TRADITIONAL IRRIGATION SYSTEMS AND LIVELIHOODS OF SMALLHOLDER FARMERS IN SAME DISTRCT, KILIMANJARO, TANZANIA

BY

MUSA AKIDA MNYENYELWA

A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURAL ECONOMICS OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

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ABSTRACT

This study presents the impact of traditional irrigation on the household livelihood in Same district, Kilimanjaro region. The overall objective of this study was to assess the contribution of traditional irrigation systems to the well-being of smallholder farmers. The specific objective was to examine the contribution of traditional irrigation in improving household food security and income; determine the profitability of crop production enterprises with and without traditional irrigation systems. Both secondary and primary data were collected and the main instruments for data collection as structured questionnaire. Data were summarized and analysed statistically using descriptive statistics. Indicators of livelihood that were used in assessing the impact of traditional irrigation; were household income and food security. The results show that farmers adopt traditional irrigation system due to high crop productivity, and possibility of multiple productions. Multiple cropping of up to three times per year was possible under traditional irrigation system. This contributes to ensuring households food security throughout the year. The difference in income from crop under traditional irrigation and rainfed system was significant. However, in years with reliable rainfall there was no significant different in crop yields between traditional irrigation and rain fed system. Based on the findings of this study it is concluded that, traditional irrigation system contribute significantly to household food security and reduction of household income poverty. This is because irrigated area provides possibilities for cultivation of high value crops and multiple cropping. The main purpose of this study was to explore the economic issues associated with traditional irrigation farming practice and develop sustainable management strategies. Infrastructures available in the area and

marketing potentials are important factors for enhanced productivity from traditional irrigation for food security and income.

DECLARATION

I**, MUSA AKIDA MNYENYELWA**, do hereby declare to the senate of Sokoine University of Agriculture that this dissertation is my own original work and that it has not concurrently being submitted for a higher degree award in any other university.

_____ _____

Musa Akida Mnyenyelwa Date

(MSc Candicate)

The declaration is confirmed.

_____ _____

Dr. Evelne, .A. Lazaro (PhD) Date

(Supervisor)

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LIST OF ABBREVIATION AND SYMBOLS

ADSP	-	Agricultural Sector Development Program
ASD	-	Agricultural Development Support Program

ASR	-	Agricultural Sector Reform
BTC	-	Belgium Technical Cooperation
CARE	-	Cooperative for Assistance and Relief Everywhere
DFID	-	Department for International Development
FAO	-	Food Agriculture Organization
FNPP	-	FAO-Netherlands Partnership Programme
GDP	-	Gross Domestic Product
GM	-	Gross Margin
IFAD	-	International Food Agriculture Development
IWMI	-	International Water Management Institute
JICA	-	Japan International Cooperative Agency
MAFS	-	Ministry of Agriculture and Food Security
MAFSC	-	Ministry of Agriculture Food Security and Cooperative
MALD	-	Ministry of Agriculture and Livestock Development
MOA	-	Ministry of Agriculture
NIMP	-	National Irrigation Master Plan
SNAL	-	Sokoine National Agricultural Library
SPSS	-	Statistical Package for Social Sciences
SSA	-	Sub-Saharan Africa
SUA	-	Sokoine University of Agriculture
SWMRG	-	Soil and Water Management Research Group
TIP	-	Traditional Irrigation Project
TNBS	-	Tanzania National Bureau Statistics
TR	-	Total Revenue

TVC - Total Variable Cost

UNCSD - United Nations Commission on Sustainable Development

URT - United Republic of Tanzania

VECO-TANZANIA - Vre desellanden Country Office-Tanzania

WUG - Water User Groups

CHAPTER ONE

INTRODUCTION

1.1 Background information

In Tanzania food production largely depends on rain fed agriculture (URT, 2001). However, food production fluctuates from year to year, due to erratic and unreliable rainfall (URT, 2001). Traditional irrigation will assume an important role towards transforming the predominantly traditional subsistence rain-fed agricultural into profitable and commercial agriculture (URT, 2006). According to the National Irrigation Master Plan (2002), when rainfall decreases, food production also decreases. Producing food by rain fed will not reduce food insecurity and income poverty, since rain is unpredictable in many parts of our country (Adams *et al.* 1994). Traditional irrigation has been reported to supplement food and income generation from rain-fed farming (TIP, 2004).

Tanzania's economy is dependent mainly on agriculture. More than 80 percent of the population is engaged in agriculture activities for their livelihood and it contribute to an average of 43.4 percent of Gross Domestic Product (GDP), (URT, 2006; World fact book, 2007). Agriculture in Tanzania is mainly rain fed and this is undertaken by farmers, sometimes in semi-arid areas, with less than 800 mm of rainfall (Baba, 1993; Kangalawe and Liwenga, 2004). This kind of agriculture is severely constrained by drought, which significantly reduces crop yields (Kaswamila and Masuruli 2004). Irrigation development is an effective way to increase crop production and productivity that may result into food self-sufficient and income poverty reduction in the country (URT, 2005). The government of Tanzania well thought-out irrigation to be the most important aspects in attaining

agricultural development, as a result brought the question of irrigation to be the forefront in their agricultural priorities (Soil Water Management Research Group, 2005).

1.2 Irrigation

The term irrigation has been defined under different perspectives and contexts. Generally however the term irrigation is associated with the artificial application of water to the soil for the purpose of improving crop productivity. Ojungu (1992) defined irrigation as a practice in which people, deliberately supply water and store surplus water in a controlled manner, so as to supplement rain or ground water and sustain or improve crop production in a cultivated field. Ojungu (1992) also reported that irrigation has mainly been practiced in the arid and semi-arid climates where rainfall is scarce.

1.3 Traditional irrigation

Nhkoma (1998) defined traditional irrigation as application of water to crop land using indigenous water harvesting techniques which are not based on scientific understanding but locally handed down.

Mrema (1984) defined traditional irrigation as an attempt to harness the available water from rivers, springs and flood plains for irrigation, it covers relatively small and scattered areas, also they employ traditional methods and their intake structures are often temporary, having to be replaced from time to time.

Mintesinot *et al.* (2004) defined traditional irrigation are mainly gravity flow of water in which the systems is constructed by villages that use local materials to

divert water from a river into a system of canal for irrigation. This study define traditional irrigation as an attempt to harness the available water from rivers, springs and flood plains for irrigation, it covers relatively small and scattered areas, also they employ traditional methods and their intake structures are often temporary, having to be replaced from time to time Mrema (1984).

1.4 Traditional irrigation and rural livelihood

Most traditional irrigation schemes are found in the homelands in the villages, where there is incidence of food insecurity (May, 2000; Aliber, 2003). In these particular socio-economic environments traditional irrigation schemes present an attractive opportunity for the development of local livelihoods. According to Chambers and Conway (1992) for example defined livelihoods as comprising people and their livelihood capabilities; assets, including both the tangible (resources and stores) and intangible (claims and access), which provide the material and social means that are used to construct livelihoods; activities, i.e. what people do; and a living, which refers to the outcomes of what people do. When viewed from this livelihood perspective, traditional irrigation schemes are assets. They can be used to increase and diversify the livelihood activity of crop production, resulting in improved livelihood outcomes, either directly in the form of food or income for farmers, or indirectly by providing full or partial livelihoods to people who provide goods and services in support of irrigated agriculture on these schemes. Livelihood outcomes include conventional indicators such as income, food security and sustainable use of natural resources. Outcomes can also include a strengthened asset base, reduce vulnerability and improvement in other aspect of

well-being such as health, self-esteem, sense of control, even maintenance of cultural asset and thus have a feedback effect on the vulnerability status and asset base.

1.5 Irrigation potential in Tanzania

Using a rigorous mult-parameter analytical process, it is estimated that 2.3 million, 4.8 million and 22.3 million hectares(ha) of land in Tanzania is high, medium and low irrigation development potential out of the estimated 43 million ha of suitable land for agriculture in Tanzania (NIMP and JICA, 2002). Currently state year area under irrigation is only 200 000 hectares (NIMP and JICA, 2002). This area is dominated by paddy, followed by sugarcane, tea and horticultural crops (NIMP and JICA, 2002; URT, 2001). In Kilimanjaro region area under irrigation is estimated to be 27 148 ha, improved irrigation constitute of 16 647 ha, and traditional irrigation is 10 501 ha (URT, 2002).

There are two major categories of irrigation systems dominant in developing countries. These are large and small-scale irrigation systems (FAO, 1986). As the names indicate, the difference between the two is scale. Scale is not only determined by the spatial coverage of the project but also by the investments required in terms of capital and technology (Maganga and Juma, 2000). Several other terms have been used to refer to small scale irrigation systems over time. These include terms, such as traditional irrigation, indigenous irrigation and local irrigation (Adam *et al*, 1994; FAO, 1995). Smallholder farmers use simple and affordable technology to practice these kinds of irrigation.

According to FAO (1997) traditional irrigation is defined as irrigation on small plots, which are owned and controlled by farmers and the level of technology used is simple, which farmers can effectively operate and maintain. In this category much of the diverted water is lost due to seepage before reaching the field. In the field the irrigation efficiency is normally very low (Kaswamila and Masuruli, 2004). This category covers more than 79 percent of the total irrigated land in Tanzania (Kaswamila and Masuruli, 2004). Traditional irrigation farming systems practiced by smallholder farmers in Same district is divided into three types. Sub-irrigation (valley bottom) also sometimes called *seepage irrigation* has been used for many years in field crops in areas with high water tables. It is a method of artificially raising the water table to allow the soil to be moistened from below the plants root zone. It is mostly practiced in high lands, characteristically moist for a long period of the year, allowing the cultivation of multiple annual crops (Region Agriculture office Moshi, 2001). Surface irrigation is a system which smallholder farmers distribute water by lined and unlined canals is mostly practiced in lowlands. Micro dam technology (Ndiva) is the irrigation to impound runoff water by digging and constructing a wall of stone in earth to keep water bank (*embankment)* (Soil Water Management Research Group, 2005).

1.6 Problem statement and justification

Tanzania is endowed with an abundance of natural resource that is yet to be exploited adequately to contribute towards the improvement of the welfare of the people and the revitalization of the economy (MAFS, 2003). Water being the essential resource, irrigation development is one of the effective approaches to

increase and stabilize food production thus to contribute towards attaining food security and self-sufficiency (IWMI, 2001). It seems irrigation is the only option to boost up and sustain overall agricultural productivity to required level (MAFSC, 2007). Improving performance of irrigation farming would have a stern impact on poverty reduction through improving incomes, food security, reducing food imports and increase employment (Lema, 1996).

Since 1980s there had been a number of efforts in Tanzania to promote irrigation farming in order to increase food security (Mwalyosi and Majule, 2005).These efforts concentrated on large-scale irrigation schemes, which were often too mechanized and expensive for most Tanzanian farmers (MAFS, 2004). To mention few Mbalali, Dakawa, Madibira, Mtibwa, Ruvu, Kapunga, Lower Moshi and Kilombero (MAFS, 2004). There is ample evidence that most of these schemes or projects failed partly due to their poor management and environmental degradation such as sedimentation and salinization (Mwalyosi and Majule, 2005). However, traditional irrigation that utilizes natural moisture or water from either natural springs or river diversions has been increasingly practiced as a means of ensuring food security and income generation to smallholder farmers Adams *et al.,* (1994). Its contribution has not been met to make farmers become food secured and raise their income Adams *et al*., (1994). It is due to this background which necessitated the study to be undertaken.

The irregular and unreliable rainfall in Same district has caused the smallholder farmers to intensify the traditional irrigation farming systems as a strategy to cope with food shortage and income poverty. Studies done on irrigation focused on

evaluation, assessment, performance, operation, socio-economic and financial analysis of large scale irrigation (Maregesi, 1993; Tarimo *at el.,* (2004); Orota, 1993; Balirwa, 1990; Kiagho, 2003). Evaluation of livelihoods and economic benefit of water utilization has also been done (Kadigi, 2006).There also considerable work on experiences with micro agricultural water management technology SWMRG (2005) and studies on Assessment of water resource for food security in Tanzania (Kasambala, 2004). All these studies have not direct mentioned the contribution of traditional irrigation to food security and income generation.

Traditional irrigation farming if well practiced can reduce food insecurity and income poverty, hence improves the well-being of the smallholder farmers (TIP, 2004). Despite all the efforts done by many stakeholders, but still smallholder farmers are facing the problem of food insecurity and income poverty, the reason which needs to be studied. The study will also help policy maker and other stakeholders realize the importance of traditional irrigation to the livelihood of smallholder farmers.

1.7 Objectives

1.7.1 General objective of the study

The main objective of this study was to assess the contribution of traditional irrigation systems to well-being of smallholder farmers in Same district

1.7.1.1 Specific objectives of the study

i) To examine the contribution of traditional irrigation in improving food security

ii) To determine the contribution of traditional irrigation to the household income.

iii) To determine the profitability of crop production enterprises with and without traditional irrigation systems in Same District

1.7.1.2 Hypotheses to be tested

i) Traditional irrigation farming has no significant impact on smallholder farmers' food security.

ii) Traditional irrigation farming has no significant impact on smallholder farmers' income.

iii) There is no significant different in profitability between crop production enterprises with and without traditional irrigation systems in Same District

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview of global irrigation

Agriculture is by far the largest water use sector, accounting for about 70 percent of all water withdrawn worldwide from rivers and aquifers for agricultural, domestic and industrial purposes (Shiklomanov, 2000). In many developing countries more than 90 percent of the water withdrawals are for irrigation (FAO AQUASTAT, 2005). In arid regions, traditional irrigation is the prerequisite for crop production (Bruinsma, 2003). In semi-arid and humid areas, irrigation serves to increase yields, to attenuate the effects of droughts or, in the case of rice production, to minimize weed growth Faures *et al*., (2002). Average yields are generally higher under irrigated conditions as compared to rainfed agriculture (Bruinsma, 2003). In the United States, for example, average crop yields of irrigated farms exceeded, in 2003, the corresponding yields of dryland farms by 15% for soybeans, 30% for maize, 99% for barley, and by 118% for wheat Veneman *et al.* (2004). Although globally only 18% of the cultivated area is irrigated (FAO, 2005), 40% of the global food production comes from irrigated agriculture (UNCSD, 1997). Both the water scarcity caused by using large amounts of water in irrigated agriculture and the importance of irrigation for crop production and food security induced several studies to quantify the different elements of the global water balance in space and time Alcomo *et a., l.*(2003). Others focused on the importance of irrigated food production in general Faures *et al.*, (2002), and the impact of irrigated agriculture on global (regional) climate or on the impact of climate change and climate variability on global irrigation water requirements (Doll, 2002).

2.2 Traditional irrigation and food security

There are strong direct and indirect linkages between traditional irrigation and food security Biltonen *et al., (*2002). Direct linkages operate via localized and household-level effects, and indirect linkages operate via aggregate or national level impacts (Bruinsma, 2003). Traditional irrigation benefits the smallholder farmers though higher production, higher yields, lower risk of crop failure, and higher and year-round farm and nonfarm employment (Sharma, 2001). Irrigation enables smallholders farmers to adopt more diversified cropping patterns and to switch from low value subsistence production to high-value, market oriented production Veneman *et al.,* (2004). The transition to the market economy integrates the poor into land, labor, and commodity markets and empowers the poor by putting them at a level playing field with other market entities, including the non poor (Bruinsma, 2003). Increased production makes food available and affordable for the poor. The poor and the landless are main beneficiaries of low food prices as they are net buyers of food (Bruinsma, 2003).

Indirect linkages operate via regional, national, and economy wide effects Biltonen *et al.,* (2002). Traditional irrigation investments act as production and supply shifters, and have a strong positive effect on growth, benefiting the poor smallholder farmers in the long run Veneman *et al.,* (2004). Recent advances in irrigation technologies, such as traditional irrigation systems, have strong increased food security Veneman *et al.,* (2004). Ongoing studies in Asian countries document strong evidence that traditional irrigation helps reduce permanent and temporary food security Biltonen *et al.,* (2002). This supports the view that traditional

irrigation is productivity enhancing food security Veneman *et al.*, (2004). Interventions should focus on reaching out to the poor smallholder farmers through improved economic, policy, institutional, and governance measures. Generating a knowledge base through multi country studies on constraints to productivity in irrigated agriculture is the first step to help identify the opportunities to serve the poor (Sharma, 2001).

2.3 Importance of irrigation to livelihood of smallholder farmers

Irrigation increases the extent of cultivated area and the harvest frequencies to two or more per year (URT, 2001).Reliable sources of water for irrigation especially in arid and semi-arid areas reduce risks and stabilize production levels of individual's farms (Majule and Mwalyosi, 2005). The consequences of irrigation on livelihood of smallholder farmers can be perceived through three different routes (Narayanamoorthy, 2001). Firstly, enhance local availability of food. Secondly, increase labour absorption and the consequent rise in wage rates and income. Thirdly, irrigation increases service opportunities leading to better quality of life and industrialization which increases economic activities, consequently improves the well-being of farmers (Narayanamoorthy, 2001). Traditional irrigation if well developed can perform an important role towards transforming the predominantly subsistence rain-fed agriculture into profitable, commercial agriculture system (Soil Water Management Research Group, 2005).

2.4 Impact of traditional irrigation on productivity

There is ample evidence to show that the individual crop yields are considerably higher under irrigated than under rainfed, and that irrigated areas grow more of high value crops which cannot be raised well under rainfed conditions (Satpathy, 1984; FAO, 2003). Increased mean yields can mean increased food surplus, high calorie intake and better nutrition levels. There are also stability effects because of reduced reliance on rainfall hence irrigation lowers the variance output, increase employment, yields, and helps to reduce adverse consequences of drought (Dhawan, 1991).

Agricultural performance in irrigation and that of rainfed in the same area, also show that land is used more intensively in irrigation, both in terms of the extent fallowing and of multiple cropping (Satpathy, 1984; Adhvaryu *at el*., 1983); that irrigated lands grows more of higher productivity, high value crops; and that the average yields of practically all crops are substantially higher in irrigated areas. The empirical evidence; for example, in the Dantiwada project of Gujarat in India, the output per hectare in irrigated is estimated to produce nearly twice per hectare of gross crop area compared to rainfed Adhvaryu *at el*., (1983), and another survey in Karnataka reported even larger differences, more than twice percent between irrigated and rainfed agriculture (Hatibu *at el*., 2002). It has also been shown that differences in output per gross acre as well as crop intensity across space are significantly and positively in irrigation than in rain fed (Andrew, 1993).

2.5 Output level

Irrigation boosts farm output and hence increases food security, with high prices raises farmer income (MAFS, 2003). It improves yields through reduced crop loss due to erratic, unreliable or insufficient rain water supply. Also irrigation allows for the possibility of multiple cropping, increase annual output and enables a greater area of land to be used for crops in areas where rain fed production is impossible or marginal (Ward and Michelsen, 2002).

2.6 Contribution of irrigation to the national economy

Irrigation and rain fed agriculture are complementary and not mutually exclusive (Ogomber, 2000). Irrigation assists agriculture diversification, enhance food self-sufficiency, increases income, generate foreign exchange and provide employment opportunities when and where water is not a constraint (Kimenye, 2000). In low income countries irrigated agriculture can reduce the risks to farming allowing families to increase their food security and nutrition. (FAO, 1996; OASIS and DFID, 2003). Irrigated agriculture provides 40 percent of the world's food production from 17percent of the cultivated land (FAO, 1996; MAFS, 2003). The World Food Summit in 1996 estimated that 60 percent of extra food required to sustain the world in future must come from irrigated agriculture which needs more investments and sustained efforts at expansion and improvement levels. Irrigation also allows farmers to reap the economic benefit of growing high value cash crops (Ogomber, 2000). Irrigation contributes much in grain crop production in Asia. For example in Pakistan irrigation makes the greatest contributions to food security, it

accounts for about 80 percent of food production, China 70 percent and over 50 percent in India and Indonesia (DFID and OASIS, 2003).

Traditional irrigation systems have sustained small scale farmers not only in Tanzania, but elsewhere in Africa. Howard (1996) reported that “the traditional irrigation techniques locally known *Fadima* has enabled farmers of *Jos* plateau in Northern Nigeria to generate income in the slack period from rain fed cultivation. The technique is sustainable for the production of wide range of vegetables as well as other crops such as sugarcane, wheat, maize, and barley (Howard, 1996).

In India, traditional irrigation has been marketed for more than three decades (Narayanamoorthy, 2001). Traditional irrigation can improve productivity; raise incomes through crop yields and outputs, and enhance food security of households. The main vehicle of Indian government policies is to promote traditional irrigation systems and product subsidies in certain cases up to 90 percent (Narayanamoorthy, 2001). Numerous studies have established the gains from traditional irrigation adoption and several government and non-government organizations are engaged in actively promoting irrigation (Sharma, 2001).

Ethiopia, traditional irrigation is essential for meeting subsistence needs of the rural poor and for livelihood activity in the Betmera Hiwane, (Tafesse, 2003). In particular, traditional irrigation is substantial for the rural poor in order to; diversify farming and non-farming activities and cope with seasonality of income, food security of the rural population, make savings, get benefits and salary from

employment (Tafesse, 2003). Therefore a lot of problems of the rural food insecurity could be removed due to improved traditional irrigation.

Smallholder farmers in Same district irrigate a wide range of high-valued horticultural crops, mainly vegetables for sale in the domestic market and maize for food (Mkavidanda and Kaswamila, 2001). The observed increased in smallholder commercial irrigation and adoption of new irrigation technologies in Tanzania, provide new opportunities for increasing agricultural productivity and income especially in semi-arid areas (SWMRG, 2005). Irrigation can lead to a reduction in production risk and therefore, provides greater incentive to increase input use, increase crop yields, intensify crop production and diversify into high-value crops (SWMRG, 2005). The resulting increase in marketable surplus and commercial activities has potential to generate and increased incomes to smallholder farmers (Arharya and Barbier, 1999).

2.7.1 Food security

FAO (2003), defined food security exists when all people, at all time, have physical social and economic access to sufficient, safe and nutritious food which meets the dietary needs and food preferences for an active and healthy life. (Rukuni and Eicher, 1987), food security was mostly concerned with food supply, usually in the form of grain stock and was being applied at regional or district level. (World Bank, 2003) defined as the access by all people at all times to enough food for an active and healthy life.

The definition encompasses many issues; it deals with production in relation to food availability, it address distribution that all should access the produce; it covers consumption in the sense that individual to be active and healthy (FAO, 2003). The availability and accessibility of the food to meet individual food needs should also be sustainable. This implies that early warning systems of food insecurity should monitor indicators related to food production, distribution, and consumption (Maxwell and Frankenberg, 1992). The performance of these indicators, therefore, will detect whether a certain place or population is food secured or insecure in relation to the spirit of the above definition. This is now a convectional concept of food security (CARE, 1995; FAO, 2003).

2.7.1.1 Household food security

Household food security refers to the ability of the household to secure food, either from own production or through purchase of adequate food for meeting dietary needs of its members (Nyange, 2001). When analyzing food security at household level we have to look at food supply and distribution, effective access of food by household and effective consumption by individuals (World Bank, 2003). Household food security implies that each member of the household in general has access to food. Although food availability at the household level is a key issue, there are intra-household factors that may affect equitable and adequate access to food by all members (Maxwell and Frankenberger, 1992).

Household food security in developing countries is determined by what a household is able to produce, process, store, prepare and buy from the market. In turn these are

determined by the agricultural resource availability to that household such as climate and ecology, the amount and quality of land, the level and type of technology, the availability of production assets as well as the amount and division of labour. According to (Maxwell and Frankenberg, 1992), household food security has social linkages including access to health services and good healthy environment, education and adequate care of children and women. These non-food linkages influence households' decisions regarding livelihood resources, such as income and labour which are direct determinant of household food security.

The Study conducted by Government of Ethiopia/IFAD addressed challenges encapsulated in Special Country Programme phase II, aimed to increase production of food and incomes through improvements and expansion of traditional irrigation schemes (IFAD, 2005). Special Country Programme aimed to directly benefit 23 600 farm families in 5 900ha of improved and expanded traditional irrigation schemes (IFAD, 2005). It was designed to benefit a further 10,000 families outside of irrigation command areas and 2,400 women farmers in or close to irrigation command areas would benefit directly through the development of irrigated vegetable gardens (IFAD, 2005).

In South Africa the term traditional irrigation or small-scale irrigation is mainly used when referring to irrigated agriculture practiced by black people. South Africa has about 1.3 million ha under irrigation, of which 0.1 million ha is in the hands of traditional irrigation (Backeberg, 2006). Backeberg (2006), estimated the number of South African smallholder irrigators to range between 200 000 and 250 000, but

most of these were farming very small plots, primarily to provide food for home consumption.

2.7.1.2 Food security indicators

According to Nyborg and Haugh (1994), food security indicators are divided into two types normally the process indicators and outcome indicators. Process indicators are used to measure the changing status of food security they are central in the effect of development activities on food security. Process indicator offers the type of information necessary in planning and adjustment of development efforts during the life of the project. Process indicator is also categorized into two types. Supply indicators and access indicators (Riely et *al.*, 1995).

Supply indicators have to do with food availability including famine early warning systems mainly used in regional and national levels (Nyborg and Haugh, 1994). Access indicators are to do with people's access to entitlement to food, through own production, purchase or transfer/gift. Access indicators reflect to a large extent peoples' responses to worsening conditions often intended copping strategies, include the meteorological data, agricultural production data, food balance sheet information on pest damage, market information and regional conflict (FAO, 2001). Food security outcome indictors measures the status of food at a given point in time, they are mainly used to evaluate the food security, status before and after intervention. The outcome indicator is also divided into two, the direct and indirect indicators.

The direct indicator is more close to the actual food consumption such as food frequency assessment (FAO, 2001). Indirect indicator include storage estimate, subsistence potential ratio such as ability of the household to produce its own food that is given by dividing own food by food required and nutritional assessment (Nyborg, and Haugh, 1994). Moreover, indirect indicator may also include household size and composition, land use and ownership and assets liquidity owned by household (IFAD, 1999). This study used food security outcome indicator to assess the status of food security to smallholder farmers.

2.7.2 Food insecurity

Food insecurity is the situation of not having enough food for all people at all times (Wisconsin, 2002). Food insecurity is among major problem to the population of Tanzania. This has persisted in spite of government's effort to improve production in agriculture from irrigation. Food insecurity not only causes much suffering to human being, but also results into substantial productivity losses due to reduced work performance, lowering cognitive ability and school performance to children as well as reduced income earning. In addition, improved food security and increased income at household level ultimately culminate into healthy national income (Wisconsin, 2002).

2.7.3 Food availability adequate

The key elements to determine food security at any time are; availability of enough food for active and healthy life, the access to food stability of supply, that is the guarantee that one has access to it at any given time (Max well and Frankenberg, 1996). Food availability is a measure of food that is, and will be, physically

available in the relevant vicinity of population during the given period through a combination of domestic production.

2.8 Income of crops from traditional irrigation

2.8.1 Commercialization of products from traditional irrigation

Irrigation can lead to reduction of crop production risk and, therefore, provides greater incentives to increase input use, increase crop yields, intensify crop production and diversify into high- valued crops (Blank, 2002).The return from traditional irrigation are the foremost incentive to invest and improve it (Kimenye, 2000) . The main markets for products from traditional irrigation in Same district urban market and small domestic markets within the districts. However, these markets can not consumer all the products from different parts of the district. On the other hand, in Same district, infrastructure such as roads are poorly developed especially in highland making it difficult to transport the products to other urban markets (VECO-Tanzania, 2006). Thus, lack of markets for vegetables and other products is one of the major hindrances to traditional irrigation development (Anthony, 2000).

Market intermediaries, rarely knew or provided important information such as price trend, seasonal requirements, market products specification or quality standard (MAFS, 2004). The cost of acquiring such information was high, precluding many smallholder farmers from using such information to make production and investment decision (Tiep, 2002).

2.8.1.1 Market of crops produced under tradition irrigation

The main crops sold in domestic markets at Same district were maize, bean, paddy/rice cabbage, onions, and tomatoes (VECO-Tanzania, 2005). Most farmers sold their crops at the farm gate price to rural traders within the village or to traders, who came from other places to avoid transport costs from the farm to the market. Rural assemblers sold the produce to large traders in local markets or large traders in local markets who, in turn, sold it to other traders in region market or large urban markets, such as Dar es salaam (TIP, 2004). Rural traders collected and assembled small quantities of produce from many farmers scattered all over the rural areas (VECO-Tanzania, 2005). However few farmers, especially those who were located close to market centers, sold directly in local markets because they could get better prices. Crops were mostly packed in bags except for tomatoes, that were packed in cartons and all transaction in local markets were in cash (TIP, 2004).

In Kenya marketing of fresh horticultural produce has been a persistent problem for smallholder farmers (Ngigi, 1999). This could be attributed to reasons such as the inaccessibility of some irrigated farms due to bad roads, coupled with flooding the market with produce due to lack of diversification and uncontrolled of production (Ngigi, 1999). Middlemen are also accused of manipulating the market and exploiting the poor farmers. Lack of an organized marketing system, season fluctuation in demand, quality concern and perishability of produce aggravate this situation (Sharma, 2001).

2.9 Gross margin analysis of agricultural products

Gross margins are determined by deducting total variable costs from the gross farm income of a crop. Young (1996) defined that Gross Margin is the different between the values of gross sale and the value of gross variable costs. It provides a useful tool in terms of farm budgeting and estimating the likely returns or losses of a particular crop. In order to estimate/calculate gross margin, production costs and income is calculated per acre basis and multiplied by the number of acres of planted crops to produce farm total costs and income. Income per acre is the on farm price received per unit sold (tins, kilograms or bags) multiplied by unit number produced per acre. On-farm price is calculated by deducting transport and levies per unit from the market price. Market price can vary significantly depending on season, generally decreasing as supply increases and vice versa. Therefore if the gross margin is used as a predictor, attempt should be made to estimate if harvests coincide with a peak or a trough in a supply i.e. dry and wet season price. The item considered were: labour cost, fertilizer and pesticides. However, Scott (1995) noted that the technique has several disadvantages including not accounting variation of fixed cost and failure to make allowance for supplementary and complimentary relationship between variables

Gross margin of an enterprise is not necessarily an indication of profitability, but it is only one aspect of enterprise profitability (Young, 1996). Many other items and factors are involved before the ultimate profitability is known. Increasing the intensity of enterprises on a farm may increase the total farm Gross Margin but will not necessarily increase the farm profit since the fixed cost may also rise in greater proportional to gross margin. A higher gross margin may be achieved on a farm but this could lead to a lower profit if the resultant increase in fixed costs were greater than the increase in Gross Margin (Mutero, 1998). Gross margin analysis was used in the comparative study of traditional and modern irrigation systems in Bauchi State of Nigeria. The study revealed that, with the exception of onion, the gross margin for all crops were higher for modern irrigation than in traditional irrigation.

2.9.1 Potato production in Europe, a gross margin analysis

The purpose of the study was to examine different cropping practices, cost structures and gross margins for producing conventional potatoes in 6 different regions within the European Union: Czech Republic, Denmark, Italy, Poland, Portugal and Slovakia. Findings from this study showed that potato cropping practices varies significantly between these countries with major differences in yields and costs (Cizek, 2003). Italy and Denmark are the two regions with highest gross margins due to high yields and revenues. Poland is by far the largest potato producing country among the 6 countries examined in this study (Cizek, 2003).

2.9.2 Gross margins analysis for potatoes

The gross margin analysis is based on data provided by project participants from each country. Various regions differ in terms of farm structure, soil conditions and climatic conditions Hamouz *et al.* (2005). In this respect the costs may be regarded as reasonable estimates for common potato practices in the various regions. Nevertheless, the cost structure and gross margin studies for each area should be regarded as case studies for that particular region rather than average figures for the entire country (Ponte, 2002). This approach may involve some uncertainties and a direct comparison between the countries should be regarded with reservations. Market prices may vary significantly during cropping season and access to irrigation as well as soil conditions may also have a large impact on the economic revenue (Ponte, 2002). Moreover, for some countries pests and insects may have been abnormal for that particular year with excessive application of pesticides. In Czech Republic the region is divided between the highlands without irrigation and lowland areas with irrigation. In Denmark, the gross margin analysis may represent all regions in Denmark with sandy loam soils. Most potatoes are grown on the peninsula of Jutland on Sealand as well as the islands south of Sealand Hamouz *et al.*(2005). Despite the differences in cropping practices and climatic conditions this analysis might nevertheless give an indication of the cost levels for various cultivation practices between the individual countries (Scott, 1995). The revenue from potato production consists of a first quality and a secondary quality. By subtracting the variable costs from the yearly revenue we obtain gross margin (Debertin, 1992). Here *variable costs* relates to the costs of using a particular

variable input that may vary within a particular year (e.g. the use of nitrogen and pesticides). Cost of machinery and labour is based on average annual contracting prices. In this respect it is assumed that these costs (price per unit) include capital costs (depreciation and cost of capital) and labour costs (Debertin, 1992).

2.10 National irrigation development plan

In Tanzania irrigation has shown little success for many years despite of substantial effort of government and donors investing in irrigation. However, some of the countries have taken it seriously, for example Sri Lanka during the twelve century reported that in the country, no even a single drop of water obtained from rain should be permitted to flow to the ocean without having given its full benefit to people (Moormann and van Bremen, 1978). To day this country is producing a lot of cereals and vegetables for export and domestic use.

Definitely, it is well known that food production in the world is increasingly depending on irrigated agriculture, which ensures increased agricultural production and productivity. According to a National Irrigation Master Plan (2002), study carried out by the Ministry of Agriculture and Food Security (MAFS) staff in collaboration with Japan International Cooperation Agency (JICA) team, estimated 2.3 million, 4.8 million and 22.3 million hectares is high, medium and low irrigation development potential out of the estimated 43million ha of suitable land for agriculture in Tanzania. These estimates outweigh the erstwhile figure of one million hectares of land suitable for irrigation (MAFS and JICA, 2003). Through Agriculture Development Support Program (ADSP), the government aim, to boost crop production through improving irrigation. This can be done when water is made

available for achieving food self-sufficient; it also leads to improvement of rural well being and sustainable livelihoods. This being the case, irrigation is no longer optional but fulfills the core needs of society as well ensuring protection of the environment.

2.10.1 Factors affecting traditional irrigation

Theoretically, it is generally accepted that the development of a farmer is constrained by a number of social, political and environmental factors (Chiza, 2005). Favorable conditions are essential for ensuring profitable and sustainable agricultural production (Dixon and Wood, 2003). In this study, a traditional irrigation farmer is trying to maximize cereals and vegetables production in order to achieve large profit. Traditional irrigation farming is faced by a number of problems due to intensive cultivation; these are depletion of land resources, intensive application of chemical fertilizers and pesticides, conflicts in water use/distribution (Karukulasuriya and Mendelson, 2007). Land and water degradation is also a serious problem in wetland farming due to poor management of these resources. A sustainable production and profits from traditional irrigation, therefore depends on how different factors are integrated together (Majule and Mwalyosi, 2003).

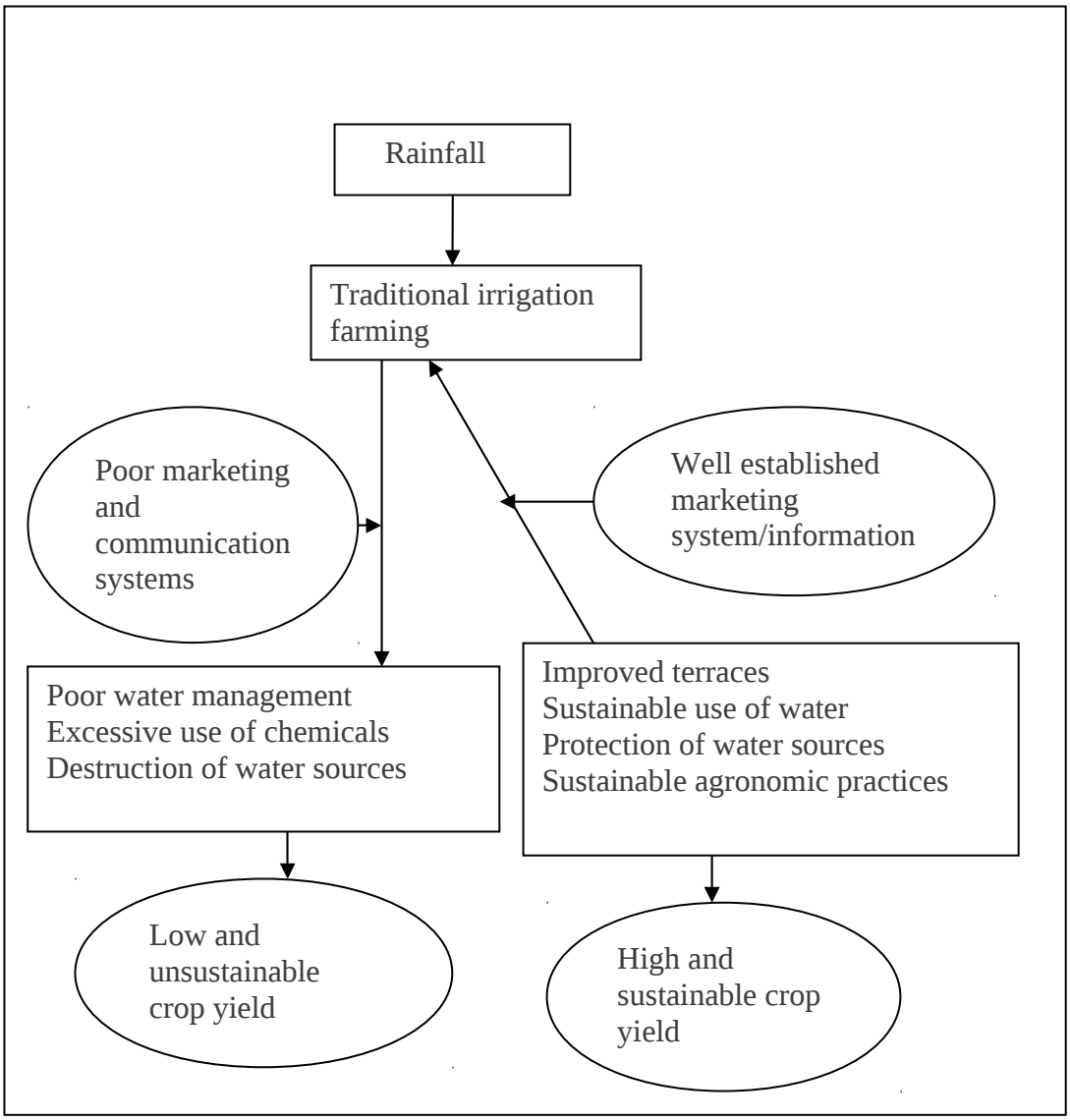

Figure1: Interrelationship of factors that affect traditional irrigation, modified from Majule and Mwalyosi, (2003)

In South Africa traditional irrigation schemes have generated public interest, mainly because their establishment and revitalization were made possible through the investment of public resources (Bembridge, 2000). Recent assessments of the sector concur that the success of traditional irrigation has been limited Crosby *et al*., (2000). Factors that contributed to their modest performance were poor infrastructure, limited knowledge of crop production among smallholders, limited

farmer participation in the management of water, ineffective extension and mechanisation services and lack of reliable markets and effective credit services Crosby *et al*. (2000).

2.10.2 Soil water management in highland.

Investigation made on traditional irrigation fields showed that, areas in steep slopes or river banks, where farming activities are dominant soil erosion also existed (TIP, 2006). This happens during rain season when river floods and rain water from up hills flowing in cultivated plots, which causes soil to be carried away. This occurs due to poor agriculture method and land management that had been practiced by farmers. Soil erosion is a serious problem in highland area where there are gentle slopes. This has been noticed more in areas where traditional irrigation farming is practiced along rivers banks, when it rains abrasion takes place. Sustainability and productivity of traditional irrigation farming systems is now a big concern due to associated land degradation (Mtatifikolo and Comoro, 1999). Deforestation and soil degradation has been reported to threaten traditional irrigation schemes in Kilimanjaro (Banzi *et al.,* 1992). Also Kaswamila and Tenge (1997) reported that over-cultivation around water sources is a threat to traditional irrigation practiced in Lushoto District. It is feared that the increase in traditional irrigation, farming practices is likely to aggravate the soil degradation process due to excessive utilization of chemicals aimed at increasing crop production. In highland soil water management is highly practiced, smallholder farmers apply different methods to prevent soil erosion; these are stone and grass terraces, contour farming and tree

planting in the sources of water. These methods are helpful to reduce effect of erosion.

2.11 Conceptual framework of the study

The study focuses on the contribution of traditional irrigation to livelihoods of smallholder farmers in terms of food security and household income in Same district.

Livelihoods analysis of irrigation water is essential. Firstly, it builds on better understanding of multiple perspectives and values of water as economic capital (agricultural input, domestic needs), physical capital (irrigation infrastructure), managerial and institutional capital (water organizations), social capital (collective action) as well as political capital (Nicol, 2000). It helps to identify what options have better potential to reduce food insecurity within the given context and what enabling conditions, policies and incentives are needed for the poor to increase the range of better livelihood options (Ellis, 2000; Moriarty *et a.*, 2004; Lankford, 2005). The approach is a relationship between the assets or resources that people own or can access to, including land, irrigation water, skill and education levels of family members, which are categorised as natural, human, social, financial and political capitals (Scoones, 1998; Nicol, 2000; Ellis and Freeman, 2005). The households utilise these assets in their productive activities in order to create food and income and satisfy their consumption needs, maintain their asset levels and invest in their future activities. The access to the assets is strongly influenced by the vulnerability context, policies and institutions.

The impact of improved smallholder farmers' livelihood is reflected in the changes of income and food security. Efficiency agricultural production increases crop yields; such efficiency is influenced by other factors of agricultural production such as inputs availability, market for the produce, education, age of the individual, extension services, financial services and improved infrastructures. Traditional irrigation, apart from normal irrigation, also plays a significant role in supplementing rain fed agriculture when there is a shortage of rainfall which in turn increases crops yields and hence it improves food security and income. The outcomes of effective utilization of traditional irrigation are expected to increase crop yields, hence increasing household income, food security, employment and investments all of which improve livelihood of smallholder farmers as an ultimate goal.

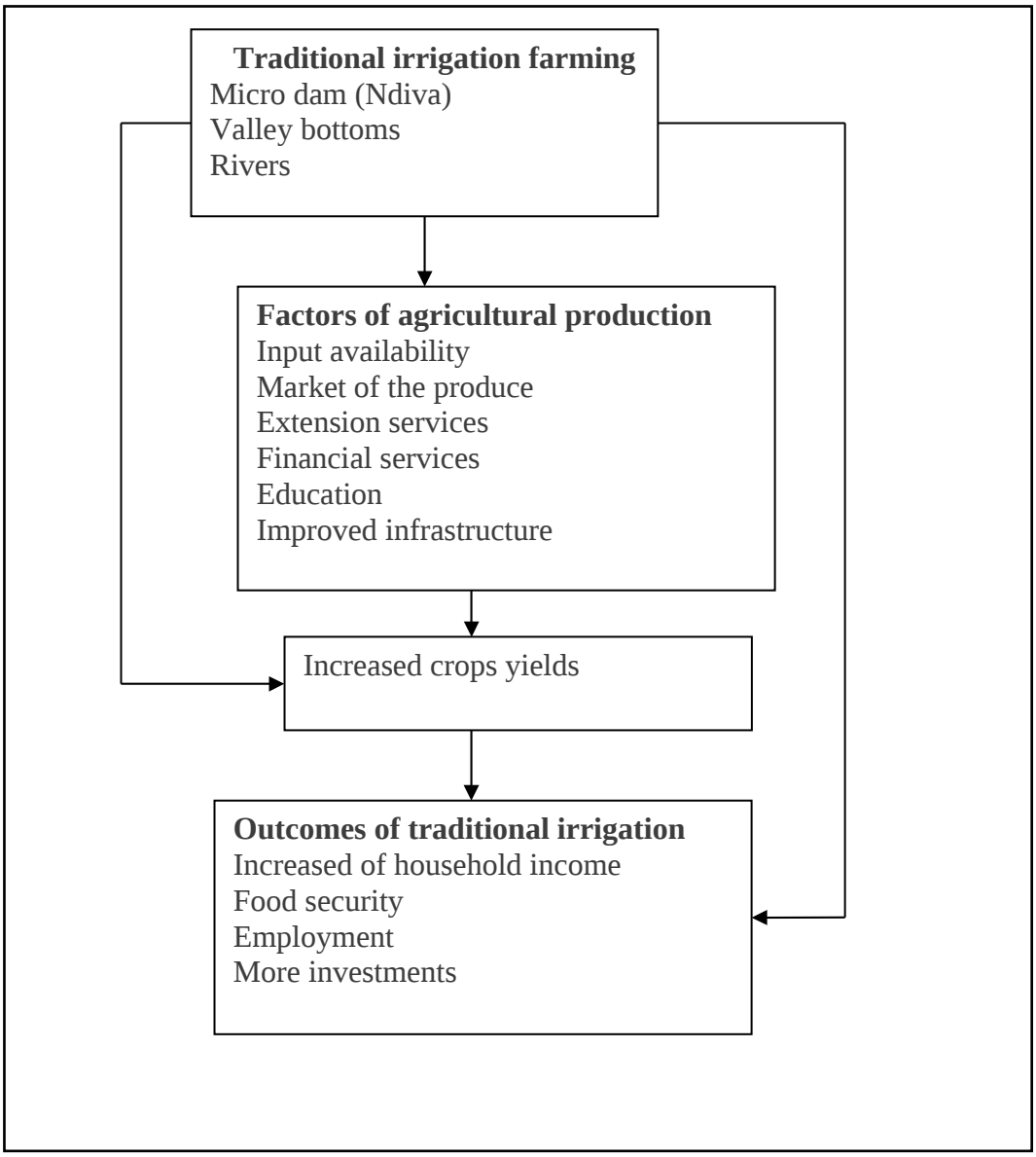

Figure 2: Conceptual framework for the study adopted and modified from CARE, (1995)

2.12 Traditional irrigation and their benefits

It is important to realize that there are important benefits to smallholder farmers practicing traditional irrigation and that these extend to health (FAO, 2003). It is often undertaken so that farmers can have a more secure food supply and that they can enrich their diet with fresh food throughout the year (Mutero, 1998). Consequently there are important nutritional benefits, besides the more generalized

health benefits which a higher income usually brings. Many farmers initiated traditional irrigation focuses on food crops and high value crops such as fruits and vegetables, which earn a considerable income (Mutero, 1998).

2.13 Conclusion

It has also been shown that different crops and vegetables grown under traditional irrigation contribute to food security and income generation. Infrastructures available in the area and marketing potentials are also important factors for enhanced productivity of traditional irrigation and they needs to be considered for more profit from cereals and vegetables. Maximum profit in most areas can be achieved when different crops are grown in a mixture and then followed by vegetables cultivation particularly during the dry season. Based on research findings done by Majule (2003), it is recommended that traditional irrigation farming should be encouraged and developed further to maximize profits. However appropriate crop mixtures and sequential cropping patterns should be further explored.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Overview

This chapter presents the methodology used in this study. It covers; the conceptual framework governing the study; description of the study area; types and sources of data used; sampling methods and tools of the data analysis.

3.2 Description of the study area

The study was conducted in Same district in Kilimanjaro region. The district is selected as the study area for the reason that it has a total of 52 traditional irrigation canals, with 58 water user groups, male 4963 and female 4399, total irrigated area is 4500 ha, (TIP,2004; Region Agriculture office, 2001). Also TIP has been working in the district since 1988 for the purpose of improving this farming in order to increase food security and income. The study area was divided into two main features lowlands and high lands. The highlands inlude *Chome* wards and study villages were *Mhero* and *Marieni*. In the lowland involved *Maore* wards and study villages include *Mpirani* and *Maore.*

3.2.1 Location

Same district is one of the administrative districts in Kilimanjoro region covering a total of 5152 Sq km, located in the North East of Tanzania. The district borders Kenya in the North East, Mwanga district in the North-west, Tanga region in the Sourth-East and Manyara region in the South- West. Same district is divided into six administrative divisions, 25 wards and 83 villages.

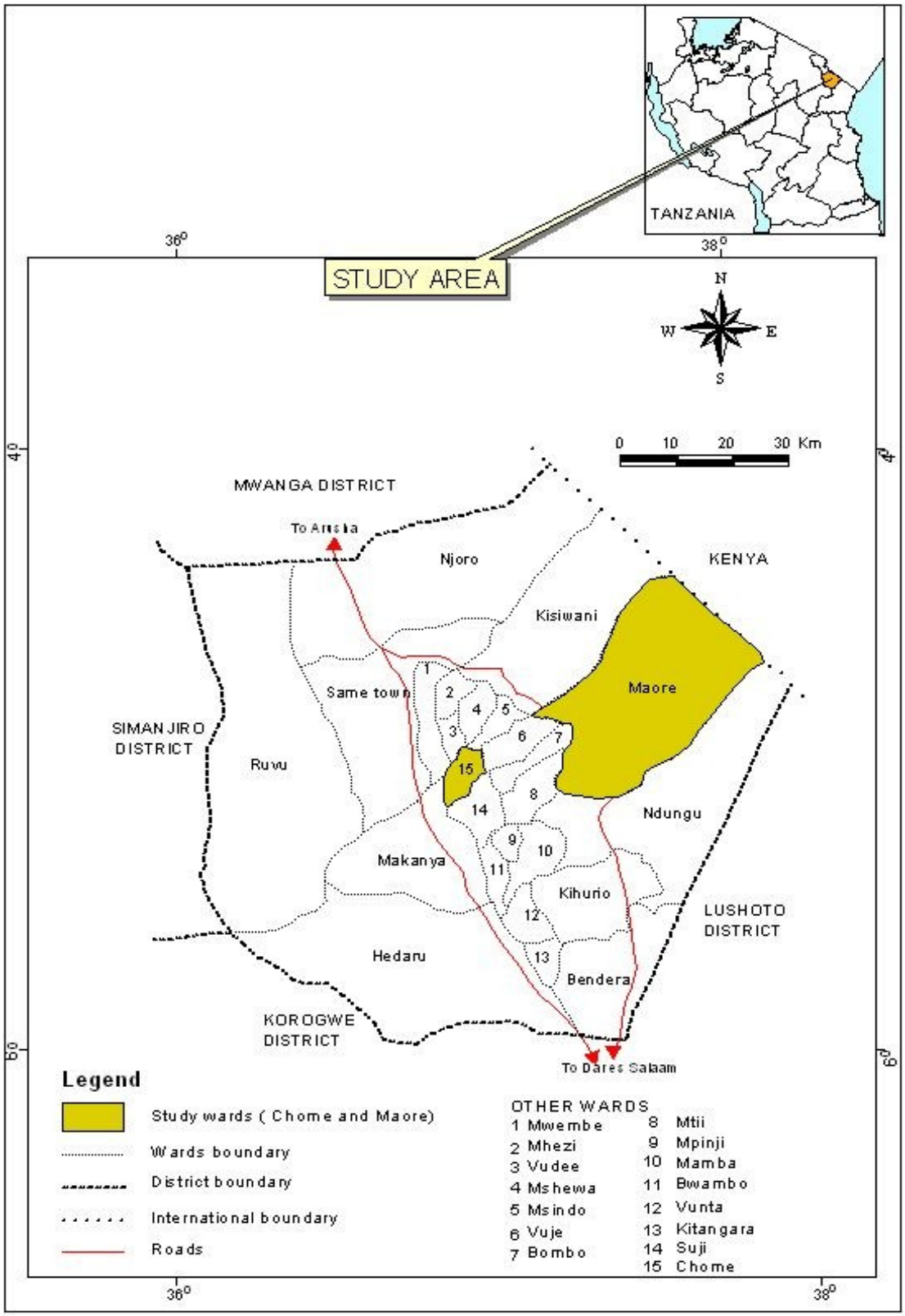

Figure3: A Map of Same district showing location of study wards

3.2.2 Agro-ecological zones

Same district is subdivided into two Agro-ecological zones, the highland and the lowland. The highlands cover 60 percent of the total area of Same district including Pare mountain ranges (VECO-Tanzania, 2005). The highlands enjoy a more frequent and reliable rainfall which makes the highland areas generally better off in terms of development and wealth. The highlanders practice both agriculture and livestock keeping. They keep few improved variety of cattle in zero grazing.

The lowlands cover 40 percent of the total area of district. The area is typically characterized by a low rainfall, lack of water and low development and wealth for the people (VECO-Tanzania, 2005). Although the drought allows the growing of resistant crops, the people still concentrate much on maize production which fails to yield anything from year to year. Livestock is therefore much practiced as an alternative to maize production; the residents keep herds of cattle and goats to fulfill the daily family requirements.

3.2.3 Climate

The district annual rainfall is bimodal from October to January is the short rain period (*vuli*), and from March to June the long rain (*Masika*). The two seasons are separated by the dry season from June to October. The highlands receive more rainfall (600 – 2000mm), than the lowlands (300 – 600mm). The main source of income in the study area is agriculture, including livestock keeping. The type of agriculture is mostly rain fed with only 15% being under irrigation (VECO-Tanzania, 2005; TIP, 2006).

3.2.4 Population, ethic groups and social economic activities

According to national census (2002), the total population of Same district is 212 325 people, 103 520males and 108 805 females' (URT, 2002). The indigenous tribe in the district is *Pare* the majority of who are subsistent farmers; the other tribe is the *Masai* who are pastoralists. The economic activities in the area are agriculture and livestock keeping. The district has Mkomazi national park which also contributes much to the district economy.

3.3 Types and sources of data

The study used both primary and secondary data; the primary data were collected through structured questionnaire from smallholder farmers who are practicing in traditional irrigation and rain fed agriculture. To ensure validity and reliability of the data the questionnaire was pre-tested. The necessary changes were made on the basis of the pre-testing results, before administering the questionnaire.

The secondary data were collected from various reports, published papers, and conference proceedings. Other types of information were obtained from electronic sources in the Internet; also, among others, the following offices were visited TIP – Traditional Irrigation Project, Moshi and Same, VECO_ Tanzania, Same programme and Agricutural department in Same district.

3.4 Sampling methods

The target population for the study was smallholder farmers who are practicing traditional irrigation and rain fed agriculture in Same district. The study employed a

multistage sampling technique. Multistage technique was used involving three stages for the *Chome Suji* and *Ndungu* divisions. Due to the heterogeneous socio-economic characteristics across wards within the divisions it was necessary from each division, to sample two wards, which were involved in crop production with and without traditional irrigation. Therefore in the first stage two wards were selected, these are *Maore* ward from *Ndungu* division and *Chome* from *Chome-Suji* division. In the second stage, for each selected two wards two villages were purposively selected from each ward to make a total of four villages, these are *Mhero* and *Marieni* in *Chome* and *Maore* and *mpirani* in *Maore* wards. Finally from each village a random sampling was used to select smallholder farmers; 25 households from each village in *Chome* ward were selected to make a total of 50 respondents; and 35 households were selected from each village in *Maore* ward to make a total of 70 respondents. Therefore the total sample of 120 household was available for the study. Fewer respondents were selected in *Chome* ward than in *Maore* ward because the population in the former is smaller than is the case in the latter ward.

3.5 Data analysis

Data collected were coded and analyzed using SPSS computer program. This includes cross-tabulation to make a comparison of crop yields, frequencies and percentages. Non- parametric test used in this study was a student’s t-test. This was used to test the significant difference of means of income and yields of crops produced from traditional irrigation and rain fed agriculture.

3.5.1 Profitability of crop production enterprises

Gross margin was employed in this study as measure of profitability of each of the enterprises. This technique is very useful in this study because of the low level of fixed costs, which suggests that the gross margin is very close to net farm income. Gross Margin analysis was calculated by;

$$GM = TR_i - TVC_i$$

Where: GM = Gross margin per acre,

TR = total revenue per acre,

TVC = Total Variable Cost per acre,

i= i^{th} crop.

Revenue was considered from the value of crops produced from traditional irrigation and rain fed agriculture, which was practiced by smallholder farmers. The prices, which were considered, were the average market price within the area. The total variable costs included were the costs of labour, fertilizers, pesticides, insecticides and seeds.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Overview

This chapter presents the empirical findings, discussion, and observation of the study on the contribution of traditional irrigation to food security and household income; profitability of crop production with and without traditional irrigation. In addition, the chapter also presents the demographic characteristics of the surveyed households, cropping systems and the impact of traditional irrigation to the livelihood of smallholder farmers in Same district.

4.2 Demographic characteristics

The characteristics of a given household have important social and economic implications to the production of crops under traditional irrigation. The composition of household usually influences the decisions on production, consumption and even storage of food. Therefore this section describes the characteristics of sampled households, focusing mainly on marital status, education level of respondents, household size and age composition.

Table 1: Demographic Characteristics

Variable estimated			
Gender of the respondent	Frequency	Percent	Mean
Male	72	60	
Female	48	40	
Total	120	100	
Age distribution			
18-45	85	71.7	
46-60	21	17.5	42
Above 60	13	10.8	
Total	120	100	
Marital status			
Married	96	80	
Single	16	13.3	
Divorced	3	2.5	
Widow	5	4.5	
Total	120	100	
Household size			5
1-5	67	55.8	
6-10	47	39.2	
Above10	6	5	
Total	120	100	
Education level			
No formal education	12	10	
Primary education	79	65.8	
Secondary education	28	23.3	
Tertiary education	1	0.8	
Total	120	100	

4.2.1 Gender of respondents

The findings in Table 1 show the proportion of female farmers in the sample is 40% of the entire sample. This situation can be attributed to the fact that irrigated agriculture is the capital and energy intensive activity which is not convenience to the majority of female farmers.

4.2.2 Household age composition

The age of an individual has influence in food production and consumption. Table 1 indicates that 71.7% of the respondents were aged 18-45 years; this implies that most of the sampled farmers fall in the economically active age group. The average years of the age across the study area was 42, which is slightly close to the National average figure, which is 39.9 years of age (TNBS, 2002). The implication of this is that most of the farmers can be fully engaged in productive activities. The survey findings show that only 10.8% of the respondents were aged above 60 years, this is the group of old people, who are likely to be less productive than those in the active age.

4.2.3 Marital status of respondents

In this study, marital status is categorized as married, single, widow or divorced; marriage included both formal and informal unions. The result in table 1 shows that, 80% of the respondents were married. This implies that these respondents have their own settlement and are independent in obtaining daily family requirements. While 2.5% and 4.2% of the respondents were divorced and widowed respectively, these figures constitute small proportion of the sampled households.

4.2.4 Household size

The household composition considered in the study area were groups in residential households whose members live together and share resources held in common such as accommodation, farm land and foodstuffs. The results in Table 1 indicate that 55.8% of the sampled households had 1-5 people; this is the reasonable number of

people in the households for getting family requirements. The results also revealed that the average household size for the entire sample was 5, which is the same to the National average of 5 people per household (TNBS, 2002). While 5% of the respondents had more than 11 people. Through observation it was revealed that the families with large population sizes involved mostly dependents who are orphaned or otherwise from among the relatives.

4.2.5 Education Level

The farmers' levels of education are presented in Table1, which indicates that 65.8% of the respondents had a primary education. This literacy level is useful for smallholder farmers to learn, use and adopt new and appropriate agricultural technologies. On the other hand 23% of the respondents have attained secondary education. This education level may be attributed to the deliberate efforts by the government in extending secondary education at community level. The results imply that more than 89.1% of the respondents had formal education. Education of the households is important in the production of food crops and income from traditional irrigation for the well being of their families.

4.3 Cropping systems

The study area is divided into two geographical features, highlands and lowlands. The cropping systems are rain fed and traditional irrigation based. The rainfall is bimodal from October to January, is the short rain *(Vuli*) season which is however not much reliable; and from March to June is the long rain *(Masika)* season, which is more reliable. These rain seasons are separated by dry season from June to

October sometimes the dry season extends up to December. The rainfall is much higher in the highland than in the lowland. During rains, the rain water flows to the lowland enabling smallholder farmers to practice traditional irrigation.

There are slight differences in crops cultivated during the different rain seasons. During the short rain season *(Vuli),* the main crop produced in the highland is maize with other crops such as cassava, round potatoes and banana. In the lowland rainfall in this season is not reliable, but farmers depend much on the water from the highlands for irrigation, which enable them to cultivate paddy and maize by using traditional irrigation. Vegetables are not grown during the short rain season because of high temperatures that affect the production.

During the long rain season *(Masika)*, main crop produced in the highland is bean; other crops are sweet and round potatoes and some varieties of vegetables. Maize is not grown during this season due to the cold weather condition. In the lowlands, when rainfall is reliable, crops produced include maize, bean, groundnuts, sunflowers and some variety of vegetables. However farms near the irrigation systems are supplemented by traditional irrigation in order to help crops to grow well in case of drought.

Table 2: Cropping System and sources of water

Variable estimated	No of respondents	Percent
Farm size for irrigation in acre		
≤0.5	28	23.3
0.6-1	44	36.7
>1	48	40
Total	120	100
Sources of water for irrigation		
Micro dam technology (Ndiva)	37	30.8
River	83	69.2
Total	120	100
Cropping system		
Traditional irrigation	67	55.8
Rain Fed	N/A	N/A
Rain fed and Traditional Irrigation	53	44.2
Total	120	100

N/A: No households depend only on rain fed

4.3.1 Traditional irrigation

Traditional irrigation is practiced in small plots of less than 0.5 acres owed by individual households. These plots are mainly along rivers and around natural wells. It is characterized by having temporary intake (which is constantly replaced), poor soil and water conservation techniques leading to water loss though leakage and soil loss through erosion (Maganga, 1998). Vegetables are the main crops irrigated; the products from irrigation are both for domestic consumption and sale in the market (Anthony, 2000). Traditional irrigation is practiced in both the highland and the lowland during dry season. In the highlands, crops produced under traditional irrigation include onions, maize, beans, potatoes, carrots and vegetables, while in the lowland the crops produced include maize, paddy, beans, ginger and vegetables. Traditional irrigation practiced in the lowland depends on the water from highlands.

4.3.1.1 Sources of water for traditional irrigation

The main sources of water used for traditional irrigation in the study area are from rivers and micro dam technology (*Ndiva*). Micro dam technology is mostly used in the highlands due to climatic condition of having small water springs. Water from these small springs is collected first into the micro dam (*Ndiva*) before being used for irrigation. Rivers are used mostly in the lowlands, however sources of rivers for traditional irrigation is from the highlands.

4.3.1.2 Micro dam technology (Ndiva)

Micro dam technology (*Ndiva*) involves impounding runoff water for traditional irrigation by digging and constructing earth embankment (Soil Water Management Research Group, 2005). Water from springs or small rivers is collected first to micro dam before being used for irrigation. *Chome* ward is the study area is in the highland where 37% of the respondents practice traditional irrigation by using this technology (Table 2). In the highland the purpose of micro dam technology *(Ndiva)* is to increase more pressure by impounding water from small streams so as to make the water flow easily during irrigation.

Plate 1: Micro dam technology (Ndiva) Mhero, Chome ward

Plate 2: Stone terraces at Mhero (WUGS) in Chome ward

4.3.1.3 Rivers

Rivers are another source of water for traditional irrigation in the study area. River water is mostly used in the lowlands. In the lowland areas, traditional irrigation depends on water from rivers. *Hingilili* River in *Mkomazi* basin is the major source of water for traditional irrigation in Maore ward. The catchment lies in the eastern

part of south Pare mountain ranges in Same district. Table 2 shows that 83% of the respondents use water for traditional irrigation directly from river. Hingilili river has six traditional irrigation furrows namely; Mariranga, Maya, Chemchem, Kalinga, Rushoto and Kikongo.

Reliable rainfall in the highland enables smallholder farmers in the lowlands to produce more crops. There are some conflicts during dry seasons, where highland irrigation groups extract almost all the water from the sources into their canals and do not adhere to the by laws of using water in the day time, and allow it to flow to the lowland in the night. If the by law is not observed by the highland water users, then water conflicts become inevitable.

4.3.2 Rain fed

Rain fed agriculture relies only on direct rainfall and this is sometimes referred to as dry land farming (MALD, 1997). In the highland areas, rainfall is more reliable than in the lowland. Crops produced in the highland include maize, beans, cassava, potatoes, sweet potatoes, and bananas. In the lowland areas rainfall is not reliable, smallholder farmers sometimes produce nothing due to lack of rainfall. However when rainfall is reliable crops produced are maize, groundnuts, sunflower and beans. The findings of this study show that none of the respondents practiced rain fed agriculture only Table 2; this is because rainfall is inadequate and erratic causing persistent drought that makes crops grow poorly. Thus irrigated agriculture becomes the main viable option in ensuring food security.

4.4 Land use management and traditional irrigation

Table 3 shows the distribution of the respondents according to farm size. The smallholder farmers practice both traditional irrigation and rain fed farming. The fields cultivated in the highland range from 0.5 to 1 acre; this is due to sharply rising landscape of the area. A large area in the highland is not suitable for crop production due to its rough topography of sharp dropping slope land. In the lowland farm size for traditional irrigation and rain fed farming range from 0.25 to 2 acres, this is due to the flatness of the land surface that the areas under cultivation become large enough for both traditional irrigation and rain fed farming. Maize and paddy are crops cultivated over large areas as opposed to vegetables which are cultivated in small farm plots. The average farm size is of fields 1.4 acres in traditional irrigation; this implies that the land under cultivation is small. These results also indicate that farmers practicing traditional irrigation cultivate small plots of land than in the rain fed system. It is practiced in small scale due to the following reasons;

Water scarcity and poor water quality especially as related to sediment concentration; land degradation as a result of poor operation management activities, this is partly related to inefficient water management resulting in water wastage and water logging. Lack of know-how in, and access to the opportunities of irrigation technology, weak economic base of most smallholder farmers and the relatively high development costs involved in developing irrigation schemes. Limited priority given to irrigation development during national and local planning and budgeting, poor management structures in place to support farmers and promote irrigation

development. For example, the infrastructure to facilitate irrigated agriculture development is underdeveloped. Land tenure system that does not encourage farmers to invest in permanent improvements on their plots and make improvements which can be used to obtain credits for further development; unclear water rights and their enforcement.

4.5 Crops produced

A total of five crops were selected for the analysis three in the highlands and the other three in the lowlands; however some of the crops are cultivated both in the highland and in the lowland. The discussion considered crops produced for food security and at least one crop for income generation. These crops are maize, paddy, beans, tomatoes, and onions.

Table3: Cultivated area and crop yields under traditional irrigation

Variable estimated					**Traditional irrigation**	
Cultivated area(acres)	Maize N=120	Onion N=120	Bean N=120	Tomatoes N=120	Paddy N=120	Mean field
Do not cultivate	16(13.3)	83(69.2)	32(26.7)	84(70)	52(43.3)	
≤0.5	49(40.8)	28(23.3)	28(23.3)	31(25.5)	22(18.3)	
0.6-1	38(31.7)	8(6.7)	27(22.5)	4(3.3)	32(26.7)	1.4
> 1	17(14.2)	1(0.8)	11(9.2)	1(0.8)	14(11.7)	
Total	120(100)	120(100)	120(100)	120(100)	120(100)	
Crops yield kg per acre						
Do not harvest	16(13.3)	83(69.2)	32(26.7)	84(70)	49(40.8)	
10-100	3(2.5)	N/A	17(14.2)	N/A	N/A	
101-500	40(33.5)	1(0.8)	58(48.3)	3(2.5)	1(0.8)	
501-1000	36(30)	N/A	10(8.3)	1(0.8)	1(0.8)	
>1000	25(20.8)	36(30)	3(2.5)	32(26.7)	69(57.5)	
Total	120(100)	120(100)	120(100)	120(100)	120(100)	
Mean yield from irrigation in kg/acre	**1077**	**5028. 33**	**322.65**	**3929**	**1948**	

Figure in parenthesis are %
N= Number of respondents
N/A: Not applicable (Farmers do not produce crops in that cropping system)

4.5.1 Maize

Maize is cultivated in the highlands and the lowlands, in both rain fed and traditional irrigation cropping systems. Table 3 shows 40.8% of the respondents cultivate maize form traditional irrigation with field size of ≤ 0.5 acre. While 21.7% of the respondents cultivate maize from rainfed farming (Table 4), with field size of ≤ 0.5 acres. This implies that in the highland smallholder farmers produce maize by traditional irrigation in small plots of farms than they do in rain fed farming due to steepness of the slopes which makes impossible to own large areas of land. In the lowland, shortage of water for irrigation forces farmers to cultivate small plots. The average yield of maize is estimated to be 1077 per acre from traditional irrigation and 1042 kg per acre for rain fed farming especially when the rainfall is reliable. Table 4 shows that 58.3% of the respondents were not producing maize from rain fed agriculture. This is due to unreliable rainfall and that smallholder farmers depend much on traditional irrigation to produce maize for food and income generation. They normally cultivate fields which can be irrigated in case of droughts, so that it becomes easy to have maize supplemented by irrigation especially in the lowland; this also reduces the number of the farmers who produce maize by rain fed agriculture.

Table 4: Cultivated area and crop yields under rainfed system

Variable estimated	**Rainfed**		
Cultivated area(acres)	Maize	Bean	Paddy
Do not cultivate	70(58.3)	100(83.3)	117(97.5)
≤ 0.5	26(21.7)	14(11.7)	1(0.8)
0.6-1	18(15)	4(3.3)	2(1.7)
>1	6(5)	2(1.7)	N/A
Total	120(100)	120(100)	120(100)
Crop yield kg per acre			
Do not harvest	70(58.3)	100(83.3)	117(97.5)
10-100	2(1.7)	8(6.7)	N/A
101-500	22(18.3)	11(9.2)	N/A
501-1000	13(10.8)	1(0.8)	1(0.8)
>1000	13(10.8)	N/A	2(1.7)
Total	120(100)	120(100)	120(100)
Mean yield rainfed kg/acre	**1042**	**247.6**	**1386.66**

Figure in parenthesis are %

N= Number of respondents

N/A: Not applicable (Farmers do not produce crops in that cropping system)

4.5.2 Beans

Beans also are cultivated both in the highlands and the lowland, using traditional irrigation and rain fed farming. In the study area beans are used as cash and food crop. The results presented in Table 3 reveals that 26.7% of respondents were not producing beans from traditional irrigation and Table 4 show that 83.3% of the respondents also were not producing beans from rain fed farming. This implies that more beans are produced by traditional irrigation than rain fed agriculture. Unreliable rainfall in the lowland forces more farmers to produce beans by traditional irrigation. Some beans are intercropped with maize in the traditional irrigation farming and sometimes beans are produced solely during the rain season especially in the highland.

In Andean highland of Colombia and Peru, common bean, Phaseolus Vulgalris is intercropped with maize in traditional irrigation farming. Multiple cropping systems are essential for development of productive and sustainable irrigated agriculture for the Andean smallholder farmers. In other areas of Colombia beans are produced under sole cropping while on-farm trials are conducted under the target multiple cropping system.

4.5.3 Paddy

Paddy is cultivated in the lowlands only because of its flatness terrain of the land; soil which impounds water, and high temperatures. In the highland paddy can not grow well because of the cold weather condition and of being geographically so hilly that the water can not be impounded. In the lowland paddy is produced by traditional irrigation, the production of the crop depends much on the water which flows from the highland. The results on Table 3 reveals that 56.7% of the respondents had access to irrigated paddy fields. Majority of the smallholder farmers' posses a farm size of 0.5 to 1 acres and few farmers' posses a farm size of more than 1 acre. Small scale farm size is caused by water scarcity in Maore ward, compared to the number of population available. The yields of paddy in the study area are estimated to be 20 to 25 bags of paddy per acre.

4.5.4 Vegetables

Vegetables are cultivated for food and cash crop in both highland and lowland. A variety of vegetables is produced seasonally by traditional irrigation, mostly in the dry season from June to November. The most common vegetables cultivated in the highland include onions, cabbage, tomatoes, chinese cabbage and amaranths. In the highland the production of onions is very expensive, smallholder farmers are required to have many inputs including insecticides, fungicides and fertilizers for the onion to grow well. The majority of smallholder farmers fail to manage these costs leading to low production. Onions have high yield and return as compared to other crops, Table 3 indicate that 30% of the respondents were getting yields of more than 1000kgs, this is due to high application of inputs and access of market. In the lowland areas, vegetables produced are okra, cabbage, tomatoes, chinese cabbage, amaranths and black night shade. Tomatoes, onions and cabbages production is done in larger scales than those for other vegetables with the field size ranging from 0.5 to 1 acre. The remaining vegetables production is done in small scale with the field size between 0.25 to 0.5 acres. This is because tomatoes, onions and cabbage fetch high market demand compared to other vegetables.

4.6 Contribution of traditional irrigation in improving food security

4.6.1 Household food security situation

Based on the study by Majule and Mwalyosi (2003) traditional irrigation farming plays a significant role in food security and income generation as well as proving buffer to the local communities during drought periods which are currently frequent. Table 5 indicates that 64% of the respondents stated that crops harvested

for food was not enough to sustain their lives throughout the year; they have to find alternatives to get food for their families, like buying food and practicing casual labour to get food.

Table5: Households food security situation

Variables	No of respondents	Percent
Meals taken per day		
Once	N/A	N/A
Twice	21	17.5
Thrice	99	82.5
Total	120	100
Crop harvested		
Enough for food	43	36
Not enough for food	77	64
Total	120	100
Food shortage(own production)		
Experienced food shortage	84	70
Did not experienced food shortage	36	30
Total	120	100
Cereals purchased for food		
Purchased food	80	67
Did not purchased food	40	33
Total	120	100

Despite the quantity of food crops harvested, it was revealed that 67% of the respondents purchased food from traders who collect maize from other regions (Table 5). The main reasons were early sales and poor storage methods of food crops produced, maize and rice were the most crops purchased for food.

4.6.2 Crops stored for food

In the study area maize was the most important food crops (staple food) in both highland and lowland, followed by paddy especially in the lowland. Table 5 indicates that 64% and 41% of the respondents stored maize and paddy respectively for food. The stored crops are mostly produced from traditional irrigation systems.

The quantity of crops harvested and stored for food was very small; the majority of farmers were vulnerable to food insecurity. This is also in agreement with Makundi (1996) studies that the amounts of food stored are one of the factors, contributing to household food insecurity. Food insecurity sometimes is caused by poor post harvest and storage methods; this also contributes to food insecurity in the community. A reasonable and durable communal storage structure could be constructed for the village's food storage. The storage could be used during the food scarcity period for the respective families.

Table 6: Crops stored for food in kg

Variable to be estimated	Traditional irrigation			Rain fed		
Crop storage	N=120			N=53		
Stored crops	116(96.7)			50(94.3)		
Did not stored crops	4 (3.3)			3(5.7)		
Total	120(100)			120(100)		
Crops produced and stored kg	Maize	Bean	Paddy	Maize	Bean	Paddy
Not producing food crops	11(10)	34(28.2)	52(43.3)	76(63.3)	106 (88.3)	197(97.5)
Qty food produced and stored kg						
<50	3(2.5)	35(29.2)	1(0.8)	3(2.5)	6(5)	N/A
51<200	1(25.8)	46(38.3)	13(10.8)	19(15.8)	6(5)	3(2.5)
201-500	64(53.3)	4(3.3)	41(34.2)	16(13.3)	2(1.7)	N/A
>500	10(8.3)	1(0.8)	13(10.8)	6(5)	N/A	N/A
Total	108(90)	86(71.7)	68(56.7)	44(36.7)	14(11.7)	3(2.5)

Figure in parenthesis are percentage

The crops produced was very low due to different reasons including water shortage for irrigation and persistence drought in rain fed agriculture, making farmers food insecure. In the rural areas, household was assumed food secured if they have more maize than is the case with any other crop. The results in Table 6 also reveal that 90% of the respondents produced maize for food from traditional irrigation and

stored as food for future use. 10% of the respondents were not producing maize from traditional irrigation (Table 6). This implies that traditional irrigation farming if well practiced together with different stake holders in assisting smallholder farmers to access production inputs, markets of the produce, extension and financial services can help to improve food security and income among smallholder farmers of Same district.

4.7 Contribution of traditional irrigation to households income

4.7.1 Sources of income from livestock

The analysis of sources of income for the sample household showed that smallholder farmers rely heavily on crop farming as a source of income. Smallholder farmers are also engaged in non farm activities to generate income that supplements income from agriculture to fulfill family requirements. Table 7 shows that 17.5% of the respondents possessed livestock used for food only and 43.3% of the respondents were generating income from livestock and their products.

Table 7: Households income from livestock

Variable	No of respondents	Percent	Mean income
Livestock possession			
Do not possess livestock	47	39.2	
Possess livestock for food only	21	17.5	
Livestock for food and income	52	43.3	194,946.2
Total	120	100	

Livestock are more important as source of income and food for smallholder farmers. This is due to the relatively high income generated by livestock, which make the impact on the smallholder budget more significant. The main parts of these sources of income related to livestock keeping for households are income derived from cattle and smaller livestock such as chicken and shoats (sheep and

goats**).** In Same district small holder farmers of lowland keep livestock in big number by grazing, while in the highland they keep few livestock in intensive farming. The study revealed that there was no much difference between farmers who are keeping livestock in lowland and highland.

4.7.2 Crops income under traditional irrigation and rain fed

The assessment of income from crop produced from traditional irrigation indicate that 8.3% of the respondents did not sell of their crops produced from the farm (Table 8), this is due to small size of plots cultivated and lack of farm production inputs. Table 8 also shows that income obtained from traditional irrigation were higher than the income from rain fed farming. High income of crops produced from traditional irrigation were probably a results of high yield of the crops cultivated especially vegetables. Table 8 indicates that 39.6% of the respondents were not generating income from rain fed farming. This situation was caused by low rainfall per year leading to persistence drought especially in the lowland, hence the low crops yield. Crop produced under this system were mostly cereals which were used for food. Results from (Table 8) also revealed that 29.2% of the respondents from traditional irrigation were earning high crop incomes of more than one million per year, this is due to the production of high value crops mainly vegetables, for example mean income from onion and tomatoes were 1,771,867 and 961,380Tsh per season respectively (Table 12).

Table 8: Households income from crops

Annual income from crops(Tsh)	**Traditional irrigation**		**Rain fed**	
	Frequency	percent	Frequency	Percent
Did not sell	10	8.3	21	39.6

10000-100000	5	4.2	14	26.4
100001-500000	34	28.3	17	32.1
500001-1000000	36	30	1	1.9
> 1000000	35	29.2	N/A	N/A
Total	120	100	53	100

The results in Table 9 is the output from paired t-test which indicate P<0.05 implying that there was a significant difference between the income obtained from traditional irrigation and that obtained from rain fed farming. This implies low production of crops from rain fed farming due to shortage of rainfall. As a result, farmers producing crops from traditional irrigation earn more income. The high income of crops from traditional irrigation is due to production of vegetables, which fetch high price in the domestic market. In the highland, farmers who produced onions in the season of 2006/07 generated high income, because the price of onions was high, while those who produced onions in the next season of 2007/08 did not generate high income due to low price. Generally the prices of agricultural products are not static, as they keep on changing with time depending on the market demand and supply.

Table 9: Annual crops income from traditional irrigation and rainfed

Variable	Crops mean income			T-Value	Sig.(2tailed)
	Traditional irrigation	Rainfed	95%CI of the Difference		
Income	1066090	167677	1632329-164496.7	2.504*	0.018

Note * Means significant at p<0.05

4.7.3 Income from off-farm activities

In the lowland which is semi arid, the observation that the poor rely more on off-farm activities for their livelihood Morris (2002), is in line with other studies in semi arid areas in Tanzania. Off-farm activities were mentioned as another important livelihood strategy. For example Sepala (1996) observed that diversification to off-farm activities provide an element of flexibility that allows household to distribute risk better. Table 10 indicates that 33.3% of the respondents were participating in off-farm activities to generate income. It was observed during the survey that males and females have strategies as far as off-farm involvement is concerned. In Same district, men and women are involved in different activities such as running shops, cereal trading, casual labour, selling local brew and food vending.

Table 10: Income from off-farm activities

Variable	No of respondents	Percent	Mean
Income from off-farm activities			
< 50000	8	6.7	
50001-200000	18	15	228,225
> 200000	14	11.7	
Total	40	33.3	

4.8 Profitability of crop enterprises

The output market prices and variable costs are presented in Table 10. Variable cost in traditional irrigation dominated the production cost. A large proportion of the variable cost is attributable to inputs used in production. The distribution of the respondents according to the level of inputs used is presented in Table 10 which shows that traditional irrigation employed significantly a higher amount of inputs than is the case in the ran fed farming. For example, inputs cost in maize production

by traditional irrigation is Tsh 51 000 per acre and Tsh 29 000 per acre for rain fed farming. The cost of inputs is high in traditional irrigation due intensive farming throughout the year, which leads to a decrease of soil fertility. Rain fed farming does not involve intensive utilization of soil, once the rain season ends; the field is not used for any cultivation until next season. This situation helps to retain the soil fertility in rain fed system for the plant growth.

4.8.2 Crops yield

There were slight differences in yields of all crops produced in both traditional irrigation and rain fed systems, however traditional irrigation exceeded the yields of the rain fed system. The results in Table 11 show the output of paired t-test of the crop yields from both traditional irrigation and rain fed system were almost equal. The insignificant difference between yields from traditional irrigation and rain fed system implies that when rainfall is reliable in rainfed farming the yields from cereals crops produced in both systems is not significantly different.

Table 11: Crop yields from traditional irrigation and rainfed farming in kg

Crops	Crops mean yields			T-Value	Sig.(2tailed)
	Traditional irrigation	Rainfed	95% CI of the Difference		
Maize	1199.4	1085.7857	1295-1068	0.194**	0.847
Bean	191.33	151.78	137.565-58.454	0.931**	0.379
Paddy	1306.666	1386	1026.49-1186.49	0.311**	0.785

Note **Means insignificant at $p<0.05$

Vegetable was not frequently grown during rain season (Table13); this is due to the weather condition which does not favour the production of vegetables. In the study area, onions and tomatoes employ high cost of inputs under traditional irrigation; but also its average yields were high compared to that of the other crops. The yields were 5028 and 3924 kg per acre of onions and tomatoes respectively; this is due to more application of inputs. The price of each crop from traditional irrigation and rain fed was also imputed; (Table 12) indicates the price and gross return of crops produced.

4.8.3 Crop production costs

Crops production involves the use of a number of inputs including seeds, insecticide, herbicides, fungicide, tools/instruments, labour, fertilizers/manure and water. Farmers in the study area use seeds of improved varieties but these are relatively expensive; furthermore new seeds need to be purchased at the beginning of each season when farmers have little cash with them. Most farmers keep a small proportion of each year's harvest as next year seed, so that improved seeds do not need to be purchased at the beginning of the season.

The use of fertilizers, pesticides, herbicides and fungicide is rare used in the production of cereal crops, but it is used highly in the production of vegetables. Table 10 shows different costs of buying inputs of one acre field. Majority of smallholder farmers do not use artificial inputs, because of the problem of liquidity in that the farmers can not afford these expensive inputs considering the higher yields expected because often the farmers do not have enough cash at the right time to make these purchases. The use of manure is common in the highland than in the

lowland, because soil fertility in the lowland is good compared to that in the highland; also rainfall is not as reliable as causing erosion and soil reaching.

4.8.4 Gross margin of crops from traditional irrigation and rain fed

Farmers in Same district grow various food and cash crops. For the purpose of this study, five major crop enterprises were selected for discussion. These were maize, onions, tomatoes, paddy and beans. The gross margins for the crops produced were established; Table 12 also shows the gross margins for the different enterprises produced under traditional irrigation and Table 13 shows the gross margin of rain fed systems. Gross margin in this study, is defined as the difference between the gross return and variable cost of each enterprise. Gross margin was employed in this study as a measure of profitability of each enterprise, instead of the net income, to avoid the difficulty of sharing the fixed costs among the enterprises. Furthermore, this technique is very useful in this study, because of the low level of fixed cost, which suggests that the gross margin is very close to the net farm income. The cost of family labour, was not imputed because most of the farm operations were worked by family members.

Table 12: GM analysis of crops enterprises from traditional irrigation per acre.

Variable	Traditional irrigation				
	Maize	Onions	Paddy	Tomatoes	Bean
Output (Yields) in kg acre	1077	5028	1947	3924	322
Market price per kg	208.20	352.40	234.50	245	585
Gross income (Tsh)	245051.4	1771867	456571	961380	188370
Operation cost (Tsh)					

seed	0	80000	0	16000	12000
Fertilizers	0	0	0	0	0
Urea	28000	60000	40000	0	0
NPK		42000	0	42000	0
Manure	15000	30000		15000	15000
Insecticides	0	0	0	0	0
Theonex	0	0	0	18000	0
Selecron	0	30000	0	0	0
Fungicide	0	0	0	0	0
Dithane	0	28000	0	21000	0
Labour cost	67000	182000	208000	56000	8000
Total variable cost (Tsh)	110000	452000	248000	168000	35000
Gross margin	**135051.4**	**1319867**	**228571**	**793380**	**153370**

The results Table 12 also indicate that crops from traditional irrigation had high gross margin. Onion is the most profitable enterprises with the gross margin per acre of Tsh 1 319 867, from the survey maize, paddy, bean and tomatoes had gross margin of Tsh 135 051.40, 228 667, 153 370 and 793 380 respectively from traditional irrigation systems. While Table 13 show that the rain fed farming, paddy had high gross margin of Tsh 198 017, followed by maize Tsh 117 944 and beans Tsh 115 495. Gross margin is not static it tends to change with time. The gross margin for agriculture products change when the supply of the commodity increases the price becomes low. For example during harvesting period, the supply of the commodity is high; this tends to lower the price of the commodity and therefore the gross margin become low; but when the supply is low the price tends to rise and the gross margin become high (Debertin, 1992).

Table 13: GM analysis of crops enterprises from rainfed per acre

Varible	Maize	Bean	Rainfed Paddy
Output (Yields) in kg acre	1042	247	247
Market price per kg	208.20	585	585
Gross income (Tsh)	216944	144495	144495
Operation cost (Tsh)			
seed	0	0	0
Fertilizers	0	0	0
Urea	0	0	0
NPK	0	0	0
Manure	35000	20000	20000
Insecticides	0	0	0
Theonex	0	9000	9000
Selecron	0	0	0
Fungicide	0	0	0
Dithane	0	0	0
Labour cost	64000	0	0
Total variable cost (Tsh)	99000	29000	29000
Gross margin	**117944**	**115495**	**115495**

4.8.5 Profitability of crops produced under traditional irrigation

Results from (Table 12), revealed that smallholder farmers producing horticultural crops from traditional irrigation is highly profitable compared to alternative investment options that farmers can undertake in other crops. For example, gross margin of selected crops, onions is the most profitable enterprise in traditional irrigation it is about 10 percent higher than that of maize. This raises the question as why every farmer in the area is not jumping on this band wagon, there are several

explain along. One important factor is that the enterprise budget value does not explicitly include transaction and production costs that are explicitly measured (Freeman and Salim, 2001). Because such costs are not included as monetary costs in enterprise budget it is likely that these budget erroneously overestimate the actual profitability of price of farm outputs. Consequently, the enterprise budget makes horticultural crop enterprises more, profitable than they actually are, especially in the study areas where poor rural infrastructure, risk and other market imperfections lead to high transaction costs. These consideration need explicitly considered when designing technology intervention for farmers in these areas (Kimenye, 2000).

CHAPTER FIVE

CONLUSION AND RECOMENDETIONS

5.1 Conclusion

Based on the findings of this study, the following conclusion was drawn;

i) Traditional irrigation farming system contributed significantly to the food security and householders' income of smallholder farmers which made their life better than those practicing rain fed system.

ii) The main occupation of the households in the study area was farming (crops cultivation), however their production from traditional irrigation is constrained by water shortage.

iii) Food insecurity among households in the area was mainly due to persistent drought, shortage of water for irrigation, low rate of using the new agricultural techniques, high price of inputs, immediately sell of crops after harvest.

iv) Despite the positive contribution of traditional irrigation to households' food security and income, the practice is limited by; inadequate water sources, poor irrigation infrastructure, poor plot borders in the field, especially in the irrigated lowland areas causing water losses.

5.2 Recommendations

a) Traditional irrigation should be encouraged and developed by all stakeholders in order to maximize crops output and profits. This can done through provision of adequate extension services, input availability, marketing, financial services, and improved infrastructures.

b) Suitable water management is the key important factor for the country to achieve sufficient food production. From the study area, farmers were complaining about the issue of water shortage for irrigation. The government and other stakeholders should assist the rehabilitation of irrigation infrastructure which can help to reduce the problem.

c) As long as water from micro dam (*Ndiva*) is very little, participatory building of irrigation canals with cement or transferring water by pipes can reduce water losses through leakages. Furthermore, the introduction of drip or/and sprinkler irrigation methods, especially in the highlands can make crop production more efficient.

d) Water harvesting is another good strategy in making irrigation more efficient for crop production through water reservoir. This will reduce the problem of water shortage.

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APPENDICES

APPENDIX 1: QUESTIONNAIRE FOR SURVEY ON

TRADITIONAL IRRIGATION SYSTEMS AND LIVELIHOODS OF

SMALLHOLDER FARMERS

A1: Basic household information

A1.1 Questionnaire number	A1.2 Date of interview	A1.3 Village/subvillage names
A1.4 Ward	A1.5 Division	A1.6 Respondent's name
A1.7 Respondent's age	A1.8 Respondent's gender	
A1.9.Marital status	A1.10 Education level	
1) Married 2) Single 3) Divorced 4) Widow	1) Informal education 2) Primary 3) Secondary 4) Post secondary	

A2 Household composition

Household characteristics	Number
Children under 15 years	
Adult above 14 years	
Elder above 65 years	
Total household size	

A3 What is the status of your house?

Wall construction	**Roof construction**	**Electricity**	**Piped water**
1 = Concrete 2 = Bricks 3 = Wood 4 = Mud	1 = Tiled 2 = Corrugated iron 3 = Thatch	1 = Yes 2 = No	1 = Yes 2 = No

A4.1 Do you possess livestock? 1= Yes 2= No

A4.2 If yes, what income earned from livestock per year?

	Type of livestock	**Total income per year Tshs**
1	Sales of cattle	
2	Sales of goats	
3	Sales of pig	
4	Sales of chickens	

5	Sales of sheep	
6	Others specify	

A5.1 Do you have any other sources of income from off farm activities?

1= Yes; 2=No

A5 If yes, what income obtained from off farm activities?

	Off farm activities	**Total income obtained per year**
1	Shop/kiosk	
2	Sales local brew	
3	Charcoal making	
4	Hotel/ food venders	
5	Bricks making	
6	Others specify	

B: SIZE OF FIELDS CULTIVATED AND CROPS PRODUCED

B1 Do you practice traditional irrigation farming? 1 = Yes; 2 = No

B2 What is form of farm ownership? 1 = Inheritance; 2 = Bought; 3 = Hired

B3 What is the cost of hiring a farm

Type of the farm	Cost per acre	Period of hiring Year/ season/ mouth
	Cash	
Maize traditional irrigation		
Maize rain fed		
Paddy traditional irrigation		
Paddy rain fed		
Vegetable traditional irrigation		

B4 What is Cost of buying a farm

Type of a farm	Cost per acre
	Cash
Maize traditional irrigation	
Maize rain fed	
Paddy traditional irrigation	

Paddy rain fed	
Vegetable traditional irrigation	

B5 What is the farm size in each crop?

Crop cultivated	Area per acre		
	Main rain season(Mach-June)	Dry season (June-October)	Short rain season (October-January)
Maize			
Paddy			
Bean			
Round potatoes			
Others specify			
Vegetables • Tomatoes • Cabbage • Onions • Chinese • Others specify			

C: EVALUATION OF TRADITIONAL IRRIGATION MANAGEMENT

C1 Which sources of water do you use for traditional irrigation?

C2 How is the furrow managed? 1 = Water user group; 2 = Farmers association; 3 = No management

C3 Does this furrow have an official statutory water right issued by the water office?

1 = Yes; 2 = No

C4 If yes when statutory water right was granted?

C5 Do you pay for the water you are irrigating from this source? 1 = Yes; 2 =No

C6 If yes how much do you pay?

C7 How often do you pay?

1 = Per year	

2 = Once per year	
3 = Once per mouth	
4 = After irrigation	
5 = Others specify	

C8 What is the use of the money you pay?

D: CONTRIBUTION OF TRADITIONAL IRRIGATION TO FOOD SECURITY

D1 Which crops is cultivated for food security from traditional irrigation?

D2 Do your crop harvested sustains the household up to the next harvest?

1 = Yes; 2 = No

D3 How frequent do you take your meals? 1 = One; 2 = twice; 3 = Thrice;

4 = irregularly

D4 Have you ever experience food deficit since 2004 to date? 1=Yes 2=No

D5 Do you purchase crops for food 1= Yes; 2 = No

D6 Comment how traditional irrigation contribute to your household food security

……

……
….

……
….

E: INCOME AND FOOD OBTAINED FROM TRADITIONAL

IRRIGATION AND RAIN FED

E1 Food and income obtained from traditional irrigation per year

E1.1 Which crop is produced and farm size per acre?

	Crop	**Area per acre**
1		
2		
3		
4		

E1.2 How much quantity of harvest obtained per acre?

	Crop	**Quantity of harvest in Kg**
1		
2		
3		
4		

E1.3 Do you store your crops for food from traditional irrigation 1= Yes; 2= No

E1.4 If yes, what quantity of crops harvested were stored for food?

	Crop	**Quantity stored in Kg**
1		
2		
3		
4		

E1.5 What quantity of crop produced were sold?

	Crop	**Crops sold in Kg**
1		
2		
3		
4		

E1.6 What is average price of crops sold?

	Crop	**Average price in Kg**
1		
2		
3		
4		

E1.7 What income obtained in each crop were obtained per year?

	Crop	**Total income obtained in Tshs**
1		
2		
3		
4		

E2 Food and income obtained from rain fed per year

E2.1 What is the crop produced and farm size per acre?

	Crop	**Area per acre**
1		
2		
3		
4		

E2.2How much quantity of harvest obtained per acre?

	Crop	**Quantity of harvest in Kg**
1		
2		
3		
4		

E2.3 Do you store crops for food from traditional irrigation1= Yes; 2= No

E2.4 If yes, what amount of crops harvested were stored for food?

	Crop	**Quantity stored in Kg**
1		
2		
3		
4		

E2.5 What quantity of crop produced were sold?

	Crop	**Crops sold in Kg**
1		
2		
3		
4		

E2.6 What is average price of crops in kg?

	Crop	**Average price in Kg**
1		
2		
3		
4		

E2.7 What income in each crop obtained per year?

	Crop	**Total income obtained in Tshs**
1		
2		
3		
4		

E3 Cost of inputs used in crop production

E3.1 What type of inputs used, cost and quantity in each crop produced under traditional irrigation

	Crop	**Type and quantity of inputs used in each crop**				
1		Type of input				
		Quantity used				
		Cost				
2		Type of input				
		Quantity used				
		Cost				
3		Type of input				
		Quantity used				
		Cost				
4		Type of input				
		Quantity used				
		Cost				

E3.2 What type of inputs used, cost and quantity in each crop produced under rain fed

	Crop	**Type and quantity of inputs used in each crop**				
1		Type of input				
		Quantity used				
		Cost				
2		Type of input				
		Quantity used				
		Cost				
3		Type of input				
		Quantity used				
		Cost				

E4 Labour cost in crop production

E4.1 Which activities is performed by family labor

…….

……

……
……

E4.1 What activities is performed and costs of labour from traditional irrigation

Crop	Activities performed	Cost inTshs
Paddy		
Maize		
Bean		
Vegetables		

E4.2 What activities is performed and costs of labour from rain fed

Crop	Activities performed	Cost inTshs
Paddy		
Maize		
Bean		
Others specify		

E5 What challenges or problems do you face in traditional irrigation farming?

……
……..
……

E6 How do you solve these challenges you face?

……
…

……
……..

E7 Do you have any comments on traditional irrigation farming?

……
…

……
…

…….

THANK YOU FOR YOUR COOPERATION