WILLINGNESS TO PAY FOR IMPROVED IRRIGATION WATER SUPPLY IN THE ULUGURU MOUNTAINS DOWNSTREAM IN MOROGORO, TANZANIA

BY

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ABSTRACT

This study attempts to determine the willingness to pay of downstream households under irrigation for improved irrigation water supply from protected Uluguru Mountains' watersheds in the upstream. A total of four villages, under traditional irrigation system, and the other two under improved traditional irrigation system, were randomly and purposefully, selected for survey. Primary data were collected using Contingent Valuation method (CVM) by combining close-and open-ended question format. Excel and STATA 10.0 packages were employed in the analysis of descriptive and inferential data respectively. Paddy and tomatoes were the most grown crops under irrigation system while banana and eggplants were the least grown crops under the system. Bid price and income from irrigated crops had the strongest negative and positive significant ($P \leq 0.01$) relationship respectively, with WTP for improved irrigation water supply for both close- and open-ended question formats across the two micro-irrigation systems. It was also found out that the households, in the Uluguru downstream, would be willing to pay for improved irrigation water supply if the new fee ranged between TAS 14 545.95 and TAS 17 900.80 per household per year and aggregate WTP was TAS 78 519 038.00 per year for 5 398 households under irrigation systems. Majority of households across the two systems were aware of the presence of water governing institution, however, the institutions were rather weak. A few respondents, (21.3%) and (21.2%), believed that the association of irrigation farmers and village water committee respectively were at least performing well amongst water-governing institutions. Most of households, across the two systems, believed that the price of improved irrigation water supply should be volume-based and that water user association (WUA) should be given the mandate to collect the fee and manage water resources.

DECLARATION

I, Aloyce Mpiri, do hereby declare to the senate of Sokoine University of Agriculture that this dissertation is my own original work and that it has not been submitted for a degree award at any other University.

25.11.09

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The above declaration is confirmed

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LIST OF ACRONMY AND ABBREVIATIONS

CPRs	-	Common Property Resources
CUMK	-	Chama Umwagiliaji Kiroka
CUMMK	-	Chama Cha Umwagiliaji Mlali-Kipera
CV (M)	-	Contingent Valuation (Method)
DALDOs	-	District Agriculture and Livestock Development Officers
DEDs	-	District Executive Directors
ES	-	Environmental Services
exp.	-	Exponential
FAO	-	Food and Agricultural Organisation
FAOSTAT	-	Food and Agricultural Organisation Statistics
FBD	-	Forestry and Beekeeping Department
GRRB	-	Great Ruaha River Basin
ha	-	Hectre
HPM	-	Hedonic Price Method
IMT	-	Irrigation Management Transfer
IWMI	-	International Water Management Institute
Kg	-	Kilogram
LAC	-	Latin America and Caribean
Ln	-	Natural logarithm
m.	-	Metre
MAFC	-	Ministry of Agriculture, Food Security and Cooperatives
mm	-	Millimetre
NENA	-	Near East and North Africa

NGOs	-	Non-Governmental Organizations
NOAA	-	National Oceanic and Atmospheric Administration
OMB	-	Office of Management and Budget
P	-	Probability
PBGs	-	Private Business Groups
PIDS	-	Philippine Institute for Development Studies
PIM	-	Participatory Irrigation Management
POs	-	Public (People) Organizations
PWS	-	Payment for Watersheds Services
R^2	-	Pseudo or coefficient of determination
RAIs	-	Research and Academic Institutions
RBM/SIIP	-	River Basin Management/Smallholder Irrigation Improvement Programme
RBWO	-	River Basin Water Office
RP	-	Revealed Preference
SMUWC	-	Sustainable Management of the Usangu Wetlands and its Catchments
STATA	-	Statistical Software
Std. err	-	Standard error
SUA	-	Sokoine University of Agriculture
SWMRG	-	Soil and Water Management Research Group
TCM	-	Travel Cost Method
TAS.	-	Tanzanian Shillings
TMAFS	-	Tanzania Ministry of Agriculture and Food Security.
UNDESA	-	United Nations Department of Economics and Social Affair

URT	-	United Republic of Tanzania
WOCAT	-	World Overview of Conservation Technologies and Approach
WRRB	-	Wami-Ruvu River Basin
WS	-	Watersheds Services
WTA	-	Willingness to Accept
WTP	-	Willingness to Pay
WUA	-	Water Users Association

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

The Uluguru Mountains watersheds, the constituent of the Eastern Arc Montane Forests Ecoregion, which for decades have been providing important freshwater resources to riparian communities and off-site communities like Coastal areas and Dar es Salaam city, apart from other ecosystem services like food, habitat for aquatic biodiversity, are facing serious threat. Tresierra (2007), attributes the threat to upstream activities such as steep slope cultivation, crops near riparian zone, Non technical irrigation systems and deforestation for charcoal production. This has resulted in negative externalities like the loss of or reduced vegetation cover, pollution, soil erosion and increased or reduced runoff that has affected water quantity and quality, in particular dry season, (Yanda and Munishi, 2007; IWMI, 2007; World Bank, 2007), of the streams and rivers flowing from the watersheds as well as sustainability of the freshwater resources further downstream.

The reduced stream flows are threatening irrigated lands that produce 40 % of the value of agricultural output even though irrigated lands accounts for only about 18 %, of total area available for agriculture in the developing countries. The overall irrigation water withdraws was projected to increase by 14% in the period 2000-2030 in developing countries as irrigated areas may increase by 20% (FAO, 2003; Faures *et al.*, 2007).

Agriculture withdraws approximately 87% of all freshwater resource available-rainfall and water in river, lake and aquifers in Tanzania (Turpie *et al.*, 2005; UNEP and IIED, 2005). Moreover, agriculture is the largest employer (over 80%) of riparian communities in the Uluguru Mountains (Tresierra, 2007), and whose livelihoods heavily depend on forests

(WWF, 2006), which consequently affects surface water flowing on streams or rivers for irrigation.

Though there are other factors such as climate change, inefficient allocation and use of available freshwater resources, which influence water scarcity in the world (Turpie *et al.*, 2005; FAO, 2006; Kadigi *et al.*, 2008), watersheds degradation, caused by market failure, has been reported to be a source of water depletion in irrigated lands in particular to downstream communities in the Uluguru Mountains (Tresierra, 2007; IWMI 2007) and hence affecting economic activities which depend on water as the raw material, in particular irrigation, by increasing production costs.

The success for improved irrigation water supply depends on the downstream communities to compensate upstream communities, through maximum willingness to pay (WTP), for engaging in conservation of watersheds and riverbanks by abandoning all environmental unfriendly agricultural practices with negative effects to watersheds and use the premium from extra payments to improve their farm productivity (Smith, de Groot, Bergkamp, 2006; WOCAT, 2007). The Tanzanian water policy (URT, 2002) acknowledges the value of water (water pricing), embedded in non-marketed value rather than marketed value and water governing institutional framework as economic and governing instrumental towards sustainable use and management of resources. However, the presence or absence of well functioning water institutions in the downstream irrigation communities such as traditional or community based institutions and political or state based institutions (Mahoo *et al.*, 2007; Acheson, 1994) can affect allocation and consequently the value of improved irrigation water supply.

1.2 Problem Statement and Justification

Degradation of forest and watershed services, in the Uluguru Mountains, is associated with market failure because services like improved irrigation water supply, is not accounted for in the conventional market. The consumers, particularly in developing world, regard it as a public good i.e. non-excludability and non-rivalry resource. Hence they have no market value.

In an attempt to curb the problem of market failure only one research so far has been conducted by the WWF-CARE-IIED in the Uluguru Mountains targeting giant beneficiaries' (such as DAWASCO-water supply and sewerage corporate, Coca coia Kwanza Limited, Tanzania Breweries Limited and other private companies) willingness to pay for improving water quality through watersheds improvement and conservation. The findings showed that they were willing to pay an extra USD 0.11 to USD 0.18 per cubic metre. The premium will be used to secure watersheds services and improving livelihood of upland pro- poor communities (Tresierra, 2007;CARE/WWF, 2007).

Despite this information, the gap still exists on the economic value of improved irrigation water supply for small-scale irrigated agriculture communities (small buyers), on the foot of Uluguru Mountains who also benefit from environmental services in the protected upland watersheds. The economic value of improved irrigation water supply has not been quantified. Without the economic representation of this value it will be extremely difficult for managers, planners and users to consider the watersheds along with domestic, and industries when making water use decision.

This study will add value to improved water supply service in the Uluguru Mountains and additional contribution to few studies that have conducted in the past to evaluate environmental good and services in Tanzania. Moreover, the results of this study will have impact on the academic community, governmental and non-governmental organization, policy makers and the public at large. It will also serve as a baseline for making rational decision on irrigation water pricing.

1.3 General Objective

The general objective of this research was to determine the willingness to pay for improved irrigation water supply from protected watersheds.

1.3.1 Specific objectives

Specifically, this study aimed to attain the following objectives

i) To identify the agricultural crops produced under irrigation in the study area.

ii) To identify the socioeconomic factors influencing farmers' willingness to pay for improved irrigation water supply from well-conserved watersheds.

iii) To estimate the economic benefits from improved irrigation water supply resources from well-protected Uluguru Mountains watersheds.

iv) To assess the strength and arrangement of water governing institutions.

The research questions included the following:

i) What are the major agricultural crops produced under irrigation? How much is produced (mean yields) and income generated per area per each crop (market value)? How does income generated from crops produced under irrigation influence household's willingness to pay (WTP) for improved irrigation water supply in the study area?

ii) What are the other socioeconomic determinants of farmer's willingness to pay (WTP) for improved irrigation water supply in the study area?

iii) What are the mean, median and aggregate WTP for improved supply of irrigation water from protected Uluguru Mountains watersheds?

iv) What are the responses of downstream communities on the strength and arrangement of water governing institution and their roles on allocation of irrigation water in the study area?

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Irrigated Agriculture

2.1.1 The type of irrigated crops and areas

Crops cultivation in developing countries, for decades, has been largely depending on rainfall except for few areas situated near water bodies that practice either supplement or total irrigation. FAO (2005) reports that irrigated agriculture occupy only 3% of the cultivated land in Tanzania.

The types of irrigated crops range from food to cash or commercial crops. Irrigated cropping system consists of high value cash and export cropping and intensive vegetable and fruits (Mahoo *et al.*, 2007; Schiffler, 1998; Dixon *et al.*, 2001; cited by Lotinopoulos, 2005). Most of the irrigated crops are cereals such as paddy (Facon, 2002; Rodgers *et al.*1998;), maize, wheat, fodder, corn, sweet potatoes (Chatterjee *et al.*, 1998)) and horticultural crops such as tomatoes, melons, grapes, mangoes, peaches, apples, alfalfa almonds (Chatterjee *et al.*, 1998) others include commercial crops such as cotton, tobacco (Latinopoulos, 2003 cited by Latinopoulos, 2005). However, the type of irrigated crop relies on household goals, labour, and technologies in use, resource base and agro-ecological factors. Das (2000) adds market development, shift in demand, agricultural services and policies, dissemination of new technologies and availability of markets and policy information, as other determinant factors.

According to FAO (2005), paddy is the leading irrigated crop in sub-Saharan Africa. Paddy is also the most grown cereal crops in many areas of Tanzania. Studies by Mahoo *et* *al.* (2007), Kadigi *et al.* (2004), and Lankford (2002), in the SMUWC, Rufiji Basin, and Lankford (2002). Ellis and Mdoe (2002) along the Ilonga and Mkata rivers, Kilosa and Uluguru mountains downstream, (Paavola. 2004) also indicate similar findings.

Moreover, paddy is a major irrigated crop in the upper basin and to less extent in lowlands or proximity to flooding areas of Pangani River Basin (Turpie *et al.*, 2005) and Mwanza, Shinyanga and Tabora in Tanzania (SWMRG. 2005). However, not only paddy is irrigated, among the cereal crops, but also maize (Kadigi *et al.*, 2004) and through *vinyungu* (Majule and Mwalyosi. 2003) in Southern highlands.

Apart from cereal crops, cultivation of horticultural or sometimes known as high value crops has been booming in Tanzania due to increased demand for local and foreign markets. According to Leijdens (2008), the major crops are tomatoes, popular in all regions except in the western and southern zones. Onions are largely grown through irrigation in central and northern zones, whereas kale, sweet pepper, cauliflowers, cabbage, okra, amaranthus, brinjal, leeks, and carrots grow well in highlands.

Turpie *et al.* (2005) and Kadigi *et al.* (2004) in their findings in Pangani River Basin and Great Ruaha River Catchment indicated that tomatoes were the leading crop among horticultural crops in the upper basin and onions and okra in the lowlands. Ellis and Mdoe (2003) and Leijdens (2008) indicate that much of the vegetables in Morogoro are cultivated in the upper and middle belt of Uluguru Mountains, particularly in Mgeta. However, vegetables and fruits cultivation have been extending to lowlands due to increased market demands in Dar es Salaam (Paavola, 2004) and Morogoro town. The crops receive good prices compared to other traditional crops. FAO (2005) also reports the increase in cultivation of high value and industrial crops such sugar canes compared to rice. The increase in area under vegetables and industrial crops and a decrease in rice-growing areas in Southern regions is a good indicator of the situation.

The type of crops under irrigation influences economic valuation of improved irrigation water supply. The underlying assumption is that Irrigation farmers' WTP increase with high value crops.

Most of areas under irrigation in Tanzania are located in flood plains or river valleys; attracting many people because of their potential for agriculture (TMAFS, 2002). This can have a negative effect on the size of farm per household, particularly pro-poor communities.

According to FAO (2005), the average cultivated area per household is 0.14 ha. The area is smaller than the national average of 0.6 ha per household reported by Maghimbi (2007) quoting in ILO report (1978). Nevertheless, other studies conducted in various parts of the country indicate that the mean household land holding for small-scale farmers is 1.8 ha in Morogoro, 25% below the national average (NBST, 2002, cited by Paavola, 2004). In Mwanza, Shinyanga and Tabora regions, where paddy is also cultivated, the farm fields ranges between 0.2 to 0.5 ha per household (SWMRG, 2005).

Leijdens (2008), reported that high value and fresh vegetables farms in Tanzania have average size of 0.5 -1 ha and few up to 4 ha. Turpie *et al.* (2005), in their findings, showed that irrigated plots in Pangani River Basin were 0.1-0.2 ha in the highlands increasing to 0.8-1.5 ha in the lowlands. Moreover, Lankford (2002) in his study in Morogoro and

Usangu, Mbeya, reported the minimum size of irrigable land being 0.4 ha but rare cases 0.2 ha. The medium was 0.4 ha for men and 0.3 ha for women. However, land sizes indicate to decline in dry season. Kadigi *et al.* (2008) had similar findings in Usangu that indicated irrigated land decline to very small plots (about 0.1-0.2ha).

The household landholding, particularly irrigated land, affects either positively or negatively the WTP for improved environmental quality. It is assumed that the larger the land sizes for an individual the higher the WTP. For instance, Tiwari (1998), in his study on economic value of irrigation water, reported that household landholding had negative influence on Willingness to pay.

2.1.2 Crop yields and income

Crop yields statistics by FAOSTAT (1995), collected from different regions of the world, showed a significant difference in crop yields between other regions and sub-Saharan Africa. In the sub-Saharan, yields were reported to be higher in irrigated than in non-irrigated. For instance, in Latin America and Caribbean recorded the highest rice average yield of 4.4 t ha^{-1} compared to 1.6 t ha^{-1}, while sub-Saharan Africa had the lowest, 2.7 t ha^{-1} compared to 1.4 t ha^{-1} for irrigated and rain-fed land respectively. East Asia recorded the highest average yield in terms of maize, 5.7 t ha^{-1} compared to 1.8 t ha^{-1} for irrigated and rain-fed respectively. South Asia had the lowest, 2.2 t ha^{-1} compared to 1.3 t ha^{-1} for irrigated and rain-fed land respectively. Besides, Near East and North Africa recorded the highest average yield for vegetables, 17.0 t ha^{-1} compared to 9.4 t ha^{-1} recorded in sub-Saharan Africa, 5.3 t ha^{-1} for irrigated compared to 3.7 t ha^{-1}, for rain-fed land.

Moreover, similar findings about improvements in average yields have been also reported in rain-fed with supplemental irrigation within many countries such as Jordan, Iraq, Tunisia and Morocco (Oweis *et al.*, 1999 quoting Perrier and Salkini, 1991), Turkey (Oweis *et al.*, 1999 quoting Tenkinel *et al.*, 1992) and Syria (Oweis *et al.*, 1999 quoting Oweis, 1997).

Other case studies carried out in Tanzania by Mahoo *et al.* (2007) in Mkoji Sub-catchment, along Rufiji Basin (Great Ruaha River Catchment) and in Pangani River Basin by Turpie *et al.* (2005) reported differences in average yields between irrigated and rain-fed land.

Though the average crop yields per acre in Morogoro have been reported to decline (Paavola, 2004), in Morogoro Rural and Mvomero Districts (Asenga and Ngwita, pers. Communication, DALDO offices, 2008), the yields in irrigated paddy were reported to rise between 26-40 bags/acre.

Nevertheless, not only water reliability in the agricultural fields attribute to relative yields on irrigated and rain-fed land but also fertilizers and other inputs (Oweis *et al.*, 1999; Ahmed, 1987, cited by FAOSTAT, 1995). Low water conditions in rain-fed land limit use of fertilizers and other inputs and hence lower yields (FAOSTAT, 1995 quoting Ahmad, 1987). Wood *et al.* (2004) and Oweis *et al.* (1999) also supports that water provides condition suitable for economic use of higher technology inputs such as high yield varieties (HYV) of seeds and herbicides irrespective of seasonal rainfall.

Finally, the increase in yields from irrigated crop has positive impact on household livelihood. However, this will depend on the types of crop, quantity supplied and price present in the market.

In a conventional market, commodity price in the market and quantity of the commodity supplied by the producer (s) determine the income of producers. In agriculture, the quantity of agricultural products, which is sold in the market by a farmer, determines agricultural income. The higher the commodity price, the higher the income earned by the farmer and the vice versa is true.

However, the situation is contrary in many developing countries where a large proportion of rural population is made up of marginal tenant farmers and the landless who are net buyers of staple food, lower agricultural prices tend to be pro-poor (Fuwa and Sajise, 2006).

The analysis of rice producer prices in Mbarali District, Tanzania, by Kadigi *et al.* (2004), showed an increase in nominal terms but in real terms, the prices were declining over time, despite the increase in paddy production with no obvious impact on farmers' income.

The agrarian average gross income per family in Usangu plain, Rufiji Basin, supported by irrigated paddy, was TAS 969 960 or US$ 911.90 per annum (Kadigi *et a.l*, 2004). While another case study in Pangani River Basin by Turpie *et al.* (2005) found out that the gross income generated from irrigated crops ranged between TAS. 350 000 to 600 000 per household per annum, though in some cases traditional furrow in the upper basin had higher income than improved irrigation scheme. Besides, irrigated areas produce higher income than non-irrigated fields (Turpie *et al.*, 2005; FAOSTAT, 1995, quoting Vaidyanathan; 1994) regardless of agro-climatic zone. The income from irrigated paddy in semi-arid areas, Mwanza, Shinyanga and Tabora, were TAS. 375 000 and 266 500 per annum for gross and net income respectively, was higher than non-irrigated crops (SWMRG, 2005).

Farmer's income has an impact on water value (Kadigi *et al.*, 2004). As the per capita income level rises, "people value more the environmental goods and services. Also regulatory institutions become effective" (Dasgupta *et al.*, 2002, cited by UNDESA, 2006). The increase in income caused by increase in yields from irrigated crops had positive influence on WTP.

2.2 Valuation of Improved Irrigation Water Supply

2.2.1 The concept of economic value

Valuation is implicit to the process of making choices on the use and allocation of ecosystem-related goods and services, as making a choice for one use implies valuing that use over other possible uses (FAO, 2006). Addition of the word "economic" to valuation refers to the application of special techniques to determine the economic value (demand or willingness to pay (OMB, 1992, cited by UNDESA, 2006)) of water services for informing policy decisions regarding the management and allocation of water.

The perfect markets, which operate under forces of demand and supply, determine the prices of most commodities (or private) such as producers and consumers' goods. Notwithstanding, market for water-related goods and services as well as other ecosystem-related goods and services tend to understate the actual value of services provided (Spash,

2008) which include the opportunity cost of water and cost of damages to third parties which also depends on the same resources (Houston *et al.*, 2002).

Production costs (operation and maintenance costs for water) normally account for price of private goods and services in a conventional market. Unfortunately, market for public goods and services such as improved irrigation water supply either is absent or if it is present distorts their values. The market easily understands price per unit and units are obvious for most marketed goods. Water tends to be more complex. A variety of physical, social, cultural, political and economical factors make water a special case with regard to economic valuation. Water users pay only a charge for access to the delivery network, but not water as a single entity (UNDESA, 2006).

Irrigation water, the producers' good from water-related goods and services that supplied to agricultural producers for crop irrigation (Young, 2005), is a classic non-marketed resource (Agudelo, 2001; Dinar *et al.*, 1997, cited by Lotinopoulos, 2005; Ward and Michelsen, 2002), particularly in the rural areas of developing countries. Failure to capture non-market value for water-related goods and services, such as improved irrigation water supply from protected watersheds has lead into three impacts; first, water users to regard water as a free good that results into unsustainable use of the scarce resources and effect on resource allocation and bias technological development (UNDESA, 2006, cited in Dasgupta and Maler, 2004). Second, undervalue or under pricing of irrigated crops and hence the rates of economic return to investment in improving environmental quality become lower than other rural development programmes (UNDESA, 2006 quoting Fan *et al.*, 2002; 2004) and third, destruction of watersheds which absorb rainfall water and store ready for draining them to rivers or streams. Some argue that the poor appreciation of complexities of water as an economic commodity contributes to the current water crisis (Hanemann, 2005).

Therefore, should we be desperate because water is complex and outside the realm of market transactions? The answer is "no". Environmental economists have developed a set of methods. for environmental services provided by water ecosystems that not priced and traded in the marketplace, to estimate their economic value (Kramer. 2005; Arrow, 2000; Bockstael, 2000; Carson, 2000; Adamowicz. 1991), which embeds in utilitarian approach based on individuals' preference satisfaction (Lange and Hassan, 2006; Navrud, 2000).

Environmental economists divide the methods into two categories: stated preference and revealed preference method. The former use survey to elicit directly from individuals the economic value they assign to non-market ecosystem services. The later rely on observations of the choice that people make to infer values of the resources they are using (Kramer, 2005). Nevertheless, lack of reliable crop data in the fields and absence of market for water-related goods and service in rural areas prompted environmental economists prefer stated preference methods to revealed preference methods to estimate irrigation water value.

There are various empirical evidences of application of hypothetical market (contingent valuation) in different parts of the world. The suitability of the method prompted Tiwari (1998) to propose its application to developing countries for survey among the poor, illiterate population and obtain reasonable and consistence answers for integrating values the poor and marginalized in decision-making.

2.2.2 Socioeconomic determinants of Willingness to Pay (WTP)

Traditional and socioeconomic factors influence the probability of "yes" response by individual household to WTP question willingness to pay for various environmental goods and services (Vargas. 2004). such as improved irrigation water supply. These factors can either have positive or negative relationship with WTP. The positive sign on factor coefficient implies that a unit increase of a factor increases WTP to a certain amount. while vice versa is true for the negative sign. For instance, study on improve watersheds management by Vargas (2004), found that the variables age, education and income had statistically significant relationship with farmers' WTP. Variables age. education and income had positive relationship with WTP.

However, the signs for factors change depending on the need of an individual for improved quality of the public goods or services in question. Sometimes this happens even for the same study when conducted in different localities for the same variables to influence differently WTP. For example, while Vargas (2004) reported education to have a positive relation with WTP for watersheds conservation, it had negative influence on WTP for irrigation water (Tiwari, 1998). Other variables reported, having different effects and statistically significant at different probability levels were farmers' attitude, household family size, age, total agricultural income, water sufficient, and gender, landholding size, out migration, area planted for dry season and land mortgaged in the bank. Water sufficient, family size and total household landholding negatively related to WTP while sex and agriculture income were positive. Besides, in the case of open-ended question, variables attitude, education, sex migration and agriculture income positively related to WTP. However, sex and education were not significant.

Besides other findings showing that relationship exists between variable and responses "yes" to the bid values (WTP) reported by Wang and Whittington (2000) indicating that bidding price and income negatively and positively related to household WTP and statistically significant.

Prior knowledge about environmental goods, concerns about protection or destruction of environmental good or service, education, income, marital status, distance positively related to WTP question and statistically significant as pointed out by Jeanty and Hitzhusen (2007) on willingness to pay for improved air quality.

However, Vargas (2004) precautions policymakers when setting up payments based on income, because farmers sometimes do not reveal their actual income for fear of paying more or taxed. It is not a reliable indicator of household WTP.

2.2.3 Contingent Valuation Method (CVM)

2.2.3.1 CVM evolution

Contingent valuation method dates back to 1947 when Ciriacy-Watrup firstly proposed its use. However, Davis became the first to apply it in 1963 to estimate the benefit of goose hunting from the survey of goose hunters (Venkatachalam, 2004). A survey technique bases on economic theory (Cumming *et al.*, 1994; Mitchell and Carson, 1989; Bishop and Heberlein, 1979). It uses hypothetical situations to elicit peoples' perceived willingness-to pay (WTP) for improvement in quality or quantity of environmental goods and services by directly asking consumers under a given condition or prescribed circumstance through carefully orchestrated elicited method (Gunatilake *et al.*, 2007). Analysis of responses to derive economic value from a randomly assigned price offered to respondents is done (Carson, 1999).

2.2.3.2 Theoretical framework for CV method

CV method has a basis in public goods and notably welfare implications, expressed in terms of a change in the monetary amount which would be taken from the individual (WTP) to keep the individual's overall level of utility constant (Carson *et al.*, 2001). The similar case arises on how to increase incentives for upstream dwellers that live close to Uluguru Mountains' watersheds and manage the watersheds, which supply irrigation water to households under irrigation in the downstream. However, the appropriate measure depends on the relevant property right to the environmental good Wattage (2002) and Carson *et al.* (2001) referred the measure to as Potential Pareto compensation test or Hicks-Kaldor compensation criterion or Hicksian consumer surplus measures. According to this criterion, the Pareto-optimal condition in the management of watersheds could be achieved if gainers i.e. households under irrigation in the downstream could compensate the losers i.e. upstream communities (on-site) and still the utility of the gainers remain constant by improved irrigation water supply.

Eventually crops production will increase or maintained and improve livelihoods as shown by the following formula:

$$V(y-WTP, p, q_1, Z) = V(y, p, q_0, Z) \qquad (1)$$

Where:

V is the indirect utility function, y is income, p is a vector of price faced by individual, q_0 and q_1 are alternative level of the good quality or quality indexes (with $q_1>q_0$ indicating that refers to improved irrigation water supply, Z is a vector of individual characteristics (Markandya, 1998, cited by Venkatachalam, 2004)

2.2.3.3 Elicitation techniques

There are about four major elicitation techniques in use for contingent valuation method namely bidding game, payment cards, open-ended and dichotomous choice (Brown *et al*, 2007; Boyle *et al.*, 1996) which CV use. However, for the sake of this study, the researcher opted to concentrate on single-bounded dichotomous choice and open–ended elicitation techniques on strength and weakness of each method.

The single-bounded dichotomous format (closed-ended or single referendum survey) is the elicitation method, which does not ask an individual to state whatever amount but to "take it or leave it" with "yes or no "answer respectively. Bishop and Heberlein (1979) firstly introduced the use of this format. Its advantages are simplified cognitive task faced by respondents, minimize non-responses and avoid outliers, received the endorsement of the NOAA panel. However, it has disadvantages such as starting point bias i.e. answers anchored in the initial figure stated by interviewer, elicitation are significantly larger than that for open-ended format, some degree of yea-saying is also possible and relatively inefficient due to less information available for each respondent (Pearce and Ozemiroglu, 2002)

Another elicitation format, which was used in this study, was open-ended question format that ask an individual to state his or her maximum WTP for a proposed environmental change. Its merits include no anchoring bias because it does not provide clues about what value of the change might be, it is straightforward, requires relative straightforward statistical techniques and very informative (Pearce and Ozemiroglu, 2002).

2.2.4 Strengths and weaknesses of CV

Although CV has been under criticism from non-practitioners (Portney, 1994), there are remarkable improvements in terms of methodological design development that include survey and analytical design (Freeman, 2003; Pearce and Ozemiroglu, 2002), which make it more preferred to other economic valuation techniques.

According to Mathew (2006), the strengths of CV include flexibility, which make it easily understood by users and ability to value multiple of environmental goods and services i.e. use and non-use values (King and Mazzota, 2005).

Furthermore, CV results when compared to other techniques are close or similar. For instance, a comparison of estimates to a vote on actual binding referendum was similar (Carson, Grove and Machina, 2000, cited by Mathew, 2006). Furthermore, a comparison between stated and revealed preference found out that both methods had the same results (Carson *et al.*, 1996). Notwithstanding, some CV estimates exceed that of revealed preferences (Carson *et al.*, 1996).

Not only CV has strengths but also weaknesses which non-practitioners have persistently criticized on the validity and reliability of CV results. The first weakness is disparity of results between WTP and WTA. The WTA values are larger than WTP (Venkatachalam, 2004; Bateman *et al.*, 1997; Brown *et al.*, 1996; Shogren *et al.*, 1994). However, weak experiment feature attribute to disparity between WTP and WTA (Horowitz and McConnell, 2002).

Besides, CV is vulnerable to biases such as scope effects, which occur when WTP value for one good differs insignificantly with the WTP value for a more inclusive good (Diamond and Hausman, 1994; Harrison, 1992). Bateman *et al.* (1997), and Randall and Hoehn (1987) had the same observation in their studies using similar methodologies and private goods. However, this can occur even in private goods (Venkatachalam, 2004).

Sequencing effect or order effect is another problem associate with CV, which occurs in multi-goods valuation (Diamond and Hausman, 1994). Hammitt and Graham (1999) reported the occurrence these effects in their study. Carson (2000) attributes to improper administration of survey and familiarity of respondents to the good.

Finally, other weaknesses are hypothetical and strategic biases emanating from the differences between actual and hypothetical (Johnston, 2006; Foster *et al.*, 1997; Brown *et al.*, 1996) and free-riding and over-pledging problem (Venkatachalam, 2004, quoting Mitchell and Carson, 1989).

2.2.5 The application of contingent valuation methods

Of the two methods mentioned earlier, Contingent valuation method (CVM) is the most preferred to travel cost method (TCM) for determining non-market value such as increased water quantity, or changes in quality of water (Fadali and Shaw, 1998; Cordell and

Bergstrom 1993; Edwards, 1988). Furthermore, CVM determines non-use value of water associated with water-related existence, bequest, and option value by asking individuals their maximum willingness to pay (bid) (Kosz. 1994; Walsh *et al.* 1990; Brookshire and Smith, 1987).

According to Department of Economics, University of California, more than 530 recent papers were published between 1994 and 2001 (Carson, 2000, cited by Mathew, 2006), which estimated willingness to pay values for various non-marketed environmental goods and services using contingent valuation method.

Various studies by Briscoe (1996), Griffin *et al.* (1995), World Bank (1995), Singh *et al.* (1992), Whittington *et al.* (1987), Gibbons (1986), Desvouges and Smith (1983) and Smith (1983), cited by Rodgers *et al.* (2002) estimated willingness to pay, a marginal value of water supply, by domestic consumers.

The water values in use that estimated from data on WTP in urban areas of Jamshedpur in Subernarekha River Basin, Eastern India and urban consumers and hotels for vended water in Phuket, Thailand were \$ 0.25 m^{-3} and \$1.30 m^{-3} respectively. The latter estimated value was higher than that indicated in normal months because the survey conducted in three summer months with extreme water shortage (Rodgers *et al.*, 2002).

The survey conducted by Shultz and Lindsay (1990) estimated mean WTP to (\$40 per household and \$100,000 per community annual WTP) for groundwater protection plan in Dover, New Hampshire. Crutchfield *et al.* (1997) estimated mean WTP (\$45- \$69 per household per year) for protection from excessive nitrate in drinking water in four regions of White River area. Indiana. Central Nebraska. Lower Susqueahanna and Mid Columbia Basin.

In addition. Loomis (1996) estimated \$59 annual value per household in Challam County, \$73 for the rest of Washington. and \$68 for households in the rest of the United States. The aggregate benefits to residents of the State of Washington are \$138 million annually for 10 years and between \$3 and \$6 billion to all U.S. households for removing two dams on the Elwha River on the Olympic Pennisula in Washington State to restore ecosystems and anadromous fishery.

A few case studies had reported the use of stated preference to determine irrigation water value rather than revealed preferences (Pattanayak. 2004; Pattanayak and Kramer, 2001; Kramer *et al.,* 1997; Whittington, *et al.*, 1992). For instance, Tiwari (1998) carried out household survey in Phitsanulok Irrigation Project (PIP), a largest government-managed system in Thailand, to determine willingness to pay (\$ 24.25 ha^{-1}) for irrigation water under existing and improved supply condition.

Another case study in Northwestern state of Haryana (Rodgers *et al.*, 2002) where irrigation charges for surface water supply were less than \$10 ha^{-1} $year^{-1}$, farmers' irrigation costs reached \$90 ha^{-1} $year^{-1}$ accounting for as much as 20% of net agriculture income, farmers willingness to pay as well as actual payment were high for timely and reliable irrigation water supply.

In addition, Mallios and Lotinopoulos (2001), in their study to determine factors affecting farmers' WTP in Greece, found that the average WTP for household was €120 per hectare.

This value was similar to that estimated by Hedonic Price Method (HPM). The lower number of CV surveys, in determining irrigation water values, might be due to complexity of the method itself, inadequate expertise and financial resources.

Nevertheless, the value of irrigation water is a site specific. Moss *et al.* (2003) states that it differs from use to use, user to user and place to place. In addition, critics are doubtful about precision of the values (Portney, 1994). Turner (1993) argue that lack of precision of values should not be considered as a great problem because their existence still leave us in a much better position (in decision-making) than we would be if that value information did not exist or totally ignored.

2.3 Water Institutions Strength and Arrangement

2.3.1 Institution strength

However, political scientists, anthropologists and economists had defined institution in accordance with their own school of thoughts, the objectives and roles played by institutions to govern natural resources are alike. North (1990), an advocate of New Institutionalism Economics (NIE), defines institution as a "rules of the game," such as constraints, norms, values and rules. North (1990), Ostrom (1990) and Ensminger, (1998) classified institutions into formal developed by state and informal developed by local communities.

Scholars and practitioners assert supremacy of local-level institutions in natural resources management schemes (Gibson and Backer, 2000; Ostrom, 1992, 1999;). Besides, cultural, local-level institutions are considered better at providing, *inter alia*, rules related to accessing, harvesting and management of CPRs. Rajagopal (2000) supports in his findings on role of institutions in a south India canal system where institutions in single caste were significantly stronger in maintenance. Moreover, another study by William *et al.* (1997), at Marakwet, Kenya, showed that social norms and practices were effective in water distribution.

However, water-governing institutions in Africa, particularly informal institutions, have been in hegemony due to various factors. Haller (2007) attributes the inexistence and poor performance of informal institutions to demographic, technological, economic and political aspects. Besides, water management regime changed, during colonial and post-colonial era, into dual existence of so-called customary law and government laws and regulation have exacerbated this problem (Haller, 2007). The African floodplain areas (Moorehead, 1989; Thomas, 1996, cited by Haller, 2007) manifest the seizure of management responsibility out of the hands of local user groups by state. Mbeyale *et al.* (2004) had also reported similar observation on weakness of water institution in Pare, Tanzania.

The absence or presence of weak water governing institutions increase transaction costs which results into information problems, measurement and enforcement costs (North, 1990). The same situation applies to PWS from downstream irrigation farmers to upstream residents. People deliberately influence economic values to lower the transaction costs involved in the exchange of natural resources.

North (1990) argues to develop institutions that affect the economy through affecting transaction costs to limit uncertainty in the exchange of these goods. This can be possible through economic valuation. Economic values are institutions that specify the terms of exchange of natural resources (Schuijt, 2003)

2.3.2 Institutional arrangement

Environmental services quantity and quality improvement projects require presence of effective institutional framework that assists in their implementation. According to Hope (2005), the institutional arrangements can be described under regulatory or reward framework. The former comprises traditional administrative, centrally managed and often threshold bound targets or limits such air or water quality standards. Costa Rica has been practicing this kind of institution arrangement (Hope, 2005). The latter consists of carrot-based approaches through incentives, subsidies or payments for good behaviour or stick-based "disincentives" through taxes or fines for bad behaviour (Tomich *et al.*, 2004). Livelihood groups in Asia apply the reward approach (van Noordwijk *et al.*, 2004) and in other tropical countries (Wunder, 2007).

Different mechanisms are available to reward the upstream communities for conserving of upland watersheds. Price is an institution (Tool, 1995, cited by Schuijt, 2003) which can serve to reward pro-poor upland communities. Premium price can be charged for volume of water used through billing system for domestic and industrial uses (UNDESA, 2006). However, it is difficult for irrigation water in developing countries because most of them have no measuring devices due to high installation cost and are vulnerable to malicious damage.

Besides irrigation water in developing countries serves thousands of small farmers, supply is below point, delivery rarely measured and controlled. FAO (2004), and Tardieu and Prefol (2002), provide various irrigation water charging basis alternative such as area, crop type, and market-based. Bosworth *et al.* (2002) suggest area and crop-based rather than volumetric are appropriate.

However, Perry *et al.* (1997) argue that neither market nor government has been efficient in the management and allocation of resources. The reasons behind this mess are inappropriate regulations and poor implementation, subsidies, imperfect knowledge, lack of financial resources, centralization, high administrative cost and excessive bureaucracy (Landell-Millis and Porras, 2002; Pagiola *et al.*, 2004).

Hence the shift from state based water-governing institutions to local or community-based institution or civil society groups (IMT or PIM), to manage water and collected financial resources, is needed (Facon, 2002).

According to Malayang (2003) and PIDS (2002), cited by Pascual (2005), community or civil society groups based water institution (i.e. non-state organization) include irrigation associations, farmers' associations, consumer groups, NGOs, people' organizations (POs), private business groups (PBGs) and research and academic institutions (RAIs).

Different parts of developing countries have been implementing the devolution of water management responsibilities to the community or civil society groups. Tanzania water policy and regulatory act (URT, 2002) have already stipulated though its implementation seems to be slow. The findings by Easter *et al.* (1998) and Khanal (2003) indicated significant capability of water users associations (WUAs) to assume water and financial management responsibilities.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Conceptual Framework

Deforestation. biodiversity loss. soil degradation, pollution, and over use and contamination of water resources. are common examples of the mismanagement of natural resources. Water is a classic example of resource degradation even though humans and ecosystems depend on water resource for their very survival.

Public goods such as water tend to be under supplied by the private sector because free markets for such goods would not be efficient and would be plagued by externalities. as public goods are both non-rival and non-exclusive. Thus arose the idea that public goods are better managed by central government which should act like social planner to provide environmental goods and services across the society. However, it must be recognized that "the public sector has generally performed miserably in all forms of water management (Perry *et al.,* 1997)"—a result of rent seeking, inappropriate regulations and poor implementation, subsidies, imperfect knowledge, lack of financial resource, centralization, high administration cost and excessive bureaucracies tend to reduce the government efficiency and sustainability (Landell-Mills and Porras 2002; Pagiola *et al.*, 2004). As an alternative to the apparently intrinsic failures of pure market or government approaches, different types of initiatives have been undergoing around the world at different levels. In consequence there are many efforts to stop deforestation and preserve critical ecosystems. One growing initiative are "Payments for Environmental Services" (PES) a tool to internalize externalities that could potentially simultaneously generate additional income for rural communities and preserve critical ecosystem services. In theory, direct payments can help promote biodiversity preservation, watershed protection, carbon sequestration and scenic views protection. Most of the water payment systems involved negotiations between downstream and upstream stakeholder such as representatives of hydroelectric facilities, water utilities, municipalities, industries, and farmers, with a little or no government intervention.

According to Perry *et al.* (1997), "water markets tend to operate locally allowing suppliers and consumers to include the opportunity cost of water in their management decisions. But who should pay and who should receive the benefit from environmental services? From the economic perspective, people who receive the benefit of a good should pay for it. Thus, irrigators who receive direct benefits of water should pay for this service. Ferraro and Kist (2002), cited by Vargas (2004) state that the easiest and cheapest way to, for example, protect rainforests or watersheds is to simply pay directly for it. The contingent valuation method (CVM) has been extensively used to identify buyers and sellers, especially in western societies and particularly for drinking water. Building the demand side and capturing a true WTP for environmental amenities has been the principal task of CV methodology. Thus the study was undertaken by carefully developing a survey that reflected the local culture and characteristics of indigent farmers and their perceptions about local resource use.

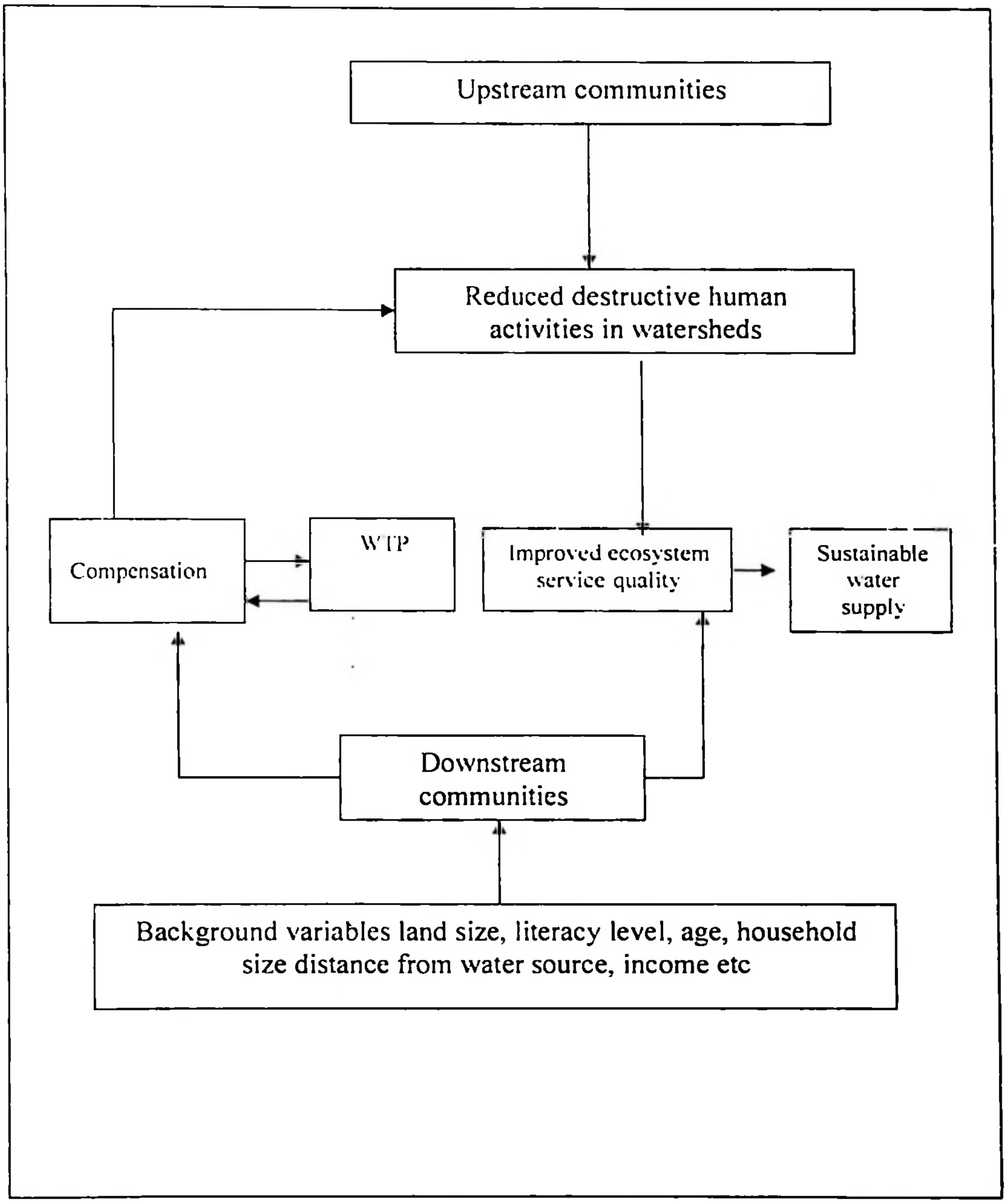

Figure 1: A conceptual framework for economic values of improved irrigation water supply

3.2 Study Area Description

3.2.1 Location and topographical features

The Uluguru landscapes are located on the lowlands of the Uluguru North and South Forest Reserves. They form part of the Uluguru Mountains, which are surrounded by Morogoro urban and rural, and Mvomero districts in Morogoro region. The landscapes lie between latitude 7^0 3'S and longitude 37^0 46'E. The Uluguru Mountains rise steeply from Mgeta and Mvuha, floodplain, 150m elevations to peak elevation of 2638m. Though the mountains form a continuous ridge, they are physically divided into the North and South (20.5km long and 8km wide and 25km long and 15km wide respectively) (Mbilinyi and Kashaigili, 2005, cited by Yanda and Munishi, 2007). The landscapes are recipient of water supply from Upper Uluguru watersheds.

3.2.2 Drainage pattern

Whereas the major perennial rivers are the main Ruvu, Mgeta, and Ngerengere, the small ones include Mlali, Mzinga, Tangeni and Mbakana in the Mgeta sub catchments; southwest. Others are Mbezi, Mvuha, Mmanga and Mvizigo in the main Ruvu (Kibungo) sub catchments in the east; and Ngerengere, Morogoro and Kiroka in the Ngerengere sub catchment in the northeast.

Most of these rivers, especially in the southwest, are perennial but make zero contribution to inflows to the downstream users such as irrigators and domestic users during dry season. The first three rivers in the southern west mentioned above supply, over 70% of water, for Mindu Dam. Ruvu River, which flows as the main river in the eastern downstream, supplies water to Dar es Salaam City.

3.2.3 Climate

The rainfall regime around the Uluguru Mountains is bimodal. It begins in early October-January and late February-May rainfall. The rainfall is of orographic type caused by incoming air masses from Indian Ocean, cooled and finally converted into precipitation (Yanda and Munishi, 2007). The average annual rainfall varies with altitude. In lowlands, the rainfall range between 1400 and 1800m (MRDC, 2007), whereas in highlands ranging from 2000-3000mm (Yanda and Munishi, 2007; Tressiera, 2007). The average annual temperature in the low altitude is 26.5^0C and ranges from 15- 20^0C in the high altitudes.

3.2.4 Land cover and land use

Buckley and Bhatia (1998). characterized land cover in upper catchments as transitional rainforests, sub-montane, montane and upper montane forest on the mountains slopes. However, Yanda and Munishi (2007), quoting Pócs (1976) reported that altitudinal zones; dry forests and Savanna woodland zone below 600 m altitude characterize the vegetations in the Uluguru Mountains. However, it is heavily cultivated and only small remnant of original vegetation detected. This is followed by sub-montane dry forest and miombo woodland zone up to 800 m altitude, which is actually replaced by open woodland of *Pterocarpus angolensis*, *Combretum* and *Terminalia* species or dry secondary grassland on the eastern foothills and widespread on the western, northern and southern slopes as high as 1500 m and in the northern 1600-1700m altitude.

Despite threats posed by forests degradation (FBD, 2005a; Munishi *et al.*, 2005; Lyamuya *et al.*, 1994, cited by Yanda and Munishi, 2007) in the Uluguru North and South Forest reserves. Forests, particularly the cloud forests, play a vital role in ground water infiltration and reducing run-off volume during rainy season and enhancement of watersheds moisture storage capacity for future release in rivers and streams, particularly in dry season.

Uluguru Mountains watersheds have been supporting agriculture in the landscape. It is reported to increase on average 9% to 38% (422% increment) between 1995 and 2000 (Tressiera, 2007). Agriculture varies from subsistence agriculture (Lyamuya *et al.*, 1994, cited by Yanda and Munishi, 2007) to small-scale irrigation schemes observed in Mgeta river sub-catchment, flood plains of lower Ruvu among others and Ngerengere sub-catchment (Yanda and Munishi, 2007). These sub-catchments are important for supporting local livelihoods for food and cash crops production, including cereal and horticultural crops, as well as providing employment for upstream and downstream rural communities.

3.3 Study Design

3.3.1 Sampling design and sample size

The study area was first stratified into strata namely, smallholder irrigation systems known as traditional irrigation and improved traditional irrigation around the north and south of Uluguru Mountains downstream. Four villages (i.e. Tullo-Kongwa, Kiroka, Mlali and Kipera) out of eight, which practice traditional furrows irrigation, were randomly selected to constitute the study sample under tradition irrigation stratum. Two villages were also purposefully selected from improved irrigation scheme stratum (i.e. Mlali irrigation scheme and Kiroka irrigation scheme). Households, as sampling units, were sampled randomly from each village selected in each stratum. Village registers were useful in selecting households. A sample of 37 households from each village was randomly selected. The selection based on meager financial resource and time constraints otherwise the large number of households could be selected. The random selection was done to avoid bias

(Deaton, 1997). A total of 219 households were randomly selected and arranged for interview schedules.

3.3.2 Data collection

Procedures for primary data collection in this study were categorized as follows:

3.3.2.1 Focus group discussions

Two Focus Group Discussions (FGDs) involving farmers practicing irrigation in the North and South Uluguru landscapes were conducted. Each group discussion involved 15 participants. The discussions aimed at obtaining relevant information that would aid in preparing the CV questionnaire (survey instrument). The topic for discussion were on the link between watersheds and irrigation water availability, irrigation water status, benefits from improved irrigation water supply, level of improvement in supply from well protected watersheds, payment vehicle, willingness to pay for improved irrigation water supply, initial bid and range of bids, criteria for collection of fee and organization assigned for water fee collection. Carson (2000) states that focus group discussion provide a way to gather information and better understanding of how people feel or think about a given phenomenon.

3.3.2.2 Pre-testing of CV questionnaire

The survey instrument was prepared based on single-referendum vote or close-ended (takes it or leaves it or discrete choice) and open-ended format. The instrument was divided into four sections as follows:

i) Socioeconomic and demographic characteristics of the household
ii) Characteristics of the current status of irrigation water supply and watersheds

iii) The attitude of the household in paying for irrigation water services

iv) Institution strength and arrangement

A face-to-face interview method was used to collect the data. This method was opted because it reduces the possibility of non-responses (NOAA, 1993). Each sub-sample comprised of 30 irrigation farmers for interview.

The payment vehicle was prepared basing on annual membership fee collected by farmers' irrigation association in the CUMMK and CUMK of TAS 5 000 per year. The starting bid price was 20% increment of annual membership fee as agreed during focus group discussion. This study used six bid price levels and a total number of 36 respondents for each price level. The six price levels used were TAS. 6 000, 10 000, 15 000, 20 000, 25 000, and 35 000. The choice of levels was within the range proposed by World Bank (1993) that the elicitation bid should not exceed 5-6% of annual income of individual interviewee. The income level in the study area ranged between TAS. 150 000 and over TAS 1 000 000 per year per household.

Pre-testing survey identified irrelevant questions and unclear words, which were eventually omitted or rephrased accordingly and new useful information previously not included, were added.

3.3.2.3 Administering of CV questionnaire

The survey instrument was finally administered for data collection in the field after it had thoroughly been refined through literature search and consultation with supervisors and WAMI-RUVU River basin authority. Four enumerators were employed to collect quantitative data from households engaged in irrigated farming.

3.3.3 Secondary data

Secondary data was collected from publications in journals, research reports, articles, theses and reports from government offices.

3.4 Data Analysis

3.4.1 Descriptive statistics

Data from CV questionnaire was statistically analysed using Microsoft Excel and STATA 10.1 packages. Descriptive statistics was used in the analysis of information on types of crops cultivated under irrigation, responses to questions on awareness of status of irrigation water, sex, marital status, occupation, institutional strengths and arrangement. Means and standard deviations were used in the analysis of variables such as crop yields, income from irrigated crops, irrigated areas, total household land size, number of years in school and household size in the area.

3.4. 2 Inferential statistics

3.4.2.1Tests of hypothesis

The hypothesis underlying this study was that the Willingness to Pay (WTP) for improved irrigation water supply in traditional furrows irrigation scheme exceeds the WTP in improved scheme. This was based on the assumption that the uncertainty of getting irrigation water (scarcity) is higher in households under traditional furrows irrigation than improved scheme due to poor infrastructure and management. Both t- and log-likelihood ratio tests were used to test this hypothesis.

3.4.2.2 Factors determining WTP of Households

The identification of the factors determining willingness to pay of households for improved irrigation water supply, the household's responses to the willingness question were regressed on the bid price the households were asked to pay and on other socioeconomic variables of the households.

The logit regression model is specified as follows:

$$Y = \frac{1}{1 - exp^{-z}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where, Y = response of the household to the WTP question which is either 1 if Yes or 0 if No.

$$Z = \beta_0 - \beta_1 x_1 - \beta_2 x_2 - \beta_3 x_3 \ldots\ldots - \beta_n x_n \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

β_0 = constant

β_1 . β_n= Coefficients of the exploratory variable X_1........... X_n as shown in Table 1.

The likelihood function used for analysis of closed-ended question, in this study, was unordered logit model expressed as a series of Bernoulli trials (Hanemman & Kenninen, 1999).

$$L = \sum_{i=0}^{n} y_i \ln P_i - (1 - y_i) \ln(1 - P_i) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

The chi-squared and McFadden pseudo R squared (McFadden, 1994) were used to measure goodness of the model and the significance of the model respectively. Three WTP logit models were developed, with assumption that an individual WTP is a function of set of explanatory variables, as follows:

Logit regression model1: Traditional furrows irrigation scheme respondents only

Logit regression model: 2 improved irrigation scheme respondents only

Logit regression model: 3 Pooled (Traditional furrows and Improved irrigation scheme) respondents.

Table1: Summary of variables: description and coding

Variable name	Variable description
WTP	Dependent variable, takes the value 1 if respondents accept the proposed bid, 0 if they don't accept the bid
Bid	Hypothetical amounts of irrigation water fee proposed to each respondent
Sex	Sex, 1 if respondent is male, 0 otherwise
Age	Number of years of household head
Education	Number of years in school of household head
Marital status	Marital status, 1 if respondent is married, 0 otherwise
Occupation	Occupation 1 if respondent is engaged in farming only, 0 otherwise
Household size	Number of individuals in the household
Distance	Distance, 1 if distance is > 500m
Alternative source	Alternative source, 1 if respondents has other source of water, 0 otherwise
Allocation	Allocation. 1 if respondent's irrigation water allocation reliable, 0 otherwise
Status	Water status, 1 if irrigation water is sufficient, 0 otherwise
Prior knowledge	Awareness, 1 if respondent is aware with watershed, 0 otherwise
Protection	Protection, 1 if watershed protection is important, 0 otherwise
Scheme	Scheme, 1 if respondent's field is under improved traditional irrigation, 0 otherwise
Land size	Total cultivated land of the household (in ha)
Income	Irrigated crop incomes

3.4.2.3 Estimation of mean and median WTP

A logit model was used to determine the mean WTP of households for an improved irrigation water supply and the determinants of WTP for closed-ended question. Logit model was adopted since the Ordinary Least Square (OLS) procedure was not appropriate particularly when the dependent variable is dichotomous (Gujarati, 1988, cited by Yusuf *et al.*, 2007). The logit model is based on the cumulative logistic probability function. Roopa (2000) cited by Yusuf *et al.* (2007), stated that logistic regression is a uni/multivariate technique that allows for estimating probability that an event will occur or not, by predicting a binary dependent outcome from a set of independent variables.

The logit model emanates from the probability that an individuals' responses to WTP question regressed on given bid prices. The basic relationship is:

$$Prob.(yes) = F\eta\Delta v$$

$$= (1 - e^{-\Delta v})^{-1}$$

$$Prob.(yes) = 1 - \{1 - exp[\beta_0 - \beta_1 X_1 - \beta_2 X_2 - \beta_3 X_3 - \ldots\ldots - \beta_n X_n]\}^{-1} \ldots\ldots\ldots (5)$$

Where Fη is the cumulative distribution function α represents intercept, β_i represents the coefficients of the bid and socioeconomic variables, X represents the bid value the household is asked to pay and socioeconomic characteristics.

The logit regression model is specified as follows:

$$Y = \frac{1}{1 - exp^{-(\alpha^* - \beta A)}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Where, Y is the response of household to the willingness to pay question which is either 1 if yes or 0 if no, α* is the adjusted constant obtained by sum of the multiple of the coefficients by their means and constant by 1 except the bid value, β ($coefficient_k$*$mean_k$)

From Equation 2,which estimates the coefficients α and β, Hanemann (1989) provided a formula, for closed-ended question format, which was also applied by (Asafu-Adjaye and Tapsuwan, 2008; Jeanty, 2007; Hanemman *et al*, 1991; Loomis *et al.*, 1996, 1999;) for estimation of restricted mean and median WTP as follows:

$$Restricted\ mean\ WTP = \frac{\sigma\pi}{\sin(\sigma\pi)} exp\left[\frac{\bar{X}\beta'}{\beta_c}\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

$$Restricted\ median\ WTP = exp\left[\frac{\bar{X}\beta}{\beta_c}\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Unrestricted mean and median WTP is estimated using the following formula (Hanemann, 1989):

$$Unrestricted\ mean\ or\ median\ WTP = \frac{\alpha}{\beta} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

The mean maximum WTP for improved scheme, traditioal scheme and two systems pooled respectively was estimated using the following Ordinary Least Square models:

$$WTP = \beta_c - \beta_1 X_1 - \beta_2 X_2 - \beta_3 X_3 - \ldots\ldots - \beta_n X_n - \varepsilon_{ij} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (10)$$

Where:

WTP is the willingness to pay for improved irrigation water supply

σ is the standard deviation

π is the pie =3.14

$\alpha = \beta_0$ is the constant

$\alpha^* = \bar{X}\beta$ is an adjusted constant

exp. is the exponential term

ε_{ij} is the standard error

The decision on which variables to include in the model was based on suggestion by Rafferty (2008) cited in Hosmer and Lemeshow (2000) that variables which exhibit significance at p ≤ 0.25 level in univariate stage should be taken forward into the multivariate analysis. However, variables, which were significant at 5% probability level, ultimately predicted the mean and median WTP for close- and open-ended question format.

3.3.2.4 Estimates of benefits to improved irrigation water supply

The total benefits from improved irrigation water supply from well-protected watersheds estimated by multiplying mean WTP with a total number of households (Batemann *et al.*, 2006; Pearce and Ozemiroglu, 2002) engaged in small-scale irrigation schemes (i.e. traditional furrows and improved scheme) around Uluguru downstream obtained from Ward Executive Offices (WEOs) as follows:

$$\text{Aggregate WTP} = \sum_{i=1}^{n} N \cdot WTP \quad \ldots\ldots (13)$$

Where:

$\sum$ is the summation sign

N is a number of irrigating population

WTP is either a mean or a median willingness to pay

Aggregate WTP is total benefits from improved irrigation water supply payments

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Identification of Crops under Irrigation

4.1.1 Types of crops

Table 2: Types of crops and acreage under irrigation

Crop types	(%) of responses on irrigation	Area under irrigation (ha)	
		Wet season	Dry season
Paddy	37.6	0.38	0.32
Tomatoes	28.7	0.90	1.12
Water melon	2.8		0.40
Sweet pepper	5.0	0.32	0.43
Okra	2.8	0.34	0.23
Cucumber	2.2	0.30	0.35
Pumpkin	1.0		0.34
Onions	1.6		0.37
Leafy vegetable	6.7	0.14	0.07
Fresh maize	4.2		0.20
Eggplant	0.6		0.25
Ngogwe	2.0	0.50	0.27
Cabbage	0.8		0.26
Pepper	0.8	0.20	0.21
Maize	1.0		0.27
Yam	1.8	0.20	0.24
Banana	0.6	0.10	0.30

The results in Table 2 above present 17 types of crops mostly grown under irrigation system. About 32% of respondents mentioned paddy as the most grown crop. Other crops include tomato, leafy vegetables and sweet pepper. Banana and eggplant were the least irrigated crops in the study area. URT (1997) reported similar results that paddy grows in lowlands and river valley apart from other crops such as sugar cane, sweet potatoes, cassava and banana in Morogoro regions. The decline of traditional crops such as cotton, coffee, and sunflower has paved the way to other crops such as fruits, vegetables and sesame seeds (Paavola, 2004). Turpie *et al.* (2005) and Kadigi *et al.* (2004) reported that paddy grows most in upper basin and to less extent in lowlands or areas proximity to flood plains of Pangani River basin and Great Ruaha River Catchments. This could be attributed to the agro-ecological factor or increasing food demand in Morogoro municipal and Dar es Salaam city. Das (2000) attributed the difference in crops growing in different regions of the world to endogenous factors such as household goals, labour, technologies in use and resource base, and exogenous factors such as market availability, market development, shift in demand, agricultural service, policies, dissemination of new technologies and information.

Field observation in the area revealed that most households cultivate paddy in wet seasons due to higher water availability, except for few households at Kiroka irrigation scheme. The uses of high yield varieties (HYV) of paddy seeds have enabled the farmers at Kiroka irrigation scheme to grow even in dry season. Less pest infestations and idle crop areas after wet season harvests favour horticultural crops cultivation in dry season. Usangu plains in Rufiji Basin showed similar experiences (Kadigi *et al.*, 2004).

It was also found out that there was variation within and between seasons, and between crops in terms of acreage. In wet season, paddy had higher land size (0.38 ha per household) than other crops i.e. sweet pepper, okra, cucumber, leafy vegetables, yam and banana. In dry season, the paddy acreage was smaller than that for tomatoes, watermelon, sweet pepper and pumpkin, but larger than the rest of the crops.

Between seasons, the average cultivated areas for some irrigated crops such as paddy, okra, tomatoes, leafy vegetable and banana showed to decline while the average area for sweet pepper increased. Yams and ngogwe remained constant. Moreover, there were crops such as pumpkins, fresh maize, maize, cabbages, and onions, which were only cultivated in, dry season. The average area under paddy in Uluguru downstream is less than that reported by Kadigi *et al.* (2004) in Usangu plains. This may be due to high population density on the Uluguru Mountain foothills compared to Usangu plains (Lankford, 2002). Nevertheless, large proportion of protected areas and small proportion of arable land in Uluguru attribute to low area of paddy (Jones, 2004).

Leijdens (2008) argues that high value crops and fresh vegetable farms in Tanzania have average size between 0.5 and 1ha and a few have gone up to 4ha. However, the areas for various irrigated crops decline during dry season. Kadigi *et al.* (2004) are of the view that the decline of irrigation plots, is usually very small (i.e. 0.1-0.2 ha in dry season) and the main crops irrigated are maize, beans, tomatoes, sugar cane, onions and vegetables.

4.1.2 Crop yields and income

The figures in Table 3 below show yields and income for different crops under irrigation system in the downstream for two seasons of the year. During wet season, the yields of horticultural crops such as sweet pepper and tomatoes were over 10,000 kg per hectare (10 ton/ha) compared to the yield of 3743.10± 146.55 kg per hectare for paddy. Leafy vegetables had least yields. In dry season, yields of paddy per ha increased due to the use of improved seeds. However, the yield was still lower than that of leafy vegetables and other high value crops such as tomatoes and eggplants.

Yields for irrigated crops in Uluguru downstream households were less than what reported by Leijdens (2008), Turpie *et al.* (2005) and Kadigi *et al.* (2004), in studies in other river basins in Tanzania. Besides, the yields were found out to be less than the yield reported in other regions. FAOSTAT (1995) reported higher yields in Latin America and Caribbean (LAC) and Near East and North Africa (NENA) for paddy, wheat, maize and vegetables.

The variation in yields could be due to poor farming practices and lack of efficient irrigation infrastructures. Oweis *et al.* (1999) argue that the use of higher technology inputs such as HYV of seeds, chemical fertilizers, pesticides and herbicides irrespective of seasonal rainfall, increase crop yields. The Uluguru downstream households rarely used high technology farm inputs.

Table 3: Crop yields and income in Uluguru downstream, Tanzania

Crop types	Unit	Irrigation season			
		Wet		Dry	
		Yields	Income (TAS/ha)	Yields	Income (TAS/ha)
Paddy	Kg/ha	3 743.10 (146.55)	708 527.75	4 710.85 (705.80)	1 549 744.00
Tomatoes	Kg/ha	127 878.80 (676.00)	5 600 000.00	12 457.60 (587.70)	1 700 889.00
Water melon	Pieces/ha			6 674.50 (1338.60)	2 782 500.00
Sweet pepper	Kg/ha	10 050.00 (4427.50)	2 348 750.00	4 158.50 (636.20)	1 910 000.00
Okra	Kg/ha	3 266.10(0.00)	891 666.75	4 608.00 (854.35)	638 312.50
Cucumber	Pieces/ha			12866.70 (9533.35)	2 225 000.00
Pumpkin	Pieces/ha			2 817.75(984.10)	1 091 250.00
Onions	Kg/ha			3 670.30 (1808.35)	608 390.00
Leafy vegetable	Kg/ha	822.20 (195.60)	671 171.40	7 360.00 (2503.90)	107 291.70
Fresh maize	Pieces/ha			22 771.10 (7421.60)	240 312.50
Eggplant	Kg/ha			16 129.00 (0.00)	1 250 000.00
Ngogwe	Kg/ha	3 619.20 (1659.60)	1 926 625.00	2 746.80 (530.50)	270 781.30
Cabbage	Pieces/ha			1 554.00 (547.00)	292 500.00
Pepper	Kg/ha	3 000.00 (0.00)	375 000.00	1 079.55 (170.50)	256 250.00
Maize	Kg/ha			3 642.20 (578.50)	542 500
Yam	Kg/ha	3 600.00 (829.40)	533 125.00	3 881.25 (966.90)	2 060 000.00
Banana	Bunches/ha	2 500.00 (0.00)	617 500.00	500.00 (250.00)	468 750.00

Numbers in the brackets are standard errors of the mean

Results in the Table 3 also indicate the income generated by farmers for various crops under irrigation system. There are income variations for the same crops in the two seasons and between crops under irrigation. During wet season, income generated is higher than that of dry season for tomatoes, sweet pepper, "ngogwe" and pepper. For instance, the average incomes for tomatoes were about 5 600 000 and 1 701 000 TAS per hectare for wet and dry seasons respectively. Paddy, okra, and yam had higher income in dry season compared to wet season. The variation in income generated per season is probably due to the number of household engaged in production.

Nevertheless, the average income per hectare generated for most horticultural crops is higher than that for cereal crops. It seems likely that the low price of cereal crops such as paddy was probably the main reason for the low amount of cereal crops under irrigation sold in the market. It could also be attributed to the fact that high amount of cereal crops are used as staple food rather than crops for sale.

The decline in price of some crops under irrigation particularly in dry season could affect the willingness to pay of the households for improved irrigation supply because it also impinges on the household income.

4.2 Socioeconomic determinants of Willingness to Pay (WTP)

4.2.1 Descriptive statistics of socioeconomic variables and survey responses

Table 4 below shows descriptive statistics of socioeconomic variables for sampled households in the improved scheme and traditional scheme. Respondents to the two irrigation systems of the survey questionnaire are relatively close in terms of average number of years of the household (age), number of individuals in the household (household size), number of years in school (education) and total landholding of the household (land size). Moreover, it was also in terms of percentage of household's employment status (occupation), and whether or not living as a couple and their location of farm fields from water sources (distance).

Table 4: Descriptive statistics of socioeconomic variables

Demographic variable	Improved scheme		Traditional furrows	
	Mean	Std	Mean	Std
Age (yr)	46.25	11.76	43.74	13.31
Education (yr)	6.59	3.22	7.16	2.86
Household size	5.27	1.95	5.47	2.03
Land size (ha)	1.46	0.86	1.62	0.93
Annual irrigated income (TAS)	1 612 410	1 452 718	2 053 263	2 422 552
Dummy variable		**Percent**		**Percent**
Sex		59		65
Marital status		87		82
Occupation		60		62
Distance (0-250m)		78		76
Water status		21		43
Prior Knowledge		90		79
Protection		94		88

However, the two types of scheme differ in terms of annual income generated from irrigated crops. This is because traditional furrows scheme's income is higher than that of improved scheme. The higher income for traditional furrows could probably be attributed to larger size of land cultivated in the traditional furrows than that of improved scheme. Besides, the percentage of responses for male sex engaged in irrigation is high in non-scheme whereas the percentage of households living as couples (marital status), and awareness on the presence of watersheds and their conditions (prior knowledge) were higher in improved scheme than in traditional furrows.

Results indicate that the majority of respondents in both irrigation systems were aware of at least one watershed out of the three: Mgeta, Ruvu and Ngerengere. It was also found out that the respondents were of the roles these watersheds play on their daily lives. Respondents were also aware of the status of irrigation water in their respective areas that was insufficient, particularly in dry season.

A good percentage of respondents relate insufficient irrigation water with degradation of watersheds and riverbanks (27%) and (33%), uncontrolled diversion in river basin (29%) and (22%) and poor irrigation infrastructures (21%) for improved and traditional scheme respectively. A few respondents believed that the growing population both downstream and upstream were the causes (7%) and (10%) for the two schemes respectively. The situation has negative effects on households' livelihood since it leads to low crop harvests, higher expenditure for irrigation water acquisition and hence low income.

Majority of the respondents were of the view that protection of these watersheds and their riverbanks was important due to their vital role on the supply of irrigation water for the existing and future generations and improving water quality, reduction of sediments and conservation of biodiversity.

However, a few respondents (17%) in improved scheme were pessimistic with if protection of watersheds and riverbanks can improve irrigation water supply. The number of respondents (50%) was higher in traditional furrows. The responses on contingent valuation questions, in the case of improved scheme, the results indicate that the percentage of respondents who were ready to participate in the improved irrigation water supply programme was higher than those who were not ready. However, in the traditional scheme, the percentages were equal.

Reasons for most respondents' willingness to pay for improved irrigation water supply, from well-protected watersheds, were found out to be the need for reliable irrigation water supply for the existing and future generations and the need for production more than once per year.

Table 5: Responses on contingent valuation questions

Question	Improved scheme (N=63)	Traditional furrows (N=156)
1. Are you willing to participate in the programme?	Percentage	Percentage
Yes	50.8	50.0
No	49.0	50.0
2. Please indicate the reason why you are willing to contribute to the project		
I need more reliable water supply.	28.6	29.8
I would like the future generations to have reliable water supply, too.	26.2	23.9
I am optimistic that the council will do a good job in administering the fund.	15.5	7.8
I want to produce more than once per year.	25.0	28.3
I want to reduce water acquisition costs.	4.8	10.2
3. If you are not willing to contribute any amount to the project, please identify your reason/s		
I am willing to pay but the tariff proposed is too high	23.4	26.8
I cannot afford to pay any amount because the income generated from irrigated crops are too low	36.2	44.1
Government should be responsible	10.6	11.0
I'm pessimistic with council that will administer funds well	6.4	0.0
I don't care about water reliability	0.0	0.8
I don't believe if payment improves irrigation water supply	12.8	3.9
I am not ready till the government evacuates upstream dwellers	10.6	10.2

For respondents who were not willing to pay for the programme, there were two categories. The first category was that of respondents who wanted to pay but either income generated from irrigated crops or tariffs imposed constrained them from paying readily. The second category was made of respondents who protested payment for the programme with a reason that it was the government's role to supply water to its people. Other respondents were of the view that upstream dwellers were posing threats to the sustainability of water resource, should be evacuated in order to conserve watersheds.

Similar qualitative analysis to find out if the respondents were aware of the environmental goods and services had been carried out in various contingent valuation studies, although the findings indicate variation (Asafu-Adjaye and Tapsuwan, 2008; Ly *et al.* 2006; Mathew, 2006; Tiwari, 1998). The variations may be attributed to varying degrees on the levels of awareness on the environmental quantity and quality and socioeconomic factors affecting an individual.

4.2.2 Inferential statistics

4.2.2.1. Hypothesis tests

Appendix 3 presents the test for the hypothesis that WTP for improved irrigation water supply for traditional furrows irrigation scheme is higher than for improved scheme. Both t-test and log-likelihood ratio (LLR) test were used to test whether the WTP for traditional furrows was higher than improved schemes. The t-test, using independent samples, indicated that there was no any significant difference between the two schemes. The same result was also found when the log-likelihood ration test was used after pooling the data (i.e., the coefficients are restricted to be equal across the two schemes) against the sum of the separately estimated log-likelihoods ratio (i.e., the coefficients are allowed to be different across the two schemes). This could be probably that the utility for irrigation water, for the two irrigation systems, is similar. That is both scheme face the same water scarcity.

4.2.2.2 Probabilities of yes response to hypothetical bids

Table 6 below presents the estimates of coefficients across the improved scheme, traditional furrows scheme and safely pooled data models after t-test and LLR test have been clearly shown. The number of variables has been included in the models. All models for improved scheme, traditional furrows and pooled data are statistically significant ($P \leq .0.01$) because the calculated χ^2 > than tabulated χ^2.

It was also found out that results show that the coefficient estimates of variables such as marital status, income level, land size, water status, and prior knowledge had positive coefficients and statistically significant at different probability levels ($P \leq 0.01$ - $P \leq 0.1$).

However, the income for traditional scheme, prior knowledge for improved scheme and Traditional furrows irrigation scheme, land size and water status for improved scheme and marital status for traditional furrows and the pooled data respectively, were not statistically significant. In overall, land size, water insufficient (status) and income had the strongest positive relationship with WTP.

Table 6: Multivariate logit regression

Variable	Pooled (N=219)	Traditional furrows (N=156)	Improved scheme (N=63)
Constant	6.8571	3.8695	24.0849
	(1.9684)***	(2.4206)	(8.5678)***
Bid	-1.415×10^{-4}	-1.26×10^{-4}	-3.99×10^{-4}
	(2.98×10^{-5})***	(3.66×10^{-5})***	(1.46×10^{-4})***
Annual irrigated crop income	2.49×10^{-7}	2.29×10^{-7}	1.46×10^{-6}
	$1.34 \times 10^{-7})$*	$(.55 \times 10^{-7})$	(6.89×10^{-7})**
Sex	0.16978	0.4015	-0.8549
	(0.4642)	(0.6106)	(1.0915)
Marital status	0.3921	0.3839	3.4415
	(0.6152)	(0.8060)	(1.8632)*
Age	-0.0911	-0.0734	-0.2866
	(0.0230)***	(0.0268)***	(0.1063)***
Education	-0.0143	0.1356	-0.6143
	(0.0819)	(0.1334)	(0.2575)**
Household size	-0.3227	-0.2430	-0.6959
	(0.1300)**	(0.1836)	(0.3174)**
Occupation	-1.7260	-1.8169	-2.7224
	(0.4848)***	(0.6637)***	(1.5076)*
Land size	1.0431	1.2386	0.0757
	(0.3335)***	(0.4523)***	(0.7274)
Distance	-1.7486	-1.7816	-3.7850
	(0.6196)***	(0.8068)**	(1.9817)*
Water status	0.8958	1.0749	2.6849
	(0.5087)*	(0.6163)*	(1.7433)
Alternative source	-0.8615	-0.9413	0.9759
	(0.6453)	(0.7484)	(1.9022)
Prior knowledge	(1.1806)	1.1983	1.5429
	(0.6604)*	(0.8463)	(1.8648)
Log-likelihood	-73.30	-45.95	-18.87
Logistic regression chi-squared	156.78	124.12	49.59
Pseudo R-squared	0.519	0.575	0.568

Significance levels at 1%, 5% and 10% are denoted by three, two and one asterisk(s), respectively and in brackets are standard error of the mean.

This implies that utility function of improved irrigation water supply is an increasing function of land size, water insufficient and income from irrigated crops. Meanwhile, the bid price, age, household size, occupation, distance, alternative sources and education had negative coefficients in improved scheme and positive in traditional furrows. Besides, the coefficients were statistically significant at different probability levels ($P \leq 0.01$ - $P \leq 0.1$) for pooled and all schemes except household size and education level for traditional scheme and pooled data.

Nevertheless, coefficients for bid price, age, distance and occupation had stronger negative relationship with the willingness to pay for improved irrigation water supply than the rest. This implies that as the bid price, number of years of household head and the closer the distance of farm field to water source increase, utility function decreases. Furthermore, being solely reliant on farm employment reduces income that ultimately influences negatively on the vote for willingness to pay for improved irrigation water supply. Vargas (2004) and Tiwari (1998) observed similar results on the effects of bid and income on WTP for watersheds conservation and irrigation water supply respectively.

Table 7: Multivariate linear regression model

Variable	Improved scheme (N=63)	Traditional furrows (N= 156)	Pooled (N=219)
Constant	-2710.46 (1259.25)**	2165.52 (4135.85)	2001.01 (3057.18)
Bid	0.9044(0.0389)***	0.7772 (0.0954)***	0.8035 (0.0637)***
Annual income	0.0013 (0.0003)***	0.0013 (0.0003)***	0.0013 (0.0002)***
Marital status		2764.20 (1816.15)	2742.18 (1373.32)
Age		-123.20 (56.58)**	-105.02 (42.71)*
Education	330.92 (107.78)	-358.61 (250.56)	-242.02 (166.75)
Occupation	713.17 (613.11)		
Land size		632.50 (696.40)	
Distance	733.08 (683.45)	1411.15 1530.24)**	1464.20(1072.32)
Water status	1422.57 (810.98)*	4244.18(1704.15)	3678.91(1212.14)**
Alternative source	4997.64 (1353.69)***h	2874.88(1997.10)	2821.58 (1512.61)
Adj.R-squared	0.960	0.662	0.727

Significance levels at 1%, 5% and 10% are denoted by three, two and one asterisk(s), respectively
Pooled, F (8,104) =38.33, Traditional scheme, F (9, 71) =18.39, Improved scheme F (7, 24) =108.0, in brackets are standard error of the mean.

Moreover. Table 7 above presents results of variables included in the model to determine factors that influence WTP in open-ended bid questions. The models were statistically significant ($P \leq 0.01$) as indicated by the calculated F-statistic > tabulated F-statistic. A small share of variables has indicated to have significant correlation with the WTP for improved irrigation supply. It was also revealed that the bid amount and irrigated crop annual income level were statistically significant ($P \leq 0.01$) across the two schemes and the pooled data. This implies that WTP increases with increasing bid and income.

This is contrary to the closed- ended dichotomous choice above where the bid is negative and WTP is a decreasing function. This could be attributed to the fact that the bid levels were too low to negatively affect the WTP of higher income earners. Besides, the WTP for environmental goods and services depends on the ability to pay (ATP).

4.3 Estimation of Economic Benefits of Improved Irrigation Water Supply

4.3.1 Estimate of mean and median willingness to pay

Fig. 2, 3, 4 and 5 below present the relationship between bid and WTP i.e., the higher the price gap between improved and non-improved irrigation water supply the less probability to vote for improved irrigation water supply.

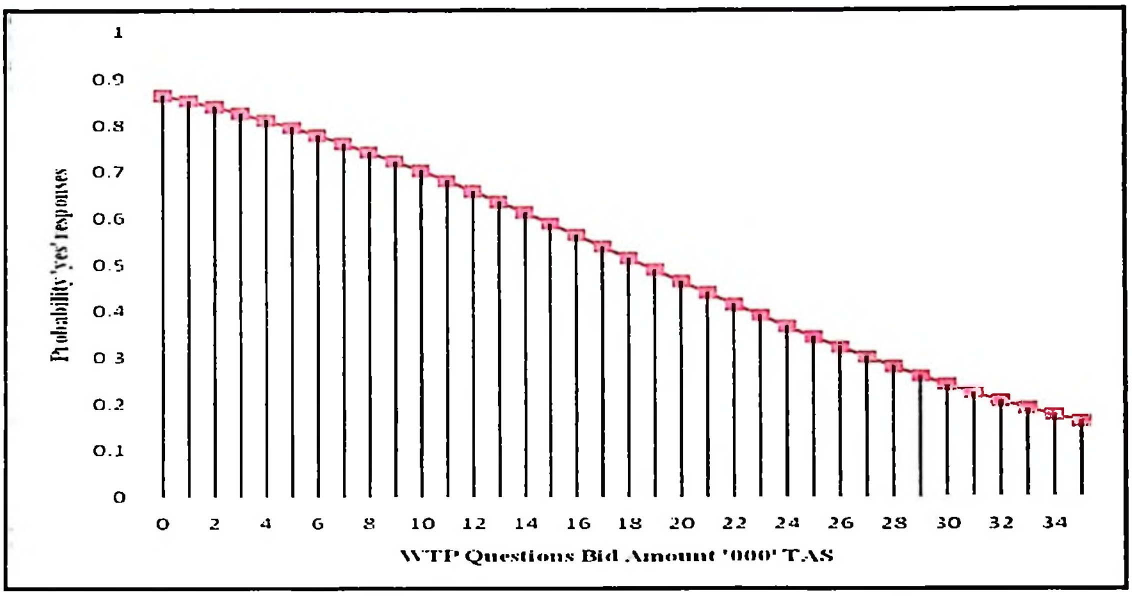

Figure 2: Probabilities of yes response to hypothetical bids for dichotomous choice for improved scheme.

The probability of saying, "yes" to starting bid amount of TAS 6 000 higher than the current annual fee of TAS 5 000 was predicted to be 0.774, 0.772 and 0.778 for improved scheme, traditional furrows and two groups pooled respectively.

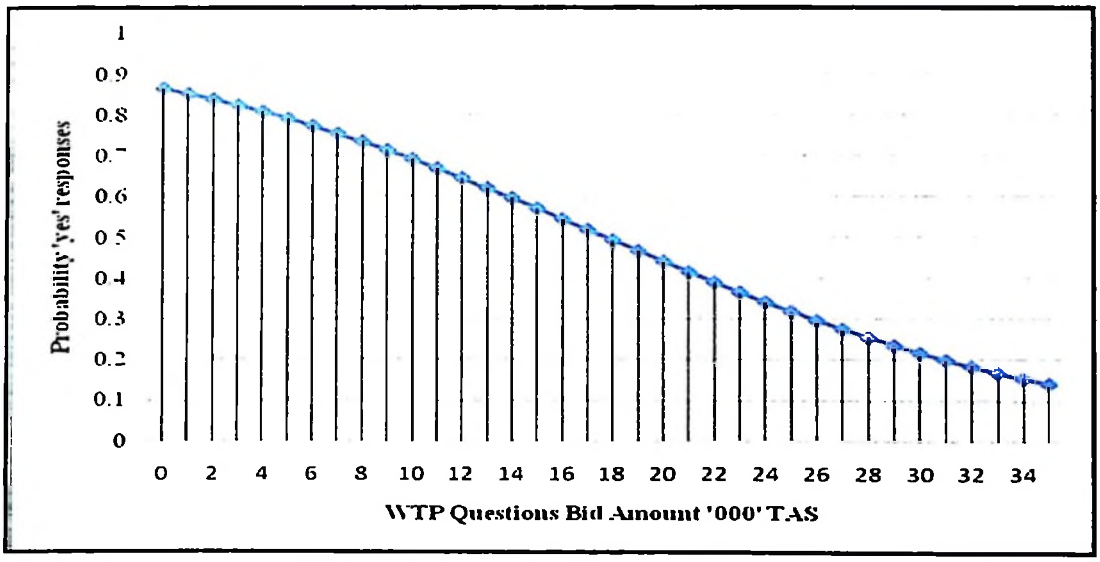

Figure 3: Probabilities of yes response to hypothetical bids for dichotomous choice for traditional furrows.

From the curve, the median is interpolated at probability 0.50 (i.e. 50[th] percentile, which is estimated at TAS 18 600, TAS 17 700 and TAS 17 900 for improved scheme, traditional furrows and Pooled respectively (see also Appendix C).

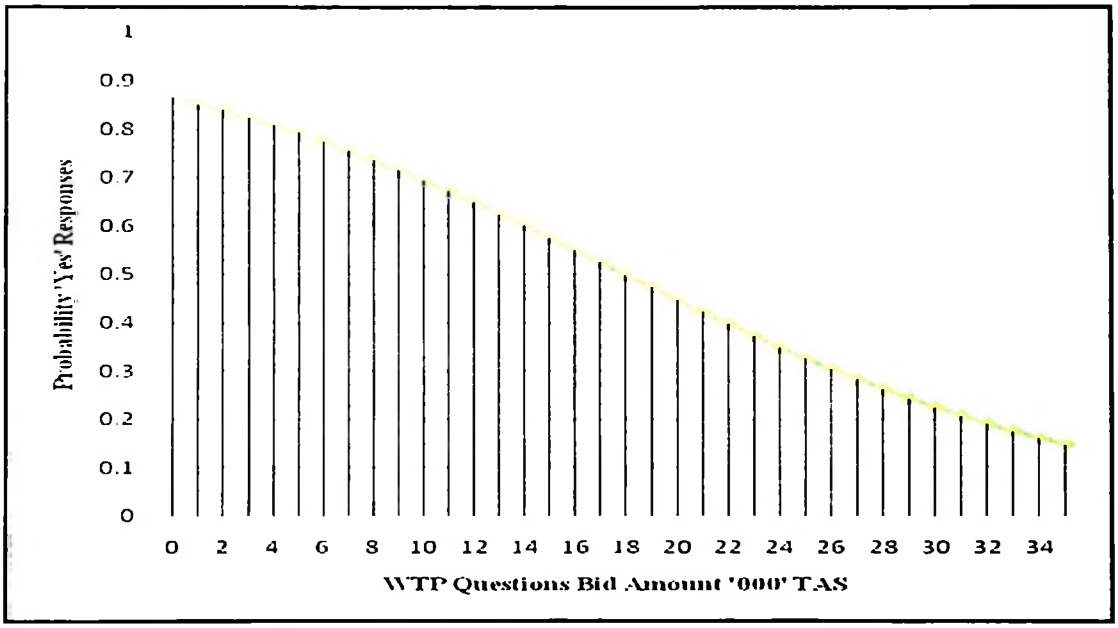

Figure 4: Probabilities of yes response to hypothetical bids for dichotomous choice for pooled data.

Table 8 below shows a summary of consumers' surplus for improved irrigation water supply for single-bounded format question. The mean and median WTP across the schemes and pooled data are too close. This indicates that the difference is not statistically significant. The mean WTP for unrestricted linear logit regression model is slightly higher than that for restricted multivariate logit regression model (log logit model) across the schemes and pooled data. However, the restricted mean WTP for traditional scheme is higher than unrestricted mean. This could be attributed to the strategic bias effects of respondents for improved irrigation supply. Besides, the median WTP value for unrestricted logit model is higher than the restricted median WTP.

Table 8: WTP for improved irrigation water supply for single-bounded format

Statistic	Improved scheme (N=63)		Traditional furrows (N=156)		Pooled (N=219)	
	Unrestricted	Restricted	Unrestricted	Restricted	Unrestricted	Restricted
Mean	18 557.50*	16 173.00	17 670.50*	18 337.90	17 928.30*	17 900.80
Median	-	15280.50	-	14 822.30	-	14 545.95

*Unrestricted mean WTP=unrestricted median, WTP values in TAS

The mean and median WTP for improved scheme were found out to be higher than those for traditional furrows. This could be due to the exposure of the improved scheme farmers to payment (annual membership fee) for water right and regular maintenance of the scheme. Asafu-Adjaye and Tapsuwan, (2008), found out the same trend for payment of environmental conservation of Scuba diving site between Thais, who frequently use the site for diving and overseas divers. The mean WTP value was higher for the Thais.

Table 9 presents the mean WTP value for open-ended questions, which sought to collect information on the maximum willingness to pay of an individual household head. For the case of improved scheme, the mean WTP was correlated with bid amount, income from irrigated crops, education, household size, occupation and alternative source. Furthermore, bid and income for traditional furrows, bid, income, water status and income for pooled data (see Appendix 7). Again, the mean and median WTP values were found out be different but not statically significant because they were too close to each other. The maximum willingness to pay for households practicing improved irrigation was seen to be higher than in traditional scheme and even for the pool data.

Table 9: WTP for improved irrigation water supply for open-ended format

Statistic	Improved scheme (N=63)	Traditional furrows (N=156)	Pooled (N=219)
Mean[1]	17 875.00	16 665.40	17 017.30
Median[1]	16 000.00	15 000.00	15 500.00
Mean[2]	17107.20	15 849.50	16 423.50

[1]Discriptive estimates, [2]Multiple regression estimates, values in TAS

However, the estimates of mean WTP for improved irrigation water supply for open-ended question format was lower than the mean WTP for dichotomous choice (i.e. single bounded referendum). Ly *et al.* (2006), Leon and Vazquez-Polo (1998) and Loomis *et al.* (1996), in their studies, reported the same observations in the economic values estimated by the two CV elicitation formats. These results also comply with standard neo-classical assumptions or are in accordance with the theory (Pearce and Ozemiroglu, 2002).

These values are interpreted as consumers' surplus for improved irrigation water supply. The consumers of irrigation water (i.e. downstream irrigating households) would be willing to pay if the new fee between the status quo and improved irrigation water supply ranged between TAS 14 545.95 - 17 900.80 per household per annum for both close-and open-ended question format. This amount is lower than the WTP for improved water supply (for domestic uses) in Mkoji Sub-catchment (MSC), Rufiji Basin of USD 87 and 32 per person per year for very rich and rich and for very poor and poor respectively (Mahoo *et al.*, 2007). This implies that investment on watersheds protection for improved irrigation water supply for domestic uses could be preferred to irrigation because every household needs water for daily uses. Therefore trade-offs should be reached before making decisions on water resource allocation to different uses (which use be given first priority and what season of the year) lest not to affect investment on watershed conservation projects. The trends in Fig. 2, 3, 4 and 5 above and Appendix 6 comply with Marshallian Consumer Theory that the demand for more quantity decreases as the price of a commodity increases.

The trend in figure 5 also indicates that out of those households willing to pay, the majorities were willing to pay an amount slightly higher than the usual charge. This implies that households in the area were willing to participate in the watersheds conservation and improved irrigation water supply project.

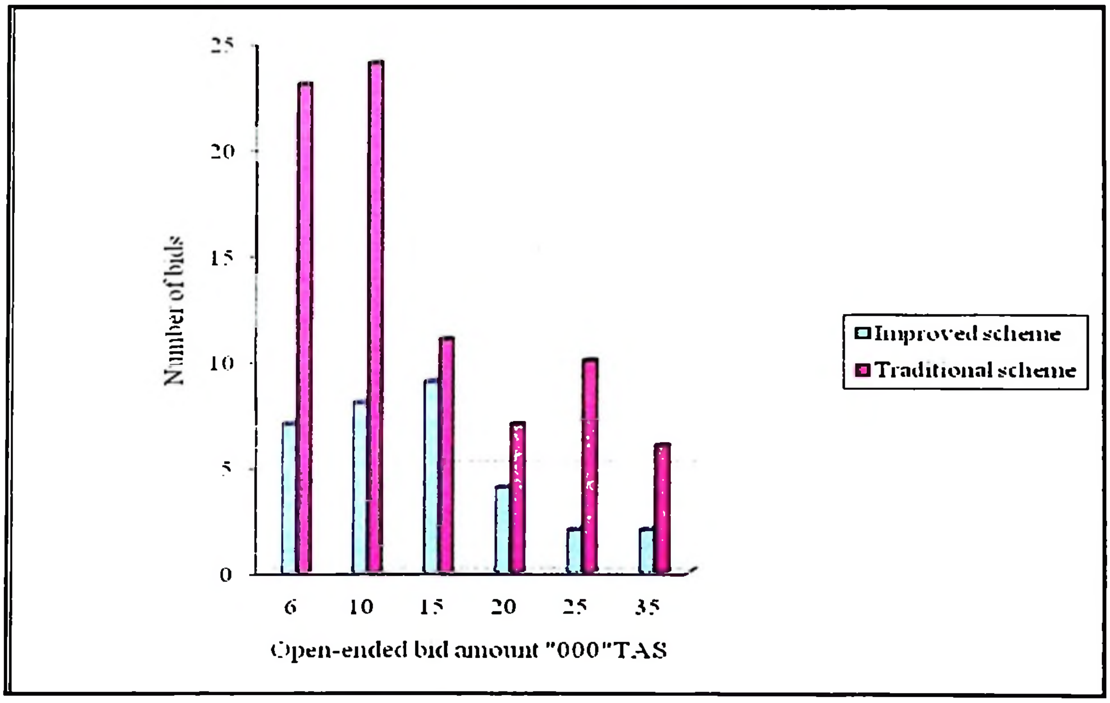

Figure 5: Distribution of responses counts to open-ended bid values.

Besides, WTP is less affected by starting point bias that affects most of the close-ended question bids.

4.3.2 Estimate of benefits to improved irrigation water supply

Table 10 below indicates the aggregate WTP value, which is the total benefit per year that a project gains from improved irrigation water supply. The aggregate WTP uses the median WTP from the sample results to estimate benefits to the population. This payment targets all households practicing small-scale irrigation (i.e. user of irrigation water) in the Uluguru Mountains downstream. The restricted median, which is estimated from statistically significant variables in pooled data from the two samples, is chosen for estimation of aggregate WTP. The choice for median WTP instead of mean WTP is because the median WTP is the value that divides the sample exactly in half (i.e., the value of WTP at which exactly 50% of the sample has lower WTP and 50% have higher WTP. This is relevant in the context of public choice i.e. the economic analysis of political decisions (Pearce and Ozemiroglu, 2002).

Table 10: Benefits estimates for improved irrigation water supply

Households under irrigation (N)	Statistic (median)	Aggregate WTP (in TAS)
5 398	14 545.95	78 519 038.10

The estimated benefit was 78 519 038 TAS, higher than that could be accrued from the normal fee of 5 000 TAS totaling 26 990 000 TAS per annum for the same number of households. Therefore the gain from paying extra for improving irrigation water supply was found out to be 51 529 038 TAS per annum. Nevertheless, the estimates are lower than those reported by Vargas (2004) and Tiwari (1998). This could probably be due to difference in bid price, income, education levels, water allocation and level of scarcity of the resources between the three locations.

The results present a true value of respondents towards improved irrigation water supply to households under irrigation in the Uluguru Mountains downstream and show the preparedness of irrigation water consumers for support of payment for environmental service policy if put in place.

4.4 Assessment of Water Governing Institutions Strengths and Arrangements

4.4.1 Institutional strength

Table 11 shows that majority of respondents agreed (in improved scheme (91%) and traditional furrows scheme (62.8%)), that there was water-governing institution in their areas, while 6.4 % and 8.1% of respondents responded that, they did not know. Of the respondents who replied "yes", majority said that the institutions were weak (not strong) in managing water resources. Mbeyale *et al.* (2004) reported similar observations about strength of water-governing institutions in Pare, Tanzania. Nevertheless, these results are contrary to findings on the role of institutions in a south India canal system by Rajagopal (2000) where institutions in a single caste were significantly stronger in maintenance and water resources allocation.

Moreover, a study on water rights in indigenous irrigation system at Marakwet, Kenya by William *et al.* (1997) indicated that there was an effective mechanism for water resource allocation and management.

Table 11: Household head responses on institution strength

Question	Improved scheme (N=63)	Traditional furrows (N=156)
	Percentage	Percentage
1. Do you have any water governing institutions in your area?		
Yes	91.0	62.8
No	2.6	29.1
I don't know	6.4	8.1
2. Are they strong in governing water resources?		
Yes	49.2	35.9
No	50.8	64.1
3. What are their strengths? Please rank them (1 the strongest, 5 weak)		
Village water committee	20.0	21.2
Association of Irrigation farmers	21.3	20.6
Irrigation unions	20.0	19.2
Water right	20.0	18.6
Cultural rules or norms	18.7	20.4

Regarding institutions performance, households under improved scheme ranked association of irrigation farmers as the best performer, while those under traditional furrows scheme ranked village water committee as the best. The ranking was different probably because water management and allocation in the two irrigation systems are under respective institutions. The results were different from observations by Johnson *et al.* (2002), Meinzen-Dick *et al.* (2002), and Vermillion (1999), in which water management and allocation were under water user associations (WUA) and were reported to perform well in terms of management and allocation. In the case of Uluguru downstream, only two water user associations were underway for establishment.

4.4.2 Institution arrangements

Table 12 above shows the basis for charging water fee and institution to be assigned the role to manage water resources in case the project comes to implementation. Most of the respondents in the two schemes preferred volume of water used basis to other user charges basis. Only 2.6% of respondents indicated that income and number of household members respectively should be the basis for charging water fee.

The survey results were different from the findings reported by FAO (2004), and Tardieu and Prefol (2002), in other areas where the charging of irrigation water was based on the farm area and crop type. This is because it is simple to apply notwithstanding, low fee recovery compared to volume of water based. The choice of Uluguru downstream irrigation farmers on volume of water used perhaps was based on the desire to control inefficient and wasteful uses that deprive other irrigation farmers of the right to use the resource.

Table 12: Household head responses on institution arrangement

Question	Improved scheme (N=63)	Traditional furrows (N=156)
	Percentage	Percentage
4. What do you think should be the basis to determine the irrigation water fee? (Choose only one)		
Volume of water used	57.1	49.7
Farm area based	3.2	12.9
Number of Household members	0.0	2.6
Fixed rate	39.7	32.3
Income	0.0	2.6
5. Which organization should take role to collect your irrigation water fee for improved irrigation water supply for watershed protection?		
Village water committee	30.3	27.0
Water user association	49.0	60.3
Catchments office	7.7	7.9
River basin office	5.2	1.6
Private organization	3.2	3.2
Irrigation unions	2.6	0.0
No trustworthy for all of the above	1.3	0.0
No comment	0.6	0.0

However, the volume-based (volumetric) approach requires political commitment and practical system assessment, billing and enforcement for successful implementation. Besides, majority of the irrigation farmers practice traditional irrigation system, hence there need for installation of irrigation infrastructure before institution of metering.

Furthermore, the results indicated that majority of respondents had a sound trust in the water user association (WUA), as an institution that would be efficient collecting payments for improved irrigation water supply. A portion of other respondents opted for village water committee and irrigation unions. The least percentage of respondents voted for catchments office, River basin office and private organization as institutions suitable for the collection of fee. The rest had neither indicated their trust nor gave their comments. The choice of WUA and Village water committee was probably because of fact that the two institutions had been familiar to them.

Khanal (2003) and Easter *et al.* (1998), reported significant management responsibilities by farmers' irrigation associations through water users associations (WUAs). Vermillion and Garćes (1996), Johnson *et al.* (1995), and Oorthuizen and Kloezea, (1995) relate significant responsibility with management of water, costs and financial resources (and lowering in irrigated area, increasing cropping intensity and yields (Wester *et al.*, 1995; Pant, 1994). The respondents' choice probably was based on the assumption that farmers' irrigation associations are non-partisan, non-political and homogenous bodies, which perform the irrigation management tasks as designed. The WUAs play intermediary roles between government agencies and farmers

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusions

The findings from the study revealed that most households grow paddy whose affinity to water is higher and has less values compared to other crops under irrigation such as vegetables whose demand for water is relatively low and but with high values in the market. This reduces the household income of the most households in Uluguru downstream whose livelihoods rely on farming only, taking into account that micro-irrigation systems, and watersheds, which supply water for irrigation, are under threat of upstream communities.

Income, water scarcity, land size and prior knowledge of watersheds were sources of positive willingness to improved irrigation water supply. A unit increase of a factor also increases WTP for improved irrigation water supply. However, bid level, age, closeness to water source, lower education level and household size were found out to have negative relationship with WTP for improved irrigation water supply. A unit increase of a factor decreases the WTP.

The mean WTP value per household per year and aggregated WTP value, for both close-ended and open-ended question formats were larger than annual membership fee paid for payment of water right fee and maintenances. This shows that irrigation water is scarce and the reasons behind this scarcity are watersheds and riverbanks degradation, and uncontrolled diversion of water.

More than 50% households were willing to invest in improved irrigation water supply. However, the presence of majority who depend on traditional furrows irrigation scheme and weak water governing institutions, as manifested by uncontrolled diversions of water to farm fields by upstream communities and traditional furrows scheme households and non-hierarchical arrangements of institutions from central to local level, hinder equity allocation of irrigation water.

CV proved to be a potential method for assessing the benefits of improved irrigation water, though it requires many precautions during its implementation in the field for estimates to be useful, especially where there is no price instituted or market price distortion and other non-marketed environmental goods and services like in Tanzania.

5.2 Recommendations

Basing on the conclusions above, there is a need for the government to supply high value crops such as horticultural crops and high yield varieties of cereal crops, with less affinity to water for upstream and downstream communities respectively, to increase crop productivity and household income. This will reduce excessive freshwater demand for irrigation, which poses negative externalities to other biodiversities whose existence also rely on this ecosystem service and ecosystem degradation.

The government and its development partners should provide education to at least secondary level to increase literacy to riparian communities along the Uluguru Mountains watersheds and the knowledge on importance of ecosystem and its goods and services should be taught from lower, the environmental custodian of the future, to higher level.

The lower the literacy level, the lower the willingness to pay for improved irrigation water supply and other ecosystem services.

It is now high time for the government to use economic instruments for protection of watershed and riverbanks to ensure sustainable supply of irrigation water (an ecosystem service) for existing and future generation by including externalities costs borne by other users in the market value. However, this can be possible through bargaining between upstream and downstream communities depending on who have right over the resource. Hence the establishment of property right is important.

There is also a need to improve from tradition furrows to improved traditional scheme, if not to construct modem irrigation schemes, to control inefficient use and wastage of freshwater resource because majority of farmers use tradition furrows and are willing to invest in improved irrigation water supply. This will solve the problem of uncontrolled diversions, the source of conflicts.

Furthermore, Institutional frameworks stipulated in water regulation Act of 2002 should be implemented by devolving power to local institutions such as WUA and facilitated to build their capacity so that they can make decision on how well to allocate freshwater resource to different users and ensure sustainable management. Increasing participation of women in decision-making is vital.

Lastly, there is a need for more researches to validate these research findings, either using CV or other valuation techniques on economic value of improved irrigation water supply and quality in the area to have a reliable baseline data for irrigation water pricing which will be utilized as a basis for PWS and water market.

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APPENDICES

Appendix 1: Contingent Valuation Survey (Questionnaire)

1: QUESTIONNAIRE FOR HOUSEHOLDS

Basic Information:

Name of Respondent: ____

Village ____
Ward/Districts: ____
Date of Interview: ____________ Interviewer: ____________
Time Interview Started: ____________ Time Interview Ended: ____________

Introduction

Good morning/afternoon/evening! I am ____________ from the Sokoine University of Agriculture, Morogoro, and I am part of a research team conducting a study to estimate the value of the improved irrigation Water supply from well managed watershed to Irrigators in Uluguru landscapess. I would like to assure you that the information that you will reveal in this interview will be used solely for purposes of research, and that your identity as well as your answers will be treated with confidentiality. In answering my questions, please remember that there are no correct or wrong answers. We are just after your honest opinion.

A.1.1. Questionnaire for Assessment of Demographic and Socio-economic profile of respondent and household

1. Gender:
_____ 1. Male
_____ 2. Female

2. Age: ________ Years

3. Marital Status:
_____ 1. Single
_____ 2. Married
_____ 3. Widowed
_____ 4. Divorced

4. Educational attainment (No. of years):
_____ 1. No formal schooling
_____ 2. Primary level
_____ 3. Elementary graduate
_____ 4. High school level
_____ 5. Vocational
_____ 6. Certificate level
_____ 7. Diploma graduate
_____ 8. Bachelor
_____ 9. Higher than Bachelor

____ Others (Please specify) ________________

5. Occupation
____ 1. Farming
____ 2. Self-employed (e.g. Retail trader, kiosk, carpentry, restaurant etc.)
____ 3. Government/ State enterprise employee
____ 4. Private sector employee (e.g. company)
____ Others, please specify ________________

6. Number of members in the household:
____ 1. Adult persons
____ 2. Children below 18 years (dependents)

7a. What is the primary source of irrigation water (wet season) for your crop field? (Choose one)
____ 1. River basin
____ 2. Rainwater harvesting
____ 3. Well
____ 4. Pond (Natural borehole)

7b. what is the primary source of irrigation water (dry season) for your crop field? (Choose one)
____ 1. River basin
____ 2. Well
____ 3. Pond (Natural borehole)

8. What is the type of irrigation system in your field?
____ 1. Improved traditional irrigation (Scheme)
____ 2. Traditional irrigation (Stream diversion)

9. In case of dry season, how does irrigation water reach your farm?
____ 1. through improved irrigation canals
____ 2. through tradition furrows
____ 3. through machine pumping from the source
____ 4. through bucket watering

10. How far is your field located from water source? (Choose only one)
____ 1. < 100m
____ 2. 101-500m
____ 3. >500m

11. Do you have any water allocation per week?
____ 1. yes
____ 2. no

12. How would you rate the availability of water in your field? (Please choose one)
____ 1. Sufficient
____ 2. Insufficient
____ 4. Not available

13. Can you give us the types of crops, which you cultivate, season of cultivation, farm area, and the total household land?

S/No.	Irrigated crops Type	Cultivation season	Farm Area	Rainfed crops Type	Cultivation season	Farm Area	h/hold land size
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

14. Following the sequence in (13) above, how much crop did you harvest in the last season in terms of kg/ha or kg/acre? How much you sold? What are their values?

S/No.	Irrigated crops				Rainfed crops			
1	Q/ha	Quant. sold	Unit Price (Tshs.)	Value/ha (Tshs./ha)	Q/ha	Quant. sold	Unit Price (Tshs)	Value/ha (Tshs./ha)
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

15. What are the expenditures incurred by your household?

S/No.	Item/Activity	Please tick (√)	Expenditure (Tshs.)
1	Seed		
2	fertilizers		
3	Cultivation		
4	Labour charge		
5	Drinking water fee		
6	Irrigation water fee (Tshs/ha/year)		
7	Land rent		
8	Others please specify		

16. The household total annual income (Please put a tick)

1.- ≤ Tshs. 150,000
2.Tshs. 150,001-200,000
3.Tshs. 200,001-300,000
4. Tshs. 300,001-400,000
5.Tshs. 400,001-500,000
6.Tshs. 500,001-600,000
7.Tshs. 600,001-700,000
8.Tshs. 700,001-800,000
9.Tshs. 800,001-900,000
10.Tshs. 900,001-1,000,000
11. >1,000,000

1.2 Questionnaire for Assessment of Watersheds Awareness and concerns

The interviewer should let the respondent answer Qn. 1&2 before briefing about watersheds and its role for water supply.

A watershed is like a kitchen sink. You've seen how the kitchen sink catches water from the faucet and drains this into an outlet. The watershed works in a similar manner. It also catches water, though from the rain and not from the faucet, and drains the water through a network of rivers and streams in the area, until it reaches a common outlet.

You can also think of the soil in the watershed as a sponge that absorbs water. If you cover the sink with a sponge and turn on the faucet, it will take some time before water will be drained because the sponge will absorb most of it first. Thus, the more water is absorbed, the less will go down the drain. In the case of watersheds, the more water it absorbs, the less water will go to the lowlands. In effect, the more water is absorbed, the fewer floods there will be. Also, the more water is stored in the watershed; the better will be the water supply during times when there are no rains. We are not saying, however, that a well-managed watershed will prevent the occurrence of floods and droughts. With prolonged rains, floods can result even from the best-managed watersheds. Likewise, droughts can happen during extremely long dry seasons.

The interviewer will demonstrate this using a small basin with one hole (outlet), a container of water, and a piece of sponge big enough to cover the bottom of the basin. Initially, only a small amount will be poured, which the sponge will absorb. As more water is added, some of it will be drained or retained on the surface, representing a "flood."

However, the amount of water that can be stored in the watershed is largely affected by its land uses. It is widely accepted that maintaining a good forest cover increases the capacity of the watershed to store water and regulate its flow. But as you may already know, our country is fast losing its forest cover. Deforestation and poor land use practices are common and these have damaged the hydrologic condition of many of our watersheds. As a consequence, floods during the rainy season and droughts during the dry season are common.

Good management will provide a whole package of benefits to you and to society as a whole.

1. Have you ever heard anything about watersheds?
   1.Yes (Proceed to #2)
   2.No (Proceed to #4)

2. Of the listed below, Which watershed can you identify?

S/no	watershed	Please tick (√)

1	Mgeta
2	Ruvu
3	Ngerengere

3. Which of the following statements do you think is/are true about watersheds you mentioned above?
(Choose more than one)

____ 1. Watersheds are the primary source of water.
____ 2. Watersheds provide other goods like timber, animal and plant products.
____ 3. Watersheds provide other services like hydroelectric power, biodiversity conservation, recreation, and carbon sequestration.
____ 4. A good forest cover enhances quantity and quality of water from watersheds.

4. How do you rate the quantity of current dry season flows in your stream/river sub-basin?

____ 1. Increased (Proceed to # 6)
____ 2. Reduced (Proceed to # 4)

5. What do you think are the causes of water supply problems? (Choose more than one)

____ 1. Uncontrolled diversions in river basin
____ 2. Insufficient water in dry season due to low rainfall
____ 3. Degradation of watersheds and river banks by upstream dwellers
____ 4. Poor irrigation infrastructures
____ 5. The growing population both downstream and upstream
____ Others, pls specify ______________________________

6. What are the negative effects of the unstable water supply to your field?

____ 1. Low crop harvest
____ 2. Higher expenditures for water (digging of water diversions)
____ 3. Food insecurity.
____ 4.Low household income.
____ Others, pls specify ______________________________

7. In your opinion, are the management and protection of these watersheds and their river banks important?

____ 1.Yes (Please proceed to # 7)
____ 2.No (Please proceed to # 9)
____ 3.I don't know

8. Why do you think managed and protected watersheds are important? :

____ 1. They absorb water and make available for future use
____ 2.They minimize floods during the rainy season which are destructive for our crops and settlements
____ 3.They improve irrigation water supply for our crop fields
____ 4.They improve water quality
____ 5.Others, please specify ______________________________

9. Why do you think well-managed and protected watersheds not important?

____ 1.They don't directly affect my household
____ 2. I don't believe in their role in improving water supply

Others, please specify

1.3 Questionnaire for Assessment of the Willingness to Pay for Improved Irrigation water supply from well managed and protected Watershed

Section A. Presentation of the Current Water Supply Situation

The interviewer will show photographs of the watersheds and describe the conditions of each.

Suppose there is a project to improve irrigation water supply in the Uluguru Mountains downstream, this will involve protection of watersheds in the upstream which have been degraded for search of soil fertility and water for crop production by improving upstream soil fertility and water, establishment of new improved traditional irrigation schemes in areas still practicing purely tradition system and maintenance of already existing ones. This will automatically improve irrigation water supply downstream, particularly dry season flows, needed for crop production.

The program costs a lot of money and, our government and donors alone cannot afford to implement the program due to inadequate funds and the burden from other programs that also depend on them.

*Suppose a trust fund (**Watersheds and Irrigation Water Service Improvement Fund**) is established to assist to run such a program. The trust fund will be managed by a council composed of various stakeholders (the government (water basin authority, district etc.) and water users like you. This council will decide the activities that will be supported by the fund, all of which should directly be related to watershed management, establishing new and improving of existing irrigation schemes. Under no circumstance will the fund be used for any other purpose.*

In order to make all these possible, your household as the beneficiaries of this program is required to pay for it as contribution for benefits which will be accrued.

1. Are you willing to pay to participate in the programme?

______1. YES (Proceed to # 2 Section B)

______2. NO (Proceed to # 6)

B 1.4 *Brief presentation by interviewer prior the CV Question*

Studies similar to this one have been conducted in other areas to estimate people's willingness to pay for the improvement of an environmental good. The respondents were presented hypothetical situations, and the payments were hypothetical, as they will be for you. (In other words, the new situation described does not actually exist yet, and the respondents did not have to pay anything on the spot). The results of these studies show that some respondents tend not to reveal their true willingness to pay by overstating to please interviewers or understate by fearing that if they reveal their WTP they will be obliged to pay. Or they simply choose not to cooperate.

2. Are you willing to pay TAS.6000/10,000/15,000/20,000/25,000/35,000 per annum as additional to the current annual fee to improve irrigation water supply from watersheds.

____1. YES (Proceed to 3)

____2. NO. (Skip to 6)

5. The council wants to know, what is the maximum willingness to pay for a household like yours to improve irrigation water supply from well-protected watersheds? TAS. _______ per annum.

6. Please indicate the reason/s why you are willing to contribute to the project.
_____ 1.I need more reliable water supply.
_____ 2.I would like the future generations to have reliable water supply, too.
_____ 3.I am optimistic that the council will do a good job in administering the fund.
_____ 4.I want to produce more than once per year.
_____ 5. I want to reduce water acquisition costs.
Other reasons, please explain

7. If you are not willing to contribute any amount to the project, please identify your reason/s.
_____ 1 I am willing to pay but the water tariff proposed is too high.

_____ 2. I cannot afford to pay any amount because the incomes generated from irrigated crops are too low.
_____ 3. It is the government role to finance the watershed and riverbank conservation activities
_____ 4.I am pessimistic that council that will not administer the fund.
_____ 5.I do not care about the reliability of water supply.
_____ 6.I do not believe that paying will result in improved water supply and watershed management.
_____ 7.I am not ready to pay till the government evacuates upstream dwellers.
_____ 8.I do not fully understand the question.
_____ Other reasons, please identify _______________________________

C 1.5 Questionnaire for Assessment of Institutional Arrangements

1. Do you have any water governing institutions in your area?
_________ 1.Yes (Proceed to #2)
_________ 2.No (Proceed to #4)

2. Are they strong in governing water resources?
_____________ 1.Yes (Proceed to # 3)
_____________ 2.No (Proceed # 4)

3. What are their strengths? Please rank them (1 is the strongest)
_______ 1.Village water committee
_______ 2. Association of Irrigation farmers
_______ 3.Irrigation Unions
_______ 4.River basin office (WAMI-RUVU Basin)
_______ 5. Cultural rules or norms

4. What do you should be the basis to determine the irrigation water fee?
(Choose only one)
_____ 1.Volume of water used
_____ 2.Income
_____ 3.Number of members in the household

____ 4.Fixed rate
____ Others (Please specify)

6. Which organisation should be assigned to collect your irrigation water fee for improved irrigation water supply for watersheds protection?

____ 1.Village water committee
____ 2.Water user association
____ 3.Catchment office
____ 4.River basin office
____ 5.NGOs
____ .Others, pls. identify

Appendix 2: Responses on watersheds and irrigation water status

Question	Improved scheme (N=63)	Traditional furrows (N=156)
1. Have you ever heard anything about watersheds	Percentage	Percentage
Yes	93.7	81.4
No	6.3	18.6
2. Of the listed below, which watersheds can you identify?	Percentage	Percentage
Mgeta	14.9	33.9
Ruvu	43.3	36.0
Ngerengere	41.8	30.1
3. Which of the following statements do you think is are true about watersheds you have above mentioned?	Percentage	Percentage
Watersheds are the primary source of water.	27.6	30.1
Watersheds provide other goods like timber, animal and plant products	26.2	26.0
Watersheds provide other services like hydroelectric power, biodiversity conservation, recreation, and carbon sequestration	24.0	23.5
A good forest cover enhances quantity and quality of water from watersheds.	22.2	20.4
4. How do you rate the quantity of current dry season flows in your stream/ river sub basin?	Percentage	Percentage
Sufficient	6.3	9.6
Fairly sufficient	7.9	0
Insufficient	66.7	73.1
Not available	19.0	17.3
5. What do you think are the causes of water supply problems (choose more than one)	Percentage	Percentage
Uncontrolled diversions in river basin	29.0	21.6
Insufficient water in dry season due to low rainfall	15.3	15.2
Degradation of watersheds and river banks by upstream dwellers	27.2	32.6
Poor irrigation infrastructures	21.3	21.2
The growing population both downstream and upstream	7.1	9.5
6. What are the negative effects of unstable water supply to your field?	Percentage	Percentage
Low crop harvest	30.7	31.3
Higher expenditures for water	21.7	23.0
Food insecurity	24.3	23.0
Low household income	23.3	22.6
7. In your opinion, are the management and protection of these watersheds and their riverbanks important?	Percentage	Percentage

Yes (proceed to # 8)	96.8	98.1
No (proceed to # 9)	3.2	1.9
8. Why do you think managed and protected watersheds important?	Percentage	Percentage
They absorb water and make available for future use	25.9	30.3
They minimize floods during the rainy season which are destructive for our crops and settlements	14.7	11.8
They improve irrigation water supply for our crop fields	24.1	29.2
They improve water quality	11.2	9.7
They conserve biodiversity	6.9	5.3
They reduce sedimentation	17.2	13.9
9. Why do you think well-managed and protected watersheds not important?	Percentage	Percentage
They are not primary source of water	33.3	50.0
I don't believe in their role in improving water supply	16.7	50.0
They don't directly affect my household	50.0	0.0

Appendix 3: Estimate of socioeconomic variables influencing WTP

```
ttest wtp, by (scheme)
```

[illegible]

```
lrtest (pool) (scheme nonscheme), stats
```

[illegible]

Appendix 4: Linear logit models for close-ended questions formats for micro-irrigation sytems and pooled data

[illegible]

[illegible]

Logistic regression

Log likelihood = [illegible]

wtp	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
irrinc[illegible]	2.29[illegible]	1.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	.40[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
farmsize	-1.81662[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
hhsize	-.2436242	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
landsize	1.239[illegible]28	.48[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
distance	-1.78[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
status	1.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Appendix 5: Linear regression models for open-ended questions formats for micro-irrigation sytems and pooled data

Appendix 6: Cont

Appendix 7: Estimation of Mean Willingness to pay

Pooled data	Trad. furrows	Improved scheme	Bid amount
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	0.3[illegible]	24
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
0.2[illegible]	[illegible]	[illegible]	31
0.1[illegible]	[illegible]	[illegible]	32
[illegible]	[illegible]	[illegible]	33
[illegible]	[illegible]	[illegible]	34
[illegible]	[illegible]	[illegible]	35

Percent "Yes" responses by bid amount for the two small-scale irrigation systems

Bid	Improved scheme			Trad. furrows		
	Yes	No	Yes	Yes	No	Yes
[illegible]	no.	no.	pct	no.	no.	pct
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	14	6	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	11	[illegible]	[illegible]
20	4	[illegible]	40.0	[illegible]	[illegible]	[illegible]
25	[illegible]	[illegible]	20.0	10	[illegible]	[illegible]
35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Distribution of number of bids to open-ended bid amount

Improved scheme	Tradition furrows	Bid Amount ("000" TAS)
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

Unrestricted mean wtp by linear logit model

System	Slope	Constant	Mean
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

Restricted mean wtp by logit model for pooled data

Variable	Coefficient	Mean	Adj. coeff
[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	16 898526
[illegible]	[illegible]	[illegible]	-4 02472
[illegible]	[illegible]	[illegible]	-1 708812
[illegible]	[illegible]	[illegible]	-1 238199
[illegible]	[illegible]	[illegible]	1 477583
[illegible]	[illegible]	[illegible]	-1 390367
[illegible]	[illegible]	[illegible]	1 0262424
[illegible]	[illegible]	[illegible]	0 9020474
[illegible]	[illegible]		15 62952
[illegible]			[illegible]
[illegible]			17900 793
[illegible]			14545 95

Restricted mean wtp by logit model for traditional furrows

Variable	Coefficient	Mean	Adj. coefficient
Log bid	[illegible]		
[illegible]	[illegible]	[illegible]	16 810596
age	[illegible]	[illegible]	-4.341626
occup	[illegible]	0.6217949	-1 603875
landsize	[illegible]	[illegible]	1 9134118
distance	[illegible]	[illegible]	-1 345944
status	[illegible]	[illegible]	1 1312638
_cons	[illegible]	1	14 73094
Adj. constant			[illegible]
Mean wtp			18337.866
median wtp			14822.34

Restricted mean wtp by logit model for improved scheme

Variable	Coefficient	Mean	Adj. coefficient
[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	40 915244
[illegible]	[illegible]	[illegible]	2 0185411
[illegible]	[illegible]	[illegible]	-7 344256
[illegible]	[illegible]	[illegible]	-2 532474
[illegible]	[illegible]	[illegible]	-3 629238
[illegible]	[illegible]	[illegible]	-0 827045
[illegible]	[illegible]	[illegible]	-2 408154
[illegible]	[illegible]	[illegible]	25 98721
[illegible]			[illegible]
[illegible]			16173 04
[illegible]			15280 531

Estimate of mean wtp (for Improved scheme)

bid	income	education	Household hsize	Alternative source
[illegible]	[illegible]	[illegible]	[illegible]	0
[illegible]	[illegible]	[illegible]	[illegible]	0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	0
[illegible]	[illegible]		[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	0
[illegible]	[illegible]	[illegible]	[illegible]	0
[illegible]	[illegible]	[illegible]	[illegible]	0
[illegible]	[illegible]	[illegible]	[illegible]	0
[illegible]	[illegible]	[illegible]	[illegible]	0
[illegible]	[illegible]	[illegible]	[illegible]	0
[illegible]	2359.265	[illegible]	[illegible]	0
[illegible]	[illegible]	[illegible]	[illegible]	0
9528.609	[illegible]	[illegible]	2402.831	0
5717.165	[illegible]	[illegible]	[illegible]	0
9528.609	[illegible]	[illegible]	[illegible]	0
5717.165	1615.02	[illegible]	2402.831	0
14292.91	1593.445	[illegible]	1922.265	0
9528.609	[illegible]	[illegible]	1922.265	0
14292.91	1962.697	[illegible]	[illegible]	0
14292.91	1594.08	[illegible]	[illegible]	0
[illegible]	[illegible]	[illegible]	[illegible]	0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible].158
[illegible]	[illegible]	[illegible]	[illegible]	40
[illegible]	1276.128	[illegible]	[illegible]	0
[illegible]	[illegible]	[illegible]	[illegible]	0
14292.91	[illegible]	[illegible]	[illegible]	0
[illegible]	[illegible]	[illegible]	[illegible]	0
9528.609	1035.163	[illegible]	[illegible]	0
14292.91	2853.963	2460.758	1922.265	0
9528.609	1406.661	2460.758	2402.831	0
5717.165	[illegible]	[illegible]	2402.831	0

[illegible]	[illegible]
Mean wtp	17107.2

Estimate of mean wtp for traditional furrows (Open-ended question format)

bid	income
[illegible]	[illegible]6.328
[illegible]	[illegible].954
[illegible]	[illegible].1801
[illegible]	501.4[illegible]
[illegible]	501.46
[illegible]	[illegible]829.78
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible].1139
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible].891
[illegible]	[illegible].479
[illegible]	[illegible].0898
[illegible]	[illegible].0159
[illegible]	1611.899
[illegible]	[illegible]7.6999
[illegible]	1118.33
[illegible]	716.4
[illegible]	[illegible].231
[illegible]	[illegible]44.745
[illegible]	1663.534
[illegible]	[illegible]45.132
[illegible]	[illegible]44.971
[illegible]	[illegible].9066
[illegible]	[illegible].851
[illegible]	[illegible].505
[illegible]	[illegible]94.342
[illegible]	[illegible].4444
[illegible]	[illegible]
[illegible]	[illegible]75.9668
[illegible]	[illegible]64.8262
7450.863	[illegible]78.6672
7450.863	[illegible]573.538
16076.02	[illegible]368.198
18627.16	[illegible]657.761
7450.863	1101.411
4470.516	1114.694
7450.863	716.5442
11176.29	9178.025

	[illegible]		[illegible]
	[illegible]		[illegible]
	[illegible]		[illegible]
	[illegible]		[illegible]
	[illegible]		[illegible]059.46
	[illegible]		[illegible]74.231
	[illegible]		[illegible]67.919
	[illegible]		[illegible]7.461
	[illegible]		[illegible]7.502
	[illegible]		[illegible]
	[illegible]		[illegible]2.15
	[illegible]		[illegible]82.755
	[illegible]		[illegible]50.798
	[illegible]		[illegible]99.327
	[illegible]		[illegible]30.31
	[illegible]		[illegible]71.93
	[illegible]		[illegible]55.751
	[illegible]		[illegible]33.237
	[illegible]		[illegible]60.132
	[illegible]		[illegible]63.802
	[illegible]		[illegible]16.085
	[illegible]		[illegible]63.253
	[illegible]		[illegible]7.7439
	[illegible]		[illegible]52.537
	[illegible]		[illegible]74.35
	[illegible]		[illegible]69.078
	[illegible]		[illegible]09.054
	[illegible]		[illegible]35.813
	[illegible]		[illegible]36.395
	[illegible]		[illegible]56.333
	[illegible]		[illegible]96.867
	[illegible]		[illegible]73.042
	[illegible]		[illegible]21.789
	[illegible]		1910.86
	4[illegible].516		1363.492
	4[illegible].519		2617.5
	[illegible]		[illegible]60.864
	[illegible]		[illegible]17.328
	[illegible]		[illegible]76.446
Mean wtp			15850.17

Estimate of mean wtp for pooled data (Open-ended question format)

bid	income	status
[illegible]	[illegible]	2940.718
[illegible]	[illegible]	0
[illegible]	[illegible]	2940.718
[illegible]	[illegible]	2940.718
[illegible]	[illegible]	2940.718
[illegible]	[illegible]	0
[illegible]	[illegible]	2940.718
[illegible]	[illegible]	0
[illegible]	[illegible]	2940.718
[illegible]	[illegible]	0
[illegible]	[illegible]	2940.718
[illegible]	[illegible]	2940.718
[illegible]	[illegible]	2940.718
[illegible]	[illegible]	2940.718
[illegible]	[illegible]	0
[illegible]	[illegible]	2940.718
[illegible]	[illegible]	2940.718
[illegible]	[illegible]	2940.718
[illegible]	[illegible]	2940.718
[illegible]	[illegible]	2940.718
[illegible]	[illegible]	2940.718
[illegible]	[illegible]	0
[illegible]	[illegible]	2940.718
[illegible]	[illegible]	2940.718
[illegible]	[illegible]	2940.718
[illegible]	[illegible]	2940.718
[illegible]	[illegible]	2940.718
[illegible]	[illegible]	0
[illegible]	[illegible]	2940.718
[illegible]	[illegible]	2940.718
[illegible]	[illegible]	2940.718
[illegible]	[illegible]	2940.718
[illegible]	[illegible]	2940.718
[illegible]	[illegible]	2940.718
[illegible]	[illegible]	2940.718
[illegible]	[illegible]	2940.718
6183.949	[illegible]	2940.718
[illegible]	[illegible]	0
[illegible]	[illegible]	0
[illegible]	[illegible]	0
[illegible]	[illegible]	2940.718
[illegible]	[illegible]	2940.718
[illegible]	[illegible]	2940.718
20459.87	[illegible]	0
4910.369	3420.476	2940.718
4910.369	993.076	2940.718
20459.87	3426.089	0
16367.9	12261.43	0
6183.949	5958.318	0

	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	1940.718
	[illegible]	[illegible]	0
	[illegible]	[illegible]	0
	[illegible]	[illegible]	0
	[illegible]	[illegible]	1940.718
	[illegible]	[illegible]	0
	[illegible]	[illegible]	1940.718
	[illegible]	[illegible]	0
	[illegible]	[illegible]	1940.718
	[illegible]	[illegible]	0
	[illegible]	[illegible]	0
	[illegible]	[illegible]	0
	[illegible]	[illegible]	1940.718
	[illegible]	[illegible]	1940.718
	[illegible]	[illegible]	1940.718
	[illegible]	[illegible]	1940.718
	[illegible]	[illegible]	1940.718
	[illegible]	[illegible]	1940.718
	[illegible]	[illegible]	1940.718
	[illegible]	[illegible]	1940.718
	[illegible]	[illegible]	1940.718
	[illegible]	[illegible]	1940.718
	[illegible]	[illegible]	1940.718
	[illegible]	[illegible]	1940.718
	[illegible]	[illegible]	1940.718
	[illegible]	[illegible]	0
	[illegible]	[illegible]	1940.718
	[illegible]	[illegible]	1940.718
	[illegible]	[illegible]	1940.718
	[illegible]	[illegible]	1940.718
	[illegible]	[illegible]	1940.718
	[illegible]	[illegible]	1940.718
	[illegible]	[illegible]	1940.718
	[illegible]	[illegible]	0
	[illegible]	[illegible]	0
	[illegible]	[illegible]	1940.718
	[illegible]	[illegible]	1940.718
	[illegible]	[illegible]	1940.718
	4910.369	[illegible]	1940.718
	4910.369	[illegible]	1940.718
	16367.[illegible]	1671.656	1940.718
	12275.92	2832.746	1940.718
	20459.87	3515.486	1940.718
	8183.949	[illegible]	1940.718
	[illegible]	[illegible]	0
	8183.949	[illegible]	1940.718
	4910.369	[illegible]	1940.718
	8183.949	3641.407	1940.718
	4910.369	2643.515	0
	12275.92	3255.005	1940.718
	8183.949	[illegible]	1940.718
	12275.92	[illegible].327	1940.718

	[illegible]	[illegible]		[illegible]
	[illegible]	[illegible]		[illegible]
	[illegible]	[illegible]		[illegible]40.718
	[illegible]	[illegible]		0
	[illegible]	[illegible]		[illegible]40.718
	[illegible]	[illegible]		[illegible]40.718
	[illegible]	[illegible]		0
	[illegible]	[illegible]		[illegible]40.718
	[illegible]	[illegible]		[illegible]40.718
	[illegible]	[illegible]		[illegible]40.718
	[illegible]	[illegible]		[illegible]40.718
	[illegible]	[illegible]		[illegible]940.718
Mean wtp				16843.82