Efforts were made to have both.

A total of 220 community members participated in the eight focus group discussions conducted in the eight irrigation schemes. Information about this group had been missed out during TAPRA II survey in areas around the irrigation schemes. This gave a comprehensive sample of comparable farmers for the survey.

In estimating the economic value of water, the marginal value product of water was estimated. The marginal value of water is the marginal physical product times the output price. A Cobb Douglass production function was estimated the yield (bags/acre) as dependent variable and of irrigation water services as a proxy of water as one of the independent variables. Farmers' willingness to pay was influenced by their perceived benefits from irrigated maize production. If maize production is viable, the resultant profits would enhance the willingness to pay.

Schultz (1996) stated that the Cobb Douglas production function gives partial elasticity of output with respect to inputs, and allows for the calculation of the economies of scale. Further, it may be applied to physical farm inputs or the operations cost. Despite its advantages, the Cobb-Douglas specification does not fully describe agricultural principles of irrigation. It never reaches a maximum, and there is no negative marginal product for irrigation water. This is important because experimental evidence shows too much water can reduce yields. However, when the researcher's objective is to evaluate economic rather than biological parameters, and the assumption is that farmers maximize profits. This problem is irrelevant because maximum profits will not occur in the range of negative marginal product.

The CV method was employed in this study to measure farmers' WTP for irrigation water (Whitehead, 2005). The WTP interview module included in the survey consisted of both close-ended and open-ended questions. In the case of close-ended, farmers were asked whether or not they would be willing to pay a specific amount under improved levels of water supply from tanks for irrigation. In the case of open-ended questions, farmers were asked about how much they would be willing to pay if the water supply was improved both in the dry (when water is too scarce) and wet seasons. The survey was conducted during 2014 and the monetary unit used is Kenyan Shillings and area in acres.

In selecting the variable to be used, first a correlation analysis was done and variables that had low correlation with WTP and amount paid and could have policy implication were selected. They included both quality values and market goods. This reduced the chances of endogeneity in the model that was used.

This study adopted a modified framework of Basic Economic Model. The model is measured on two determinants of WTP; income and the use of the good in question (Yusuf, K. Obeng, F.K and Ansah, I.G.K, 2017). It posits that individual's choices and responses in paying for goods or services are constrained by their disposable income (Carson et al., 2001). Income and amount of money consumers are willing to pay for goods should therefore correlate. In line with this narrative, Donkoh et al. (2014) posit that for goods considered superior or normal goods, consumers are expected to purchase more as their incomes increase. Income is therefore expected to positively relate to WTP in WTP model.

In solving the problem, the study used a combination of quality factors and market good. The quality factors were based on farmers' value judgement (perception) and prices for market good. Quality factors included crop type, cropping season, water availability, produce quality, training, location along the canals and rules and regulations. In minimizing utility, farmers use factors that would increase yields at a low cost. These include, training, enforcement of rules and regulations, crop type, cropping season, and produce quality. Market factors were yields, labour and water. Further, a joint evaluation of WTP and amount paid helped to reduce the effects of endogeneity (Whitehead, 2005).

Heckmans two step regression model with correction for the selection bias was used in analyzing the decision variables affecting how much the farmers were willing to pay in relation to the farmers' willingness to pay (Stan and William, 2003; Yirga, 2007; Dreressa et al, 2008; Kaliba et al. 2000). In the study, farmers' willingness to pay was analyzed followed by the amount farmers' were actually paying in the second stage. Heckman two step model was used to analyse the willingness to pay for irrigation and the economic viability of irrigated maize production in Kenya. The Heckman's model has two equations of interest that are modelled, namely: the selection (willingness to pay) equation, and the amount paid (outcome) equation.

Maddison (2006), and Deressa et al. (2008) specified the Heckman's sample selectivity model based on two latent variables as follows:

$$y_1 = b^{'}x + u_1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

$$y_2 = g^{'}z + u_2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

where x is a k-vector of regressors; z is an m-vector of regressors, possibly including 1's for the intercepts; and the error terms are jointly normally distributed, independently of X and Z, with zero expectations. $Y_1$and Y_2 are the regressands denoting perception and adaptation to irrigation among farmers. Note that the relationship here is that perception will influence farmers behavior which is reflected by the farmers WTP and also how they adapt i.e the actual payments they make. The two, WTP and Adaptation are then analyzed simultaneously using Heckmans model. Although the study is primarily interested in the first model, the latent variable Y_1 is only observed if $Y_2 > 0$. Thus, the actual dependent variable is:

$$y = y_1 \; if \;\; y_2 > 0; y \; is \; a \; missing \; value \; if \;\; y_2 \leq 0 \ldots\ldots\ldots\ldots 3$$

Here, Y_1 is taken as a latent variable, which is not observable, but only its sign. The resulting ordinary least squares (OLS) estimator of β would be biased, since:

$$E[y_1 \mid y_2 > 0, x, z] = b'x + rs\frac{f(g'z)}{F(g'z)} \ldots\ldots\ldots\ldots 4$$

$$E[y_1 \mid y_2 > 0] = b'x + rs\frac{\Phi(g'z)}{\Theta(g'z)}$$

where F is the cumulative distribution function of the standard normal distribution, f is the corresponding density. Thus:

$$E[y_1 \mid y_2 > 0, x,] = b'x + rsE\left[\frac{f(g'z)}{F(g'z)} \mid x\right] \ldots\ldots\ldots\ldots 5$$

The last term gives rise to the inverse mills ration which is used to overcome the problem self-selection bias. The maximum likelihood procedure was used to estimate the model parameters.

2.1 Empirical model for the study

The algebraic representation of the Heckman's probit selection model was gives as:

$$M_i = (\phi x_i) + \varepsilon \ldots\ldots\ldots\ldots 6$$

where: M_i = the willingness to pay by the i^{th} farmer for irrigation water.

i = the i^{th} vector of explanatory variables of probability of farmers WTP for irrigation by the i^{th} farmer.

x = the vector of the parameter estimates of the regressors hypothesized to influence

the probability of farmer WTP for irrigation.

Consequently, the empirical specification of the Heckman's probit selection model was given as:

$$M_i = \phi_0 + \phi_1 x_1 + \phi_2 x_2 + \phi_3 x_3 + \phi_4 x_4 + \phi_5 x_5 + \phi_6 x_6 + \phi_7 x_7 + \phi_8 x_8 + \phi_9 x_9 + \phi_{10} x_{11} + \phi_{11} x_{12} + \varepsilon \ldots\ldots\ldots\ldots 7$$

Where

Yield =x1, rules=x_2, training=x_3, end crop=x_4, labour =x_5, crop=x_6, fert use =x_7, quality=x_8, water=x_9, yields=x_{10}, short crop=x_{11},

In the Heckman's probit outcome model, the regressor and was the amount. It was regressed on a set of relevant explanatory variables, namely: land, fertilizer, chemical, labour, water, seeds and output. The empirical specification of the Heckman's probit outcome model was given as:

$$T_i = (\phi X_i) + \varepsilon \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 8$$

where: T_i = the yield of the i^{th} farmer from irrigated maize.

i = the vector of explanatory variables of probability of paying for irrigated maize production by the the i^{th} farmer.

x_i= the vector of the parameter estimates of explanatory variables hypothesized to

influence the probability of farmer is paying for irrigated maize production

Thus, the empirical specification of the Heckman's outcome model was given as:

$$T_i = \phi_0 + \phi_1 x_7 + \phi_2 x_9 + \phi_3 x_{12} + \phi_4 x_{13} + \phi_5 x_{14} \qquad + \phi_6 x_{14} + \phi_7 x_7 + \phi_8 x_3 + \varepsilon \ldots\ldots\ldots\ldots\ldots\ldots 9$$

Where WTP= fert use =x_7, water=x_9, HHsize=x_{12}, OMI=x_{13}, Land =x_{14}, fert=X_7, skills=x_3

The farmers' willingness to pay for water is expected to increase with be influenced by scheme regulations, levels of training, position along the water canal, type of crop, seasons and water negative impact Table 2.

The amounts paid for irrigation services, position along the distribution canals and labour requirements tend to enhance WTP while product quality and season negative impact on the farmers WTP. High yields are associated with efficient fertilizer use, good product quality, and availability of sufficient irrigation water. The effects of high yields, good rules and regulations together with low premiums would increase the farmers WTP for irrigation services. High yields are associated with high incomes and this increases the farmers' willingness to pay because different income sources positively influence the farmers' participation in irrigation management activities and hence the WTP. As income from different sources increases, the farmers are likely to pay more for the water. As such, the sign of the response of this variable on the farmers WTP is uncertain. Table 2 below shows the possible signs of the various variables that were evaluated and have an effect on farmers' perception on willingness and viability to pay for irrigated maize production services.

Table 2: Descriptive Statistics

	Minimum	Maximum	Mean	Std. Deviation	Expected sign
Yields under irrigation are high	3	5	4.73	0.629	+
Production is convenient	2	5	4.7	0.681	+
Water supply schedule is good	1	5	3.19	1.533	+
Allows for area expansion	1	5	4.25	1.188	-
Improves quality of produce	1	5	4.59	0.796	+/-
Reduces crop failure	2	5	4.7	0.66	+
Reduces soil erosion	1	5	4.26	1.291	+
Ensures efficient fertilizer use	2	5	4.53	0.867	+
Ensures efficient manure use	1	5	4	1.179	+
Reduces insect/ disease incidences	1	5	3.12	1.607	-
It has a high cost	1	5	4.44	1.236	-
It is crop specific	1	5	2.22	1.766	-
Increases labour demand	1	5	4.71	0.79	-
No water logging in the scheme	1	5	3.82	1.522	+
Tail end crops receives less water	1	5	3.16	1.708	-
Farmers are trained on new irrg skills	1	5	3.47	1.591	+
Rules are enforced in the scheme	1	5	3.55	1.344	+
Regular reviews	1	5	3.68	1.268	+
Farmers have the required skills	1	5	3.74	1.375	+
There are no conflicts btwn stakeholders	1	5	3.12	1.545	+
Method of water distribution is the best	1	5	3.26	1.608	+
Water is evenly distributed to all farms	1	5	3.38	1.621	+
Irrigation has no adverse envt effect	1	5	4.3	1.288	+

3.0 Results and discussion

3.1 Crop production characteristics

It was established that about 64% of the households were located at most 1.5 km from their field plots. Although about 75% of the households had an average field size of 2.1 acres. The tenure system had four categories and the distribution showed that 34.8% of the land owners had no title deeds followed by 24.52% with title deeds and those operating government were 25.8% respectively. The rest of the land was under the ownership of parents or relatives. The opportunity cost of the land ranged between KES 1,500 in Tana delta to almost KES 30,000 in Mwea.

The highest number of farmers working full time on the same farm was 4, with an average of 2.2 full time farmers. These were mostly adults in the household who did not have off-farm employment. The average farms household size was 5 persons who provided field labour. The age of the respondents has a mean of 49 years.

Within the sample, all farmers in Mwea, Perkerra, Bura and Hola practiced irrigation. Nandi, Bunyala and Galana farmers practiced both irrigation and rainfed farming. All the farmers in Busia practiced rain fed maize production while in Mwea, 22.2 % practiced rain fed maize production with the rest producing irrigated maize.

It was found that men owned 96.2% of the land and were responsible for 78.1% of the crops, women owned 3.8% of the land and were responsible for 20.3% of the crop. In terms of irrigation, the male and female ratio practicing irrigated maize to non-irrigated maize production were found to be 4:1 and 2:1 respectively. This is expected since it is the men who own farms while the females constitute the largest number of people working there.

The average household heads had an average age of 49 years (Table 2). In Perkerra and Nandi, household heads had a lower ages of 41.3 and 42.6 respectively while the oldest mean age was observed in Bura irrigation scheme. Majority of young farmers tended to practice rain fed farming.

Table 3: Mean age of household head by sample

	Main watering system used		
Sample	**Rain fed**	**Irrigated**	**Total**
Mwea		53.0	53.0
Pekerra		41.3	41.3
Nandi	33.0	42.6	40.4
Bunyala	46.8		46.8
Nyatike		51.3	51.3
Bura		59.3	59.3
Hola		50.4	50.4
Galana/Kulalu	50.0	50.8	50.5
Overall	**45.9**	**49.8**	**49.0**

The land parcels had an average rental rate of KES 6,686.55. Pure stand dominated most of the fields at 62.2%. Practicing agronomic practices in these fields was easier. The intercrop occupied 36.6% of the land. The use of tractor plow by 64.9% of the farmers was the most dominant land preparation method followed by animal power at 26.7% and the rest of the land is prepared by manual labor.

The average age by category of education of the household head shows that the most educated heads (with more than seven years of schooling) are the youngest, aged 42 years on average, whereas household heads with no education are 52 years of age on average. The educated look to early innovators (who, incidentally, are also hypothesized to tend to be well-educated but who may innovate even if they have little education, if they are highly motivated or highly able) and are quick to copy, whereas those with less education are more influenced by the behaviour of their peers than by observing successful farmers in their site. Thus, the less- educated are expected to be slower to copy an innovation. This is important as it influences trends in the utilization of irrigation technology. The mean age group of farmers in Nandi and Perkerra was lower than in Bura, Hola, Nyatike, Galana and Mwea. Education is a very important factor in development of agriculture. Among the sampled famers, 91.9% had no tertiary level education. Table 3 shows that about 60.8% and 31.1% of the farmers interviewed have primary and secondary school level of education, respectively. Most (56.9%) of farmer's practicing irrigation had primary level education, the same category constituted the bulk (75%) of the farmer's not practicing irrigation. This is in line with past reports where the lack of formal education was considered as the main factor for the non-adoption of innovations (Chambers, 1994). Majority of farmers in Nandi and Bunyala practiced rain fed maize production and had primary level education. Only 10% of the farmers had tertiary level education with the bulk found in Perkerra.

Table 4: Percentage education level of household head by sample and farming system

	Primary			**Secondary**			**Tertiary**		
Sample	**Rain fed**	**Irrigated**	**Total**	**Rain fed**	**Irrigated**	**Total**	**Rain fed**	**Irrigated**	**Total**
Mwea		90.0	90.0		10.0	10.0			
Pekerra		36.4	36.4		18.2	18.2		45.5	45.5
Nandi	50.0	42.9	44.4	50.0	57.1	55.6			
Bunyala	70.0		70.0	30.0		30.0			
Nyatike		25.0	25.0		75.0	75.0			
Bura		60.0	60.0		40.0	40.0			
Hola		70.0	70.0		30.0	30.0			
Galana/Kulalu	100.0	50.0	70.0	0.0	33.3	20.0	0.0	16.7	10.0
Overall	**75.0**	**56.9**	**60.8**	**25.0**	**32.8**	**31.1**	**0.0**	**10.3**	**8.1**

Source; Field data 2015

In terms of seed use, 89.1% of the farmers have adopted hybrid seeds which are high yielding and adapted to these arid conditions. A small number from Lower Kuja irrigation project were still using the local variety of seeds. The mean output from irrigated maize production was found to be 11 bags per acre. This translates to 27 bags per ha and was higher than the average output from rainfed production. With high poverty levels, irrigated maize farmers sold 95% of their output and their households were left with very little thus making majority of the households to be food deficient. The farmers adaptive strategy for food security was thus to have a second season period during which they produced food for household consumption and market as well. Season one is for seed and season two for the market. In terms of food security these households have to use the revenues obtained to purchase food.

3.2 Gross margin analysis

Gross margin analysis was carried out to evaluate the profitability of irrigated maize production. Table 4 shows the cost structure of irrigated maize production. These results show that the most expensive factor of production is fertilizer followed by water, other intermediate costs (costs associated with transport, pesticides, herbicides and gunny bags) and land preparation activities. Land preparation is mechanized and it also contributes a substantial amount of the cost. Mechanization reduces the cost of labour used in weed and pest control, and other tillage activities. Irrigated lands had more demand for labour due to weeding, high yields and also for operating the machines compared with non-irrigated lands. Weeding accounted for between 35% and 53% of the total labour costs. The pay rate for labourers in irrigated farms was slightly higher than non-irrigated. This could be attributed to the fact that irrigated farmers had more field activities to carry out and spent more time in the field especially controlling the water flow on their farms unlike their non-irrigated counterparts. The ASAL areas are also labour scarce and to get labourers one has to offer higher wages to attract them from other competing activities. Group sourcing intermediate factors and seeds by irrigation farmer's lowered their procurement costs unlike the non-irrigation farmers who operated as individuals and had higher procurement costs. Figure 1 shows the percentage factor use as a proportion of the total cost. The overall cost of production for irrigated maize was KES 15,705 per acre which was much higher than non-irrigated maize, Table 4.

Table 5: Production cost structure of irrigated maize production in Kenya (KES)

	Irrigated	**Non irrigated**	**Simulated 1 crop**	**2 crops**
Maize yield (bags/acre)	11	7.6	11	22
Sale price per 90kg bag	2,200	2382	2,382	2,382
Total revenue	**24,200**	**18,103**	**26,202**	**52,404**
Land preparation	2,500	2,500	2,500	5,000
Water	3,086		3,086	6,172
Total production costs (TC)	**15,705**	**13,100**	**15,705**	**31,410**
Working capital (WC)	1571	1310	1,571	3,141
Total production costs (TC) with WC	17,276	14,410	17,276	34,551
Cost per bag w/o WC	**1,428**	**1,724**	**1,428**	**1,428**
Cost per bag with WC	**1,571**	**1,896**	**1,571**	**1,571**
Profit=TR-TC (per acre)	8,495	5,003	8,927	17,853
Breakeven yield (90kg bags)	7.14	5.5	6.59	13.19
Margin per bag (Ksh) w/o WC	772.3	658.3	954.3	954.3
Margin per bag as % of cost w/o WC	54%	38%	67%	67%

Source: Author 2015

The profit margins and percentage margin of the cost per bag for irrigated maize was higher than non-irrigated maize due to high productivity. The breakeven point was however inversely related to price and directly related to the cost of production and irrigated maize had a breakeven point of about 7 while non-irrigated maize had 5. Through simulation, an 8.3% price increase for irrigated maize increases the margin by 23% from KES 772 to KES 954. Equally, it was established that a 1% price increase increases profit margins by 0.615 % and percentage margin of the cost increase by 29%. Irrigated maize also has an additional advantage in that output can be increased by increasing the number of seasons. Food security can thus be enhanced from the supply side via higher incomes that boosts the ability of producers to access other commodities and consumers benefit by getting their food supply at a lower cost. This is one way through which food security can be enhanced. Figure 1 shows factor cost as a proportion of the total cost for irrigated and non-irrigated farms the relative contribution of factors of production for irrigated maize. The production of irrigated maize is flexible and more than one crop can be produced in a year. This implies high returns if production targets the seasons when there is low supply of maize in the market (Hatibu *et al*, 1999).

The mean willingness of farmers to pay for irrigation services and water was Kenya Shillings (KES 2,952. 73.4% of the farmers were willing to pay. This could be attributed to a high gross margin of KES 772 per bag at a cost of (KES) 15,705. The unit cost of production for non-irrigated maize of KES 13,100 per bag. The breakeven point was found to be inversely related to price and directly related to the cost of production with irrigated maize having a higher breakeven point of about 7.14 bags compared with non-irrigated maize of 5.5 bags. The study further showed that it takes 9 and 21 years to payback an investment of 600,000 in a one acre plot at KES 3,200 per bag and a production cost of KES 15,075 the output levels for a one and three season respectively.   Further, increasing productivity to 20 bags per acre cuts back the repayment period four years. As output and price increase, the time it takes to recover the initial investment declines. It was assumed that the project was expected to last for 30 years. The low output level could be attributed to scheme and plot level factors. Scheme level factors which had significant influence on willingness to pay and thus output were availability of sufficient water, enforcement of scheme level rules, produce quality, cropping season and efficient fertilizer use. Produce quality, efficient fertilizer use and cropping season had a negative influence. On irrigated maize viability, crop type.

3.3 Farmers perception about the viability of irrigated maize production.

The willingness to pay discussion was elicited through Contingent Valuation (CV) questionnaire. The prices suggested in the payment options were: <KES 3100, KES 3100, and >KES 3100) per acre per season. The mean WTP for irrigation service delivery per acre per season was KES 3085 with a standard deviation of 1196. Whilst the highest WTP bids was KES 4155 the least WTP bids was pegged at KES 0. Also the analysis of respondents WTP figures revealed that only 73 people, representing about 75% of the respondents, were willing to pay above the mean WTP whereas the remaining 25% of them peg their WTP bids below the mean WTP.

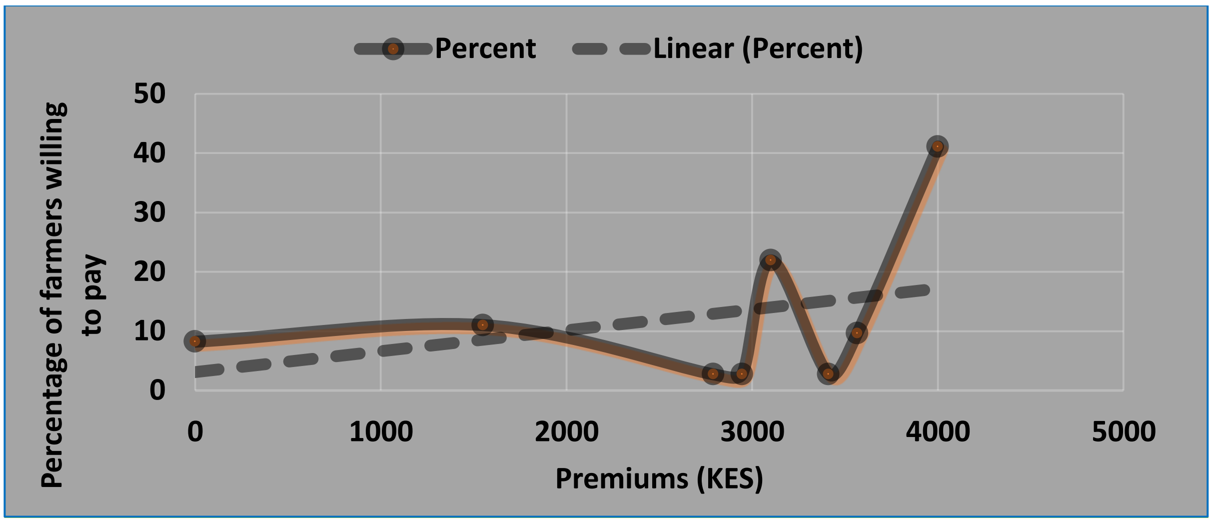

Figure 1: Distribution of willingness to pay for irrigated maize production

As shown in the Table 5 above, 21% and 51% of the respondents were willing to pay less and more than the mean willingness to pay than the required mean payment for irrigation. Conversely, those who stated higher WTP bids have their farms along up-streams and mid-streams. This suggests that farm locations within the irrigation scheme influences farmers' willingness to pay.

3.4 Factors influencing farmers' WTP using multiple regression

The perception of farmers about the benefits of irrigated maize production were evaluated based on their willingness to pay. They were asked how scheme and plot level factors influenced their willingness to pay for irrigation services in the scheme. From the choice experiment, the factors influencing farmers' willingness to pay are presented in Table 2 with the expected signs. A positive sign meant the farmers perceived that the factor had a positive effect on viability of irrigated maize. Based on this a regression results for the variables with a proxy for amounts paid and willingness to pay is presented in Table 6.

Table 6: Heckmans regression results on willingness to pay

WTP	Coef.	Std. Err. z	P>z
tacres	0.0000426	0.0000418	1.02
shotcrop	-0.3472526	0.0856268	-4.06
yields	0.1030074	0.0782305	1.32
watsuply	-0.0225317	0.0272436	-0.83
impqty	-0.1303367	0.0551274	-2.36
effert	-0.0596643	0.0651065	-0.92
cropspec	-0.0422898	0.0251425	-1.68
ilabour	0.105917	0.0511038	2.07
endcrop	0.0461783	0.0232534	1.99
train	-0.00433	0.0266433	-0.16
enforce	0.0966955	0.0325578	2.97
_cons	0.9282532	0.402811	2.3
Payment	**premium**	**premium**	
reskills	0.2340281	0.211634	1.11
totfert	0.003589	0.0016709	2.15
useval	0.0004261	0.0002838	1.5
omi	-0.4170262	0.1849083	-2.26
hhsize	-0.1193006	0.127101	-0.94
impqty	0.438197	0.3607702	1.21
yields	-0.068229	0.415157	-0.16
_cons	-0.6432361	2.495308	-0.26
mills	**mills**	**mills**	
lambda	0.0089853	0.2722287	0.03
rho	0.03178	0.03178	
sigma		0.28277752	

Source: field data 2015. Only significant variables are included

The results concur with Aheeyar (2006) who found that the 'Willingness to pay for improved irrigation services in Mahaweli' depended on the level of income with the high income earners willing to pay more for improved irrigation services. The same if reflected here where OMI was used as a proxy for income. Increasing cost had a negative impact on the amount the farmers were willing to pay. Regular review and enforcement of irrigation rules had significant positive relations with the willingness to pay. This is because the involvement of the farmers in the management of the scheme gives them the sense of ownership that makes them feel they also own and contribute to the scheme's development. They are thus more likely to pay for the services hence their willingness to pay.

The position along the irrigation canal determines how much water the farmers will get away from the water source. Farmers situated towards the tail end of the canals are more likely to pay more so as to be able to get water for irrigation. In this study, we established that tail end location has a significant effect on willingness s to pay at 10% level of significance. The marginal areas are abit deficient of labor hence its availability has a significant positive effect on willingness to pay. The nature of work involved on these small farms is labour intensive; hence the availability of labour to work on the fields is a prerequisite for increased willingness to pay. Product quality and cropping season had a negative influence. Successful enforcement through water use associations (WUAs) can be achieved by devising and enforcing the rules for water distribution, fee collection and conflict resolution. This instills a sense of security among farmers in using irrigation facilities and thus their willingness to pay is enhanced. Produce quality had a negative impact on farmers' willingness to pay. Low quality product fetches a low price in the market and this discourages increased production, leading to a low willingness to pay for irrigation water. High produce quality is also associated with increased labour, which is scarce in the ASAL areas

Water scheduling and distribution in the scheme also had a positive effect on the amount farmers were willing to pay. Farmers with plots at the tail end the distribution canal received insufficient water and were willing to pay more to get enough water. Production of high product quality and efficient fertilizer are quite expensive and increased the cost of production. This reduces their willingness to pay. Fertilizer was among the major contributors to the high cost of production in irrigated maize farming. Second season crops are prone to breeding diseases thus as the number of seasons increase, the cost burden had a negative effect on the farmer's willingness to pay. The cost of production and level of fertilizer use had a negative effect on how much farmers were willing to pay.

The requirement to meet high product standards was a problem to poor small holder farmers and it discouraged their willingness to pay more since they are inherently resource constrained and also feared losing incomes from the rejection of their low quality produce. As expected, the respondents from farms with higher yields earn higher incomes. The average income of 60.3% of the farmers was KES 273,000. This is just sufficient to keep them barely on the poverty line of US$ 1.25 per day. Little was thus left for investment in irrigation activities. We established that a large number, 73.4% of farmers were willing to pay for irrigation services with an odds ratio of 1.772 in favour of paying for irrigation. The mean willingness to pay for irrigation water and services was KES 2,952/acre/season were paying KES 3,082.

The high willingness to pay was due to the potential gains the farmers would obtain from irrigated maize production. This observation supports the findings of (Tang, Nan and Liu, 2012 cited Otieno, Kirimi and Odhiambo, 2015) who established that at low premium levels, the farmers were unwilling to pay for irrigation water since they found the value of water to be too low. But as the value of water increase, they are willing to pay more. Because they realize the value of water in increased yields.

Major public irrigation schemes are located in the marginal areas. Here, it was found that about 93% of the farmers had primary and secondary level education. While age increased farmers experience and knowledge about the pattern of rainfall over time, it also decreased their likelihood of paying for irrigation water due to low incomes and high demands on proceeds from irrigated maize production. Training farmers on good water management practices can enhance their understanding of the value of water for food production. It is easier to work with an informed group of farmers since their willingness to pay tends to be much higher. They practice better agronomic practices and are more efficient in factor use. The less educated farmers are more likely to benefit from improved yields and better returns if they adopt irrigation as mitigation for unreliable rainfall. Their level of awareness can be increased through training and education which enlightens them and increase their willingness to pay for irrigation services and water. Studies in Nigeria, Ghana have also shown the desire of farmers to pay for irrigation services ((Amondo, Kironchi and Wangia, 2013; Alhassan et al, 2013).

3.5 Economic value of water

A Cobb Douglass production function with yield (bags/acre) as the dependent variable was used to derive coefficients which were needed to determine the economic value of water. The coefficients Table 7, showed that increased use of water and land would lead to a decline in output while labour, fertilizer and seed have a significant positive effect at 5% level of significance. This shows the need to intensify land use in maize production and seek water saving technology to prevent excessive wastage of water under waterlogged production conditions. Fertilizer, seed and labour have the potential to increase output if additional amounts are used. The economic value of irrigation water was determined by employing a production function approach.

Table 7: Regression results for irrigated maize production function

Yield	Coef.	Std. Err	t	P>t	[95% Conf. Interval]	
land	-0.0962	0.0392	-2.45	0.017	-0.1745	-0.0179
fertil	0.092	0.021	4.39	0	0.0502	0.1338
chem	-0.0787	0.089	-0.89	0.378	-0.2559	0.0984
labor	0.1162	.0407	2.85	0.006	0.0349	0.1974
water	-0.2081	.1081	-1.92	0.059	-0.424	0.0078
seeds	0.6045	.0928	6.56	0	0.4206	0.7884
cons	-617.78	361.1388	-1.71	0.092	-1338.82	103.2575
R-squared = 0.7042, Adj R-squared = 0.6773						

Source: Author 2015

In estimating the economic value of water, the marginal value product of water was calculated. The marginal value of water is the marginal physical product times the output price.

Table 5 shows a higher output level for irrigated maize despite inefficiency. So if the farmers are to be efficient, their output would be greater than what they were producing. The same result was maintained by a significant paired difference between the MVP of water and the actual amount paid. The MVP was far much greater than the actual amount paid. This implied that farmers were paying far much less than they should pay for irrigation water. The farmers undervalued the water they used. The average O & M expenditure showed farmers paying KES 3808 and the opportunity cost of irrigation water was KES 9109, an equivalent of increased output in maize produced under irrigation over non irrigation.

Their willingness to pay was less than the marginal value product of water. The average value of WTP for the water irrigation water was found to be more than the opportunity cost of the irrigation water. A paired sample t-test showed that there was a statistically significant difference between the two values with the marginal value product for irrigated maize being high with a p-value = 0.035. This meant that farmers could still exploit the resources they were underusing to realize more returns. From table 5, since the farmers are able to realize positive returns after using irrigation and efficiency tests shows that MVP of water services is greater than MFC of water, then we can conclude that there exists a scope to expand production through intense use of water Figure 2. The figure shows the MVP greater than MFC upto the equilibrium point, the (*). Beyond that MVP is lower than MFC. Efficiency requires that MVP=MFC. Arrows shows increase (for water and land use) and decrease Fertilizer to attain efficiency.

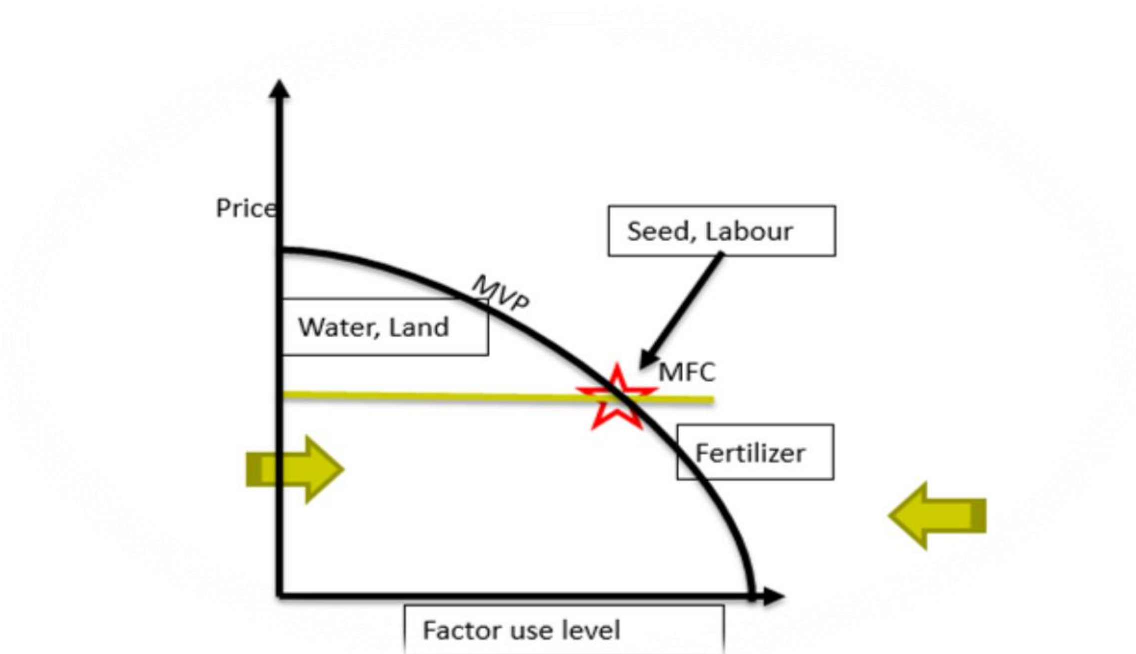

Figure 2: Allocative efficiency

A free or very low water charge encourages overuse, reduces the incentive for farmers to cooperate or participate in irrigation originations, and may result in low system productivity and poor conservation.

Sustainability of irrigation systems is very important from both farmers' and government perspectives. The Kenya government has faced increased national budgetary pressure arising from the need to lower irrigation costs. Due to insufficient O & M budget, farmers do not receive adequate service and this undoubtedly affects crop productivity and farming income. A lower budgetary burden of government can be obtained through local control and support

4.0 Conclusion and policy recommendations

4.1 Is irrigated maize profitable?

Irrigated maize production is profitable. This is shown by the positive gross margin O&MI, FPI and RI are an indication of the profitability of irrigated maize production. The mean gross margin was KES 772 per bag at a cost of (KES) 15,705.

The study further showed that it takes 9 and 21 years to payback on an investment of 600,000 in a one acre plot at KES 3,200 per bag and a production cost of KES 15,075 the output levels for one and three seasons respectively. Further, increasing productivity to 20 bags per acre to close the inefficiency gap (Otieno et al, 2015) cuts back the repayment period four years. As output and price increase, the time it takes to recover the initial investment declines.

The profitability of maize production, however, depends on optimal utilization of factors of production at the plot level. The low output level could be attributed to scheme and plot level factors. Scheme level factors which had significant influence on willingness to pay and thus output were availability of sufficient water, enforcement of scheme level rules, produce quality, cropping season and efficient fertilizer use. Produce quality, efficient fertilizer use and cropping season had a negative influence. On irrigated maize viability, crop type.

4.2 Are small scale farmers willing to pay for irrigation services in Kenya?

This study found that 73.4% of farmers were willing to pay for irrigated maize production. Such a high percentage can be attracted to this farming due to its profit margins, increased incomes food security and employment to the households. The willingness to pay for irrigation was influenced by a number of factors at the scheme and plot level factors. Important plot level factors influencing willingness to pay significantly are fertilizer, seed, labour and water use. At the scheme level, enforcement of irrigation rules and regulations, premiums, sufficient water, season and crop type. The mean WTP KES 2908 Kenya Shillings per season. This was not significantly different from what they were paying of KES 3085 and lower than the present market price due to government subsidy. Many of the respondents stated that they would prefer a lower price since they found the venture not profitable. A lower price would thereby increase their returns. There were however some farmers 51% who were willing to pay more than the real market price. This showed the importance of irrigation services and water in the ASAL areas. The mean willingness to pay was also found to increase with increasing irrigation rates. The NIB had a monopoly in offering irrigation services on behalf of the government. This creates an opportunity for potential distortion of the market price through the involvement of the government. By providing the infrastructure and subsidizing the price of the services, the government expected more farmers to participate in irrigated agriculture including the youths.

The use of these services is expected to lead to increased output and make sure that household welfare and food security are improved. Willingness to pay can be enhanced through educating and training farmers to change their attitude towards irrigated maize production and enhancing adoption of modern and efficient irrigated maize production methods. Farmers need to change their attitude towards irrigated maize farming for improved maize productivity. They also need a good land tenure system, accessible markets, affordable and efficient production technology, and, management of pre and post-harvest losses in order to realize good returns. This will enhance their willingness to pay for irrigation services offered by the NIB.

There were however some farmers who were willing to pay more than the real market price. This showed the importance of irrigation services and water in the ASAL areas. The mean willingness to pay was also found to increase with increasing premiums. The NIB is the only government agency offering these services and can be unfortunate to be a monopoly. This leaves a potential for distortion of the market price through the involvement of the government by providing the infrastructure and subsidizing the price.

4.3 How can the available water be used sustainably in irrigated maize production in Kenya?

Sustainable use of water is highly dependent on the value attached to water. Farmers harvest 4 more bags when using water than when they do not. This implies that the marginal value product of water to be higher than the opportunity cost of water and thus farmers were making positive profits above their costs and can still increase their margins. The basics of economics will require that sustainable use of water requires that charges match the cost of supplying water. In this case, the farmers are paying KES 3085 for a supply cost of KES 2908. This is slightly more than the cost of irrigation water services. Their profit margins are low despite getting 4 more bags compared with their non-irrigation maize farmers and this translates to a lower profit margin than what they should actually make.

Therefore, in as much as irrigated maize production is profitable, its sustainability requires that farmers pay more for the highly subsidized irrigation services. Assuming that the water services cover 63% of irrigation services, then actually the farmers should pay about KES 4,600. They are also highly inefficient in factor use. Therefore, efficient use of water and fertilizer are two main approaches that can be used to increase productivity. Earlier studies had shown that through efficient resource use, 70% of inefficiency gap can be closed. These coupled with the adoption of low cost technology are key to sustainable use of irrigation water at an increased fee.

In conclusion, this study establishes that irrigated maize production is profitable and sustainable under the current subsidy arrangement. The higher incomes that farmers get can go along way to cover the O&M cost. However, because farmers can make more profits through efficient resource use, we recommend that the government reconsider its subsidy on irrigation services and let the market rates determine the charges for water services. If water is valued appropriately, farmers will attach a greater value to it. We recommend a gradual increase of the irrigation rates to match the market price. Efficient water use will enhance sustainability of irrigated maize production.

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Appendix I
Focus group discussion questions.

1. Do you consider maize farming as a business or not?

2. How suitable is the environment for irrigated maize production?

3. What is the market price of maize? Do you consider it a good incentive for increased production?

4. Tell us about your maize marketing and the kind of markets exist for your maize around here?

5. How significant are post-harvest losses from your field and how have you been managing them?

6. What kind of production technology is commonly used by irrigation farmers in maize production?

7. Who owns the land you are working on and do you like this ownership arrangement?

8. Considering your household size, do you have enough labourers to work on your fields?

9. Do you think you have enough experience for successful production of maize under irrigation?

10. Do the irrigation farmers have a working partnership with the national and county governments and how has this worked so far?

Appendix II

Table 8: Descriptive Statistics for willingness to pay data

	N	Minimum	Maximum	Mean	Std. Deviation	Expected sign
Yields under irrigation are high	73	3	5	4.73	0.629	+
Production is convenient	73	2	5	4.7	0.681	+
Water supply schedule is good	73	1	5	3.19	1.533	+
Allows for area expansion	73	1	5	4.25	1.188	-
Improves quality of produce	73	1	5	4.59	0.796	+
Reduces crop failure	73	2	5	4.7	0.66	+
Reduces soil erosion	73	1	5	4.26	1.291	+
Ensures efficient fertilizer use	73	2	5	4.53	0.867	+
Ensures efficient manure use	73	1	5	4	1.179	+
Reduces insect/ disease incidences	73	1	5	3.12	1.607	-
It has a high cost	73	1	5	4.44	1.236	-
It is crop specific	73	1	5	2.22	1.766	-
Increases labour demand	73	1	5	4.71	0.79	-
No water logging in the scheme	73	1	5	3.82	1.522	+
Tail end crops receives less water	73	1	5	3.16	1.708	-
Farmers are trained on new irrg skills	73	1	5	3.47	1.591	+
Rules are enforced in the scheme	73	1	5	3.55	1.344	+
Regular reviews	73	1	5	3.68	1.268	+
Farmers have the required skills	73	1	5	3.74	1.375	+
There are no conflicts btwn stakeholders	73	1	5	3.12	1.545	+
Method of water distribution is the best	73	1	5	3.26	1.608	+
Water is evenly distributed to all farms	73	1	5	3.38	1.621	+
Irrigation has no adverse envt effect	73	1	5	4.3	1.288	+
Valid N (listwise)	**73**					

Appendix III

Table 8: Descriptive statistics for factor use levels

	N	Minimum	Maximum	Mean	Std. Deviation
Farm size Field acres	**73**	**.46**	**12.00**	**3.2481**	**2.59907**
Willingness to pay Ksh 3100/ acre/year	**73**	**0**	**1**	**.75**	**.434**
Distance to plot (Km)	**73**	**.00**	**8.00**	**1.5076**	**1.69565**
hhsize	**73**	**1**	**14**	**6.23**	**2.547**
Total revenue	**73**	**4125.00**	**587950.00**	**64619.8869**	**76921.81785**
Irrigation premium	**73**	**.00**	**4000.00**	**3085.5479**	**1196.70136**
Land use value	**73**	**.00**	**57240.00**	**2776.1918**	**6841.08693**
Fertilizer value	**73**	**.00**	**77400.00**	**10411.2329**	**13956.67930**
Chemical value	**73**	**.00**	**13200.00**	**2410.3151**	**3168.11292**
Labor value	**73**	**.00**	**36000.00**	**6592.2948**	**6209.80080**
Water value	**73**	**500.00**	**10200.00**	**4811.4795**	**2115.93757**
Transport value	**73**	**.00**	**14000.00**	**572.8767**	**1816.68691**
Gunny bag value	**73**	**.00**	**8100.00**	**1256.4384**	**1502.20289**
Seed value	**73**	**.00**	**14760.00**	**3867.2260**	**3190.70736**
Valid N (listwise)	**73**				