THE INFLUENCE OF NDANDA TRADITIONAL IRRIGATION SCHEME ON CROP PRODUCTIVITY IN MASASI DISTRICT

BY

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ABSTRACT

Small scale irrigation has immense potential to improve agricultural productivity and incomes of poor rural households. A survey of 150 randomly-selected household heads using semi-structured interviews was undertaken to assess the influence of irrigation on crop productivity. The specific objectives of the study were to; examine and compare the socio-economic factors that influence crop yield and income of irrigating and non-irrigating households; determine and compare area cultivated, crop yield and household income of irrigating and non-irrigating households; estimate the benefits of irrigation water on agricultural crops in Ndanda traditional scheme and identify constraints affecting farmers in the study area. The results show that irrigating households were better off compared to non irrigating households in many aspects related to crop yield, income and had higher benefits. The regression results show that irrigation is an important determinant for crop yield and household income. The Heckman's two-stage estimation was used to estimate determinants of Ndanda traditional small scale irrigation participation and household income and it was revealed that age, sex, and education level, size of cultivated land, agricultural inputs; access to extension services and access to credit were important determinants for participating in small scale irrigation schemes. The analysis further revealed that irrigation participation, age and size of cultivated land are positively and significantly associated with household income at $p < 0.05$. The average annual net benefit from irrigation was Tshs 245 480 901. The constraints affecting crop yield identified by farmers include: poor infrastructure system, higher cost of production, inadequate improved varieties, inadequate farm machinery, inadequate marketing system and crop pests and diseases.

DECLARATION

I, Oscar Adam Mwilongo do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my original work and that to the best of my knowledge it has not been submitted to any other university for a degree award**.**

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Date

The above declaration is confirmed by:

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(Supervisor)

Date

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All praises and thanks are to God "Who is, and Who was, and Who is to come, the Almighty" The compassionate, the Merciful, the only creator of the universe, and the source of all knowledge and wisdom who blessed me with health, thoughts, talented supervisor and opportunity to make some contribution to the already existing ocean of knowledge.

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DEDICATION

This dissertation is dedicated to the memory of my late father Adam Philip Mwilongo who died before enjoying the fruits of the seed he sowed and to my lovely mother Mrs Elekia Paul Mwilongo who laid the foundation of my education.

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LIST OF ABBREVIATIONS AND ACRONYMS

ANOVA	:	Analysis of Variance
ASDP	:	Agricultural Sector Development Programme
ASDS	:	Agricultural Sector Development Strategy
DADP	:	District Agricultural Development Plan
ETB	:	Ethiopian Birr (Currency)
FAO	:	Food and Agriculture Organization
GoT	:	Government of Tanzania
CBOs	:	Community Based Organisations
Kg	:	Kilogram
MDC	:	Masasi District council
NGOs	:	Non Governmental Organisations
IMR	:	Inverse Mills Ratio
SPSS	:	Statistical Package for Social Sciences
SUA	:	Sokoine University of Agriculture
TARPII	:	Tanzania Agricultural Research Project II
TFP	:	Total Factor Productivity
BIW	:	Benefit of Irrigation Water
NRI	:	Net Revenue on Irrigated Crops
NRD	:	Net Revenue on Dry land Crops
VCI	:	Variable Costs on Irrigated Crops
VCD	:	Variable Costs on Dry land Crops
Tshs	:	Tanzania shillings
URT	:	United Republic of Tanzania
USD	:	United State Dollar

ha : Hectares

PPP : Public Private Partnership

FBOs : Faith Based Organisations

OLS : Ordinary Least Square

VIF : Variance Inflation Factor

CHAPTER ONE

INTRODUCTION

1.1 Introduction and Background Information

Agriculture in Tanzania plays an important role in the overall development of the economy and the livelihood of its people. It provides livelihood to more than 80% of the population most of them living in rural areas. The Agriculture sector is the main pillar to food security at the household and national levels. The sector contributed about 26% towards the country's Gross Domestic Product and provides strong inter-sectoral linkages with non-farm sectors, both forward and backward linkages. At present, only 10.56 million hectares which is about 24%, out of about 44 million hectares of the total land area suitable for agriculture is under cultivation and mainly by smallholder farmers. Several factors have contributed to the modest performance of the agricultural sector in Tanzania. Among the major reasons has been heavy dependence on rain-fed agriculture, use of hand hoe and low level of mechanization for most of the Agricultural operations (URT, 2011).

The government of Tanzania, through Agricultural sector Development Strategy and Agricultural Sector Development programme (ASDS and ASDP) aims at boosting crop production through irrigation development and improvement. Specifically, the ASDP aims to support a reduction in over dependence on rain-fed agriculture by rehabilitation and management of low cost smallholder irrigation schemes, including rainwater harvesting, to reduce fluctuations in production (URT, 2007). The primary reason for irrigation is to improve agricultural productivity in areas where surface soils are naturally drier. Semi-arid regions often have higher agricultural productivity if irrigated. Also the agricultural sector aided by technological change has a comprehensive and a broad impact on the poverty alleviation of the people of the rural areas. As it reduces poverty in rural areas it also reduces inequalities (Desai, 2002).

Tanzania has a total irrigation development potential of 29.4 million hectares at varying levels. Out of 29.4 million hectares, 2.3(7.8%) million hectares have a high development potential, 4.8(16.3%) million hectares, medium potential and 22.3(75.9%) million hectares, low potential. However, out of 29.4 million hectares with irrigation potential, only 310 745 hectares which is about 1% is currently under irrigation (URT, 2011). Furthermore, out of the total area under irrigation, 80% is under traditional irrigation schemes with low level of water use efficiencies and the remaining 20% is centrally managed irrigation schemes owned by public and private institutions and individuals (TARP II – SUA Project, 2004).

Traditional small-scale irrigation refers to schemes that involve temporary and unstable structures, established by the community members themselves and often destroyed by the water flow during the rainy seasons. In Ndanda, irrigation is not a recent phenomenon. Farmers of the area do practice irrigation to alleviate moisture stress problems for crop growth. However, the practice is of primitive type, consisting of flash floods, temporary diversion structures across the beds of rivers and earth canal following the contours of rugged terrain. According to the information from the Department of Agriculture, the use of existing springs and streams for irrigation purpose has increased through time in response to increasing food shortage and drought situation in the area. Farmers presently irrigate cereals, vegetables and some perennials that have a good market in the vicinity. The methods of irrigation practiced by most of the farmers are wild flooding and the water is distributed to the scheme beneficiaries on a rotation basis. The water distribution system of traditional structure is inefficient to deliver the required amount of water. In this case, high soil erosion and seepage losses are major problems. The needs to irrigate at night so as to irrigate more land are the common experiences of the traditional irrigation beneficiaries. One major problem of irrigation practice in Ndanda traditional scheme is that such temporary and unstable structures are often destroyed by the water flow during the main rain season.

1.2 Problem Statement and Justification

The potential of irrigated agriculture in enhancing crop productivity, food security and alleviating poverty has led to many governments in developing countries to point out sustainable agricultural development strategies through better use of water as a resource for improving crop productivity. Irrigation increases agricultural productivity and farm income per hectare (Nhundu *et al.*, 2010; Hussain, 2006; Gebremedhin and Peden, 2002). It supports the process of transforming traditional subsistence agriculture in to market-oriented production of high value crops such that irrigation makes it possible to grow cash crops, which give good returns to the farmers than the other crops they might have grown in the absence of irrigation (Asfaw, 2007).

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Smallholder farmers under Ndanda traditional irrigation scheme have practiced irrigation since 1997. However, little is known to what extent the scheme has influenced on crop production, productivity and households income under cultivated area. In Tanzania, fewer studies have been conducted on the economics of irrigated agriculture in Usangu basin, Kapunga irrigation project, Mombo, Kivulini and Lekitatu irrigation schemes, Ndiwa irrigation system, Igurusi irrigation schemes, Chamazi traditional scheme and Vinyungu traditional scheme (Kadigi, 2003; Mkojera, 2008; Sokoni, 2005;

Mwakalila, 2004; Kaswamila, 2004; Mkavindala 2001). Therefore, this study was look on the influence of Ndanda traditional irrigation scheme in increasing agricultural production and its contribution to generate income. The significance of the study was that it attempts to provide realistic information on the overall issues of small-scale irrigation development in the study area and for formulating future strategies on smallholder irrigation investment.

1.3 Objectives of the Study

1.3.1 Overall Objective

The overall objective of this study is to investigate the contribution of Ndanda traditional irrigation scheme on crop productivity and household income.

1.3.2 Specific Objectives

i. To examine and discuss the socio-economic factors that influence crop yield and income of irrigating households and non-irrigating households.

ii. To determine and compare the cultivated area, crop yield and household crop income for irrigated and non-irrigated agriculture in the study area.

iii. To estimate the benefits of irrigation water in Ndanda traditional irrigation scheme.

iv. To identify constraints facing smallholder farmers who practicing traditional irrigation and those who do not practicing traditional irrigation in the study area.

1.3.3 Study hypotheses

Based on the above objectives the following hypotheses were tested:

Ho_1: There is no significant difference between the socio-economic conditions irrigating households and non-irrigating households**.**

Ho_2: There is no significant difference between area under cultivation per acre yield of crops and income of irrigating and non irrigating households

Ho_3: Benefits of irrigation water: It was hypothesized that, the net revenue obtained by irrigating crops is much higher than those of non-irrigating crops

1.3.4 Research Questions

The major research question is:

1. What are the major constraints faced by smallholder farmers in Ndanda traditional irrigation scheme?

1.4 Theoretical Framework of Irrigation and Crop Productivity

The analytical framework used to guide the assessment of impact of irrigation on crop productivity in this study is shown in Figure 1.1. The framework based on literature review and observed realities in the study area. The framework highlights the different levels of direct and indirect benefits of irrigation development. Hence, it simplifies the analysis of linkage between irrigation and agricultural productivity at household and community level. The assumption in this study is that access to irrigation water has a positive influence on overall crop production, productivity and income of a household by allowing the possibility of multiple cropping under dry land conditions, increasing cropping intensity, crop diversification and crop yield. This in turn has a direct positive effect in boosting total farm output, raising farm incomes, and increasing farmers' household consumption (Samad, 2002, Ali and Pernia, 2003). Thus, the magnitude of the direct influence of irrigation development is given by the difference in yield between dry land and irrigation production. Another direct linkage between irrigation and agricultural production is through reducing crop loss from erratic, unreliable or insufficient rainwater supply. This also has an effect in increasing yields which leads to an increase in household food self sufficiency and high level of consumption expenditure (Lipton *et al.* 2003).

Another explanation given for irrigation – agricultural production linkage hypothesis is on the use of farm inputs such as fertilizer, improved seed, pesticides, herbicides that are intended to improve yield are highly complementary with availability of reliable water for irrigation. Hence irrigation is likely to boost output and income levels via adoption of increasing usage of yield -enhancing farm inputs. This in turn enables people to move out of poverty and increase sustainable livelihoods. Irrigation development leads to higher production, which implies increased consumption of inputs (Madhusuda *et al.* 2002).

Apart from crop productivity linkages, irrigation also reduces poverty via the creation of additional rural labour employment. There are two sources of additional demand for labour created by irrigation. The first is labour required for construction and maintenance of irrigation infrastructure work. Second, access to irrigation leads to practice of multiple cropping (both dry and wet season cultivation), increased cropping intensity, crop diversification, and higher farm input use; which in turn increases the demand for additional farm labour. Rural poverty levels may therefore be reduced by creating additional employment opportunities and higher farm wages (Hussein, 2007).

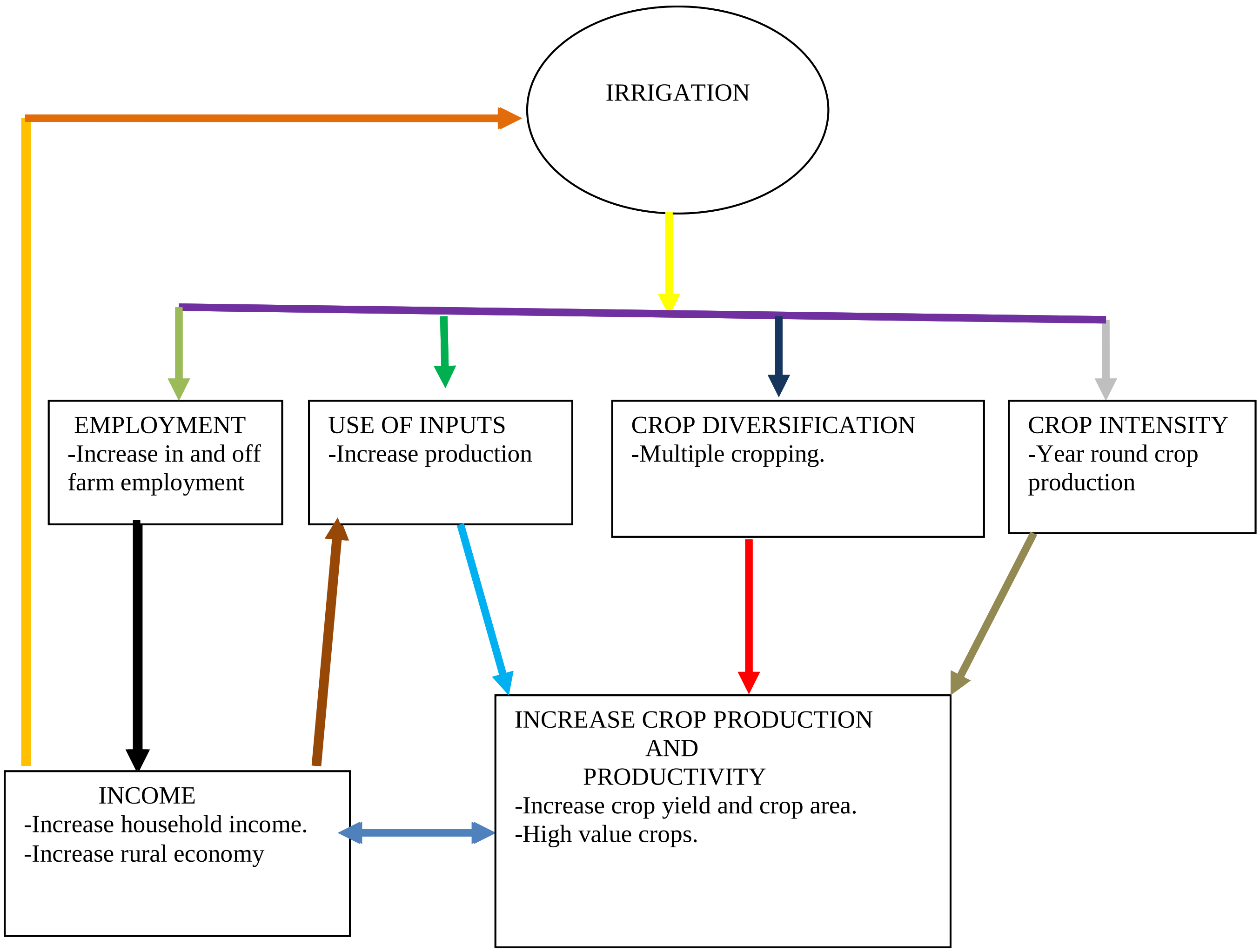

Figure 1: A Conceptual Framework of Irrigation and Agricultural productivity

Source: Own Conceptualization

CHAPTER TWO

LITERATURE REVIEW

2.1 Irrigation and Productivity Concept

Irrigation means the application of a specific amount of water at a particular location in order to meet the requirements of a crop growing at that location in amounts that are appropriate to the crops stage of growth. It can also mean the application of water in amounts necessary to bring soil to the desired moisture level prior to crop planting (URT, 2009). It is a method by which land precipitation may be maintained by supplying water to the intended farmland. In this case, water for crop production can be sought from flowing rivers, collection of rainwater by building dams and reservoirs and pumping up from the ground (Teju, 2000).

Productivity is a ratio between a unit of output and a unit of input. Concept of water productivity in agricultural production systems is focused on ‘producing more food with the same water resources’ or ‘producing the same amount of food with less water resources’ (Molden *et al.* 2001; Bastiaanssen *et al*. 2003). Economic productivity is the gross or net present value of the product divided by the value of the water diverted or depleted, which can be defined in terms of its opportunity cost in the highest alternative use (Jacob *et al.* 2003).

2.2 Measurements of Productivity

According to Umoh and Yusuf (1999), productivity is generally measured in terms of the efficiency with which factor inputs, such as land, labour, fertilizer, herbicides, tools, seeds and equipment are converted to output within the production process. Goni *at el.* (2007) identified two measures of productivity namely, partial productivity and Total

Factor Productivity (TFP). Partial productivity is measured as the ratio of output to a single input. The ratio of output to all inputs combined is the total factor productivity. Generally, two approaches are used in measuring Total Factor Productivity (TFP). These are the growth accounting or index number approach and the econometric or parametric method. The econometric method is based on an econometric estimation of the production function or the underlying cost or profit function (Goni *at el.* 2007).

The measurement of agricultural productivity has been a subject of much interest since long time. Many researchers in the recent years have comprehensively reviewed previous works in agricultural productivity. Different studies have used distinct methodologies such as Cobb-Douglas production function, Data Envelopment Analysis, Stochastic Frontier Analysis, Tornqvist-Thiel Indexes and Malmquist Total Factor Productivity (TFP) indexes to estimate agricultural productivity. Examples of agricultural productivity studies using different methodologies are that of Coelli, and Rao (2003) using Data envelopment analysis and Malmquist Index Analysis, Kumbhakar (1994) a Profit Maximizing Model, Msuya *et al.* (2008) using stochastic frontier methodology, Mukherjee, and Yoshimi (2005) using Tornquist-Theil Index. Wiebe *et al.* (2000) and Kalirajan and Shand (2001) using Cobb-douglas production function

2.3 Current status of Irrigation Development in Tanzania

For years the Tanzania government’s strategy on irrigation development has been stressed on attainment on national food security, increased productivity and income. It has been stated that priority is on rehabilitation of the traditional irrigation schemes because this is where maximum impact will be felt with a minimum of investment.

Their contribution towards achievement of the country's policy objective of obtaining food security is what makes them unique. However, most of the existing traditional irrigation schemes have fallen into disuse and therefore need either rehabilitation and/or modernization to ensure maximum production (Maganga *et al.* 2004).

Tanzania national committee for irrigation and drainage argue that, irrigation in the form of traditional irrigation schemes goes back hundreds of years in the country (URT, 2007) and that those schemes have however become inadequate due to increase in population, wear and tear, catchments degradation etc. Traditional irrigation is through surface irrigation supplied from direct river diversion with distribution of water by lined or unlined canals. It also includes water harvesting and flood recession water control methods. The furrows and basins widely used in water harvesting (capturing floods from seasonal rivers via bunds, dams or flood diversion for gravity).

Since 2001, the Government of Tanzania (GoT) has been promoting the Agricultural Sector Development Program (ASDP) and the District Agricultural Development Plan (DADP) under the Agricultural Sector Development Strategy (ASDS). Under the ASDP/DADP framework, Development of irrigated agriculture, including irrigated rice farming is one of the pillars of the agricultural sector (URT, 2007).

2.4 Smallholder Traditional Irrigation Schemes in Tanzania

Traditional irrigation systems form an important component of the small-scale irrigation activities in Africa. It plays an important role in alleviating poverty through its generation of rural incomes and food security especially where rain-fed agriculture is limited. There has been a resurgence of interest in irrigation in Sub-Saharan countries as an engine for natural development and food security, as evidenced by increased activity of regional institutions working in these fields.

In their study of the traditional irrigation system (*vinyungu*) in Iringa district, Mkavidanda and Kaswamila (2001) found that irrigation enabled income increase through the multiple cropping seasons and higher prices fetched in the dry season. Mowo *et al.* (2002) noted that irrigation has improved yields and has led to a shift by most farmers to production of high value crops. In traditional irrigation activities, the local communities use and manage the water resources. Traditional irrigation offers greater participation of farmers and is more adapted to local environmental conditions than large-scale projects. However, the physical, socio-economic environments under which the traditional irrigation systems operate have kept changing. The implications of these changes to rural producers are a subject that draws attention of researchers.

2.5 Relevance of Irrigation in Crop Production and Productivity

Bhattarai and Hussain (2002) have quantified the impact of irrigation on agriculture productivity along with the impact of inputs other than irrigation on agriculture productivity. The study showed (with the help of the regression analyses) that irrigation had a positive impact on the agricultural productivity. It is also evident from the regression result that irrigation has a positive and significant impact on the growth as well as productivity of all factors. Elasticity calculated was positive such as 0.32 and significant. The conclusion that was drawn from the analysis was that if irrigated area was to be increased by one percent the productivity of all factors, which is total factor productivity (TFP) would increased by about 0.32 percent in India between 1970 to 1994.

Kadigi *et al.* (2003) found that, irrigated paddy in Usangu was estimated to produce about 105 000 tonnes of paddy (equivalent to 66 000 tonnes of rice) per annum which is about 14.4% of the total annual rice production in Tanzania. Also Mkojera (2008) did his research at three irrigation schemes of Mombo, Kivulini and Lekitatu and found that, an average paddy yield for Mombo irrigation scheme were 3.88 tons per hectare and that for Kivulini and Lekitatu irrigation schemes were 3.55 and 4.18 tons per hectare respectively which give an average of 3.87 tons per hectare for all studied irrigation schemes. Huang *et al.* (2005) studied the case of China. Data of 60 villages from 6 provinces was randomly selected and a sample of 1 192 household was taken. The study showed that irrigation has a positive impact on agricultural productivity. Due to increase in per acre yield, the income of the farmers also increased. This showed that irrigation has a strong positive correlation with crop revenue and income.

2.6 Relevance of Irrigation in Crop Income

The role of irrigation in increasing job opportunities and income has been studied, and found significant (FAO, 2000). Mkojera (2008) found that, an average income per household from paddy sales per hectare in Mombo, Kivulini and Lekitatu irrigation schemes were Tshs 1 728 350, 1 649 396 and 2 148 753 respectively. Furthermore, a study undertaken by Bhandari *et al.* (2006) using farm-level data collected from 324 households in Nepal also indicated that shallow tube wells, irrigation has generated a significant positive effect in increasing the rice yields and overall farmers' incomes. On an average yield of shallow tube well irrigation owners was increased by 86% when compared to that of rain fed farmers. The net income of shallow tube well irrigation owners exceed that of the rain fed farmers by 69 USD per hectare, which has an obvious effect on the ability of the farmers to reduce poverty and sustain their livelihood strategies.

2.7 Benefits of Irrigation water on Crop Net Revenue

Irrigation has increased the returns from crop production for more than a century and has enhanced economic activity. Irrigation enables growers to produce crops such as paddy which require more water than traditional dry land crops such as Maize, sorghum and legumes. In their study, Samarawickrema and Kulshreshtha (2008) noted that the main advantage of irrigation water is its role in increasing yields of crops. In a careful analysis, they found that the short-run benefits from irrigation during the drought years of 2001 and 2002 ranged from USD 37 per dam in the Bow River sub-basin to USD 42 per dam in the old man river sub-basin. The estimated benefits of irrigation water were defined as the differences in producer surpluses between irrigated and dry land farming systems in a drought year.

2.8 The National Irrigation Policy and Development

The policy environment is critical to irrigation development and management, providing the framework of national goals and requirements within which regional and local aspirations are to be met. The objectives of the National Irrigation Policy are to ensure sustainable availability of irrigation water and its efficient use for enhanced crop production, productivity and profitability that will contribute to food security and poverty reduction. To accelerate investment in the irrigation sector by both public and private sector players; ensure that Irrigation Development Funds are established with a legal status; promote efficient water use in irrigation systems; ensure that irrigation development is technically feasible, economically viable, socially desirable and environmentally sustainable; reliable water for irrigation so as to facilitate optimisation, intensification and diversification of irrigated crop production to supplement rain-fed crop production effectively; demand driven, productive and profitable irrigation development models that are responsive to market opportunities (URT, 2009).

2.8.1 Unimproved Traditional Irrigation Schemes

Unimproved Traditional Irrigation Schemes in the country rely on the run-of-the river abstraction and gravity flows with the irrigation infrastructures in the state of temporal, poorly constructed and thus poses difficulty in water abstraction and overall water management, with low irrigation efficiencies. However, the Government will continue to support the improvement of traditional irrigation schemes infrastructures and software; encourage the private sector, NGOs, CBOs, FBOs and other stakeholders to support the improvement of the irrigation infrastructures and software; promote awareness for the beneficiary contribution to the improvement of their irrigation scheme infrastructures; and train farmers on irrigation techniques covering water management and support district staff to ensure improved agronomic practices (URT, 2009).

2.8.2 Improved Traditional Irrigation Schemes

Improved Irrigation schemes are schemes originally initiated and operated by smallholder farmers that have received interventions by an external agency in the form of construction of a new diversion structure, gated canal intake, water division boxes and other farm related structures. The layout of the irrigation canals and drainage system is well defined. These schemes have high initial investment cost; heavy equipment required for construction and maintenance. Some of these are characterised by weak and inefficient irrigation organisations, inadequate skills on operation and maintenance resulting in water use inefficiency as well as inadequate environmental consideration when planning and implementing irrigation schemes (URT, 2009).

The Government will promote and encourage Public Private Partnership (PPP) in the development of improved and new irrigation schemes; development of improved and new irrigation schemes on the basis of demand driven, cost sharing and cost recovery; provide technical facilitation for farmers to form Irrigators Organisations for management of their irrigation schemes as a step towards commercialisation and participation in the market economy; set standards to ensure that irrigation development will only take place where demand is clearly articulated and that the scheme involved can be shown to be a beneficial, effective, efficient and competitive user of water resources; ensure that irrigation development is undertaken in tandem with all social and environmental issues; raise awareness on the existing irrigation potential and on the rights and responsibilities of irrigators utilising it; support the establishment of a mechanism that will identify potential irrigation investments with special emphasis on those that could attract private sector investors and/or progressive smallholder farmers schemes (URT, 2009).

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Description of the Study Area

Ndanda traditional scheme is located in Masasi district which is 40 km East along Masasi – Mtwara road. The scheme has an approximate potential to irrigated land of about 350 ha but only 110 ha are currently under cultivation. The scheme receive water from Ndanda river which is flowing from south of Makonde plateau spring water to the north through the irrigation area. The river is flowing throughout the year and farmers use traditional irrigation system for paddy and horticultural crops production (MDC, 2010).

The major economic activities in the study area are agriculture and livestock keeping. The major crops grown are cashew nuts, paddy, cassava, groundnuts, sesame, maize, pigeon peas and horticultural crops. Livestock kept include cattle, goats, sheep, pigs and poultry. Over 90% of people live in rural areas and their live hood depends mainly on farming. In the irrigated households major crops grown during main rain seasons are rice, maize, sesame, and vegetables include tomato, onion, pepper and cabbage. On the other hand, in non-irrigated household’s rice, tomato, maize, and sorghum are grown. During dry season, rice and tomato are the main crops grown in irrigated households while no crops are being grown for non-irrigated households (MDC, 2010). This research focuses on rice and tomato cultivation during both production seasons, as it is by far the most important cultivated crops in the study area after cashew nuts.

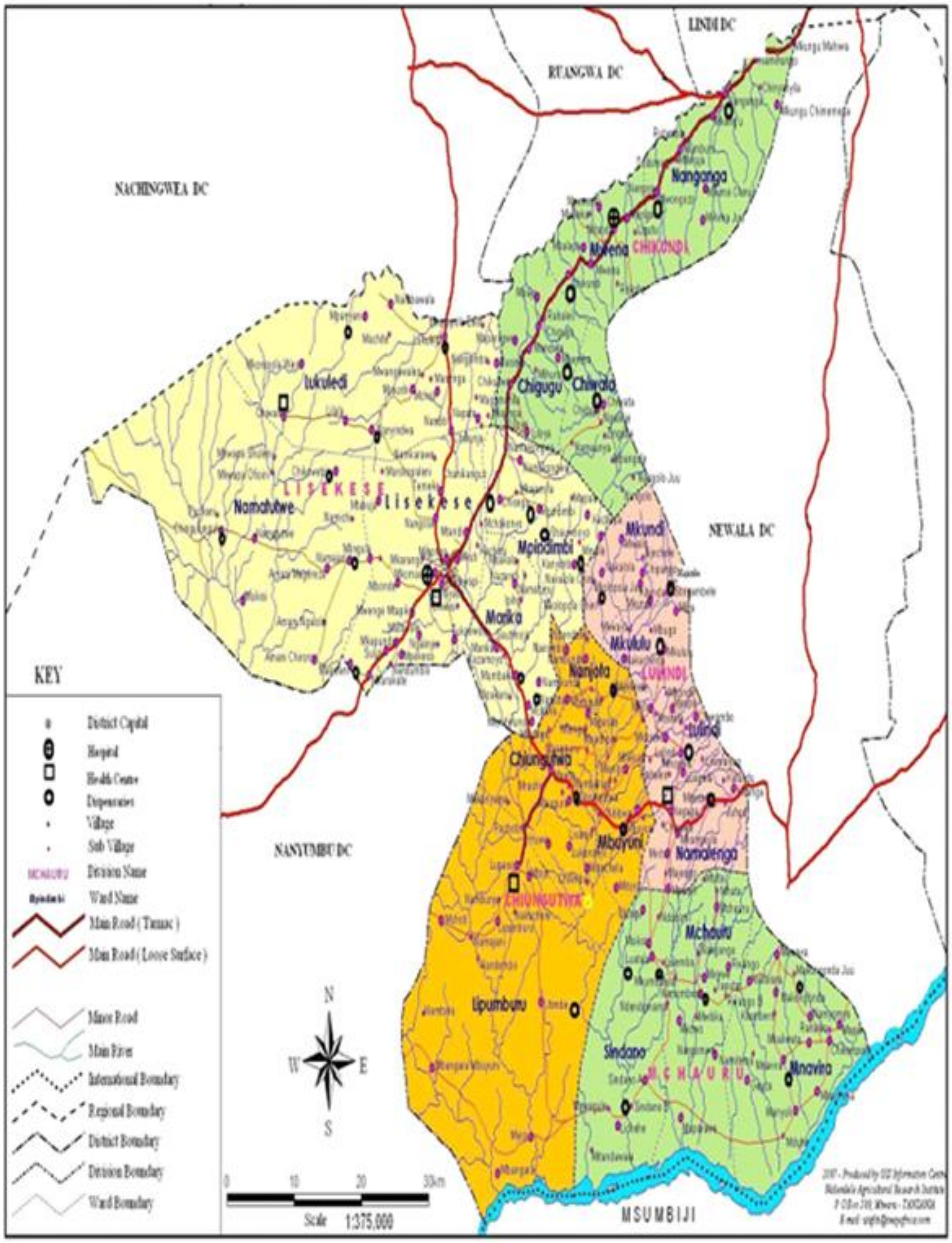

Figure 1 : Map of Masasi District
Source: Masasi District profile

3.2 Research Design

This study has made use of a cross-sectional approach. According to Casley and Kumar (1987), Babbie (1990) and Bailey (1994) the design allowed data to be collected at a single point in time to capture important aspects in irrigation practices. Cross-sectional design is the most appropriate for screening hypotheses because they require a relatively shorter time commitment and fewer resources to conduct. It afford good control over the measurement or ascertainment process, can maximize completeness of key data (compared to retrospective study) and have greater control over precision of estimates in subgroups (stratified sampling).

It demerits is that, in secondary data analysis, no control over purpose, choice, or method of data collection and cannot tell us about causal relationships (only correlation). Data on production activities was collected from a sub-set of irrigating and non irrigating farmers to determine whether there were relationships between irrigation and agricultural productivity, types of resources used to produce crops and the efficiency of a given irrigation practices.

3.3 Sampling Procedure

A formula by Yamane (1973) was adopted to determine a sample size from a population affected by the phenomenon being studied. The formula assumes a degree of variability of 0.5 and a confidence level of 95%. The number of smallholder farmers in the study area for irrigators and non-irrigators are 300 and 800 respectively which gives a total population of 1 100 farmers (MDC, 2010)

Therefore, the sample size by Yamane's formula (1973) is as follows;

$\mathbf{n = N/1+Ne^2}$

Where;

n = sample size,

N = population size (total number of households affected by a phenomenon being studied),

e = the level of precision, (0.05)

1 = a theoretical or statistical constant

The reasons to choose this formula are due to the availability of the exact number of total population. Also using the Yamane formula, make it easily to determine the minimal sample size that have to investigate for any given population size. The demerits to this formula however, is that it gives at most a confidence level of 95%.

Paddy farmers in the study were used as basis for selecting the sample size. Irrigating and non-irrigating farmers were the sampling frame for the study. Irrigating farmers were defined as those who practiced irrigation by river diversion and non–irrigating farmers were defined as farmers who have never ever participated in any irrigation activities while residing in the same study area. The later group served as a control group in the study in relation to impact assessments against irrigation user households. The key difference between the two sample household groups was that beneficiary groups had irrigation water while the control group or non-beneficiary groups did not have irrigation water. This was done to obtain clear evidence on the influence of irrigation on beneficiaries' livelihoods.

A total of 560 farming households were obtained through projections of the population. Putting the total number of households of 560 in the formula above resulted in a sample size of 233 for both users and non-users. However due to time and budget constraints, only a sample size of 150 farmers were interviewed. Simple proportions were then used to allocate a sample size for each community based on the numerical strength of households in the respective communities. The quotas for users and non-users were

50% for each group. The sample size allocation to the three selected village, Mwena, Mpowora, and Njenga were 50, 50, and 50 respectively.

3.4 Data Collection

A single household was taken as the basic survey unit for the analysis. A household was defined as a number of people (it may be only one person) living and eating together in the same dwelling who share the same budget. Given that the household is a production unit, a farm is defined as all the agricultural activities under the control of the household members (Upton, 1996). A structured questionnaire was designed to elicit answers from the respondents. Data on the size of land cultivated, quantity of output, quantity and cost of input, labour used for land preparation, planting, fertilizer applications, harvesting, extension services, household income and the problems faced during the production of the crop were collected.

3.4.1 Pre-testing of research questionnaire

To address the amount of systemic or “in-built” error, the questionnaire developed was tested by administering to a sample of 10 farmers at Mkungu irrigation scheme in Masasi district to gain their reactions to the questions and determine questionnaire content validity. The content validity under consideration was intended to see if the wording of questions was understood equally by different classes of respondents, whether the questions as they are worded could achieve the intended results and to see if the questions were arranged in the best order. Additionally, pre testing was carried out to eliminate unwanted questions and adding new questions needed and to make sure that the questionnaire instructions were equally understood by different enumerators.

3.4.2 Primary data

For collection of primary data, the researcher interviewed the respondents personally at their farms. Direct personal interviews (face to face semi-structure interviews) were conducted with 150 farm households from the three villages (Mwena, Mpowora and Njenga) to collect the information necessary for the research. Since the respondents were smallholder farmer and most of them have little education, direct personal interviews were considered more efficient than other methods such as mailing of questionnaire, telephone interview because the researcher can explain directly the contents of the questionnaire to respondents. Also, the method has highest response rate and the interviewer can observe the surrounding and record non-verbal communication (Babbie, 2001; Scheyvens and Storey, 2003).

Other advantages of personal interview are that, more information depth can be obtained and there is greater flexibility as the opportunity to restructure questions is always there. Also observation method can as well be applied to recording verbal answers to various questions. Moreover, the sample can be controlled more effectively as there arises no difficulty of the missing returns, non-response generally remains very low. With direct personal interviews, the languages of the questions can be adapted to the ability or educational level of the respondent and misinterpretations concerning questions can be avoided. The interviewer also can collect supplementary information about the respondent personal characteristics and environment which is often of great value in interpreting results. The weakness of this method is that it is a very expensive and relatively more-time consuming, especially when large and widely spread geographical sample is taken (Kothari, 2004).

During data collection (questionnering) it was observed that, out of 75 irrigators 6 were cultivate tomato only (without cultivate paddy), 12 irrigators cultivated both crops paddy and tomato. For non-irrigators 6 farmers were cultivate both crops paddy and tomato. Therefore out of 150 farmers 144 of which 69 were irrigators and 75 were non-irrigators were cultivate paddy while 24 farmers who grows tomato, 18 were irrigators and only 6 farmers were non-irrigators.

Although the questionnaire was in English, the questions were asked in Kiswahili for the convenience of interviewees to get the required information with maximum accuracy. While interviewing, the researcher tried his best to maintain informal and friendly atmosphere in order to obtain relevant data from the respondents. Records of irrigation activities and transaction records for the years 2011/10 and 2010/09 growing seasons were also collected.

3.4.3 Secondary data

Apart from data collected through the interviews of farmers, the household survey data were supplemented by gathering an enormous amount of secondary data through literature reviews. Information on agricultural production, irrigable land size and the population together with maps were collected from reviewing reports from the Masasi district agricultural office, Mtwara Irrigation zone, and Ministry of Agriculture and Food security.

3.5 Data Processing and Analysis

Primary data collected from individual household head were edited, verified, coded and entered in the computer. Both Field and Central Editing were done to examine the collected raw data so as to detect errors and omissions and to correct them accordingly. Editing was done also to assure that the data are accurate, consistent with other facts gathered, uniformly entered as completed as possible and have been well arranged to facilitate coding and tabulation.

The collected data were analyzed in Microsoft excel and Statistical Package for Social Sciences (SPSS/PC+ version 16) using various statistical tests and econometric models. Microsoft excel spreadsheet was employed to calculate benefits from irrigated crops. Descriptive statistics were used for comparison purposes of different variables of interest for explaining the phenomena. Additionally, means and standard deviations were used to summarize variations between production practices. Cross tabulations were used for assessing the relationship between the irrigators and non-irrigators in terms of their household characteristics, income and crop yield.

In order to compare yields of crops, area under cultivation, cropping intensity, land use intensity, cropping patterns, income, of irrigating and non-irrigating households a independent t-test was used. The independent t-test was employed to compare average annual mean households income of both groups of farmers. The independent t-test is an inferential statistical test that determines whether there is a statistically significant difference between the means in two unrelated groups. The independent samples t test is appropriate when the scores in the two samples that are compared are independent of each other; that is, when they are uncorrelated with each other. The groups that are compared may correspond to naturally occurring groups (for this case, the groups that are compared are irrigators and non irrigators).

The multiple responses were used to analyze response to questions where the respondent can give more than one answer. For the socio-economic analysis particular importance is given to age, sex, and education of household head, family size, family labour, landholding size, provision of extension services, Farming experience, input and technology availability and market services. These variables were analyzed using descriptive statistics such as average, percentage, minimum, maximum and frequency distributions.

3.5.1 Estimation of Regression Model

Collected data was then cleaned and actual analysis was carried out for 144 farmers and 24 farmers who grow paddy and tomato respectively, of which out of 144 farmers, 69 were irrigators and 75 were non-irrigators while out of 24 farmers who grows tomato, 18 were irrigators and only 6 farmers were non-irrigators. Analysis of data was carried out to estimate the effect of irrigation on crop productivity and farm income from paddy and tomato crops. The model is estimated by employing Ordinary Least Square (OLS) estimation method. The analysis was carried out for the two major crops in the study area namely paddy and tomato. The surveyed farmers have provided information on total yield of each crop at the individual farm level, and price per kilograms of each crop.

Regression model for average yield of paddy and tomato was estimated using the average yield (kg/acre) as the explanatory variable. The dependent variable in this model is crop yield. The independent variables include area cultivated, Family labour (man’s hours per day), costs of hired labour and agricultural inputs. The main objective of this study is to estimate the contribution of irrigation and other factors in the crop productivity. The Cob-Douglas transformed double log function for the four (4) variable input is specified as:

$$\text{Log } Y = a + b_1 \log CL + b_2 \log INPT + b_3 \log HL + b_4 \log FL + e \quad (1)$$

Where;

In Y_i = Natural logarithm of per acre yield of the ith crop, Y = yield of Paddy (kg/acre) CL = area under crop production in acres, FL = Family labour used in man hours per days during the entire crop season, HL = Cost of hired labour in Tanzanian shillings INPT = Cost of agricultural inputs in Tanzanian shillings a = intercept (constant term) $b_1 - b_3$ = regression coefficients and e = error term

3.5.1.1 Specification of variables

Data on crop yield, area under cultivation, costs of agricultural inputs such as fertilizers, pesticides seeds, hired labour and family labour was collected at the farm level.

3.5.1.2 Dependent variables

Crop yield(Y): This is a continuous variable represent the level of production (kilograms produced per acre cultivated). The plausible explanation to consider this as a possible explanatory variable is that, when analysing factors that affect farmers' production level, productivity of the crop may cause production level variation among the sampled farmers, in addition to other factors. This means, each household produces different amount of outputs, sometimes on the same land size cultivated. More clearly, farm household may records different crop yield (kg/acre), due to a number of factors. This implies that the variation in the level of that crop production might also be influenced by crop yield variation, in addition to factors that cause different level of production participation. Therefore, this variable is proposed as one possible explanatory variable in determining the level of paddy and tomato production.

3.5.1.3 Independent variables

Area under cultivation (CL): Farmland is the major input for agricultural production in rural households. The total size of farm land cultivated by a farmer is among the variables that could influence crop production. If a farmer cultivates more land, the probability of crop yield for rice and tomato would increase. Total cultivated land should have a positive relationship with income of a household (Kamara *et al*. 2001).

Agricultural inputs (INPT): The use of inputs influences household to increase crop production. Costs of agricultural inputs included costs of fertilizers, seeds, and chemicals, hired tractor for ploughing, equipments and hired land. Total cost of agricultural inputs at the farm level has been obtained by multiplying cropped acre with the costs incurred under the said crop. In the irrigated farms inputs like fertilizer is widely used and is an important input, than in the non-irrigated farms. Households who use one or more of these farm production inputs will usually have higher crop yields and hence higher income. Thus, a binary variable was specified with a value of one for households that had used one or more of these inputs during the previous cropping season, and 0 for households that had not used any of these inputs during that time.

Hired labour (HL): is a continuous variable referring to farmer’s access to hired labour. Costs of hired labour included land preparation (using hand hoe), planting, weeding, harvesting and processing during the production year

Family labour (FL): is a continuous variable referring to farmer’s access to family labour. Data on labour have been collected in man hours per days on a per acre basis for each crop. The appropriate measure of labour input is obtained by breaking down farm labour hours into its main activities such as land preparation, weeding, sowing, transplanting, harvesting and processing. In this study, active family labour considered as those who can participate in agricultural activity in the household. Thus, this variable is expected to positively affect the probability decision to produce crops (paddy or tomato) and the amount to be produced. This is because paddy and tomato are labour intensive crops, thus requires high labour and in these rural areas there is no market for labour or if any imperfect. Thus, family labour is the main source of labour force in such cases.

3.5.2 Household cropping income analysis

Household gross income is derived from agricultural crops sales and value of crops products retained for household consumption. The value of retained crop products was calculated using annual constant market prices. Individual household cropping income was computed from both groups of farmers. The most common crops grown in the study area are rice and tomato. These crops are grown as staple and cash crops in the study area. Cross tabulation was employed to analyze and compare households' income of the two groups of farmers.

3.5.3 Econometric model for income analysis

The econometric analysis employed the Heckman two-step procedure to identify the influence of Ndanda traditional irrigation scheme on household crop income from among possible other household income influencing factors. Analyzing the influence of irrigation on an outcome variable using regression analysis can lead to biased estimate if the underlying process which governs selection is not incorporated in the empirical framework. The reason for this is that, the effect of irrigation may be over (under) estimated if irrigation participants are more (less) able due to certain unobservable characteristics, to derive these benefits compared to eligible non-participants (Zaman, 2001). Such a problem can be overcome by following two-step procedure, as suggested by Heckman (1979). In this present study therefore, the Heckman's two-stage selectivity model is used to investigate the factors that influence the probability of being participated in irrigated agriculture. While secondly estimating the factors affecting household income using Ordinary Least Square (OLS).

The first stage of Heckman's two stage model is 'irrigation participation equation' that captures the factors governing participation employing a binary probit equation. This equation is used to construct a selectivity term known as the 'Inverse Mills ratio (Lambda), which is added to the second stage 'outcome' equation or" income". If the coefficient of the 'selectivity' term is significant then the hypothesis that an unobserved selection process governs the participation equation is confirmed. The empirical specification of the probit model to be estimated by maximum likelihood estimation is defined as:

$AIRR^*_i = \beta^*_0 + \beta^*_1 CL + \beta^*_2 AG + \beta^*_3\ ED + \beta^*_4 SEX + \beta^*_5\ HL, + \beta^*_6\ AINPT + \beta^*_7 AEXS + \beta^*_8 ACRDT + \beta^*_9 FS + \varepsilon_j$ .... (2)

$AIRR_I = 1$, If $AIRR_i^* > 0$ and $AIRR_I = 0$, If $AIRR_i^* < 0$

The second stage of heckman's two stage procedure for this study is specified as:

$HINC = \beta_0 + \beta_1 CL + \beta_2 AG + \beta_3 ED + \beta_4 SEX + \beta_5 HL + \beta_6 AINPT + \beta_7 AEXS + \beta_8 ACRDT + \beta_9 FS + \beta_{10} AAIRR + \eta_n \lambda_n (X_i\ \beta_j) + \varepsilon_j$ .... (3)

The above equations were estimated simultaneously using Stata econometric software. The program estimates the parameters on the following principles:

Where,

HHINC = Household crop income in Tshs, CL= Total area under cultivation, AG = Age of Household heads (years), ED = Education level of the household heads, SEX = Sex of household heads, HL=Hired labour, FS=Family size, AINPT= Agricultural inputs, AEXS=Access to extension services, ACRDT= Access to credit, $AIRR_i^*$ = is the estimated irrigation participation probability, β_j = parameter coefficients, β^* = is the vector of parameter coefficients, λ_j (Xi β_j) = the Inverse Mill's Ratio derived from the first stage, ε_j Random error term for the selection equation and ε_i= error term in the second stage

The dependent variable (HINC) is annual total crop income. The values of crop incomes are computed by multiplying the amount of each agricultural product (sold and consumed) with their annual average price. The independent variables are education status, Age of household head, sex of household head, family size and irrigation access. These variables are expected to result in (and therefore, explain) income variation across households in the study area. The independent variables are as follows:

Cultivated land size (CL): total cultivated land is the total sum of the households own and/or rented in/out from/to other households and measured in acres. Farmland is the major input for agricultural production in rural households. Total cultivated land should have a positive relationship with income of a household (Kamara *et al*. 2001).

Use of input (INPT): the use of inputs influences household income from crop production. The main inputs used in the study area are chemical fertilizers, improved seeds and agricultural chemicals. Households who use one or more of these farm production inputs will usually have higher crop yields and hence higher income. Thus, a binary variable was specified with a value of 1 for households that had used one or more of these inputs during the previous cropping season, and 0 for households that had not used any of these inputs during that time.

Access to irrigation (IRR): Irrigation supplements moisture, which enables farmers to maximize agricultural production. It is assumed to have a direct relation with the total income of a household. Nhundu *et al*. (2010), Hussain and Biltonen, (2001) and Haile (2008) identified a strong positive relationship between access to irrigation and household income. Access to irrigation for household is a dummy variable, 1 if a household has access to irrigation and 0 otherwise.

Education level of a household head (ED): Education has paramount impact on income improvement and poverty alleviation. It is likely that educated farmers would more readily adopt irrigation technologies and may be easier to train through extension support. The variable entered in the model as dummy variable with 1 if a household head can read and write, and otherwise 0.

Sex of the household head (SEX): This is a dummy variable with 1 for male and 0 otherwise. Male household heads are expected to have higher income compared to female household heads because of better labour inputs used in male-headed households.

Age of a household head (AG): Age is a continuous variable and measured in years. In Ethiopia, household head is the decision maker for farm activities. Age is one of the factors that determine decision making of a person. Advanced aged household heads are more reluctant to accept new technology and agricultural production styles than younger household heads. Thus, age of household head is hypothesized to have negative contribution to household income. The relationship between age of household head and total income of a household is assumed to be a linear function, based in part on estimated equations.

Extension frequency (EXS): This is a dummy variable indicating the extension service farmers were getting. This variable was expected to influence crop production and household income. Obviously, as farmers learned more and knew much it would be obvious that they would produce much and ultimately household income.

Family size (FS): This is the total number of family members that can be taken as a proxy for the level of production. This continuous variable is expected to influence household income.

Access to credit (ACRDT): It is dummy variable taking one for those who have access to credit, and zero otherwise. Access to credit would enhance the financial capacity of the farmer to purchase the necessary inputs. Therefore, it is hypothesized that access to credit would have positive influence on irrigated agriculture and would enhance the financial capacity of the farmer to purchase the bird. Therefore, it is hypothesized that access to credit would have positive influence on level of crop production and household income.

Table 1: Summary of dependent and independent variables codes, definitions and expected sign of effect on household income.

Variable	Variables definition and measurements	Expected sign
INCOMEHH	Annual household gross income in Tshs	Dependent
CL	Continuous variable for total cultivated land in acres	+
FS	Continuous variable for total number of family members	+
HL	Costs of hired labour in crop production(1 = use of hired labour, 0 = No use of hired labour)	+
AINPT	Costs of production inputs (1 = use of inputs, 0 = No use of inputs)	+
ED	Education of the household head (1 = formal education, 0 = No formal education)	+
AG	Age of a household head, years	-
SEX	Sex of the household head (1 = male, and 0 = female)	+
AIRR	Dummy variable for irrigation (1 = access to irrigation, 0 = No access)	+
AEXS	Dummy variable for access to extension service (1= access, 0=no access)	+
ACRDT	Dummy variable for access to credit (1=access, 0=no access)	+

3.5.4 Multicolinearity Tests

Before executing the final model regressions, all the hypothesized explanatory variables will be checked for the existence of statistical problems such as multicollinearity problems. Basically, multicollinearity may arise due to a linear relationship among explanatory variables and the problem is that, it might cause the estimated regression coefficients to have wrong signs, smaller t-ratios for many of the variables in the regression and high R^2 value. Besides, it causes large variance and standard error with a wide confidence interval. Hence, it is quite difficult to estimate accurately the effect of each variable (Gujarati, 2004; Woodridge, 2002).

According to Gujarati (2004), the larger the value of VIF indicates the more collinearity among one or more model explanatory variables. As a rule of thumb, if the VIF of a variable exceeds 10, which will happen if a multiple R-square exceeds 0.90, that variable is said be highly collinear (Gujarati, 2004). For detecting both multicollinarity tests for continuous and dummy variables, Statistical package SPSS version 16 was used to compute both VIF and tolerance.

3.6 Estimating the Benefits of Irrigation Water in Crop Production

The benefits of irrigation water in crop production is defined as the difference between the net revenues of crop production on irrigated land and net revenues of crop production on dry land. The net revenues are calculated as gross revenues minus variable costs. Fixed costs are excluded from the calculation because they are affected by the level of profitability of the enterprise. The method used to calculate the producers' surplus of irrigation water is described in Equations 1-3.

BIW = NRIt - NRDt…………………………………………………...…………... (1)

NRIt = NRIt – TVCI.....………………………………………………………….. (2)

NRDt = NRDt-TVCDt………………………………………………………….. (3)

Where;

BIWt is Benefits from irrigation in years t (t=2010 and 2011),

NRIt is net revenues on irrigated land in years t (t=2010 and 2011),

NRDt is net revenues on dry land in years t (t=2010 and 2011),

VCIt is variable costs on irrigated land for crop years t (t=2010 and 2011), VCDt is variable costs on dry land for crop for years t (t=2010 and 2011).

3.6.1 Net revenue

Net revenue is the income remaining after covering the specified costs included in the production. The net revenue in this study was calculated by subtracting total variable costs from total revenue.

3.6.2 Total variable Costs

In this study total variable costs included the summation of land preparation costs, crop management costs, inputs costs (seed, fertilizer, and pesticides) and hired labour.

3.6.3 Prices used in the analysis

Prices play an important role in economic analysis. Normally market prices are used, although there may be differences in prices right after harvest and the prices received after farmers have stored their produce. A decision between the uses of current prices versus constant price needs to be made before hand as it has implications in incorporating inflation in the calculation. Normally constant prices are used because of the assumption that general inflation will exert the same relative effect on both costs and benefits (Senkondo *et al.*, 2004). To reflect economic analysis in this study, prices used to value inputs and outputs were taken in such a way that transfer payments (such as taxes, subsidies and credit transactions) are eliminated. Although no adjustments were made in correcting price distortions of traded goods, this study opted for market prices which were believed to reflect the opportunity cost.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Socioeconomic Characteristics of the Household heads

A total of 150 farmers were involved in the present study of which 75 (50%) are irrigators and the rest are non-irrigators. The head of the household generally was responsible for the co-ordination of the household activities so it is pertinent to probe on the sex of the household head as one component of irrigation participation decisions.

4.1.1 Distribution of household heads by sex

Of the 150 sampled households, about 35 (23.3%) and 36 (24%) are male-headed for irrigating and non-irrigating households while 40 (26.7%) and 39 (26%) are female headed for irrigating and non-irrigating household respectively. This implies that, there is equal distribution of gender headed-households. The involvement of both sexes in the production shows its importance both as an economic activity and for food security. This is also in line with the National target in Her development vision that states: "By the year 2025, racial and gender imbalances will have been redressed such that economic activities will not be identified by gender or race" (URT, 2000).

Table 2: Distribution of household heads by sex

Sex	Irrigator		Non-Irrigator		Total	
	n	%	n	%	n	%
Male	35	23.3	36	24	71	47.3
Female	40	26.7	39	26	79	52.7
Total	75	50	75	50	150	100

4.1.2 Distribution of household heads by education level

Human resource plays an important role in economic development. Literacy and education enable farmers to increase crop productivity through better management of other resources. It is widely believed that literate farmers have usually higher crop yield than illiterate farmers. Table 2 show that, 55 (36.7%) and 63 (42%), irrigating and non-irrigating household heads indicated to had completed primary education, 11 (7.3%) and 5 (3.3%) had finished form four and one (0.7%) of irrigating household head had completed Diploma course. Yet, 4 (2.7%) of irrigating household head indicated to have attended standard ten, 2 (1.3%), and one (0.7%) of irrigators and non-irrigator indicated to have attended standard eight, 2 (1.3%) and 5 (3.3%) indicated to have attended adult literacy classes and 3 (2%) of non-irrigator had not attended any formal education.

This results are in line with the findings of Sokoni *et al*. (2005), on Changes in the Upland Irrigation System and Implications for Rural Poverty Alleviation; Mkojera, (2004) on Economic analysis of farmers-managed irrigation schemes in Tanzania and Mkavindala *et al*. (2001) on the role of traditional irrigation systems (*vinyungu*) in alleviating poverty in Iringa rural district, Tanzania. The variation in education status of the two groups of farmers is evident that, irrigated households are more educated than non-irrigated households and it could be because of the reason that irrigated household get higher yield and income than non-irrigated households such that education is positively affected by household income.

Table 3: Distribution of household heads by education level

Education status	Irrigators		Non-Irrigators		Total	
	n	**%**	**n**	**%**	**n**	**%**
No formal	0	0.0	3	2	3	2
Adult education	2	1.3	3	2	5	3.3
Primary	55	36.7	63	42	118	78.7
STD 8	2	1.3	1	0.7	3	2
STD 10	4	2.7	0	0.0	4	2.7
Secondary	11	7.3	5	3.3	16	10.7
Diploma	1	0.7	0	0.0	1	0.7
Total	75	50	75	50	150	100

4.1.3 Distribution of household heads by age

Age of economic agents have an important bearing upon productivity. It is expected that age and experience are positively correlated up to a certain extent and an inverse correlation may emerge thereafter. About 16 (10.7%) and 13 (8.7%), of irrigating and non-irrigating household head had age between 18-35, 29 (19.3%) and 19 (12.7%) had age between 36-45, 18 (12%) and 21 (14%) had age between 46-55, 6 (4%) and 19 (12.7%), had age between 56-65, 6 (4%) and 3 (2%) had age between 66-76 years old respectively.

The minimum age was 26 years and maximum was 76 years. The age of the household head influences whether the household benefits from the experience of an older person, or has to base its decisions on the risk-taking attitude of a younger farmer. Table 3 show the largest age groups are 36-45 and 46-55 which accounts for 38.7% and 25.3%. This confirms that youth people are massively involved in agriculture. The result is in line with the findings of Ayele, (2011), Anyanwa in Akinbile *et al.* (2007), Mkojera, (2008), Kaswamila *et al*. (2004), Mkavinda *et al*. (2001) which shows that the active participants in farming activities were between 40 and 50 years.

Table 4: Distribution of household heads by age

Age	Irrigators		Non-Irrigators		Total	
	n	%	n	%	n	%
18- 35 years	16	10.7	13	8.7	29	19.3
36-45 years	29	19.3	19	12.7	48	32
46-55 years	18	12	21	14	39	26
56-65 Years	6	4	19	12.7	25	16.7
66 and above	6	4	3	2	9	6
Total	75	50	75	50	150	100

4.1.4 Distribution of household heads by family size

Household size may affect the supply of family labour involved in farming activities. About 40 (26.7%) and 50 (33.3%), of irrigating and non-irrigating household heads had family size of 1-5, 34 (22.7%) and 23 (15.3%), had heads family size of 6-10 while one (0.7%) and 2 (1.3%) had family size of 11-15 respectively. The minimum family size was one and maximum family size was 15. The result is closely related with the findings of Assefa, (2008) and Kaswamila *et al*. (2004) which show minimum family size of 2 and 3 and maximum family size of 13.

Table 5: Distribution of household heads by family size

	Irrigators		Non-Irrigators		Total	
	n	**%**	**n**	**%**	**n**	**%**
1-5	40	26.7	50	33.3	90	60
6-10	34	22.7	23	15.3	57	38
11-15	1	0.7	2	1.3	3	2
Total	75	50	75	50	150	100

4.1.5 Distribution of household heads by family labour

For most of the respondents, family labour is the main source of labour for all production activities and is strongly related to the household level of crop productivity. Family labour in adult equivalents indicates that, the sample household average family labour force for agricultural production and other income-generating activities. The minimum family labour in adult equivalents in the study area was one with a maximum of six. As shown in Table 5, there is wide variation in the family labour between irrigation and non-irrigation households. However, since irrigation is a labour-intensive agricultural practice, labour demand for irrigation households is expected to be higher than that of rain fed households.

The family labour supply is not enough for irrigated farming in most cases while non-irrigated farms have almost enough aggregate labour needed for the farm operation. The total labour required in man-days for irrigated crops is significantly higher than non-irrigated crops assuming that no quality difference between the labour inputs of the different age and sex groups. Hired labour is needed for land clearing, pudding, preparation of seed beds, nursing of seed beds, fertilizer application, seed preparation, transplanting, weeding, bird scaring, harvesting, filling rice bags and sealing. A farmer needs to employ labourers because the work follows a tight schedule to enhance water management. Since there is so much work, one or two people in a family cannot cope unaided. Farmers explained that labour costs have been increasing every year.

Table 6: Distribution of household heads by family labour

Family labour (Adult equivalent)	**Irrigators**		**Non-Irrigators**		**Total**	
	n	**%**	**n**	**%**	**n**	**%**
1	12	8	11	7.3	23	15.3
2	38	25.3	46	30.7	84	56
3	13	8.7	9	6	22	14.7
4	8	5.3	5	3.3	13	8.7
5	3	2	3	2	6	4
6	1	0.7	1	0.7	2	1.3
Total	75	50	75	50	150	100

4.1.6 Farming experience of the household heads

Experience of a farm household in agriculture has implications for crop productivity. Table 6 show that, about 69 (46%) and 61 (40.7%), of irrigating and non irrigating households had experience between 1-20 years in agriculture production, 4 (2.7%) and 13 (8.7%) had experience between 21-40 years in agriculture production. It has been found that, about 2 (1.3%) and one (0.7%) of irrigating and non irrigating household heads had experience between 41-60 years in agriculture production. Most of experienced household heads, were able to get more productivity of crops by timely sowing of crops, avoid flood irrigation hence saving water and balanced use of fertilizers on account of their experience. The majority of respondents were doing agriculture over the last 1 to 20 years.

Table 7: Farming experience of the household heads

Years in production	Irrigators		Non-Irrigators		Total	
	n	%	n	%	n	%
1-20	69	46	61	40.7	130	86.7
21-40	4	2.7	13	8.7	17	11.3
41-60	2	1.3	1	0.7	3	2
Total	75	50	75	50	150	100

4.2 Irrigation Practices and Techniques

Table 7 and 8 show the irrigation techniques, farming practices and reasons for non-irrigating households not irrigating in the study area. Of 150 respondents, 75 (100%) were irrigators and 75 (100%) were non-irrigators. All 75 irrigators' practice traditional irrigation which uses diversion weirs made from local material and need annual reconstruction. The canals are usually earthen and the schemes are managed by the community.

4.2.1 Frequency of irrigating

Of 75 irrigating households, 6 (8.0%), 33 (44.0%), 36 (48.0%) were irrigating their farms once per week, twice per week, and triple per week respectively. There is variation on the frequency of irrigation within irrigated farmers such that some farmers 6 (8.0%) irrigate their farm only once per week. This is due to the fact that their farm plots are located far away from the water source and poor distribution of irrigation water which is caused by poor infrastructure. The result is in line with that of Mwakalila *et al.* (2004) and Ayele (2001) which show that, 40% and 42% of irrigators harvest paddy twice per year.

Table 8: Frequency of irrigation

Irrigation frequency (per week)	Irrigators	
	n	**%**
Once	6	8.0
Twice	33	44.0
Thrice	36	48.0
Total	75	100.0

4.2.2 Reasons for not irrigating

Of all 75 non-irrigating household heads 67 (89.3%), and 8 (10.7%) indicated that, the major reason for not irrigating were lack of surface water access in their farm plot and their farm plot had sufficient soil moisture during rainfall seasons respectively. Lack of water source was the most important limiting factor. Thus, irrigation development might be given additional consideration as a means of irrigation development in the study area. The result is in line with that of Ayele (2011) which show that, 85% of non-irrigators were not irrigating because of lack of farmland near water source.

Table 9: Reasons for not practicing irrigation

Reasons for not irrigating	Non-Irrigators	
	n	**%**
No farmland near water source	67	89.3
Sufficient soil moisture	8	10.7
Total	75	100.0

4.2.3 Reasons for engaging in production

The results of survey in Table 9 show that, 60 (80.0%) and 62 (82.7%) of irrigating and non-irrigating household heads indicated that they undertook farming activities mainly for household food security, 71 (94.7%) and 62 (82.7%) of irrigating and non-irrigating household heads indicated that they undertook farming activities mainly for household income generation, 19 (25.3%) and 12 (16.0%) of irrigating and non-irrigating household heads indicated that they undertook farming activities mainly as a means of self employment as poverty alleviation initiative while only 1 (1.3%) irrigator indicated that it was for mitigating frequent droughts. This implied that agriculture serve as multiple purposes in the households needs. The result is closely in line with the findings of Kaswamila *et al*. (2004) which show that, 55% of irrigators were engaged in agriculture for food security and 3% was engaged in irrigated agriculture for mitigating frequent drought.

Table 10: Reason for being engaged in agricultural production

Reasons	**Irrigators**		**Non-Irrigators**		**Total**	
	n	**%**	**n**	**%**	**n**	**%**
Food security	60	80	62	82.7	122	81.3
Income generation	71	94.7	62	82.7	133	88.7
Employment	19	25.3	12	16	31	20.7
Frequency drought	1	1.3	0	0.0	1	0.7
Total	75	50	75	50	150	100

4.3 Land Availability and Ownership

Land is the major productive asset in agrarian countries like Tanzania. Cultivated land appears to be the most important scarce factor of production. In the study area, own and hired lands were used for cultivation. The average land holding size of the sample households in the study area is one acre.

4.3.1 Land holding size

Table 10 show that, 49 (32.7%) and 63 (42%) of irrigating and non-irrigating household heads indicated that they own land. Majority of farmers own land size between 0.5-5.5acre which is about 45 (30%) and 61 (40.7%) of irrigating and non-irrigating household heads while 3 (2%) and one (0.7%) indicated that they own land size between 5.6-10.5 acres. Only one irrigator own land size of 30 acres. The minimum land size owned by farmer is 0.5acre with a maximum of 30 acres. Non-irrigating farmers owned more land than irrigating farmers and this is due to the fact that of 350ha potential land for irrigation, only 110ha is under cultivation (MDC, 2012). Low utilisation of irrigation area can be explained in terms of constraints faced by the farmers in irrigation farming and these constraints include funding irrigation development, working capital for irrigation activities and other challenges.

Table 11: Distribution of land holding size by farmer type

Size of land (Acre)	Irrigators		Non-Irrigators		Total	
	n	**%**	**n**	**%**	**n**	**%**
0.5-5.5	45	30	61	40.7	106	70.7
5.6-10.5	3	2	1	0.7	4	2.7
10.6-15.5	0	0.0	1	0.7	1	0.7
15.6 and above	1	0.7	0	0.0	1	0.7
Total	49	32.7	63	42.1	112	74.8

4.3.2 Mean comparisons of landholding size

The mean land holding size for both groups of farmers is 1.02 and 1.00 acre and mean difference of 0.02 acre. However there is small variation on landholding size between irrigating and non-irrigating households. This is closely in line with the findings of

Mkojera, (2004) and Mkavindala *et al*. (2001) which shows that, mean land holding size of 0.8 and 1.5 acre of irrigating and non-irrigating land holding size.

Table 12: Means comparison of landholding size

Farmer	Obs.	Mean	Std.dev	Mean diff	Min	Max	t-Value
Irrigators	48	1.02	0.14		0.5	12	
Non-irrigators	64	1.00	0.0	0.02	0.5	30	
Total	112	2.24	3.14		0.5	30	1.16ns

Ns =not significant at 5% level

4.3.3 Means of acquiring land

Table 12 show that, 31 (20.7%) and 37 (24.7%), of irrigating and non-irrigating household heads indicated that they obtained land by inherit from their parents, 17 (11.3%) and 25 (16.7%) indicated that they obtained land by bought and one (0.7%) of irrigating and non irrigating household heads indicated that they obtained land by given by government. Non-irrigating households inherited and bought more land than irrigating households. This is because it is easy to obtain land in dry farms than in irrigating farms. The result is closely in line with the findings of Mwakalila and Noe, (2004) and Mkavindala *et al*. (2001) which show that, 15 (30%) irrigating household heads were bought land.

Table 13: Means of acquiring land

Means of obtaining land	Irrigators		Non-Irrigators		Total	
	n	**%**	**n**	**%**	**n**	**%**
Inherited	31	20.7	37	24.7	68	45.3
Bought	17	11.3	25	16.7	42	28
Government allocation	1	0.7	1	0.7	2	1.3
Total	49	32.7	64	42.1	112	74.6

4.3.4 Distribution of hiring land size by farmer type

Of those who own land 14 (9.3%) and 5 (3.3%) indicated that they hire-in extra land. Table 13 show that, 41 (27.3%) and 19 (12.7%) of irrigating and non-irrigating household heads hire-in land size between 0.25-1.5acres, 3 (2%) and one (0.7%) hire-in land size between 1.6-2.5 acres and only one irrigator hire-in land size of 3acres. Irrigating households hire-in more land than non-irrigating farmers due to the problem of land scarcity in irrigation farms.

Table 14: Distribution of hired land size by farmer type

	Irrigators		Non-Irrigators		Total	
	n	**%**	**n**	**%**	**n**	**%**
0.25-1.5 Acres	41	27.3	19	12.7	60	40
1.6-2.5 Acres	3	2	1	0.7	4	26.7
2.6-3.5Acres	1	0.7	0	0	1	0.7
Total	45	30	20	13.4	65	67.4

4.4 Provision of Extension Services

Agricultural extension services play a pivotal role in the motivation of farmers towards the adoption of improved irrigation practices. The introduction of high value crops, efficient use of water and proper use of inputs have all been deemed as significant factors for crop production and productivity (Madhusuda *et al.* 2002).

4.4.1 Getting extension services

Extension services are one of the prime movers of the agricultural sector and have been considered as a major means of technology dissemination. Table 14 show that, 59 (39.3%) and 37 (24.7%) of respective irrigating and non-irrigating household heads indicated that, they did access extension services while 16 (16.7%) and 38 (25.3%) respective of irrigating and non-irrigating household heads indicated that, they lack extension services. Again, out of 96 (64.0%) of irrigating and non-irrigating household heads whose did access to extension services, 16 (34.8%) and 11 (11.5%) indicated that they did access extension services from public sectors, 6 (6.3%) and 10 (10.4%) indicated that they did access extension services from non government organization while 21 (21.9%), and 8 (8.3%) indicated that they did access extension services from both public and private sector respectively and only 3 (3.1%) of irrigating household heads, indicated that they did access extension services from private sector.

More irrigators did access extension services than non-irrigators due to the fact that irrigation practices is intensive and needs skilled technical assistance from extension agents to provide farmers new technologies such as the use of improved seeds, efficient use of water, proper use of fertilizers and timely field operation. The result is closely in line with the findings Mkojera (2008) and Philip (2001) which indicated that, 54% and 47.2% of the interviewed paddy farmers had access to extension services. Also Haile (2008) reported 37% and 18% of irrigating and non irrigating households receive government extension advice related to crop and horticultural production.

Table 15: Provision of extension services

Extension service access	Irrigators		Non-Irrigators		Total	
	n	%	n	%	n	%
Yes	59	39.3	37	24.7	96	64
No	16	10.7	38	25.3	54	36
Total	75	50	75	50	150	100
Service provider						
Public sector	16	34.8	11	37.9	27	36
Private sector	3	6.5	0	0.0	3	4
Both 1and 2	21	45.7	8	27.6	29	38.7
NGO's	6	13	10	34.5	16	21.3

4.4.2 Changes in access to extension services

Table show that, 41 (27.3%) and 26 (17.3%), of respective irrigating and non-irrigating household heads indicated that, access to extension services is increasing and 33 (22%) and 49 (32.7%) of irrigating and non-irrigating household heads indicated that, there is no changes in access to extension services while only 1 (0.7%) irrigator indicated that access to extension services was decreases.

Table 16: Changes in access to extension services

Changes in extension services access	Irrigators		Non-Irrigators		Total	
	n	%	n	%	n	%
Increased	41	27.3	26	17.3	67	44.7
No change	33	22	49	32.7	82	54.6
Decreased	1	0.7	0	0.0	1	0.7
Total	75	50	75	50	150	100

4.4.3 Training on production techniques

The results in Table 16 show that, 52 (34.7%) and 29 (19.3%) of irrigating and non-irrigating households respectively indicated that they had received training on production techniques while 23 (15.3%) and 46 (30.7%) indicated that they lack training on production techniques. Of those who received training, 35 (23.3%) and 27 (18%) indicated that they receive training from non government organizations, 27 (18%) and 10 (6.7%), indicated that they receive training from extension agents 4 (2.7%) and one (0.7%) indicated that they receive training from training institutions.

On types of training received, 49 (94.2%) and 30 (96.8%) of irrigating and non-irrigating households indicated that, they received training on paddy production 9 (17.3%) and 1 (3.2%) indicated that they received training on vegetable production, 25 (48.1%) and 12 (38.7%) indicated that they received training on Fertilizer application, 14 (26.9%) and 3 (9.7%) indicated that they received training on chemical application, 16 (30.8%) and 7 (22.6%) indicated that they received training on irrigation techniques.

Table 17: Training on production techniques

Training on production	**Irrigators**		**Non-Irrigators**		**Total**	
	n	**%**	**n**	**%**	**n**	**%**
Yes	52	34.7	29	19.3	81	54
No	23	15.3	46	30.7	69	46
Total	75	50	75	50	150	100

4.5 Input Availability and Technologies Used

It is known that irrigation is not a stand-alone technology. Although it helps to increase agricultural production, high return depends on other factors such as adequate usage of fertilizer improved varieties and labour. Irrigation promotes the use of other inputs through supply of moisture at time of unreliable rainfall. According to the FAO (2002), the expansion of irrigation encourages irrigation user farmers to make investments on more intensive uses of agricultural inputs particularly fertilizer, water-conserving technologies complementary to irrigation use and allow selection of higher-yielding over drought-tolerant crop varieties. Table 17 shows that, 57 (86.4%) and 20 (83.3%) of irrigating and non-irrigating household heads indicated that they use improved seeds, 24 (36.4%) and 5 (20.8%) of irrigating and non-irrigating household heads indicated that they had spray pesticides, 62 (93.9%) and 19 (79.2%) of irrigating and non-irrigating household heads indicated that they had apply inorganic fertilizers in their farms.

The results indicated that levels of inputs in terms of quantity are higher in irrigation schemes than in dry land areas, suggesting that there is more intensive crop production in irrigation schemes than in dry land agriculture. This was due to the fact that the productivity of rice and vegetables that are grown under irrigation relies heavily on improved seed, fertilizer and pesticides. Moreover, income from crops and increased production enables irrigation farmers to afford the high price of inputs. The result is closely in line with the findings of Haile, (2008)) and Mkavindala *et al*. (2001) which show that, 24% and 20% of shallow well irrigators and non irrigators had used fertilizer whereas 38% of *vinyungu* farmers had used inorganic fertilizers.

On technology improvement, 65 (43.3%) and 31 (20.7%) of irrigating and non-irrigating household heads indicated that, the use of agricultural technologies have increased whereas 10 (6.7%) and 44 (29.3%) indicated that agricultural technologies have not increased. On machinery, 26 (17.3%) and 49 (32.7%) of irrigating and non-irrigating household heads respectively were cultivated their land using tractors. The reasons for few number of irrigating household heads using tractors was due to the facts that most of irrigated farms have uncontrolled water flow and poor drainage systems which hinder mechanizations.

Plate 1: Improved variety of paddy in irrigated field

Plate 2: Local variety of paddy in rain-fed field

Table 18: Responses on inputs and technologies used

Technology used	Irrigators		Non-Irrigators		Total	
	n	**%**	**n**	**%**	**n**	**%**
Improved seed	57	86.4	20	83.3	77	85.6
Pesticides	24	36.4	5	20.8	29	32.2
Fertilizer	62	93.9	19	79.2	81	90
Tractor	26	17.3	49	32.7	75	100

4.6 Influence of Irrigation on Area under Cultivation

4.6.1 Area under paddy cultivation

Table 18 show that of 150 respondents under paddy production, 50 (34.7%) and 65 (45.13%) of the irrigating and non irrigating household heads respectively had farm size between 0.5-1.5acre, 17 (11.8%) and 10 (6.9%) indicated that they had farm size between 1.6-2.5 acres, 1 (0.7%) of irrigating households had farm size of 2.6-3.5 and 3.6-4.5 acres respectively.

Table 19: Distribution of area under paddy cultivation

Paddy area(acre)	Irrigators		Non-Irrigators		Total	
	n	**%**	**n**	**%**	**n**	**%**
0.5-1.5	50	34.7	65	45.1	115	79.9
1.6-2.5	17	11.8	10	6.9	27	18.8
2.6-3.5	1	0.7	0	0.0	1	0.7
3.6-4.5	1	0.7	0	0.0	1	0.7
Total	69	47.9	75	52.1	144	100

4.6.2 Mean area under paddy cultivation

Table 19 shows the mean area under paddy cultivation of both groups of farmers. The mean is 1.32acre and 1.13acre for irrigating households and non-irrigating households. The mean difference of the two groups of farmers is 0.19acre with irrigators taking the upper hand. The minimum area under paddy cultivation of irrigators and non-irrigators was 0.5acre, while the maximum area was 2 acres and 4 acres respectively. Irrigating households have larger cultivated land area than non-irrigating households. This is due to the fact that, irrigation may generate income and allow accumulation of other productive assets which facilitate cultivation of additional land.

Table 20: Means area under paddy cultivation

Farmer	Obs	Mean	Std. dev	Mean diff	Min	Max	t-Value
Irrigators	69	1.32	0.81		0.5	4	
Non-irrigators	75	1.13	0.44	0.19	0.5	2	
Total	144	1.22	0.66		0.5	4	2.36**

**=significant at 5% level

4.6.3 Area under tomato cultivation

Table 20 shows that, out of 24 farmers who cultivate tomato 17 (70.8%) and 6 (25.0%), of the irrigating and non irrigating household heads respectively had farm size between 0.5-1.5acres respectively. Only one (4.2%) of irrigating household had farm size of 2 acres.

Table 21: Area under tomato cultivation per acre

Tomato area (acre)	Irrigators		Non-Irrigators		Total	
	n	%	n	%	n	%
0.25-1.5	17	70.8	6	25.0	23	95.8
1.6-2.5	1	4.2	0	0.0	1	4.2
Total	18	75	6	25.0	24	100

4.6.4 Mean area under tomato cultivation

Table 21 show the mean area under tomato cultivation of both groups of farmers. The mean is one and 1.1acre for irrigating households and non-irrigating households respectively. The mean difference of irrigating and non irrigating household is -0.06are. The minimum area under tomato cultivation of irrigators and non-irrigators is 0.25acre and 0.5acre while the maximum area is one and 2 acres respectively. Non-irrigating households have larger cultivated land area than irrigating households and they are able to produce tomato because their farms are located in the wetland area where soil moisture is available throughout the production period.

Table 22: Mean area under tomato cultivation

Farmer	Obs	Mean	Std. dev	Mean diff	Min	Max	t-Value
Irrigators	18	1	0.00		0.25	2	
Non-irrigators	6	1.1	0.24	-0.06	0.5	1	
Total	24	1.04	0.2		0.5	2	0.57ns

ns =not significant

4.6.3 Cropping patterns and intensity

Irrigation is now found to contribute a lot in intensifying agricultural production over limited land holdings. Agricultural intensification has been considered as a strategy for increasing crop production and productivity. Even though, a great deal of African irrigation potential is supplementary to rain-fed agriculture, irrigation developments' contribution in densely populated high lands and relatively low rainy areas is very important (Fuad, 2001).

Analysis of the fieldwork show that, 56 (37.3%) and 2 (1.3%) of irrigators harvest at least twice and thrice a year respectively, whereas 17 (11.3%) of irrigating households harvest once a year due the fact that their farms were located far from water sources whereas all 75 (50.0%) of non-irrigating households harvest once a year due to low and unreliable rainfall distribution. The result is closely in line with the findings of Mwakalila and Noe (2004) which show that 40% of irrigating households harvested paddy twice per year and 30% of non irrigators harvested paddy once a year whereas Assafa, (2008) found 42% and 12% of irrigating household harvested tomato twice and thrice a year and 46% of non irrigating households harvested tomato crop once a year.

There are double and few triple cropping seasons in Ndanda irrigation scheme. In the irrigated farms major crops grown during production seasons are paddy and tomato. Table 22 shows that, 69 (47.9%) and 75 (52.9%) of irrigators and non-irrigators had grown paddy whereas 18 (75.0%) and 6 (25.0%) had grown tomato crop.

Table 23: Cropping patterns and intensity

Cropping patterns	Irrigators		Non-Irrigators		Total	
	n	**%**	**n**	**%**	**n**	**%**
Paddy	69	47.9	75	52.9	144	100
Tomato	18	75	6	25	24	100
Cropping intensity						
one season	17	11.3	75	50	92	61.3
Two seasons	56	37.3	0	0.0	55	36.7
Three seasons	2	1.3	0	0.0	2	1.3
Total	75	50	75	50	150	100

4.7 Influence of Irrigation on Crop Yield

4.7.1 Influence of irrigation on rice yield

Paddy being a staple food crop is grown almost consistently in all sample villages. Table 23 gives a comparison of paddy yield between irrigating and non-irrigating households of which 38 (26.4%) and 75 (50.0%) had an average yield between 80-3 080kg, 19 (13.2%), 10 (6.9%) and 2 (1.4%) of irrigating households had an average yield between 3 081-6 081kg, 6 082-9 082kg and 9 083-12 083kg in the two cropping seasons of 2010 and 2012 respectively. The results show that paddy yield for irrigating households is significantly higher than non-irrigating households. The higher paddy yield for irrigating households is contributed by availability of irrigation water which allows farmers to yield twice a year. Also, timely agricultural practices such as land preparation, transplanting, use of fertilizers, weeding and harvesting are reasons for higher yield to irrigating farmers.

Table 24: Average paddy yield

Paddy yield(Kg)	Irrigators		Non-Irrigators		Total	
	n	%	n	%	n	%
80-3 080	38	26.4	75	52.1	113	78.5
3 081-6 081	19	13.2	0	0.0	19	13.2
6 082-9 082	10	6.9	0	0.0	10	6.9
9 083-12 083	2	1.4	0	0	2	1.4
Total	69	47.9	75	52.1	144	100

4.7.2 Influence of irrigation on tomato yield

Tomato has increasingly become an important cash crop in the study area which contributes significantly to the household income. Table 24 below show that, 16 (66.7%) and 6 (25.0%) of irrigating and non-irrigating household heads had an average yield between 1 400-20 400kg whereas 1 (4.2%) of irrigating household heads had an average yield between 20 401-40 401kg and 140 497-160 407kg respectively. The higher tomato yield for irrigators is contributed by availability of irrigation water which allows farmers to harvest twice or triple a year.

Table 25: Average tomato yield

Tomato yield(Kg)	Irrigators		Non-Irrigators		Total	
	n	%	n	%	n	%
1 400-20 400	16	66.7	6	25	22	91.6
20 401-40 401	1	4.2	0	0	1	4.2
140 497-160 407	1	4.2	0	0	1	4.2
Total	18	75	6	25	24	100

4.7.3 Mean yield of the two crops

Table 25 shows the mean yield of paddy and tomato crops of the two groups of farmers. The mean yield for paddy crop is 42.88kg and 9.52kg of irrigating households and non-irrigating households respectively. The mean difference of irrigating and non irrigating households is 33.36kg. On the other hand, mean yield for tomato crop is 409.06kg and 192.42kg and the mean difference of the two groups of farmers is 216.64kg.

Table 26: Mean crop yield of two crops (Kg/acre)

Crop	Farmer	Obs.	Mean	Std.Dev	Mean diff	Min	Max	t-Value
Paddy	Irrigators	69	42.88	30.9		360	13050	
	Non-irrigators	75	9.52	6.14	33.36	90	2475	
Total		144						9.16**
Tomato	Irrigators	18	409.06	754.11	216.64	562.5	78875	
	Non-irrigators	6	192.42	153.48		1162.5	11250	
Total		24						0.69ns

**=significant at 5% level, ns =not significant

4.7.4 Results of Regression Model

Multicollinearity was examined using Variance inflation factor (VIF) and correlation coefficients. The values of the VIF for explanatory variables were found to be less than 10 and four explanatory variables were entered in to the regression analysis. The dependent variable, crop yield has non-zero value.

Table 27: Variance inflation (VIF) factor test

	Collinearity Statistics	
Variables	**Tolerance**	**VIF**
CL	0.57	1.75
INPUTS	0.79	1.28
FL	0.85	1.18
HL	0.51	1.96

The estimated parameter and the related statistical test results obtained from the analysis are presented in Table 26. From the results all independent variables in paddy production of irrigating and non irrigating households were positive sign suggesting that more output would be obtained from the use of additional quantities of these variables, ceteris paribus. In case of tomato crop, the coefficients of output with respect to family labour (man hours per day) for irrigators and non-irrigators were negative of -0.18 and -12.01 respectively. Land area and costs of agricultural inputs (fertilizers, seeds, pesticides and hired land) of non-irrigators had a negative signs of -9.3 and -3.82 respectively and not statistically significant at 5% level showing that family labour and land are not important factors in tomato production in the study area.

The coefficient of land size for irrigators in paddy production was positive and found not to be statistically significant at 5% showing that land size was not important factors in crop productivity. The coefficient of output with respect to family labour (man hours per day) and costs of agricultural inputs (fertilizers, seeds, pesticides and hired land) of irrigating and non irrigating households of paddy crop had positive sign of 0.63 and 0.4, 0.21 and 0.28 respectively and was statistically significant at 5%, showing that family labour and agricultural inputs appears to be an important factors in explaining variations in paddy productivity. If family labour and agricultural inputs are increased by 10%, output level would improve unproportionately by the margin of 6.31 and 3.95, 2.1 and 2.84 respectively. The regression coefficient of output with respect to hired labour of irrigating and non irrigating households had positive sign 0.12 and 0.07 of paddy crop, 0.35 and 0.8 of tomato crop and not statistically significant at 5% in all cases, showing that hired labour is not important factors in crop productivity.

The coefficient of multiple determinations (R^2) for paddy crop was found to be 0.72 under irrigation and 0.41 under dry land which indicates 72% and 41% variations in paddy crop, whereas the value of R^2 for tomato crop was 0.72 under irrigation and 0.98 under dry land which indicates that the independent variables included in the production function explained about, 72% and 98% of the variations in tomato yield. The regression model is best fit since the F-ratios were significant at 5% level.

Table 28: Estimated yield parameter of paddy and tomato crops

Variables	**Irrigating households**				**Non-Irrigating households**			
	Paddy		**Tomato**		**Paddy**		**Tomato**	
	Coeff	t-ratio	Coeff	t-ratio	Coeff	t-ratio	Coeff	t-ratio
Constant	-1.94	-1.17	10.22	0.83	1.33	0.8	338.59	3.51
Land area	0.05	0.35	0.73	1.25	0.09	0.69	-9.3	-3.45
Family labour	0.63	4.89**	-0.18	-0.28	0.4	0.84**	-12.01	-3.56
Hired labour	0.12	1.31	0.35	1.24	0.07	0.67	0.8	3.06
Inputs	0.21	2.53**	0.21	1.22	0.28	0.92**	-3.82	-3.01
R^2	0.72**	-	0.72	-	0.41**	-	0.98	-
F. Stat	32.84**	-	6.27**	-	12.04**	-	15.55	-

**=significant at 5% level

4.8 Analysis of Household Income

4.8. 1 Income from paddy

Table 12 show that, 41 (28.5%) and 75 (52.1%) of irrigating and non- irrigating household heads had average income between Tshs100 000-5 000 000, 22 (15.3%) of irrigating household heads had average income between Tshs5 000 001-9 900 001, 5 (3.5%) of irrigating household heads had average income between Tshs9 900 002-14 800 002, 1 (0.7%) of irrigating household head had average income between Tshs14 800 003-19 700 003. Farmers' incomes from irrigated agriculture are significantly higher than income from dry land farmers.

Table 29: Household average annual income from paddy production

Paddy income (Tshs)	Irrigators		Non-Irrigators		Total	
	n	%	n	%	n	%
100 000-5 000 000	41	28.5	75	52.1	116	80.6
5 000 001-9 900 001	22	15.3	0	0	22	15.3
9 900 002-14 800 002	5	3.5	0	0	5	3.5
14 800 003-19 700 003	1	0.7	0	0	1	0.7
Total	69	47.9	75	52.1	144	100

4.8.2 Income from tomato

Table 12 show that, 11 (45.8%) and 3 (12.5%) of irrigating and non irrigating household heads average income between Tshs 1 00 000-5 000 000, 1 (4.2%) and 2 (8.3%) of irrigating and non irrigating household heads had average income between Tshs 5 000 001-9 900 001, 4 (16.7%) and 1 (4.2%) of irrigating and non irrigating household heads had average income between Tshs 9 900 002-14 800 002 whereas only one (4.2%) of irrigating household heads had average income between Tshs14 800 003-19 700 003 and Tshs 24 600 005-29 500 005 respectively.

Table 30: Household average annual income from tomato production

Tomato income (Tshs)	Irrigators		Non-Irrigators		Total	
	n	%	n	%	n	%
1 00 000-5 000 000	11	45.8	3	12.5	14	58.3
5 000 001-9 900 001	1	4.2	2	8.3	3	12.5
9 900 002-14 800 002	4	16.7	1	4.2	5	20.8
14 800 003-19 700 003	1	4.2	0	0.0	1	4.2
24 600 005-29 500 005	1	4.2	0	0.0	1	4.2
Total	18	75.0	6	25.0	24	100.0

4.8.3 Mean annual income

The mean annual cropping income of irrigating and non-irrigating households from paddy crop were Tshs 2 761 600 and Tshs 581 800 whereas mean cropping income from tomato crop were Tshs6 705 000 and Tshs 1 935 000. The minimum annual income of irrigating and non-irrigating households from paddy crop were Tshs240 000 and Tshs60 000 whereas minimum income from tomato were Tshs450 000 and Tshs 500 000. The maximum annual mean income were Tshs16300000 and Tshs1 650 000 from paddy crop, and Tshs 63 000 000 and Tshs 4 500 000 from tomato crop.

The mean income difference from paddy crop was Tshs 2 179 790 whereas the mean difference from tomato crop were Tshs 4 770 000. This shows that irrigating households were better off in all cropping income than non-irrigating households. The largest income was from tomato produced using small-scale irrigation. This suggests that small-scale irrigation development increases the incomes of rural household because it directly influences the higher income source of cropping. The t-test shows that there is a significant difference on cropping income between irrigating and non-irrigating households at 5% level for paddy crop (Table 29). This suggests that irrigation markedly increases household income.

Table 31: Household cropping income for two cropping seasons (000Tshs)

Crop	Farmer	Obs	Mean	Std.Dev	Mean diff	Min	Max	t-value
Paddy	Irrigators	69	2761.6	2480.92		240	16300	
	Non-irrigators	75	581.8	391.52	2179.79	60	1650	7.51**
Total		144	1626.3	2049.46		60	16300	
Tomato	Irrigators	18	6705	14430.7		450	63000	
	Non-irrigators	6	1935	1523.89	4770	500	4500	0.8ns
Total		24	5512.5	12604.6		450	63000	

**=significant at 5%, ns = not significant

4.8.4 Total mean income

Total cropping income is the amount of income a household obtained from paddy and tomato crops. The total mean income of irrigating and non-irrigating household was Tshs 4 385 500 and Tshs 812 670 respectively and mean difference is Tshs 3 572 800. The minimum total mean income of irrigating and non-irrigating households was Tshs 240 000 and 60 000 while the maximum total mean income was Tshs 67 800 000 and Tshs 5 20 000 (Table 30).

The total mean annual cropping income of irrigating households was substantially higher than that for non-irrigating households. There is significance difference of total mean annual income between irrigating and non-irrigating households at 5% level. This significant difference in income generated by the two groups of farmers is mainly due to high income of irrigators from increased paddy production and tomato as a cash crop. The above findings have an important implication on the role of small-scale irrigation to improve the living standard and food security status of rural households. Increasing crop production and income from the sale of cash crops such as tomato have enabled irrigators to feed their family throughout the year from their own resources. Thus, if successfully preformed and cash crops are adopted, small-scale irrigation development is a viable intervention to break the vicious circle of rural poverty and food insecurity.

Table 32: Total mean income (000, Tshs)

Farmer	Obs.	Mean	Std. dev.	Mean diff	Min	Max	t-Value
Irrigators	75	4 385.5	8 025.77		240	67 800	
Non-irrigators	75	812.67	851.79	3572.8	60	5 720	
Total	150	2 599.1	5 963.5		60	6 7800	3.83**

**=significant at 5% level

4.8.5 Results of Econometric model for income analysis

Multicollinearity was examined using Variance inflation factor (VIF) and tolerance. The values of the VIF for explanatory variables were found to be less than 10 and total of nine explanatory variables were entered in to the regression analysis. The dependent variable, total income of a household, has non-zero value.

Table 33: Variance inflation (VIF) factor test

		Collinearity Statistics
Variables	**Tolerance**	VIF
AG	0.78	1.28
SEX	**0.89**	1.12
FS	**0.85**	1.17
EDU	**0.93**	1.07
IRR	**0.78**	1.28
CL	**0.81**	1.24
HL	**0.79**	1.25
INPT	0.83	1.20
EXS	0.85	1.18
CRDT	0.92	1.08

4.8.5.1Results of the probit model

The first stage of the Heckman model predicts the probability of access to the irrigation scheme of a household. Among the observable hypothesized variables, those that significantly influenced the probability of participating in irrigation farming include age, sex, and education level, size of cultivated land, family size, agricultural inputs, hired labour, access to extension services and access to credit (Table 32).

The results of the econometric model proved that age and sex of the household have negative sign and statistically significant with probability of participation in irrigation. The marginal effect of sex indicates that the probability of participation in irrigation for a male-headed household decreases by 12% compared to a female-headed household given other variables are kept at the average level. The extra old age affect irrigation participation through reduction of active labour for production. The negative sign indicates that the extra old age the lower the likelihood of participation in irrigation farming.

Conversely, the youth age, the higher the probability of participating in irrigation scheme due of active labour for production. The marginal effect of age indicates that the probability of participation in irrigation for old aged household decreases by 1%.

Education of household head has statistically significant positive influence on the probability of participation in irrigation. This seems rational; educated human capital can more easily adopt technologies like irrigation and make more informed production decision. Education can increase the marginal productivity of labour. The increase in productivity of labour is one of the important factors to increase crop production. The analysis shows that education significantly increases the probability of participation in irrigation by 23.2%.

The relationship between family size and participation in irrigation is linear. As the size of a household increases by one adult equivalent, the probability of access to irrigation increases by 17.2% but only up certain point beyond which a unit increase in household size starts decreasing the likelihood of participation in irrigation.

Land size for cultivation is statistically significant and positively associated with probability of participation in irrigation. The regression result show that as the cultivated land size increases, a household is able to increase and diversify the quantity and type of crop produced, which may in turn lead to increased production and household income. The results confirmed that there is a positive and significant relationship between area cultivated and irrigation participation at 5% significant level.

Agricultural inputs are statistically significant and positively associated with probability of participation in irrigation. The main inputs used in the study area are chemical fertilizers, improved seeds and pesticide. Households who used one or more of these inputs increase their crop production significantly. The marginal effect of the probit model revealed that access to inputs can increase probability of participation in irrigation farming by 24.5%. Hired labour is not statistically significant but is positively associated with probability of participation in irrigation. The marginal effect revealed that, access to hired labour can increase probability of participation in irrigation farming by 9%.

Access to extension service was also found to be statistically significant and positive associated with probability of participation in irrigation. The positive effect of access to extension service may indicate that in the study area, those households who get technical advice and training or those who participated in field demonstrations are well aware of the advantage of agricultural technologies and adopt new technologies and produce more. Access to credit was found to be statistically significant and positive associated with probability of participation in irrigation According to the result, the probability of participation in irrigation of households who have access to credit will increase by 31% compared to households who do not have access to credit.

Table 34: Estimates of the probit model variables

Variable	Coefficient	Marginal effect	t-value
constant	-2.09		-3.52**
Age	-0.02	-0.01	-3.5**
Education level	0.83	0.3	2.32**
Sex	-0.29	-0.12	-2.11**
Family size	0.06	0.02	1.72
Cultivated land	0.42	0.17	3.76**
Use of inputs	0.85	0.31	2.45**
Use hired labour	0.24	0.09	0.87
Access to extension service	0.67	0.26	4.8**
Access to credit	0.83	0.31	4.77**
LR chi2	115.2		
Prob > chi2	0.00		
Log likelihood function	-254.32		

**=significant at 5% level

4.8.5.2 Model results of the second stage estimation

The second stage of Heckman's procedure also referred to as the outcome or selection equation uses Ordinary Least Square (OLS) for analyzing household total income as a measure of household income. The likelihood function of the two-step Heckman model was significant showing a strong explanatory power. Also, the coefficient of the Inverse Mills Ratio (IMR) was not significant (P>0.0000) implying the absence of self-selection.

The relationship between age and income is non-linear. The negative and significant coefficient of household head age reveals that older age leads to low income. The marginal effect of the variable indicates that as age of household increases by one year household income decreases by Tshs 91 389.24. The marginal effect shows that when the head of the household is male, household income increases by Tshs 299 768 (or a 44% increase in the mean income compared to female headed household. The income of male-headed households is higher, compared to female-headed households further increasing the comparative advantage of male-headed households to engage in irrigated farming than female-headed households do.

Education of household head has positive but not statistically significant influence on the total income of a household. This seems rational, educated human capital can more easily adopt technologies like irrigation and make more informed production decision. Education can increase the marginal productivity of labour. The increase in productivity of labour is one of the important factors to increase crop production and household income of a household. The analysis shows that education increases the household's total income by Tshs 212 469.8.

Household family size is negatively associated with household total income. The relationship between family size and income is non-linear (see the coefficient for family size). The negative coefficient of family size reveals that larger family size leads to low income, but only up to a certain point. The coefficient of the variable indicates that as the family size increases by one adult equivalent household income decreases by Tshs 93 790.54.

Land is important fixed input to increase crop production and household income. The marginal effect estimates reveal that the cultivate land has the largest influence on household income. That is, a unit increase in irrigable land of a household increases total income of the households by Tshs 4 167 421. In other words, irrigation user households with one acre irrigable land are better off in their income by Tshs 4 167 421 than non-user households. Access to irrigable land by allowing households to use family labour and other farm resources more intensively makes households more productive and hence better off. The regression result also shows that as the cultivated land size increases, a household is able to increase and diversify the quantity and type of crop produced, which may in turn lead to increased production and household income. Thus, land is very important input in rural poor households to increase their annual income.

Access to irrigation has a significant influence on the total income of a household, Tshs 2 414 174 per year (or a 45% increase in the mean income without irrigation). Households who have access to irrigation can cultivate their irrigated land two or more times a year. Although the econometric analysis cannot indicate directly why the increase in income occurs, irrigation allows the farmers to practice crop intensification and diversification which increases crop yields and revenues from crop sales. Irrigation likely also increases the marginal land and labour productivity, increases the crop production and then promotes household income.

The econometric results confirmed that there was a negative relationship between the uses hired labour, agricultural inputs, access to credit and household income. This negative effect suggests that less labour, inputs and credits have been used in irrigated agriculture. The marginal effect shows that as labour, inputs and credits decreases by one unit, household income decreases by Tshs 1 089 757, Tshs 223 042.3 and Tshs 210 283.2 per year.

Access to extension service is also found to have a positive relationship with household income. The positive effect of access to extension service may indicate that in the study area, those households who get technical advice and training or those who participated in field demonstrations are well aware of the advantage of agricultural technologies and adopt new technologies and produce more, thereby improving the household income status.

Table 35: Estimates of the ordinary least square model variables

Variable	Coefficient	Marginal effect	t-value
constant	1036700		0.14
Age	-91389.24	-91389.24	-2.03**
Education level	212469.8	212469.8	0.10
Sex	299767.5	299767.5	0.44
Family size	-93790.54	299767.5	-0.58
Cultivated land	4167421	4167421	5.98**
Irrigation participation	2414174	2414174	4.51**
Use of inputs	-223042.3	-223042.3	-0.10
Use hired labour	-1089757	-1089757	-0.93
Access to extension service	209359.2	209359.2	0.16
Access to credit	-210283.2	-210283.2	-0.15
Lambda	629978	629978	0.22
R-square	0.3056		
Prob value	0.0000		
Log likelihood function	-254.32		

**=significant at 5% level

4.9 Benefits of Irrigation Water in Crop Production

Analyses of production costs show important differences between irrigating and non-irrigating farmers in the study area. Production costs incurred by non-irrigating farmers were significantly lower than those of irrigating farmers. Table 31 shows that, the costs of variable inputs for irrigating farmers was significantly higher than non-irrigating farmers. The higher expenditures on these inputs translate into relatively high production costs for these producers. Variable inputs such as fertilizers, improved seeds, labour and timely operations in land preparations, planting, weeding, pests control, harvesting are important factor cost for most farmers in the study area. Improving the efficiency and cost effectiveness of these factors will have important implications for increasing productivity and profitability.

Calculated net revenue from irrigated crops and dry land crops are presented in Table 34. It must be noted here that the values for the calculations were derived from discussions with farmers. Net revenue was calculated from two production years of 2009/2010 and 2010/2011 and constant price from local markets for both inputs and produce were used. Calculated net profits per acre are positive for both farm categories in sample. However, the net revenue obtained from irrigated crops is much higher than those of non-irrigated crops. This suggests that irrigating farmers are more cost effective, efficient and higher returns to irrigation agriculture than in rain-fed agriculture. The higher profitability of irrigating farms is partly explained by availability of irrigation water, multiple cropping, crop intensity and higher yield. The result show positive net revenue for both groups of farmers in the study area.

Benefit of irrigation water in crop production was defined as the difference between net revenues on irrigated crops and net revenues on dry land crops. The benefit of irrigation water for both years is Tshs 463 568 894.

Table 36: Benefit of Irrigation Water in Crop Production (000, Tshs)

Irrigated crops	**Paddy**	**Tomato**	**Total**
Total revenue	381 100.6	241 310	622 410.6
Production costs	129 802.8	23 614	153 416.8
Net revenue	**251 297.8**	**217 696**	**468 993.8**
Dry land crops			
Total revenue	87 270	23 210	110 480
Production costs	30 508.1	4 547	35 055.1
Net revenue	**56 761.9**	**18 663**	**75 424.9**
Irrigation benefit			**463568.9**

4.10 Assessment of Major Constraints in Irrigated agriculture

Small-scale irrigation has immense potential to improve agricultural productivity and household incomes of poor rural households in developing countries like Tanzania, but it is never free from problems. Perceptions of important opportunities and constraints of actors in the irrigated production sector were evaluated through informal field discussions, semi structured interviews and secondary data. The discussions highlight the important constraints that must be addressed in order to improve agricultural productivity of Ndanda traditional irrigated systems.

4.10.1 Poor infrastructure system

Ndanda Irrigation scheme is a good example of a traditional irrigation system. The system has been built and is managed by the farmers. Usually, local available materials such as stones, grass, wooden poles and earth are used to build the traditional weir. The building and maintenance of these system is labour-intensive, with the earth canals dug and cleaned by hand hoes and machetes. Water for irrigation from Ndanda river, is divided to feed three sub-channels on the left to Mwena village, at the middle to Mpowora village and on the right to Njenga village as depicted in plate 2.

Plate 3: Traditional Weir which supplies water to three villages

The amount of water feeding the sub-channels is uncontrolled because of absence of the gates. It was noted that the traditional weir is subject to frequent destruction as floods often washes away the weir especially during heavy rains period and hence demanding reconstruction of the weir every year. In some cases the river might change its course and do not follow the dug canal. Water is conveyed into the fields through traditionally hand dug canals which are not properly designed and have no definite shape for efficient conveyance. The channels lack control devices for effective conveyance and distribution. The primary canals were dug by hand and therefore, they are relatively narrow and shallow with low water carrying capacity. Water is diverted from the primary canals to secondary canals using bags filled with sand. There are tertiary canals redirecting irrigation water to individual farmers' fields. Most irrigated fields have no drainage systems; hence a lot of water is being wasted. This results in the formation of swamps downstream and thus raising water table and increasing salinity of soils and lowering soil fertility and causing poor crop production.

Plate 4: Traditional primary canal

Plate 5: Traditional secondary canal

Plate 6: Traditional tertiary canal

The maintenance of the traditional irrigation systems is done at the beginning of each season under the supervision of the formed irrigation committee by collecting money from each beneficiary in the three villages. Records shows that maintenance costs during the 2009/2010 and 2010/2011 production years were approximately Tshs1.6 million respectively. The maintenance activities include the removal of sediments and weeds and repair or reconstructions of damaged weir and canals.

Loss of water through seepage is the main problem in Ndanda irrigation scheme. The non-durability of the physical structure of irrigation schemes and the Vertisol nature of the study area causes high water seepage from river diversion canals. Seepage from irrigation canals is the main causes for water losses. Also problems with irrigation water distribution also exist in the study area. Water distribution and water use principles are unregulated despite the fact that, there are water use association committee in the study area. This causes many conflicts between upstream and downstream irrigating households. Generally, water distribution is the main issue in any irrigation schemes. The present study revealed that there are no standardized programs and plans to irrigate each cultivated crops. Irrigation water use depends only on spatial location of the farm plot; it does not consider the amount of water required for the type of cultivated crop, time interval of water application and the size of each irrigated land sizes.

4.10.2 Costs of productions

High cost of inputs and lack of credit were identified as primary constraints in the study area. Farmers in all villages indicated that fertilizers and pesticides were too expensive, and that formal credit for the purchase of inputs was largely unavailable. Table 32 shows that, 42 (28%) and 28 (18.7%), of irrigating and non-irrigating households indicated that, costs of productions such as mechanization, hired labour, land preparation, planting and weeding is too high, whereas 48 (32%) and 36 (24%) indicated that, inputs are unavailable and if available they are very expensive. Irrigated rice production is associated with application of external inputs like fertilizers and pesticides. However, it must be noted that a significant proportion of farmers engaged in irrigated rice production are considered resource poor and have limited access to credit for input purchases.

4.10.3 Access to improved varieties

Poor access to improved varieties and good quality seed was cited as a principal constraint during the surveys. This constraint was attributed by unavailability of seed (37.0%), high input prices (40.7%) and low capital (48.1%). Most farmers in the study area indicated using seed from their previous harvests or purchasing seed from local markets. Therefore, the emphasis was on short duration and high yielding varieties. Farmers and extension officers indicated a preference for high yielding varieties that are tolerant to pests and diseases. Opportunities exist for addressing this constraint using high yielding short duration varieties such as super utafiti, Txd 220, 302 and 306 from Naliandele research institute (NARI).

4.10.4 Machinery for farm operations

The unavailability of appropriate machinery such as tractors, power tillers, harvest and post-harvest equipment is another constraint in the study area. Most of farmers perform farm operations by hand hoes. Table 32 show that, 26 (17.3%) and 49 (32.7%) of irrigating and non-irrigating household heads hired tractors for land cultivations. Other operations such as rotavation, transplanting, weeding and harvesting is done manually.

Farm machinery is generally unreliable and unavailable when needed. Manual operations are labour intensive, expensive and associated with crop losses due to late operations that result from chronic labour shortages. Cost-effective and efficient small machinery for farm operations could have significant impact on irrigated rice production in the study area.

Plate 7: Slashing of the field

Plate 8 : Rotavation activities

Plate 9: Transplanting activities

Plate 10: Weeding activities

4.10.5 Pests and diseases

Insect and bird damage were identified as the problem in the study area. Locust/grasshoppers and Quelea birds were specifically insect pests affecting rice crop while cutworms and white flies were affecting tomato crop in the study area. The important disease is the rice yellowing mottle virus for rice crop while early blight, late blight, tomato mosaic virus were serious tomato diseases in the study area. With the exception of extensive bird scaring efforts, no clear control measures are suggested or observed for the problems in the study area. Fagade (2001) attribute potential crop losses of 10% to 100% to pest and disease problems. Agricultural pesticides to control these problems are costly for farmers to purchase. Therefore, diseases and pests can limit the economic benefits of small-scale irrigation activities in the study area. Table 32 shows that 13 (8.7%) and 6 (4%) of irrigating and non-irrigating households indicated that their crops are destroyed by pests and diseases respectively.

4.10.6 Marketing system

Inadequate market and marketing facility is another constraint, although not directly related to the functioning of irrigation system per se and cultivated vegetables particularly tomato is highly perishable, so an efficient marketing channel is necessary. Table 32 shows that, 68 (45.3%) and 75 (50.0%) of irrigating and non-irrigating households indicated that they had market constraints. One reason is the similarity of products and marketing patterns. Paddy and tomato are the dominant crops and often harvested by farmers at the same time, which leads to abundant availability and low prices to the farmers.

Table 37: Responses on constraints faced by farmers in production

Constraints	**Irrigators**		**Non-Irrigators**		**Total**	
Water	**n**	**%**	**n**	**%**	**n**	**%**
Yes	17	11.3	73	48.7	90	60
No	58	38.7	2	1.3	60	40
Total	75	50	75	50	150	100
Land						
Yes	25	16.7	27	18	52	34.7
No	50	33	48	32	98	65.3
Total	75	50	75	50	150	100
Market						
Yes	68	45.3	75	50	143	95.3
No	7	4.7	0	0.0	7	4.7
Total	75	50	75	50	150	100
Agricultural credit						
Yes	2	1.3	3	2	5	3.3
No	73	48.7	72	48	145	96.7
Total	75	50	75	50	150	100
Production						
production costs	42	57.5	28	37.3	70	47.3
Input availability	48	65.8	36	48	84	56.8
Pest and Diseases	13	17.8	6	8	19	12.8
Total	75	50	75	50	150	100

CHAPTER FIVE

CONCLUSIONS, POLICY IMPLICATIONS AND RECOMMENDATIONS

5.1 Conclusions

Small-scale irrigation schemes aim to increase agricultural production, improving food security as well as income of participating farmers. The presence of Ndanda river has made irrigation water available to farmers. This has brought more area now under cultivation which could not be cultivated previously and thus increase agricultural production, food security and household income in the study area. Based on this study, various lessons can be learned for improving the sustainability of Ndanda traditional irrigation scheme:

The study has concluded that Ndanda traditional irrigation scheme plays a crucial role in the socio-economic development of the study area. It works just like an engine of development for the area under consideration. The study showed that, the mean of area under paddy cultivation of irrigating and non irrigating households is 1.32acre and 1.13acre. The mean difference is 0.19 with irrigators taking the upper hand. The mean yield for paddy crop is 42.88kg and 9.52kg of irrigating households and non-irrigating households and the mean difference is 33.36kg. On the other hand, mean yield for tomato crop is 409.06kg and 192.42kg and the mean difference is 216.64kg.

The total mean income of irrigating households and non-irrigating household was Tshs 7 395 200and Tshs 1 379 900 respectively and mean difference is Tshs 6 015 280.The total mean annual cropping income of irrigating households was substantially higher than that for non-irrigating households. There is significant difference in mean annual income between irrigating and non-irrigating households at 5% level. The present study concludes that due to irrigation and intensive farming, crop yields and household income is higher in irrigating households.

The results of the regression equations indicated that almost all the independent variables significantly affected the yields of various crops. The coefficient of multiple determinations (R^2) was found to be 0.72 and 0.41, 0.72 and 0.98 for paddy and tomato crops of irrigating and non irrigating households, which indicates that the independent variables included in the production function explained about 72% and 41%, 72% and 98% of the variations in the dependent variable such as crop yield. The Cobb Douglas production function model is best fit since the F-ratios highly significant at 5% level.

The results of Heckman's two stage analysis shows that, variables that significantly predict access to irrigation are size of cultivated land, age, sex, and education level, agricultural inputs; access to extension services and access to credit. The variables that reduce the probability of access to irrigation are age and sex of household head. The variables that increase the probability of participation of farmers in irrigation farming include family size, size of cultivated land, education level, agricultural inputs; hired labour, access to extension services and access to credit. In the study area the use of Ndanda traditional small scale irrigation contributes significantly to improve household income. In addition to irrigation participation, age and size of cultivated land significantly influence household income.

Calculated net profit of irrigating and non irrigating households is Tshs 468 993 795 and Tshs 75 424 901 respectively. The net benefit from irrigation was Tshs 463 568 894. However, the net revenue obtained by irrigating crops is much higher than those of non-irrigating crops. This suggests that irrigating farmers are more cost effective, efficient and higher returns to irrigation agriculture than in rain-fed agriculture. It is obvious that irrigation plays an important role in crop production in Ndanda traditional irrigation scheme.

The study show that, 59 (39.3%) and 37 (24.7%) of respective irrigating and non-irrigating household heads indicated that, they did access extension services while 16 (16.7%) and 38 (25.3%) respective of irrigating and non-irrigating household heads indicated that, they lack extension services. More irrigators did access extension services than non-irrigators due to the fact that irrigation practices is intensive and needs skilled technical assistance from extension agents to provide farmers new technologies such as the use of improved seeds, efficient use of water, proper use of fertilizers and timely field operation.

The study identified many problems in irrigation development through observation, group discussion and key informant interviews. The main problems are poor infrastructure system, high cost of production, inadequate improved varieties, inadequate farm machineries, inadequate marketing system and crop pests and diseases.

5.2 Policy implications

Traditional irrigation systems, such as Ndanda irrigation scheme, have a great potential for increasing crop production and household incomes hence, enhancing rural livelihoods and reducing rural poverty. Ndanda traditional scheme is important to the livelihoods of the farmers; however, the scheme is facing a lot of constraints, including poor infrastructures, high costs of production, unavailability of improved seeds, lack of farm machinery and pest and diseases. The inefficient method of land preparation and cultivation where the use of hand hoe is dominant contributes to low production and productivity. The challenge is how to raise crop production with restricted resources of land and water, finance, agricultural inputs and support services. The likely outcome of this, unless addressed, will be declining crop productions. There is the need to promote and support Ndanda traditional irrigation scheme on construction of permanent infrastructure and promotion of appropriate technologies in irrigated agriculture such as improved seeds, inorganic fertilizers and agricultural implements.

From the policy context, national agricultural and irrigation policy calls for proper irrigation management for sustainable development. In a broader context, both policies aims at attaining national food security through increased production, increased industrial crop production for export, and integrated and sustainable use and management of water resources. The potential implication of the Ndanda traditional scheme is that if it is improved, it will lead to sustainable increases in small farmer’s productivity and income, thus alleviating rural poverty.

5.3 Recommendations

Based on the conclusions drawn from the findings, policy recommendations for enhancing irrigated agriculture should aim at investing in combinations of strategies to the constructions of modernized irrigation infrastructures and improving agricultural production techniques.

5.3.1 Construction of improved irrigation infrastructure

The study recommends that, special attention must be paid to the construction of modernized irrigation infrastructures so as to overcome problems of lack of access to surface water, loss of water through seepage, problem of irrigation water distribution poor drainage systems and yearly reconstruction of traditional weir and irrigation canals. Also the construction will increase area under cultivation and crop yield per area. For instance, the potential irrigable area is approximated to be 350 hectares but only 110 hectares is so far under traditional cultivation.

5.3.2 Improving agricultural production

Although little improvements have been brought in agriculture, yet agriculture of the area is still faced with many problems which results to low yield of the crops. It is recommended that the department of agriculture in Masasi district to give special attention to further development of this sector in the area. The farmers must be advised on right and timely operations and agricultural practices.

Extension services must approach and promote crop production in a holistic manner, not one isolated factor at a time, good seed this year, increased fertilizer use next year. In order to have potential crop yields, proper knowledge and management of inputs, soil water, quality seed, fertilizer, plant protection, etc are applied in an optimum integrated manner. This is referred to as “a package of production technologies”. If any one of the factors is non optimum then the potential cannot be reached. If all inputs are the adequately available, but proper and timely irrigations not applied, then target yields will not be reached and resources will be wasted.

The important inputs are chemical fertilizers, herbicides and pesticides. In the study area, these inputs are used below the recommended level because of their high cost and shortage of supply. Access and proper utilization of agricultural inputs are important for sustainable agricultural productivity and improvement. Different stakeholders such as government, cooperative organizations and private organizations should give attention on the supply of these inputs on time and in adequate amounts.

5.4 Limitations and future studies

The study looked at one irrigation scheme of Masasi district for a relatively short period of time. This can make it difficult to generalize about the influence of irrigation elsewhere in Tanzania and in other developing countries. It is also a challenge to sort out the dynamic influence of irrigation from a single-period study. Another limitation is that the study considered crop income, rather than net income, and did not assess whether higher incomes resulted in improved outcomes such as nutritional status, health status or education.

This study focuses on the influence of Ndanda traditional irrigation scheme on crop production and crop income at household level. However, there are limitations that need further in-depth analysis, including the net benefit analysis of irrigation technologies using cost-benefit analysis. The influence of Ndanda traditional irrigation scheme on actual livelihood change on the community like nutritional outcomes, and other indicators of household well-being need further study.

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APPENDICES

Appendix 1: QUESTIONNAIRE FOR HOUSEHOLD

TITLE: THE INFLUENCE OF NDANDA IRRIGATION SCHEME ON CROP PRODUCTIVITY

A	**HOUSEHOLD SOCIO-ECONOMIC CHARACTERISTICS**	
A1	Name of Respondent	______________________
A2	Village	1= Njenga; 2= Mpowora; 3= Mwena
A3	Date of Interview	__________________2012
A4	Age of head of household	_____________ (Years)
A5	Sex	1= male; 2= female
A6	Marital status	1= single; 2= married; 3= divorced; 4=widow
A7	Total family size of the household	_____________ (Number)
A8	Education level(Head of household)	1=No formal 2= Adult education 3=Primary 4=Secondary5=Other (Specify)_______________
B	**IRRIGATION PRACTICES**	
B1	Are you irrigation user?	1=Yes 0=No
B2	If the answer is No, what was the reasons not using irrigation?	1=No farmland in surface water access 2=No awareness about it 3=Sufficient rain and moisture 4=Others, Specify______
B3	If Yes which small-scale irrigation type do you use?	1 = Modern irrigation 2 = Traditional river diversion 3 = Motor pump 4 = well or borehole 5 = natural pool/pond 6= shallow dug-out 7=Others specify________________
B4	Farmer's years in irrigated agriculture	_____________ (number)
B5	How much of the total area cultivated is under irrigation?	______________________ (Acres)
B6	How many times do you get maximum available weekly days for irrigation?	1=Once per week 2=Twice per week 3=Triple per week 4=Others, specify..
B7	What is the main reason that prompted you to engage in agricultural production? [*Tick all that apply*]	1= Food security, 2= Income generation, 3= Employment,

		4= Frequency drought, 5= Others, specify_____
B8	What are the major problems encountered in running agricultural production in your area? [*rank in order of priority of 1 to 8*]	1= Land scarcity, 2= Water scarcity, 3= Higher production costs, 4= Poor market access, 5= Insufficient extension services, 6= unavailability of required inputs, 7= Low market prices 8= Pest and Diseases
C	**AGRICULTURAL PRODUCTION**	
Ca	**LAND ISSUES**	
Ca1	Do you own the land you are currently using for crop production activities?	1= Yes 0= No **(If no GO TO B4)**
Ca2	If answered YES in Q.Ca1 above, what is the size of land you own?	___________ (acres)
Ca3	How did you obtain the land owned?	1=Inherited 2=Bought 3= Given by village Government 4= Accessed free land 5=Others Specify______________
Ca4	If bought land, then What was the price per acre?	________________(TZS)
Ca5	If you own land, do you hire extra land for irrigated agriculture?	1= Yes 0= No
Ca6	If you do not own the entire land you are using for farming, then whose land do you use for crop production activities?	1= Relative's land (free land) 2= Hired (Monetary payment) 3= Hired (Payment in produce)
Ca7	If you paid in cash, then what was the rent for hiring one acre of land? Provide value in TZS:	________________(TZS)
Cb	**CROP PRODUCTION**	
Cb1	How many cropping seasons do you have per year?	1=one season 2=Two season 3=Three season 4=Others, Specify_____
Cb2	Has the crop yield increased?	1= Yes 0= No
Cb3	If answered Yes in Q Cb2 above what are the reasons.	1=Adequate water 2=Availability of inputs 3=Availability of credits 4=Extension services 5=Other Specify_______
Cb4	If answered No in Q Cb2 above what are the reasons.	1=Inadequate water 2= Lack of inputs 3=Lack of credits

				4= Lack of extension services 5=Other Specify_______		
Cb5	***Indicate crop yield for the two (2) latest/most recent production seasons (0= none, 99 = missing)***					
	Crop grown	**Area cultivated (Acres)**	**Yield(kgs) 2010/2011**	**Yield(kgs) 2009/2010**	**Total**	**Average yield/Acre**
Cb5.1	Paddy					
Cb5.2	Tomato					
Cb5.3	Onion					
Cb5.4	Other Specify					
Cc	**PRODUCTION TECHNOLOGY AND INPUT USE**					
Cc1	Have you ever used any of the following technologies?				1=Improved seeds 2=Pesticides 3= Inorganic fertilizer 4=Improved irrigation 4=Other, Specify__	
Cc2	Has access to crop technologies generally increased?				1=Yes 0=No	
Cc3	If NO in Cc2 above, what is the problem for not getting all the required technologies				1= Unavailable, 2= Higher prices, 3= Low capital, 4=Others, Specify_	
Cc4	Have you ever received any formal training related to production of your main irrigation enterprise?				1= Yes, 0= No	
Cc5	If you received training, who conducted the training?				1=NGO 2=Extension agent,3= Training Institute, 4= Others, specify_	
Cc6	What types of training did you received?				1=Paddy production 2=Vegetable production 3= Fertilizer applications 4=Chemical application 5=Irrigation 6=Others, Specify_	
Cc7	Are you using the following Machinery in the production				1=Tractor 2=Planter 3= Harvester 4=Others, Specify______	
Da	**VARIABLE COSTS [FARM LEVEL COSTS]**					

Da1	Information on variable costs of inputs used on production before and after the project:						**(TZS) [see amount and cost of each inputs below]**
Crops	**Inputs**	**2010/2011**			**2009/2010**		
		Amount	**Unit/ price**	**Total cost**	**Amount**	**Unit/price**	**Total cost**
RICE	Land preparation						
	Fertilizer						
	Seeds						
	Chemicals						
	Labour						
	Hired land						
	Others,						
	Total						
TOMATO	Land preparation						
	Fertilizer						
	Seeds						
	Chemicals						
	Labour						
	Hired Land						
	Others, Specify						
	Total						

Db	**FARM LABOUR COSTS**	
Db1	***Explain the labour resources in household as specified below(if none= "0")***	
Db1.1	Number of household members who regularly sleep here	________________ (number)
Db1.2	Number of adults (above 18 years)	________________ (number)
Db1.3	Number of children (< 18 years)	________________ (number)
Db1.4	How many are involved in your main irrigation enterprise?	________________ (number)
Db1.5	What is the main occupation of head of household?	
Db2	Information on Family labour hours per day used for various activities performed in relation to crop production.	

Crops	**Activities**	**Family Labour (Hours/day)**					
		2010/2011			**2009/2010**		
		Men	Women	**hrs/day**	Men	Women	**Hrs/day**
	Land preparation						
	Nursery preparation						
	Planting						
RICE	Weeding						

	Fertilization						
	Spraying						
	Bird scaring						
	Harvesting						
	Processing						
TOMATO	Land preparation						
	Nursery preparation						
	Planting						
	Weeding						
	Fertilization						
	Spraying						
	Harvesting						

Db3.	If hired labour was used, indicate the average cost per operation per acre of each crop before and after the project.						
Crop	**Season**	**2010/2011**			**2009/2010**		
	Activity	**Size (Acre)**	**Unit Cost**	**Total Cost**	**Size (Acre)**	**Unit Cost**	**Total Cost**
RICE	Land preparation						
	Nursery preparation						
	Planting						
	Weeding						
	Fertilization						
	Spraying						
	Harvesting						
	Bird scaring						
	Processing						
	Others, Specify						
	Total						
TOMATO	Land preparation						
	Nursery preparation						
	Planting						
	Weeding						
	Fertilization						
	Spraying						
	Harvesting						
	Processing						
	Other, Specify						
	Total						

Db4	What other expenses did you incur in production? {C*ost for Tractor services, transport, equipment hired e.g. Ox-cart, hoes Sprayers etc*}				
Crop	**Activities/services**	**2010/2011**		**2009/2010**	
		Unit Cost	**Total Cost**	**Unit Cost**	**Total Cost**
	Transporting				
	Tractor services				
	Power tiller services				

	Equipment hired				
	Others, Specify				
	Total				

Dc	**HOUSEHOLD INCOME**						
Dc1	Income from all crops enterprises?						
	Season	**2010/2011**			**2009/2010**		
No	**Crop**	**Amount (kgs)**	**Price /kgs**	**Total income**	**Amount (kgs)**	**Price/kgs**	**Total income**
1	Rice						
2	Tomato						
4	Others Specify						
Total							

E	**ADVISORY SERVICES**	
E1	Do you get extension services?	1= YES, 0=NO
E2	Do you get all advisory services required in your production and marketing chain of your enterprise?	1= YES, 0= NO
E3	If answered NO in Q E3 above, what services do you lack?	1= production, 2=marketing, 3= promotion, 4=packaging, 5= others specify__________
E4	If answered YES in Q. E3, who are the supplier of the extension services in your area?	1= public sector 2= private sector 3= Both 1&2 4=NGO's
E5	Would you say access to advisory services has generally increased, remained the same or decreased	1=Increased…2=No change…. 3= Decreased……
E6	Would you say your access to agricultural extension has increased, remained more or less the same or worsened	1=Increased.... 2=No change…. 3=Worsened……
F	**CONSTRAINTS TO PRODUCTION PROCESS**	
F1	Do you have constraints on accessing water for your enterprise?	1=YES, 0=NO
F2	Do you have constraints on accessing land for your enterprise?	1=YES, 0=NO
F3	Do you get trainings on production techniques for your enterprise?	1=YES, 0=NO
F4	Do you get trainings on accessing markets for your enterprise?	1=YES, 0=NO
F5	Do you get trainings on accessing credits for your enterprise?	1=YES, 0=NO
F6	Do you have access to extension service for your enterprise?	1=YES, 0=NO
F7	Are there farmer markets created for products?	1=YES, 0=NO

F8	Do you have constraints on accessing markets for your enterprise?	1=YES, 0=NO
F9	Do you have constraints on accessing credits for your enterprise?	1=YES, 0=NO
F10	Do you have constraints on accessing extension service for your enterprise?	1=YES, 0=NO

THANK YOU VERY MUCH FOR COOPERATION