EFFECT OF SMALL SCALE IRRIGATION ON FOOD SECURITY IN MIRIGA MIERU EAST DIVISION OF IMENTI NORTH DISTRICT, KENYA

BY

SAMUEL MURURU M'NABEA

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DECLARATION

This research project report is my original work and has not been presented for a degree in any other university.

Signed …… Date ……

Samuel MururuM'Nabea

L50/71932/2011

This research project report has been submitted for examination with our approval as the University Supervisors.

Signed …… Date ……

Professor T. Maitho

Department of Public Health Pharmacology and Toxicology

University of Nairobi

Signed …… Date ……

Mr.Chandi John Rugendo

Lecturer,

School of Continuing and Distance Education

University of Nairobi

DEDICATION

I would like to dedicate this report to my beloved wife Mrs. Becky Mururu, my daughters, Mercy and Brenda for their understanding and moral support during the preparation of this report.

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ABBREVIATIONS AND ACRONYMS

AIDS	Acquired Immunodeficiency Syndrome
ASAL	Arid and Semi Arid Land
DIO	District Irrigation Officer
FAO	Food and Agriculture Organization's
HIV	Human Immunodeficiency Virus Infection
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IWUAs	Irrigation Water Users Associations
MDGs	Millennium Development Goals
MoFED	Ministry of Finance and Economic Development
NIB	National Irrigation Board
O&M	Operation And Maintenance
SNNPR	Southern Nations, Nationalities, and Peoples' Region
SPSS	Statistical Package for Social Sciences
SSA	Sub-Saharan Africa
SSI	Small-Scale Irrigation
UNFAO	Food and Agriculture Organization of the United Nations
US	United States
WHO	World Health Organization
WRI	Water Research Institute
WUAs	Water Users' Associations

ABSTRACT

About 80% of the Kenyan population depends on agriculture. Again 80% of the country is arid and semi-arid lands (ASAL) and typically characterized by low (100-1,200 mm per annum) and erratic rainfall, high evaporation rates and generally fragile ecosystems. The Government of Kenya has identified irrigation as an important tool in addressing food insecurity and enhancing households' income in the rural areas. In the arid and semi-arid areas there is much food insecurity due to over reliance on rain-fed agriculture. In these areas sustainable agriculture can only be achieved through well planned and operated irrigation projects. Miriga Meru division benefited from the government of Kenya funds in improving food self-sufficiency, and enhancing household incomes. The purpose of this research was to determine the effect of small scale irrigation on household food security in MirigaMieru East Division of Imenti North District, Kenya. The study sought to determine the effect of type of crop grown, household income and cost of the irrigation systems on household food security in Miriga Mieru East Division in line with the economic pillar of Kenya vision 2030. This study used a descriptive research design. The target population of the study was1036 small scale irrigation farmers in Miriga Mieru East Division, 3 extension officers from the Ministry of Agriculture and 15 Executive Committee members of the three projects. The data was collected from a sample size of 196 farmers using simple random sampling procedure. The researcher used purposive sampling also to select 3 extension officers and 15 executive project committee members. The total sample size used in the study was 214. Primary data was collected using household survey questionnaires, key informant interviews and focused group discussions. Pre-testing of research tools was carried out to ensure that the questions were relevant and clearly understood. Data was analyzed using the statistical package for social sciences. For the quantitative data, both descriptive and inferential statistics techniques were employed for analysis. The qualitative data took conceptual content analysis process. The strength and direction of a linear relationship between the variables was analyzed using Pearson's correlation coefficient. The study found that 50% of the farmers grew bananas, 25% grew French beans, 15% grew sweet potatoes while 10% grew watermelons. It was clear that high value crops and subsistence crops affected household food security to a very great extent with a mean score of 2.978 and 2.932 respectively using a scale of 1-5. The study also established that household income affected household food security in Miriga Mieru East Division to a very great extent(40%) as they earned between Kshs20,001 – 30,000 per month. Most (30%) of the farmers indicated that the cost of the irrigation system affected household food security in Miriga Mieru East Division to a very great extent. It is concluded that there is a positive relationship between food security and type of crop grown, household income and cost of irrigation system. The positive relationship indicates that there is a correlation between the factors and food security with type of crop having the highest value and cost of irrigation systems having the lowest correlation value with r-values of 0.794,0.652 and 0.735 respectively. The study recommends that farmers should embrace crop diversification so as to increase crop portfolio so that they are not dependent on a single crop to generate their income and guard against food insecurity. This study will help Ministries of Agriculture, Water and Irrigation, service providers, and the local community for assistance and effectiveness in management of existing irrigation projects in improving food security in the study area.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Global efforts aimed at ensuring food sufficiency by increasing staple food production have adopted irrigated farming as one of the main strategies. Projections by FAO (2007) predict a much slower expansion of irrigation in sub-Saharan Africa over the next 20-30 years (0.6% per year) as compared with 1.6% per year recorded from 1960-1990.

The extreme variability in rainfall, long dry seasons, recurrent droughts, floods and dry spells pose a key challenge to food production. The sole dependence of farming on rainfall has been a major cause of low food productivity, food shortages, undernourishment and famine in sub-Saharan Africa. The world's hotspots for hunger and poverty are concentrated in the arid, semiarid and dry subhumid regions of the world which depend solely on rainfall for food production (Faurès et al., 2007). In large parts of Africa, the fight against poverty and the prospects to reach the Millennium Development Goals (MDGs) has been the focus of governments (Birner et al., 2005).

Irrigated agriculture has been a major solution used in addressing water challenge affecting food production in areas of unreliable rainfall patterns. Approximately 70% of the world's irrigated land is in Asia, where it accounts for almost 35% of cultivated land. Of the total cultivated area in Africa, estimated at 198 million ha, just 4% (slightly above 7 million ha) is equipped with irrigation infrastructure (Svendsen et al., 2009).

Irrigation has historically had a large positive impact on poverty reduction and livelihoods, in both urban and rural areas, producing relatively cheap food for everyone and providing employment opportunities for the landless poor (Hussain, 2005). Through increased productivity irrigation produces secondary benefits for the economy at all levels, including increased productivity of rural labour, promotion of local agro-enterprises, and stimulation of the agricultural sector as a whole (Faurès et al., 2007). About 46% of the gross value of global agricultural production comes from irrigated areas, which makes up 28% of the total harvested area (de Fraiture et al., 2007). Many expect that the contribution of irrigated agriculture to food production and rural development will increase in the coming decades (Bruinsma, 2003).

Population growth is particularly high in emerging and developing countries. This means that these countries have an additional challenge in meeting the Millennium Development Goal of food security. They can overcome this challenge by increasing production in their own region, combined with increased import of food, where possible. Research estimates that in the coming decades, about 80-90% of the required increase will need to be realized on existing cultivated land and about 10-20% on newly reclaimed land (Hussain and Hanjra, 2004).

Irrigation is expected to play an increasingly important role in the agriculture of the developing countries. At present, irrigated production is estimated to account for 20 percent of the arable land (but about 30 percent of harvested area because of its higher cropping intensities) to contribute some 40 percent of total crop production (nearly 60 percent of cereal production). This share is expected to increase to 47 percent by 2030. The developing countries are estimated to have some 400 million ha of land which, when combined with available water resources and equipped for irrigation, represents the maximum potential for irrigation extension. Of this total, about one half (some 202 million ha) is currently equipped in varying degrees for irrigation and is so used. The projections conclude that an additional 40 million ha could come under irrigated use, raising the total to 242million ha in 2030. In principle, by that year the developing countries would be exploiting for agriculture some 60 percent of their total potential for irrigation. Naturally, the harvested area under irrigation will increase by more (33 percent), following fuller exploitation of the potential offered by controlled water use for multiple cropping.

In Africa, agriculture forms the backbone of most of the continent’s economies, providingabout 60% of all employment. During the last decade, per capita agricultural production has not kept pace with population growth. Consequently, as per the Food and Agriculture Organization's (FAO’s) assessments, at the end of the 1990s, 30 countries in Africa had over 20% of their population undernourished, rising to 35% in the 18 worse affected countries (FAO, 2012). In terms of absolute numbers, between 1997–99, 200 million people were malnourished, with 194 million of these people living in sub-Saharan Africa (SSA). The food gap estimated at 17 million tons in 2000 was filled by imports (14.2 million tons) and food aid (2.8 million tons) at a cost of US$18.7 billion. In 2001, close to 30 million people required food emergencies due to droughts, floods and civil strife.

According to the FAO (2007) sub-Saharan Africa has an irrigation potential of about 42 million hectares of which only 17% is developed. The average rate of expansion of the irrigated area over the past 30 years was 2.3% per annum. Expansion slowed to 1.1% per year during 2000–2003 but has since picked up as a result of renewed investments by multilateral and bilateral donors and foundations (Makombe, 2010). In sub-Saharan Africa there is thus great potential for expansion of irrigated agriculture.

While investments in irrigation have yielded significant impacts in terms of improving food security and poverty reduction in areas such as South-East Asia and East Asia, the same cannot be said for sub-Saharan Africa (Hussain 2005). Regions such as South-East Asia have almost exhausted their irrigation development potential, making the potential irrigable land in Sub-Saharan Africa a major hope for the world in terms of feeding the future population (FAO, 2007).

Development of the agricultural sector in Africa is therefore seen as central to combating hunger, reducing poverty, and generating economic growth (through the reduction of food imports and the boosting of exports). However, progress in the sector can only be achieved if the main constraints are successfully addressed including variability in climate, limited access to technology, low levels of rural infrastructure and poor institutional structures. Other areas that need addressing are the poor political and economic governance, the need to introduce supportive policy and legislation, the need to develop rural entrepreneurship capacity, combat HIV/AIDS, mobilize savings for investment and improve the performance of cash crops (Kay, 2001).

Until recently, irrigated agriculture was almost exclusively supported by the state. However, government-managed (large- and small-scale) schemes have generally performed far below expectations and most of the time, initial capital costs have not been recouped and the financial returns have not been able to cover operation and maintenance (OandM) costs.

Meanwhile, privately developed and managed (small-scale) irrigation schemes in most of the SSA countries show that there is business potential for private entrepreneur involvement in irrigation. Groups of farmers or water users' associations (WUAs) running parts of irrigation schemes for which responsibility was transferred to them by government, can also be considered as operating private irrigation schemes. Recent developments have shown the

increasingly important role of these new operators. However, for private operators to functionefficiently, a clear institutional framework is required – in many parts of SSA this framework is not in place.

According to Demese, Getinet, GoshuandYaddesa(2009), the current yield levels by rural smallholders is not able to produce to fulfill their minimum food requirements since one-third of the rural household owns less than 0.5 ha of farming land that are dependent on rainfed agriculture system. Similarly, a research made by Seleshet al (2005) confirmed that the food production status of the country has to be doubled till 2025 as compared with the current level of production so as to meet the food demands of the growing population of Ethiopia concurrently. Otherwise, continuing with the production momentum, supplying the required amount of food for the population will be a challenge at large.

Hence, resolution of both the short and long term food shortage situation of the countrybrings to apply modern agricultural mechanisms so as to boost production and improvethe overall economic, social and institutional contexts of the country (Mekuria, 2003).Tothis end, the large food deficit situation of the country both at national and householdlevel cannot be resolved on rainfed agriculture alone (Desta, 2004). Due to this fact, theEthiopian government has been involved in irrigation development works to improve thesituation of agricultural production level mainly focusing in drought-prone affected areasof the country since the mid of 1980s (Woledeab, 2003). A priority is given for irrigation by the current government to promote multiple croppingof food and cash farming systems in order to cope up with the problem of climatevariability and ensure food security at household and national level (MoFED, 2010).

Irrigation in Kenya has a long history spanning over 400 years. Records reveal that irrigation in Kenya has existed for many years in West Pokot, along River Tana, and Baringo districts. Rice irrigation activities also existed along river valleys such as Kipini, Malindi, Shimoni and Vanga. This was in the era of slave trade (19^{th} century) where slaves were used to construct the rice schemes. Asian workers building the Mombasa-Nairobi Railway line also started some irrigation activities around Makindu and Kibwezi (NIB, 2010). Currently, Kenya's total irrigated area is about 80, 000 hectares. Public and private small-scale irrigation is still less than 50, 000 ha. The estimated potential is more than 300, 000 ha, meaning that there is a long way to go (NIB, 2010).

Research by the International Food Policy Research Institute (IFPRI) in the Gambia, Kenya and Rwanda showed that cash crop production can result in significant increases in household improved household food security (Kennedy and Haddad, 1992). Ngigi (2002) disclosed that in Kenya for the two decades agricultural production has not been able to keep pace with the increasing population. To address this challenge the biggest potential for increasing agricultural production lies in the development of irrigation. According to the same study, irrigation can assist in agricultural diversification, enhance food self sufficiency, increase rural incomes, generate foreign exchange and provide employment opportunity when and where water is a constraint. Ngigi concluded that the major contributions of irrigation to the national economy are food security, employment creation, and improved foreign exchange earnings.

In Kenya irrigation may be seen as both a major cause of and an important solution to the country's increasing water scarcity and water insecurity. On one hand, irrigated agriculture in Kenya accounts for 76 percent of the water resources used and thus irrigation itself is aggravating water scarcity. On the other hand, expanding irrigation is one of the most important ways out of this situation, because in many locations rain-fed agriculture is no longer able to generate adequate yields and thus addressing food insecurity (WRI, 2005).

MirigaMieru East division has been facing substantial difficulties in producing adequate food and cash crops to feed the residents and generate income respectively. This is attributed to unreliable and insufficient amounts of rainfall. The Kenyan government in partnership with IFAD and German government, through the Ministry of Water and Irrigation has commissioned three major irrigation schemes in the division namely; Kioru-Giaki, Thuura-Giaki and Gachua irrigation projects to address these challenges(NIB 2010).

1.2 Statement of the Problem

Sub-Saharan Africa has an irrigation potential of about 42 million hectares of which only 17% is developed. While investments in irrigation have yielded significant impacts in terms of improving food security and reducing poverty in areas such as South-East Asia and East Asia, the same cannot be said for sub-Saharan Africa. Despite several investments in irrigation from governments (colonial and post-colonial), multi-national donor agencies and private investors, irrigation development in Sub-Saharan Africa has been slow. Except for a few countries in northern Africa, Madagascar and South Africa, the potential for irrigation

development has not been effectively tapped in Africa. Out of a total arable land of about 874 million hectares (ha), the current area under managed water and land development totals 12.6 million ha, or 3.7 % of the surface area of SSA. In spite of this potential, and the demand for more dependable sources of water, the development of irrigation has not picked up. Furthermore, existing irrigation farms operate at sub-optimal levels.

According to IFAD (2008), there has been a decline in the food production in various areas especially in the relatively arid areas due to climate change. This has in turn led to a decrease in productivity of rain-fed agriculture. Population increase, deforestation and frequent land distribution has affected agriculturalproduction in Kenya. This is reflected in a decrease in household production, a decreasein grazing land and scarcity of manure. That is why in most occasions; food insecurityquickly turns into famine when there are some climatic irregularities (Seleshi et al, 2005).Thus, it has become a common phenomenon to appeal for emergency food assistance foracutely food insecure people in Kenya.

So far, studies on analyzing contribution of irrigation on food securityimprovement have been focused on large-scale irrigation schemes which were establishedand managed by the state (Selesh et al., 2005).Cognizant to this fact, a lot of effort has been made by government, development partnersand communities to improve the food security situation of smallholders through creatingaccess to irrigated agriculture.But, according to the assessment made by the regional concerned bodies who verifiedthat most of the constructed irrigation schemes is found at zero level of practices and theoverall land coverage is below 50% of its planned capacity although expansion efforts isongoing by regional government until now (Muluken, 2005).

There is so much effort and investment in rural water supply for irrigation purposes to improve rural household's foodsecurity through improved productivity. The Kenyan government through the Ministry of Water and Irrigation appreciates the role of irrigation in enhancing/increasing crop production thus assisting in poverty reduction, food security and improving the overall quality of life for the rural populations. It is from this fact that the government started an irrigation programme known as the smallholder irrigation programme through the bilateral cooperation agreement between the Kenya government, Germany Development bank and IFAD (IFAD, 2008). In Meru County the programme started its operations in September 2005.In spite of all these efforts, food insecurity still prevails. More

than 30% of all Kenyas are food insecure (UNFAO Kenya, 2005). Miriga-Mieru East division was selected as a beneficiary under this programme with a purpose of increasing agricultural production, income and subsequently food security. My study therefore sought to establish the effects of the irrigation projects in this division on household food security.

1.3 Purpose of the Study

The purpose of this studywas to determine the effect of small scale irrigation on household food security in MirigaMieru East Division of Imenti North District, Kenya

1.4 Objectives of the Study

The specific objectives of the study were:

1. To determine the effect oftype of crops grownon household food security in MirigaMieru East Division
2. To establish how the household income affect household food security in MirigaMieru East Division
3. To assess the effect of cost of the irrigation systems on household food security in MirigaMieru East Division

1.5 Research Questions

This research study sought to answer the following questions;

1. What is the effect of type of crops grown on household food security in MirigaMieru East Division?
2. To what extent does household income affect household food security in MirigaMieru East Division?
3. What is the effect of cost of the irrigation systems on household food security in MirigaMieru East Division?

1.6 Significance of the Study

It is important to evaluate how irrigation schemes help in increasing agricultural production and its contribution to generate income, asset creation and improving the living standard of the rural households. The significance of the study is that it attempts to provide realistic

information on the overall issues of small-scale irrigation development in the study area and for formulating future strategies on smallholder irrigation investment.

In Kenya, numerous public and civil society funded food security and irrigationprogrammes have been implemented at national and local levels to ameliorate foodinsecurity and hunger. Hence, assessing the household food security situation can help toidentify and understand this basic aspect of well-being of the population and to informgroups or areas with severe conditions so as to take solution by concerned bodies.

Particularly, this study can help public officials, policy makers, service providers, and thelocal community at large to assess the changing needs for assistance and the effectivenessof existing programmes in the study area. Moreover, at grass root level, determining thefood security status of the households comprising the community can provide anindispensable tool for assessment and planning. The implications of increasing irrigated agriculture are significant. Knowledge of the hydrological impact of up-scaling irrigated agriculture on downstream users will be essential for decision making and negotiating tradeoffs between competing water uses.

Irrigation is an important input in household food security. It is through the use of irrigation that farmers are able to increase their farms agricultural productivity. Study on effect of irrigation on food security will help farmers identify various irrigation techniques and approaches which lead to a high cropping intensity thus improving the status of household food security. This will ensure farmers reap maximally from their farms thus reducing poverty and hunger. The result can be also used as an inputfor researchers involved in similar thematic area to further knowledge generation inconcepts related to irrigation development and food security in Kenya and other parts of the world.

1.7 Limitations of the Study

Some target respondents failed to give the required information during data collection due to the nature of the data and the subject matter.One limitationwas the difficulty in getting proper responses from sample respondents concerning income level directly because respondents were not willing to give true information by relating to social assistance, despite all the efforts made to alleviate the problem. The researcher however worked at winning the confidence of those involved in this research by giving them the reasons for the research and assured them of confidentiality.

Communication was also a problem due to language barrier and education level of the respondents. The researcher however used local interpreters from within the interview locations. Local school leavers were also engaged at a fee to help in data collection.

The descriptive research design was used as the research involvedanalyzing social issues and interviewing the respondents in their natural setting which was time consuming. Time constraints and financial limitations were all experienced, but this was solved by organizing the groups to be visited into three areas and the study has limitation ofonly using current year crop production information rather than time series data of thearea.Moreover, the vastness of the region, remoteness of the selected sample study areas from oneanother and poor transportation system were also some of thelimitations during the work.

1.8 Delimitations of the Study

The study focused on effect of small scale irrigation on household food security in Kenya. The area to be studied is in Imenti North District, MirigaMeru East division occupied by irrigation farmers each irrigating one acre of land through support from donors and Kenya government to fight poverty through increased cropping intensity. The farmers are sharing a common water source and are well organized through their Irrigation Water Users Associations(IWUAs).

1.9 Basic Assumptions of the Study

Theresearcher assumed that the respondents answered the questions to the best of their knowledge and correctly in spite of the subject matter. He also assumed that the sample selected represented the views of the general population.

The researcher also assumed that the instruments for data collection were appropriate and that the results of the study will provide a guide to the community, the government and other development partners in the use of small scale irrigation to address food insecurity.

1.10 Definition of Significant Terms

Food Access Refers to the way in which different people obtain available food. Normally, the way of accessing food is through a combination of means. This may include: home production, use of left-over stocks, purchase, barter, borrowing, sharing, gifts from relatives, and provisions by welfare systems or food aid.

Food Availability Thismeans that food is physically present because it has been grown, processed, manufactured, and/or imported.

Food Security This is achieved when it is ensured as "all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life.

Household Refers to a person or a group of people living in the same residence

IrrigationIs the artificial application of water to the land to facilitate crop growth.

Smallscale irrigation Is irrigation on plots less than one acre in which farmers have the major controlling influence using a level of technology which they can effectively operate and maintain.

Traditional irrigation Thisrefers to those schemes that have been initiated and constructed by farmers using the knowledge and resources available to them. Farms under traditional irrigation are in many instances, characterized by temporary diversions/ structures and channels not built following formal engineering designs and as a consequence, may not contain optimum grades and cross-section.

1.11 Organization of the study

The study is organized into five chapters each containing specific information. Chapter one introduces the background of the study, statement of the problem, purpose and objectives of the study, research questions, significance of the study, limitations and delimitations of the study, basic assumptions and the definition of significant terms. In chapter two, a literature review concerning concepts and issues on small scale irrigation and food security, its impacts

on global, national and household food security is discussed. Chapter three covers research methodology, describes the research design, target population sampling procedure, instruments and methods of data collection,data analysis and ethical considerations of the study. Chapter four presents results of data analysis and interpretation. Chapter five gives the summary of the research findings, discussion, conclusions and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The relevant literature consistent with the objectives of the study is reviewed in the chapter. The chapter presents a review of the related literature on the subject under study presented by various researchers, scholars, analysts and authors. Important issues and practical problems are brought out and critically examined so as to determine the current facts. This section is vital as it determines the information that link the current study with past studies and what future studies will be needed to explore so as to improve knowledge. It also contains the conceptual framework and research gaps.

2.1.1 Small Scale Irrigation

According to FAO (2007) irrigation is defined as the artificial application of water to thecrop for the purpose of food and fiber production overcoming deficiencies in rainfall andhelp in creating stabilized agriculture. Irrigation development could also be defined as acase of agricultural development in which technology intervenes to provide control forthe soil moisture regimes in the crop root zone in order to achieve a high standard ofcontinuous cropping. A working definition of irrigation for this paper istherefore as defined by Uphoff (1986) “Irrigation is the practice of applying water to soilto supplement the natural rainfall and provide moisture for plant growth.

Before embarking on defining small-scale irrigation, it is useful to come across atdifferent criteria used to categorize and classify different types of irrigation. Around theworld, scholars use different standards for classification of irrigation schemes. Regardingthe ways of supplying water, flood irrigation, furrow irrigation, sprinkling or sprayirrigation and drip irrigation are identified (Nigussie, 2002). Irrigation may also becategorized using other criteria such as ownership, economic objective and modernity.

Turner (1994) also points out that irrigation systems can be classified according to size,source of water, management style, degree of water control, source of innovation andtype of

technology. Most authors, however, agree that concepts of local management andsimple technology should be combined with size.

Moreover, small-scale irrigation can be defined as irrigation, usually on small plots, inwhich small farmers have the controlling influence, using a level of technology, whichthey can operate and maintain effectively. In terms of management, there are three broadtypes of smallholder schemes: government-managed, farmer-managed, and jointlymanagedschemes. Farmer-managed schemes are developed either by community or bygovernment but owned and managed by farmers' irrigation management committees orwater users' associations with minimal government interventions.

Small-Scale Irrigation is, therefore, farmer managed: farmers must be involved in thedesign process and, in particular, with decisions about boundaries, the layout of thecanals, and the position of outlets and bridges (Tafesse, 2007). Insimilar fashion, Brown (1992) defined SSI as: Farmer-managed irrigation schemes of afew hundred square meters to a several thousand hectares, developed, operated andmaintained by individuals, families, communities, or local rulers and landowners,independently of government, and generally for the production of basic food or fibercrops and vegetables for local markets. Indeed, small-scale schemes are defined asschemes that are controlled and managed by the users themselves.

2.1.2 Household Food Security

Food security is a situation that exists when all people, at all times, have physical, social and economic access to sufficient,safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FAO, 2003; WHO, 2011). At the household level, food security implies physical and economic access to foods that areadequate in terms of quantity, nutritional quality, safety and cultural acceptability to meet each person's needs.

Studies on assessment of food security can take different level of unit of analysis, atnational, regional, community, household and individual levels. Since collecting preciseinformation for each individual might be impossible or too costly, especially in poorcountry like Kenya, there is an option which is widely practiced in food securityresearch. This is a study starts at household level analysis by applying a weight (Adultequivalent scale or ratio) to adjust to its composition and drives weighted per capitaestimate (Jacobs, 2009). Hence, it is worthwhile

to look at the concept of household foodsecurity since this study's center of attention is at household level.

The concept of household food security is a more recent development and the bulk ofliterature dated from 1980s equating national food security with food self-sufficiency is aproblem that needs to be clearly understood. Many countries those used to be consideredas self sufficient in food were found to be food insecure due to the fact that they eitherlack an efficient food system or the capacity to the level of food entitlement. Thisindicates that attaining macro-level food self sufficiency does not ensure the achievementof household food security (Getahun, 2003)

Therefore, food security strategy has to address household-level food production andinvestment in food production and storage. These, however, are essential but notsufficient vehicles for solving household-level malnutrition and household foodinsecurity problems. Ayalew (2003) indicatesthat household food security mainly conditioned by factors, which are related to theprocess of acquisition, household procurement strategies and socio economic condition ofthe society. With regard to this, the key elements that are critical to household foodsecurity are availability and access. The former is further influenced by the differentsource of food and handling patterns which facilitate the time dimension of foodavailability in the household.Besides, household is identified as food secured if entitlements of demand for foodsecurity is greater than food needs, which is defined as the aggregation of individualrequirements. At individual level, the definition is much more straightforward. Anindividual is food secure if his or her food consumption is determined by claim theindividual has on household food source.

Jacobs (2009) defined entitlements as a set of alternative commodity bundles that aperson can commend in a society using rights and opportunities that he or she faces. Thismeans, what can a person produce, buy or borrow, given what they own and whatsocially and state regulations allow them to do with that. He identified four maincategories of entitlement, namely, trade based entitlement, which describes what anindividual can buy with the commodities and cash they own; production basedentitlement, which describes the right to own what one produces with one own resource;inheritance or transfer entitlement which refers to the right to own what is willingly givenby others as remittance, bequest, as well as transfer from state such as social security,pensions and food distribution. All these

entitlements give an individual control overresource which they can use.Generally, the most common indicators to household food security are food availability,food consumption or access and composite food security. Measuring food security interms of food availability focuses on national or household agro food output or supply(Jacobs, 2009).

2.2 Theoretical Review

Theories are set of ideas that describe a social situation, and theories gives a directives on what needs to be done to deal with a particular problem. As Africa lags behind other regions in adoption of technologies, particularly, irrigation,fertilizer and improved seed verities, as a result the numbers of food insecure people willbe rise by 2020, and those of malnourished children will increase correspondingly(Rukuni, 2002). As one of the reasons access and efficient utilization of land is indicated.Not only that land has not been used as source of resource in much of Africa but also landenhancement has not been a priority for African farmers (Maxwell, 2001). At countrylevel, irrigation with higher yields can allow countries to grow more of their own foodand be less dependent upon imports especially in view of the common occurrence ofdroughts in the region.

Development of agricultural water resources brings significant changes at various levels,from farm to national levels. These are changes in production patterns, land and propertyvalues, expansion in the use of improved agricultural inputs (such as high yielding varietyseeds, fertilizers, pesticides, etc.) and expansion in overall economic activities throughbackward and forward linkages. The impacts of these changes vary greatly from one levelto another. Some of the impacts are confined to only farm level, while others spread tothe whole project command and others spread to wider region and province/state ornational level. Where conditions are favorable use ofirrigation can raise the incomes of smallholder farm households by reducing productionrisk and farm output diversification, thereby encouraging farmers to gain the benefits ofgreater specialization and commercialization at the same time enabling farmers to adaptproduction concerned on market demand and higher prices (Hasnip et al., 2001).

In areas where communities and households depend to a great extent on agriculture fortheir livelihoods, access to irrigation is a necessary, but not a sufficient condition forpoverty alleviation. For instance, access to other production inputs and services by thepoor and

marginal farmers is also important to enhance benefits of irrigation for povertyalleviation. In line with this, Birhanu and Pedy (2003) also indicated the need forpolicy and institutional interventions to boost the impacts of irrigation so as to enhance itscontribution to sustainable livelihoods of rural people. According to these writers, thiscould be achieved through household asset building by strengthening market access, bypromoting high-value crops, and improving farming systems by providing extension andtechnical support to smallholder irrigation.

Therefore, the challenge that Kenya faces in terms of food insecurity is associated withboth inadequate food production even during good rain years and natural failures due toerratic rainfall. Therefore, one means by which agricultural production can be increasedto meet the growing food demands is through increasing agricultural yield and increasingcropping intensity. Increasing yields in both rain-fed and irrigated agriculture andcropping intensity in irrigated areas through various methods and technologies are themost viable options for achieving food security in Kenya (Mekuria, 2003).

2.3 Empirical Review

Even though land augmenting impact of use of irrigation has been studied in terms ofincreases in crop yield, income, diversification and generating off-farm activities bydifferent scholars, specific empirical studies on the contribution of irrigation to householdfood security measured in terms of calorie acquisition is very scant or almost nil.Therefore, this empirical review is bounded only to these studies.

An Impact study by Desta (2004) revealed that contribution of irrigated agriculture toincome is about 70 % in the highly irrigated villages as compared to 60 % in two otherlow irrigated areas. At the same time, the absolute size of agricultural income is also thehighest in the highly irrigated village despite the lower landownership size and cultivatedholding by more than 30 % over the low irrigated village. The share of agriculturalincome (in terms of both owned and cultivated land) is also found to increase with theincrease in irrigation intensity of the village. The highly irrigated village has higher perhectare agricultural income by over 50% over the low irrigated village.

An econometric analysis of the link between irrigation, markets and poverty bysmallholder vegetable and Fruit Production in the North Omo Zone, SNNPR findingssuggested that promoting small scale, low cost and labour-intensive irrigation projects andbuilding the capacity of farmers are very important for reducing poverty in the cashgrowing rural areas of Ethiopia (TadelandDebel, 2006).In household food security, irrigated agriculture plays a crucial role in the sustainablelivelihoods of rural communities. Improvement in access to irrigation water serves as apowerful tool to diversify livelihoods and reduce vulnerability for smallholder producers(Birhanuand Pedy, 2003).

There are five key dimensions how irrigated agriculturecontributes to socioeconomic uplift of rural communities. These are production, income,consumption, employment, food security, and other social impacts contributing to overallimproved welfare (Hussian, 2004).The same author in the same year notes that irrigation can benefit the poor throughraising yields and production, lowering the risk of crop failure, and generating higher andyear-round farm and nonfarm employment. It can enable smallholders to adopt morediversified cropping patterns and to shift from low-value subsistence production to highvaluemarket-oriented production, which increase income of household. Furthermore,(Abebaw, 2003) explains use of irrigation will enable farm households to produce highvalue crops, in most cases vegetables, which eventually increase crop income. Increasedincome creates consumption stability since the farmers will have access to purchaseenough food for household.

On the other hand, farm households who participate in irrigated agriculture would able toincrease crop production through increased use of complementary inputs (such as highyielding variety seeds, fertilizers, pesticides, etc.), which enables them to produce moreand retain food for household consumption i.e. availability of food in household will beenhanced. Access to irrigation also creates an opportunity for rural farm households toproduce crop throughout a year since water will be available for crop to grow wheneverneeded, that means risk of crop failure is reduced. Hence, the household will not faceconsumption shortfall, as production of crops are possible during off periods where foodstocks are depleted.

Shiferaw et al (2004) in their analysis of household food security determinants inSouthern Ethiopia, they concluded that the supply-side variables were more to determinethe household food security than the demand-side variables. In their study adopting ofimproved technology,

having better farm size and land quality were found an importantrole in ensuring household food security in the study area.

Epherm (2008) studied determinants of household food security in SekotaWoreda usinglogit model. The study found that poverty household food security in the north easternpart of Ethiopia were strongly associated with various socio-economic and bio-physicalfactors that influence the food security status of households were age of household head,dependency ratio, size of cultivated land, total number of livestock owned (excludingoxen), number of oxen, manure application, land quality index and farmer's knowledgeon the effect of land degradation on food security.

There are direct and indirect linkage between irrigation and poverty. Directlinkages operate through localized and household leveleffects, whereas indirect linkages operate throughaggregate or sub-national and national level impacts.Irrigation benefits the poor through higher production,higher yields, lower risk of crop failure, and higher andyear-round farm and non-farm employment. Irrigationenables smallholders to adopt more diversified croppingpatterns, and to switch from low value staple productionto high-value market-oriented production. Increasedproduction makes food available and affordable for thepoor (Muluken, 2005).

The preceding description of irrigation types in sub-Saharan Africa may paint a picture that irrigation development is well on course. However, this is not the situation as irrigation development in sub-Saharan Africa happens to be the slowest in the world (FAO, 2006a). As a result sub-Saharan Africa has the highest potential to accelerate irrigation development in comparison to other continents to help solve projected world food shortages. However, projections by FAO (2007) predict a much slower expansion of irrigation in sub-Saharan Africa over the next 20-30 years (0.6% per year) as compared with 1.6% per year recorded from 1960-1990. These predictions are informed by the numerous challenges facing irrigation development in sub-Saharan Africa.

Ayalew (2011) did a study linking small-scale irrigation and household food security in drought prone area of North East Ethiopia a case study of Alawuha Irrigation Scheme in GubalaftoWoreda, North Wollo Zone.In this thesis, an attempt made to identify household food security status and itsdeterminants in one of drought prone area- GubalaftoWoreda.

Moreover, the linkagesbetween Small Scale Irrigation and household food security in provision of food energyassessed. A multi- stage stratified sampling procedure was used to select 115 samplehouseholds from both irrigation users and non-users living within the targeted kebeles. Acombination of quantitative analysis like descriptive statistics, Household Food BalanceModel, binary logit model and qualitative study were used to reach at reliable results byusing data gathered from both primary and secondary sources. The survey resultrevealed that 29 % of sample households were food insecure and 71 % food secure.There is huge gap in food calorie availability ranging from 788- 8405Kca in the studyarea. Food insecure households were found to have an average of 24% food gap in termsof dietary energy, which is needed to fulfill the national minimum requirements. Theaverage per capita calorie supply for irrigation users was found substantially increasedby 889 Kcal, which is about 42 % percent of the minimum requirement of food calorierequires by an individual. The use of SSI was found significantly related to householdfood security situation in provision of household dietary energy and taking a lion share inthe proportion of study areas major consumable from food crops production. The logitmodel revealed that household size, educational status of household head, number offarm oxen, cultivated land size, engagement in non-farming, access to irrigation andcredit service were found significant determinants. Correspondingly, the study disclosedthat the long distance between irrigated land to farmers residence, lack of cleaning andmaintenance of scheme, free grazing , poor irrigation methods and crop selection werethe major constraints in the irrigation farm. SSI is one of the viable solutions tohousehold food supplement and hence promoting of smallholders to produce directlyconsumable food grains is advantageous.

Tsegaye et al (2005) did a study on the impact of small scale irrigation on household food security: the case of Filtino and Godino Irrigation Schemes in Ada Liben District, East Shoa, Ethiopia. Irrigated production is far from satisfactory in the country. The country's irrigation potential is estimated at 3.7 million hectare, of which only about 190,000 hectare (4.3 percent of the potential) is actually irrigated. The aim of the studywas to identify the impact of small-scale irrigation on household food security based on data obtained from 200 farmers in Ada Liben district of Ethiopia. Different studies revealed that access to reliable irrigation water can enable farmers to adopt new technologies and intensify cultivation, leading to increased productivity, overall higher production, and greater returns from farming. In the study area also about 70 percent of the irrigation users are food secure while only 20 percent of the non-

users are found to be food insecure. Access to irrigation enabled the sample households to grow crops more than once a year; to insure increased and stable production, income and consumption; and improve their food security status. The study concludes that small-scale irrigation is one of the viable solutions to secure household food needs in the study area but it did not eliminate the food insecurity problem.

In Kenya, given the tremendous potential for improving horticultural crop production, farmers have demonstrated their interest in practicing irrigation by opening schemes through their own efforts.

2.4 Type ofCrops Grown

The introduction of new cultivated species and improved varieties of crop through irrigation is a technology aimed at enhancing plant productivity, quality, health and nutritional value and/or building crop resilience to diseases, pest organisms and environmental stresses. Crop diversification refers to the addition of new crops or cropping systems to agricultural production on a particular farm taking into account the different returns from value-added crops with complementary marketing opportunities. Major driving forces for crop diversification include: increasing income on small farm holdings, withstanding price fluctuation, mitigating effects of increasing climate variability, balancing food demand, improving fodder for livestock animals, conservation of natural resources, minimising environmental pollution, reducing dependence on off-farm inputs, depending on crop rotation, decreasing insect pests, diseases and weed problems and increasing community food security(Hall, 2003). New crop species diversify crop production systems which need to take into account availability and quality of resources, access to technologies, household related factors, price and market related factors, institutional and infrastructure related factors including irrigation, rainfall and soil fertility.

Breeding new and improved crop varieties using irrigation technologies enhances the resistance of plants to a variety of stresses that could result from climate change. These potential stresses include water and heat stress, water salinity, water stress and the emergence of new pests. Varieties that are developed to resist these conditions will help to ensure that agricultural production can continue and even improve despite uncertainties about future impacts of climate change. Varieties with improved nutritional content can provide benefits

for animals and humans alike, reducing vulnerability to illness and improving overall health (Mengistu, 2007).

The aim of crop diversification is to increase crop portfolio so that farmers are not dependent on a single crop to generate their income. When farmers only cultivate one crop type they are exposed to high risks in the event of unforeseen climate events that could severely impact agricultural production, such as emergence of pests and the sudden onset of frost or drought. Introducing a greater range of varieties also leads to diversification of agricultural production which can increase natural biodiversity, strengthening the ability of the agro-ecosystem to respond to these stresses, reducing the risk of total crop failure and also providing producers with alternative means of generating income. With a diversified plot, the farmer increases his/her chances of dealing with the uncertainty and/or the changes created by climate change. This is because crops will respond to climate scenarios in different ways. Whereas the cold may affect one crop negatively, production in an alternative crop may increase (Getahun, 2003).

Irrigation of low value crops like cassava does not provide that much incomecompared to the cost of piped water supplies (Moriarty andButterworth, 2003). Higher value crops are preferable. Also,beneficial use of water by poor people who may not be served by other systems and for whom any diversification oflivelihoods is critical should be encouraged.It is commonly believed that crop diversification among smallholder farmers is incompatible with maintaining or improving household food security when cash crops are included in the new crop mix (Fleuret and Fleuret, 1980). The main concern is that food availability of smallholder farm households will be affected by the displacement of food crops by cash crops. It has been postulated that the household's vulnerability to food insecurity and dietary inadequacy may be increased, particularly when household food availability does not change much in response to higher household income from cash crops. Household labour inputs per hectare are often higher for production of cash crops than for basic food crops; thus the household's daily energy requirements, particularly those of women and children, may be raised. Increased female employment may lead to reduced child care, with detrimental nutritional consequences for small children (Popkin, 1980). On the other hand, the need to migrate seasonally to find off-farm employment is likely to be reduced when cash crops are introduced, with positive benefits resulting from more social interaction within the household and lower incidence of morbidity.

A consistent body of evidence from different settings indicates that the income effects from agricultural transformation in the subsistence sector are positive and can reduce income inequality among diversified smallholder farmers (Immink and Alarcón, 1992). However, in spite of higher economic returns to household resources (land and labour) from cash crops compared with basic staple crops, a number of risks for smallholder farmers are associated with increased commercialization. These include: income loss from crop failure, market price variability over time, weak and inefficient marketing institutions and higher input requirements, and thus greater need for credit and extension services, both of which are typically lacking for farmers with little land.

The key to preventing negative food availability effects of diversified farming is significant yield increases in food crops, which will offset the reduction in land allocated for the production of these crops. In Guatemala, farmers producing a diversity of crops raised maize yields by using additional labour and by increasing fertilizer application as a direct result of the adoption of new technology (von Braun, Hotchkiss and Blanken, 1991). This supports the general point that farm-level specialization leads to the adoption of new technological production techniques and thus to yield increases. However, agricultural technologies may have different nutritional impacts, and sole emphasis on production expansion may not result in nutritional improvements for the rural poor (DeWalt and DeWalt, 1987).

Even if yield increases offset the reduction in land allocation, the total household availability of own-produced foods will decline when the share of total production that the household sets aside for its own consumption decreases. Under these conditions, the effect on income for food purchases must consistently be strong enough to compensate for the reduced availability of own-produced food. The evidence is not encouraging, since the availability of purchased foods (expressed as dietary energy availability) has been shown to be fairly unresponsive to income changes (Bouis and Haddad, 1990). Thus, consumption of own-produced foods by the household may remain a critical element of household food security, even when income levels rise substantially.

This article focuses on maize, the single most important food of the rural poor in Guatemala, and beans, which are often grown together with maize on the same plot of land. To see whether higher maize and bean yields are indeed the key to household food security among diversified smallholder farmers in Guatemala, how the critical parameters of yields, the share

of land allocated to these crops and the share of own-produced maize and beans consumed by the household might change among smallholder farmers who diversify their crop mix were examined. Determinants of these elements in the household food production-consumption chain were also examined, as well as the food availability outcomes for the household and especially for the most vulnerable household members, preschool children. Finally, some policy and programmeme lessons from the analysis were drawn.

Research carried out by Rukuni (2002) indicated that the process of farmer experimentation and the subsequent introduction of adapted and accepted varieties can potentially strengthen farmers' cropping systems by increasing yields, improving drought resilience, boosting resistance to pests and diseases and also by capturing new market opportunities. To make the products of the research process more relevant to the needs of smallholder farmers, research organisations are increasingly engaged in participatory research in recognition of its potential contribution to marginal areas with low agricultural potential. There is a need to identify crops and varieties that are suited to a multitude of environments and farmer preferences. Crop diversification can enable farmers to gain access to national and international markets with new products, food and medicinal plants. Diversifying from the monoculture of traditional staples can have important nutritional benefits for farmers in developing countries and can support a country to becoming more self-reliant in terms of food production. Diversification can also manage price risk, on the assumption that not all products will suffer low market prices at the same time. Compared to producing monocultures, management techniques for diversified crops generally consist of more sustainable natural resource practices.

2.5 Household Income

Household food security depends on adequate income and assets including land and other productive resources owned (FAO, 1997). In terms of income, irrigation has a strong land augmenting impact. The value per hectare of crop production under irrigated settings is about twice that of under rain-fed settings. Household income and consumption are much higher in irrigated settings than in rain-fed settings, and a 50 percent point gap is common (Food and agriculture organization (FAO), 1997). It is estimated that in Amhara Region farmers earn up to about Birr 15,000.00 (about $1,800.00) from farm products, mainly horticultural crops from modern small scale irrigation(SSI) schemes (Awulachew et al, 2005). Besides, the study

concluded that irrigation investments can have broader food security and poverty reduction impacts, if efforts are geared towards revitalizing and up-grading existing traditional SSI schemes, with support to enhance access to input supply, output marketing and extension to facilitate access to information and innovations.

Fuad (2001) findings verified that that cash crop economy with important cash flow offers a wide range of off-farm income possibilities as compared to subsistence farming. He shows that about 45% of farmers involved in cash crop production are engaged in income generating off-farm activities while 13 % are from the non-cash crop producers. Moreover, (Maxwell, 2001) studies in two irrigation schemes around DoniKumbi and BatoDegaga peasant associations in East Shewa showed that average income obtained from irrigation agriculture for three consecutive years accounts 69 %, 76 %, 76 % in DoniKumbi and 70%, 75 %, 61 % in Bato Degage. The study has shown the importance of smallholder irrigation development as a drought mitigation measure and improvement of household food security.

A study made on socio-economic assessment of two small-scale irrigation schemes in AdamiTulluJidoKombolchaWoreda, Central Rift Valley of Ethiopia, result showed that irrigation schemes increased households' income compared to situation before implementation of the schemes and thus contributed to improvement of household food security status (Mengistu, 2007). He also found that households had grown mixed crops such as onions, maize and green beans though the net revenue gained by the two irrigation schemes were significantly different. This is a means of reducing risks from temporary food shortage by rural households using diversification strategy in their irrigation land.

One of the key issues in providing productive water is demand management. Unrestricted productive uses of domestic water may not always be positive and desirable. Hope, Dixon and Maltitz (2003) established that improved domestic water supply for kitchen garden farming as a significant livelihood activity and a component of food security. They also found out that access to domestic water is disproportionately skewed in favour of the male headed income wealthier households. The authors argue that improved domestic water access offers greater equity and food security benefits to poorer households but the efficiency and sustainability of such a poverty reduction intervention is questioned.

Babatunde and Qaim (2011) analyzed the role of off-farm income in enhancing food security and nutritionfor households in rural Nigeria. The analysis builds on a survey of 220 households in KwaraState, which was conducted in 2006. Food consumption data were elicited through a 7-day recall,covering 105 food items. The food consumption data were supplemented by anthropometricmeasurements that were taken from pre-school children up to 60 months of age. In the 220 samplehouseholds, weight and height data from 127 children were obtained. Different Econometricanalyses were employed to examine the mechanisms by which off-farm income affects householdcalorie and micronutrient supply, dietary quality, and child anthropometry. We hypothesized thatoff-farm income contributes to better nutrition in terms of calorie and micronutrient supply andchild anthropometry. Issues of endogeneity were taken into account by using instrumental variableapproaches. The studyfound that off-farm income has apositive net effect on food security and nutrition, which is in the same magnitude as the effect offarm income. The study also showed that the prevalence of stunting and underweight is remarkably loweramong children in households with off-farm income. Accordingly, improving poor households'access to the off-farm sector can contribute to reducing problems of rural malnutrition. The results demonstrate that both farm and off-farm activities can equally contribute to better foodsecurity and nutrition. Yet, while investing into agricultural growth is currently featuring high onthe development policy agenda, promoting the rural off-farm sector receives much less attention.

Jayne (1994) further identified groups most vulnerable to chronic and transitory food insecurity and these include asset-poor rural people in rural and resettlement areas that farm but are often net purchasers of food. This group is said to lack the resources to produce enough income to buy their residual food requirements and this group includes female households and households in war-torn and environmentally disrupted areas, urban households with unemployed or more frequently underemployedfamily members. These groups typically have low levels of income and the landless labourers.

Rukuni, *et, al* (2006) argue that food security status among the households differs due togreat variation in household s' resources and the ability to shift their resources intogrowth sectors with specific capital and climatic or infrastructure requirements. As aresult, most smallholders in the semi-arid communal areas of natural region IV and V arenot producing enough grain to meet the annual household demand. The existingliterature suggests that the

establishment of smallholder irrigation schemes has thepotential of ensuring food security in the communal areas. Literature has also proposeddifferent views regarding the possible impact of smallholder irrigation on food security inthe communal lands.

2.6 Cost of the Irrigation Systems

The cost of developing government-led small scale irrigation schemes vary widely. Jones (1995), reviewing the experience of the World Bank in irrigation development for a few decades, estimated that the average unit cost for 191 irrigation government-led projects was US$4,800 per ha in 1991. The average for the whole of Africa was US$13,000 per ha while that for sub-Saharan Africa was US$18,300 per ha when indirect costs for social infrastructure, including roads, houses, electric grids, and public service facilities, are included. According to the FAO (2003), irrigation investment costs are generally much higher in sub-Saharan Africa compared to a world average of 5,600 $/ha. On the other hand, there are sporadic studies showing relatively cheaper irrigation projects in sub-Saharan Africa with average unit costs comparable to Asia (IFAD, 2000).

Other studies (Awulachew et al., 2005; Moris and Thom, 1990) have identified the following problems: the high costs of investment and negative rates of return; technical flaws in infrastructural design, seepage, sedimentation, cracks in dams and silting up of reservoirs; high input costs, especially cost of fertilizer; pests and diseases especially for onions and tomatoes; high interest rates on loans; management failures; political difficulties; and finally marketing problems. Awulachew et al. (2005) observed that where these types of failures occurred, they have generated lack of maintenance, broken down scheme machinery due to lack of spare parts, and lack of access to input and output markets.

Shah et al. (2002), studying smallholder irrigation systems in sub-Saharan Africa, identified the following challenges: mismanagement, high cost of working capital, poor linkages to credit, input and output markets, institutional vacuum, land tenure issues, improper management transfers, damaged soils, expensive and ineffective mechanisation, poor farmer capacity and lack of farmer entrepreneurship development.

Inocencio et al. (2007) compared irrigation development in sub-Saharan Africa with other developing areas, and confirmed that it is more expensive to develop irrigation in sub-

Saharan Africa than in other parts of the world. In sampling 314 irrigation schemes implemented in developing countries, the average cost of a new irrigation scheme in sub-Saharan Africa was US$14,500/ha and US$6,000/ha elsewhere. Rehabilitation costs amounted to US$8,200/ha in sub-Saharan Africa against US$2,300/ha elsewhere. The high cost is related to the lack of economies of scale because sub-Saharan Africa has many relatively small irrigation schemes (Faurès et al., 2007). Inadequate local expertise in planning, designing and construction of irrigation projects and, hence, the involvement of expensive expatriate expertise at all stages of the project cycle at the early stages of nationhood have also been cited as reasons for high cost of irrigation development (Namara et al., 2010). It is further speculated that the best areas for irrigation schemes development in sub-Saharan Africa have been almost exhausted leading to higher construction cost in future irrigation projects (Faurès et al., 2007). This is further compounded by the need to mitigate the social and environmental costs associated with these developments. This has reduced the rate of development of new irrigation schemes across sub-Saharan Africa.

Desalegn (1999) also noted that even though all the irrigable land is used for food cropproduction, the significance of its impact on food security couldn’t be very high. However,costs of such projects are huge and must be justified by the value of their return. Thus, it isimperative to examine the importance of irrigation development in the context of the areaschosen. Recently, the Support to Farmers' Association Project through external financing has created a credit line for small-scale farmers. Lack of financial resources in Kenya is reflected through smallholders' declining share in the volume of exports.

2.7Conceptual Framework

A conceptual framework is an explanation of the relationships between the variables identified in the study as shown in the figure below;

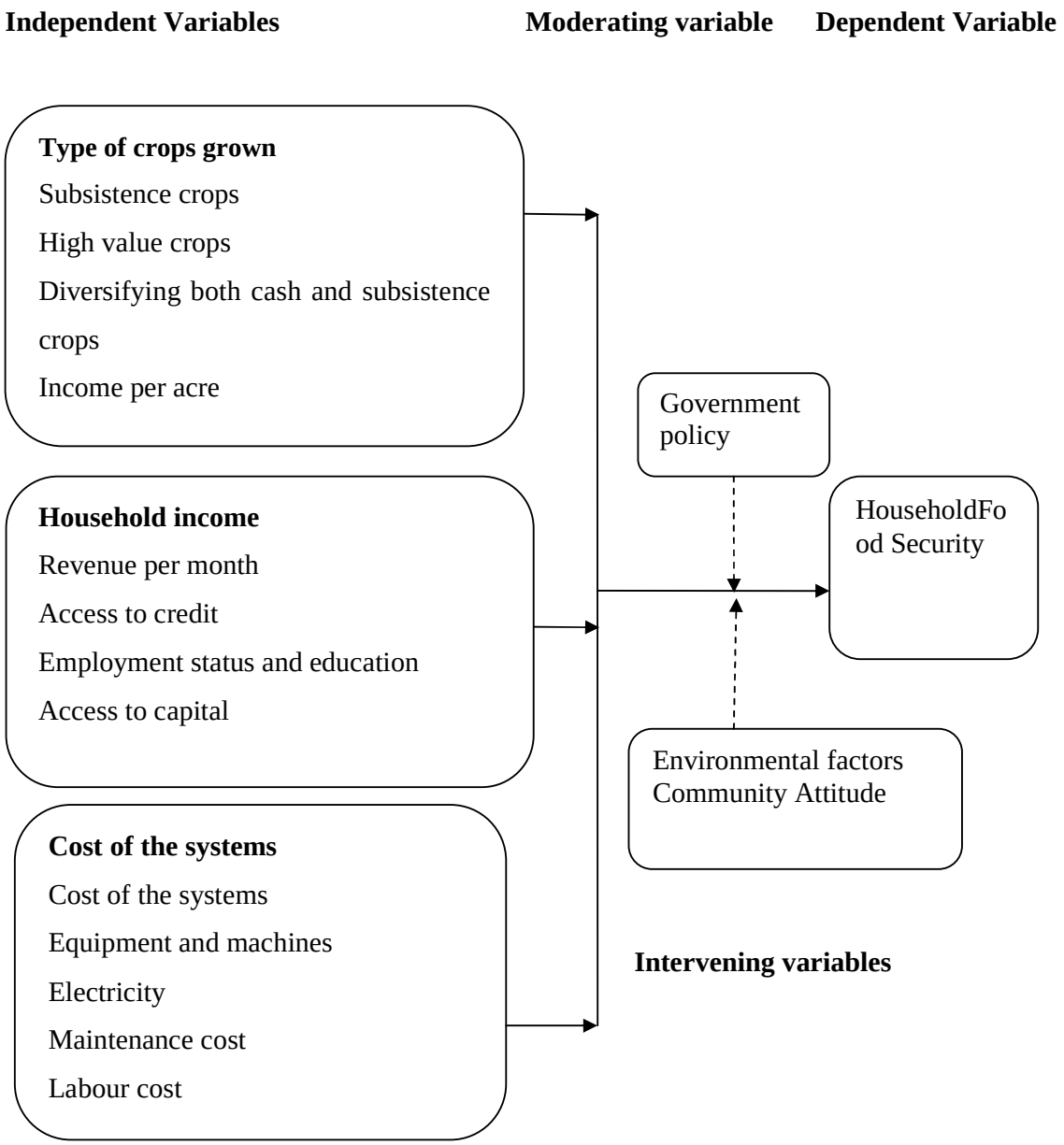

Figure1: Conceptual Framework

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter gives the methodology whichwas used by the researcher to find answers to the research questions. The research methodology is presented in the following order: research design, target population, sampling procedure, tools and techniques of data collection, pre-testing, data analysis and ethical considerations.

3.2 Research Design

This study useda descriptive research design. The method was chosen since it was more precise and accurate since it involved description of events in a carefully planned way. For the descriptive design, the respondents were interviewed in their natural settings as well narrating of their experiences in describing a social situation (Mugenda and Mugenda, 2003).

3.3 Target Population

The target population of the study was1036small scale irrigation farmers in the three major irrigation schemes inMirigaMieru East Division,3 Extension Officers from the Ministry of Agriculture and 15 Executive Committee members of the three projects.

Table 3.1: Target population for farmers

Name of Irrigation Scheme	Population	Percentage
ThuuraGiaki	427	41.2
Gachua	315	30.4
KioruGiaki	294	28.4
Total	**1036**	**100.0**

Source: Imenti North District Irrigation Office, (2011)

3.4 Sampling Procedure and Sample Size

Sampling is the process of choosing the research units of the target population which are to be included in the study. Sampling is done because a complete coverage of the population is not possible. It also requires small portion of the target population, sampling also offer more detail information and high degree of accuracy as it deals with smaller units and it also representative of a larger population.

The sampling procedure used in the study was a multi stage sampling procedure.The data was collected using a sample size of 196 using simple random sampling employing random number tables to select small scale irrigation farmers by applying the Mugenda and Mugenda (2003) formula. The researcher used purposive sampling also to select 3 extension officers from the Ministry of Agriculture and 15 executive project committee members of the three projects.The total sample size was 214.

For normal distribution the sample was estimated as shown below.

$$n = \frac{Z^2 PQ}{\alpha^2}$$

Where:

Z is the Z – value = 1.96

P Population proportion 0.50

Q = 1-P

$\alpha = level\ of\ significance$ = 7%

n = 196

Table 3.2: Sampling frame for farmers

Name of Irrigation Scheme	Population	Ratio	Sample size
ThuuraGiaki	427	0.19	81
Gachua	315	0.19	60
KioruGiaki	294	0.19	56
Total	**1036**	**0.19**	**196**

3.5 Tools and Techniques of Data Collection

To generate the required primary data from different primary sources, research tools suchas household survey questionnaires, key informant interview, focus group discussions and fieldobservations were employed. These techniques were used to collect data that belonged tohousehold demographic and the study variables. Consequently, to collect best quality datathe following procedures were used in this survey.

3.5.1 Household survey

For the household survey, a semi-structured questionnaire that contains both open andclose-ended questions were prepared to gather data from total 196 sampled householdheads. Prior toconducting actual process of data collection using this questionnaire, pre testing ofquestionnaire wasdone to ensure validity and reliability. Moreover, in order to minimizeerrors in data collection and properly administer the questionnaire two day trainings weregiven for five enumerators including pretesting work. Finally, minor modification weredone on questionnaire based on the feedback gained and the final modified semi-structuredquestionnaire wereadministered on selected sampled households residingwithin the area.

3.5.2 Interview Schedule

An interview guide with open-ended questions was used to collect in depth information from the extension officers from the Ministry of Agriculture and executive project committee members. This enabled oral administration of questions in a face-to-face encounter therefore allowing collection of in depth data. This involvedin-depth discussion through individual meetings with the respondents. With unstructured questions, a respondent's response may give an insight to his feelings, background, hidden motivation, interests and decisions and give as much information as possible without holding back. Copper and Schindler (2003), emphasize the value of personal interview when they stated that it enables in depth and detailed information to be obtained.

3.5.3 Secondary Data Sources

Secondary data wascollected in order to analyze contribution of irrigation for householdfood security. The secondary data included data regarding total grain production andcropping intensity followed by farmers with irrigated land and rain-fed farmers atcommunity level.

The secondary sources of information included respective Zonal government annual reports, National and Regional official statisticalabstracts, and researches undertaken in the area.

3.6 Validity of Instruments

Validity is the degree to which results obtained from the analysis of the data actually represents the phenomenon under study. Validity was reaffirmed by having objective questions included in the questionnaire and by pre-testing the instrument to be used to identify and change any ambiguous, awkward, or offensive questions and technique as emphasized by Cooper and Schindler (2003). Expert opinion was requested to comment on the representativeness and suitability of questions and give suggestions of corrections to be made to the structure of the research tools. This helped to improve the content validity of the data that was collected.

3.7 Reliability of Instruments

Reliability on the other hand refers to a measure of the degree to which research instruments yield consistent results (Mugenda and Mugenda, 2003). The test-retest aimed at determining the reliability of the research tools including the wording, structure and sequence of the questions. This test-retest involved 10 respondents from the target population. The respondents were conveniently selected since statistical conditions are not necessary in the pilot study. This was done by administering the tool to the pilot group and then using the data to calculate the reliability of each variable using statistical package for social sciences. The purpose was to refine the research tools so that respondents in the major study had no problem in answering the questions and examining whether the same response were obtained.Gliem and Gliem (2011) established the Alpha value threshold at 0.6.

3.8 Data Analysis

After data was collected from both primary and secondary sources, it wasanalyzed usingdifferent methods. Before analysis, quantitative data gathered using thesurvey wascoded and entered into statistical software known as Statistical Package forSocial Sciences Version 21. The data wasthen be cleaned.For the quantitative data, both descriptive and inferential statistics techniques of dataanalysis wereemployed. Descriptive statistical techniques such as mean, percentage,standard deviation wereused for presenting difference in the study variables

inanalysis of data. Specifically, SPSS softwarewasused to analyze most of quantitativedata collected in the survey. The qualitative data took an exploratory/conceptual content analysis process, this was more ideal as the information gathered from the open ended questions which were large and could be time consuming if not well planned. The strength and direction of a linear relationship between the variables wasanalyzed using Pearson's correlation coefficient.This was because correlation analysis illustrated both the direction and strength of the relationship between two variables.

3.9 Ethical Considerations

Ethical considerations in research can be defined as ensuring that the researcher conforms to the standards of conduct of the authorities in the area of research. Examples of ethical issues that may arise are voluntary participation of respondents, deception to participants, anonymity and confidentiality of information given, analysis and reporting, harm or danger to participants and any other professional code of ethics expected. To ensure that the research was done in an ethical manner according to the expectations of all authorities, a letter from the university was obtained.

The researcher informed the respondents that the instruments being administered were for research purpose only and the responses from the respondents would be kept secret and confidential. The researcher obtained an introductory letter from the University to collect data from the organization. The researcher also pursued a permit from the National Council of Science and Technology and a letter of approval from MWI offices in Imenti, permitting the research. Also, due to sensitivity of some information collected, the researcher held a moral obligation to treat the information with utmost propriety. Further, since the respondents might be reluctant to disclose some information, the researcher needed to reassure the respondents of use and confidentiality of the information given.

3.10 Operationalization of Variables

The operationalization of variables is shown in Table 3.3

Table 3.3: Operationalization of variables

Objective	Variable	Indicators	Measurement scale	Tools of analysis	Type of data analysis
To determine the effect of type crops on household food security in MirigaMieru East Division	**Independent** Type of crops under irrigation	Subsistence crops High value crops Diversifying both cash and subsistence crops Income per acre	Ratio	Mean and Percentage	Descriptive Statistics
To establish the effect of household income on household food security in MirigaMieru East Division	Household income	Revenue per month Access to credit Employment status and education Access to capital	Ratio	Mean and Percentage	Descriptive Statistics
To assess the effect of cost of the irrigation systems on household food security in MirigaMieru East Division	Cost of the irrigation systems	Cost of the systems Equipment and machines Electricity Maintenance cost Labour cost	Ratio	Mean and Percentage	Descriptive Statistics

To establish effect of small scale irrigation on household food security	**Dependent** Household food security	Food availability/ accessibility Food supply consistency Food self-sufficiency	Ratio	Mean and Percentage	Descriptive Statistics

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION AND INTERPRETATION

4.1 Introduction

This chapter covers data analysis, presentation of resultsand interpretation of findings from the research. It provides the frequencies and the corresponding percentages and an analysis of how these findings relate to the study.

The research aimed at: determining the effect of type of crops grown on household food security in MirigaMieru East Division: establishing how the household income affect household food security in MirigaMieru East Division and assessing the effect of cost of the irrigation systems on household food security in MirigaMieru East Division. The data collected is arranged into categories and interpreted on the basis of each research objective.

4.1.1 Response Rate

A total of 196 respondents were identified for the research sample. Out of the 196 questionnaires sent, a total of 120 questionnaires were dully filled and returned which is 61.22% of the total respondents. This is significant enough to provide reliable and valid finding for this study,(Mugenda and Mugenda ,2003).

4.1.2 Reliability Analysis

Table 4.1 showsreliability analysis which was done using Cronbach's Alpha which measures the internal consistency by establishing if certain items within a scale measure the same construct.

Table 4.1: Reliability Analysis

Scale	Cronbach's Alpha	Number of Items
Type of Crop	0.825	6
Household Income	0.772	6
Cost of Irrigation Systems	0.721	4

The Table shows that type of crop had the highest reliability (α= 0.825), followed by household income (α=0. 772), and cost of irrigation systems (α=0. 721). This illustrates that all the three variables were reliable as their reliability values exceeded the prescribed threshold of 0.6.Gliem and Gliem (2011) established the Alpha value threshold at 0.6, thus forming the study's benchmarked. Cronbach Alpha was established for every objective which formed a scale.

4.2 Respondent's Demographics

This section presents the respondents classification by gender, age, respondents' education level and respondents' duration of stay.

4.2.1 Respondents Gender

Table 4.2 shows the respondents' gender.

Table 4.2:Respondents Gender

Gender	Frequency	Percentage
Male	72	60
Female	48	40
Total	**120**	**100**

Majority of the respondents were male as indicated by 60% while the rest 40% were female. This therefore indicates that majority of the farmers are male.

4.2.2 Respondents Age

Table 4.3 shows respondents' age in years.

Table 4.3: Respondents' Age

Age	Frequency	Percentage
20-30 years	72	60
31-40 years	30	25
41-50 years	6	5
51 and above years	12	10
Total	**120**	**100**

Most of the respondents(60%) were aged between 20 to 30 years, 25% were aged between 31 and 40 years, 10% were aged 51 and above years while 5% were aged between 41 and 50 years.

4.2.3 Respondents' Education Level

Table 4.4 showsrespondents' level of education.

Table 4.4: Respondents Education Level

Education level	Frequency	Percentage
No formal education	24	20
Primary level	36	30
Secondary education	42	35
College	6	5
University	6	5
Postgraduate	6	5
Total	**120**	**100**

The Table indicates that, 35% had a secondary level certificate, 30% had a primary level certificate, and 20% had no formal education while 5% had a college, university and postgraduate certificate respectively.

This illustrates that majority of the farmers had a secondary certificate as their highest level of education.

4.4.2 Number of years Lived

Table 4.5 shows the respondents' number of years they lived in MirigaMieru East Division.

Table 4.5: Respondents' Number of Years Lived in MirigaMieru East Division

Duration of stay	Frequency	Percentage
Less than 2 years	6	5
2 to 4 years	18	15
4 to 6 years	24	20
Above 6 years	72	60
Total	**120**	**100**

Most of the respondents (60%) had lived in MirigaMieru East Division for more than 6 years, 20% for 4 to 6 years, and 15% for 2 to 4 years while 5% said that they had lived in MirigaMieru East Division for less than 2 years. From the results, it is clear that majority of the respondents had lived in MirigaMieru East Division for more than 6 years and therefore could give relevant information as sought by the study.

4.3 Type of Crops under Irrigation

This section covers data analysis on type of crops grown under irrigation.

4.3.1 Type of Crops Grown

Table 4.6 shows type of crops grown under irrigation.

Table 4.6: Type of Crops Grown

Crop	Frequency	Percentage
Bananas	60	50
Sweet potatoes	18	15
Watermelon	12	10
French beans	30	25
Total	**120**	**100**

Majority(50%) of the respondents indicated that they grew bananas, 25% grew French beans, and 15% grew sweet potatoes while 10% grew watermelons. From the results,majority of the respondents grew bananas as well as French beans.

4.3.2 Type of Crops Grown Affected Household Food Security

Table 4.7 depicts type of crops grown affected food security. The study required that the respondents state the extent to which the type of crops grown affected household food security in MirigaMieru East Division.

Table 4.7:Type of Crops Grown Affected Household Food Security

	Frequency	**Percentage**
Very great extent	42	35
Great extent	24	20
Moderate extent	30	25
Little extent	6	5
No extent	18	15
Total	**120**	**100.0**

The result depicts that most (35%) of the respondents indicated that the type of crops grown affected household food security in MirigaMieru East Division to a very great extent,25% of the respondents indicated that the type of crops grown affected household food security in MirigaMieru East Division to a moderate extent,20% of the respondents of the respondents indicated that the type of crops grown affected household food security in MirigaMieru East Division to a great extent,15% of the respondents of the respondents indicated that the type of crops grown affected household food security in MirigaMieru East Division to no extent while 5% of the respondents of the respondents indicated that the type of crops grown affected household food security in MirigaMieru East Division to a little extent. These findings infer that the type of crops grown subsequently affected household food security.

4.3.3 Aspects of Type of Crops Grown

The respondents were asked to respond to the extent to which the type of crops under irrigation affected their household food security using the likert scale, where: very great extent = 5, great extent= 4, moderate extent = 3, low extent = 2 and not at all = 1. Table 4.8 shows the results obtained.

Table 4.8:Aspects of Type of Crops Grown

	Mean	Std. deviation
Subsistence crops	2.932	1.160
High value crops	2.978	1.041
Diversifying both cash and subsistence crops	2.912	1.759
Income per acre	2.642	0.656

The respondents indicated that high value crops and subsistence crops affected household food security to a very great extent as shown by a mean score of 2.978 and 2.932 respectively. Further, the respondents indicated that diversifying both cash and subsistence crops and income per acre affected household food security to a great extent as shown by a mean score of 2.912 and 2.642 respectively. From these findings we can infer that high value crops affected household food security.

4.4 Household Income

This section shows data analysis for household main sources of income.

4.4.1 Main Sources of Income

The study required that the respondents state their main source of income. Majority (45%) of the respondents indicated that crop farming were their main source of income, 35% indicated that social assistance were their main source of income, 10% indicated that salaries and wages were their main source of income, 5% indicated that pensions/seniors/ benefits were their main source of income, 3% indicated that livestock farming were their main source of income while 2% indicated that worker's compensation were their main source of income. From the findings we can therefore infer that most of the respondents had engaged in an income generating activity.

Table 4.9:Main Sources of Income

Source of income	Frequency	Percentage
Salary/Wages	12	10
Social assistance	42	35
Crop farming	54	45
Livestock farming	3.6	3
Worker's compensation	2.4	2
Pensions/Seniors/ benefits	6	5
Total	**120**	**100.0**

4.4.2 Level of Income per month

Table 4.10 indicates level of income per month.

Table 4.10:Level of Income in Kshs per month

Income (Kshs)	Frequency	Percentage
Less than 20,000	54	7
20,001 – 30,000	42	40
31,001 – 40,000	12	20
51,000 – 60,000	3.6	10
61,000 – 70,000	2.4	20
Above 70,000	6	3
Total	**120**	**100.0**

In determining the level of income earned by the respondents per month,40% of the respondents indicated that they earned between Kshs20,001 – 30,000,20% of the respondents indicated that they earned between Kshs31,001 – 40,000 andKshs 61,000 – 70,000 respectively,10% of the respondents indicated that they earned betweenKshs 51,000 – 60,000,7% of the respondents indicated that they earned less thanKshs20,000 while 3% of the

respondents indicated that they earned above Kshs70,000. From these findings we can therefore infer that most of the respondents had enough income to cater for their families.

4.4.3 Household Income Affected Household Food Security

Table 4.11 shows household income affected food security.

Table 4.11:Household Income Affected Household Food Security

	Frequency	Percentage
Very great extent	48	40
Great extent	30	25
Moderate extent	18	15
Little extent	12	10
No extent	12	10
Total	**120**	**100.0**

The study required that the respondents state the extent to which household income affected household food security in MirigaMieru East Division. 40% of the respondents indicated that household income affected household food security in MirigaMieru East Division to a very great extent,25% of the respondents indicated that household income affected household food security in MirigaMieru East Division to a great extent,15% of the respondents indicated that household income affected household food security in MirigaMieru East Division to a moderate extent while 10% of the respondents indicated that household income affected household food security in MirigaMieru East Division to a little and no extent respectively.From these findings we can therefore deduce that household income affected household food security in MirigaMieru East Division.

4.4.4 Aspects of Household Income

Table 4.12 shows the aspects of household income affecting food security.

Table 4.12:Aspects of Household Income

Aspect	Mean	Std. deviation
Revenue per month	2.35	0.15
Access to credit	2.89	0.34
Employment status and education	3.44	0.61
Access to capital	2.64	0.41

In response to the extent to which household income affected household food security in MirigaMieru East Division.The respondents indicated that employment status and educationaffected household food security to a very great extent as shown by a mean score of 3.44,the respondents also indicated that access to credit and access to capital affected household food security to a great extent as shown by a mean score of 2.89 and 2.64 respectively, the respondents further indicated that revenue per month affected household food security to a great extent as shown by a mean score of 2.35.From these findings we can therefore deduce that employment largely affected the food security.

4.5 Cost of the Irrigation Systems

This section shows data analysis for cost of the irrigation systems.

4.5.1 Cost of the Irrigation Systems Affect Household Food Security

Table 4.13 shows cost of irrigation system affected household food security.

Table 4.13:Cost of the Irrigation Systems Affect Household Food Security

	Frequency	Percentage
Very great extent	36	30
Great extent	35	29
Moderate extent	20	17
Little extent	17	14
No extent	12	10
Total	**120**	**100.0**

The study required that the respondents state the extent to which the cost of the irrigation system affected household food security in MirigaMieru East Division. Most (30%) of the respondents indicated that the cost of the irrigation system affected household food security in MirigaMieru East Division to a very great extent.29% of the respondents indicated that cost of the irrigation system affected household food security in MirigaMieruEast Division to a great extent.17% of the respondents indicated that cost of the irrigation system affected household food security in MirigaMieru East Division to a moderate extent and14% of the respondents indicated that cost of the irrigation system affected household food security in MirigaMieru East Division to a little extent.

10% of the respondents indicated that cost of the irrigation system affected household food security in MirigaMieru East Division to no extent. From these findings we can therefore deduce that cost of the irrigation system affected household food security in MirigaMieru East Division.

4.5.2 Aspects of Cost of the Irrigation Systems

The respondents indicated aspects of cost of irrigation system as shown on Table 4.14.

Table 4.14:Aspects of Cost of the Irrigation Systems

Aspect	Mean	Std. Deviation
Cost of the systems	2.74	0.68
Equipment and machines	2.04	0.46
Electricity	2.88	0.29
Maintenance cost	2.34	0.43
Labour cost	2.44	0.70

The respondents indicated that electricity and cost of the systems affected household food security to a very great extent as indicated by a mean of 2.88 and 2.74 respectively. The respondents also indicated that labour and maintenance cost affected household food security to a great extent as indicated by a meanof 2.44 and 2.34 respectively. The respondents further indicated that equipment and machines affected household food security to a great extent as indicated by a mean of 2.04.We can therefore deduce that electricity largely affected household food security.

4.7 Household food security

This section provides data analysis on household food security.

4.7.1 The Trend in the Last Five Years

In determining the trend of food availability/accessibility, food supply consistency and food self-sufficiency the results are shown in Table 4.15.

Table 4.15:The Trend in the Last Five Years

	Mean	Std. deviation
Food availability/accessibility	3.44	1.42
Food supply consistency	3.34	1.36
Food self-sufficiency	3.23	1.23

The respondents indicated that food availability/accessibility and food supply consistency had greatly improved as shown by a mean score of 3.44 and 3.34 respectively, while food self-sufficiency had improved as shown by a mean score of 3.23.Inferences can be made that there had been a great improvement in food availability as well as food supply consistency.

4.8 Correlation Analysis

In order to establish the relationship between the various factors and food security Pearson correlation analysis was used. The research used statistical package for social sciences version 21 (SPSS V 21) to code, enter and compute the measurements of the multiple regressions correlation analysis. The results obtained are shown in Table 4.16.

Table 4.16: Correlation Analysis

	Food security	Type of crop	Household Income	Cost of the Irrigation Systems
Food security (r)	1.000			
(p) Sig. (2 tailed)				
Type of crop (r)	0.794	1.000		
(p) Sig. (2 tailed)	0.006			
Household Income (r)	0.652	0.716	1.000	
(p) Sig. (2 tailed)	0.012	0.047		
Cost of the Irrigation Systems (r)	0. 735	0.601	0.626	1.000
(p) Sig. (2 tailed)	0.013	0.019	0.047	

The results of data obtained on, type of crop, household income and cost of the irrigation systems were computed into single variables per factor by obtaining the averages of each factor. Pearson's correlations analysis was then conducted at 95% confidence interval and 5% significance level 2-tailed. Table 4.16 indicates the correlation matrix between the factors (type of crop, household income and cost of the irrigation systems) and food security. According to the table, there is a positive relationship between food security and type of crop, household income and cost of the irrigation systems of magnitude 0.794, 0.652 and 0.735 respectively. The positive relationship indicates that there is a correlation between the factors and food security with type of crop having the highest value and cost of irrigation systems having the lowest correlation value.

This notwithstanding, all factors had a significant p-value ($p<0.05$) at 95% confidence level. The significance values for relationship between food security and type of crop, household income and cost of the irrigation systems were 0.006, 0.012 and 0.013 respectively. This implies that type of crop was the most significant factor, followed by household income and then cost of the irrigation systems was the least significant.

CHAPTER FIVE

SUMMARY OF FINDINGS, DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the summary of findings, discussion, conclusions drawn from the findings and recommendations made therefore. This study sought to determine effect of small scale irrigation on food security in MirigaMieru East Division of Imenti North District, Kenya.

5.2 Summary of Findings

Majority(50%) of the respondents indicated that they grew bananas, 25% grew French beans, 15% grew sweet potatoes while 10% grew watermelons. From the results,majority of the respondents grew bananas as well as French beans.

The study also revealed that high value crops, subsistence crops affected household food security to a very.The result depicts that most (35%) of the respondents indicated that the type of crops grown affected household food security in MirigaMieru East Division great extent and that diversifying both cash and subsistence crops and income per acre affected household food security to a great extent.

The study found out that crop farming were their main source of income. The study established that majority (40%) of the respondents earned between Khs20,001 – 30,000. Household income affected household food security in MirigaMieru East Division to a very great extent. The study also established that employment status, access to credit access to capital and revenue per month affected household food security.

The study also found out that cost of the irrigation system affected household food security in MirigaMieru East Division to a very great extent (30%). The study revealed the cost of irrigation systems, labour and maintenance cost affected household food security.

5.3 Discussion of key findings

A detailed discussion of the findings is given below. The main aim of this research was to determine the effect of small scale irrigation on food security in MirigaMieru East Division

of Imenti North District, Kenya. On this basis, a descriptive research design was done targeting small scale irrigation farmers in the major irrigation schemes in MirigaMieru East Division. To this end, a questionnaire was used for the farmers.

5.3.1 Type of Crops Under Irrigation

The study established that the respondents grew bananas and French beans, sweet potatoes and watermelons. These findings are in line with Hall (2003) who established that crop diversification entailed the addition of new crops or cropping systems to agricultural production on a particular farm taking into account the different returns from value-added crops with complementary marketing opportunities. Major driving forces for crop diversification include: increasing income on small farm holdings, withstanding price fluctuation, mitigating effects of increasing climate variability, balancing food demand, Improving fodder for livestock animals, conservation of natural resources, minimising environmental pollution, reducing dependence on off-farm inputs, depending on crop rotation, decreasing insect pests, diseases and weed problems and increasing community food security.

The study revealed that the type of crops grown affected household food security in MirigaMieru East Division. According to Mengistu (2007) breeding new and improved crop varieties using irrigation technologies enhances the resistance of plants to a variety of stresses that could result from climate change. Varieties that are developed to resist these conditions will help to ensure that agricultural production can continue and even improve despite uncertainties about future impacts of climate change.

The study also established that high value crops, subsistence crops affected household food security to a very great extent and that diversifying both cash and subsistence crops and income per acre affected household food security.Moriarty and Butterworth (2003) points out that irrigation of low value crops like cassava does not provide that much income compared to the cost of piped water supplies. Higher value crops are preferable. Also, beneficial use of water by poor people who may not be served by other systems and for whom any diversification of livelihoods is critical should be encouraged.

5.3.2 Household Income

The study revealed that salary and wages were their main source of income. Fuad (2002) findings verified that cash crop economy with important cash flow offers a wide range of off-farm income possibilities as compared to subsistence farming. He shows that about 45% of farmers involved in cash crop production are engaged in income generating off-farm activities while 13 % are from the non-cash crop producers.

The study also established that household income affected household food security in MirigaMieru East Division. A study made in socio-economic assessment of two small-scale irrigation schemes in AdamiTulluJidoKombolchaWoreda, Central Rift Valley of Ethiopia, result showed that irrigation schemes increased households' income compared to situation before implementation of the schemes and thus contributed to improvement of household food security status (Mengistu, 2007). The study also established that employment status, access to credit access to capital and revenue per month affected household food security. Hope, Dixon and Maltitz (2003) established that improved access to credit access to capital offers greater equity and food security benefits to poorer households.

5.3.3 Cost ofthe Irrigation System

With regard to the cost of the irrigation system ,the study found out that the cost of the irrigation system affected household food security in MirigaMieru East Division. According to the FAO (2003), irrigation investment costs are generally much higher affecting he household food security in sub-Saharan Africa compared to a world average of 5,600 $/ha.

The study revealed that electricity, cost of the systems, labour and maintenance cost affected household food security. Shah et al. (2002), studying smallholder irrigation systems in sub-Saharan Africa, identified the following challenges: mismanagement, high cost of working capital, poor linkages to credit, input and output markets, institutional vacuum, land tenure issues, improper management transfers, damaged soils, expensive and ineffective mechanisation, poor farmer capacity and lack of farmer entrepreneurship development. He concluded that high costs of irrigation largely affected food security.

5.4 Conclusions of the study

It is concluded from the study that there is a positive relationship between type of crop under irrigation and household food security in MirigaMieru East Division. The study revealed that high value crops, subsistence crops,diversifying both cash and subsistence crops and income per acre affected household food security.

It is also concluded from the study that there is a positive relationship between household income and household food security in MirigaMieru East Division. This is to mean that household food security depends on adequate income and assets including land and other productive resources owned.

The study reveals that there exists a positive relationship between cost of the irrigation system andhousehold food security in MirigaMieru East Division.This meansinadequate expertise in planning, designing and construction of irrigation projects and, hence, the involvement of expensive consultancy expertise is reasons for high cost of irrigation development.High cost of irrigation infrastructure is the other reason for overall cost of irrigation development which impact on food security.

5.5 Recommendations of the study

The following recommendations are made from the study based on the findings and conclusions.

1. New crop species diversify crop production hence improved income and food security. Systems need to take into account availability and quality of resources, access to technologies, household related factors, price and market related factors, institutional and infrastructure related factors including irrigation, rainfall and soil fertility.

2. Farmers should embrace crop diversification so as to increase crop portfolio to ensure that they are not dependent on a single crop to generate their income. With a diversified plot, the farmer increases his/her chances of dealing with the uncertainty and/or the changes created by climate change. This is because crops will respond to climate scenarios in different ways.

3. The study recommends that the key to preventing negative food availability effects of diversified farming is significant yield increases in food crops, which will offset the reduction in land allocated for the production of these crops.

4. Research organizations need to engage in participatory research in recognition of irrigation contribution to marginal areas with low agricultural potential to improve on food security and income generation.

5. Use of local expertise in irrigation planning, design and implementation should be emphasized to cut on costs to improve on food security.

6. The government should reduce taxes on irrigation equipment especially pipes and fittings to encourage expansion of land under irrigation.

7. Analysis of market channels and value chain should be done to establish areas of intervention in order to address food securityand improve income generation.

8. Training needs assessment to establish areas of intervention.

5.6 Suggestions for Further Research

This study sought to determine effect of small scale irrigation on food security in MirigaMieru East Division of Imenti North District, Kenya. It is recommended that further research in the area of factors affecting food security in Kenya should be done. It is also recommended that further research be undertaken to establish multipleuses of high value crop to maximize on the income generation. Further research should be done on water conservation strategies that enhance the quantity to increase area under irrigation. Water harvesting is another area which needs further research in order to supplement the other sources of irrigation waterandother water use efficiencies.

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APPENDICES

Appendix 1: Introduction letter

Samuel MururuM'Nabea

P.O. BOX 1152,

Meru.

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

RE: REQUEST FOR PARTICIPATION IN A RESEARCH STUDY

I am a final year Master of Arts student at the University of Nairobi, specializing in project planning and management. I am currently undertaking a research on "EFFECT OF SMALL SCALE IRRIGATION ON HOUSEHOLD FOOD SECURITY IN MIRIGA MIERU EAST DIVISION OF IMENTI NORTH DISTRICT, KENYA".

I will be grateful if you could spare sometime from your busy schedule and fill in the questionnaire. All the information provided will be purely used for academic purposes and your identity will be treated with utmost confidentiality.

Thank you for your cooperation.

Yours faithfully,

SAMUEL MURURU M'NABEA

L50/71932/2011

Appendix 2: Questionnaire for Household Heads

Please fill in or tick in the appropriate bracket or provided spaces.

1) Please indicate your gender

Female	[ ]	Male	[ ]

2) Indicate your age bracket

20-30 yrs	[ ]	31-40 yrs	[ ]
41-50 yrs	[ ]	51 and above	[ ]

3) State your highest level of education

No formal education	[ ]	Primary level	[ ]
Secondary level	[ ]	College	[ ]
University	[ ]	Postgraduate	[ ]

4) For how long have you lived in MirigaMieru East Division?

Less than 2 years	[ ]
2 to 4 years	[ ]
4 to 6 years	[ ]
Above 6 years	[ ]

Type of crops under irrigation

5) What type of crops do you grow?

Bananas	[ ]	Watermelon	[ ]
Sweet potatoes	[ ]	French beans	[ ]

6) To what extent does type of crops grown affect household food security in MirigaMieru East Division?

To a very great extent	[ ]	To a great extent	[ ]
To a moderate extent	[ ]	To a little extent	[ ]
To no extent	[ ]		

7) What is the extent to which the following type of crops under irrigation affect your household food security?

	Very great extent	Great extent	Moderate extent	Low extent	Not at all
Subsistence crops					
High value crops					
Diversifying both cash and subsistence crops					
Income per acre					

Household Income

8) What is the main source of income for your family?

Salary/Wages [ ]
Social assistance [ ]
Crop farming [ ]
Livestock farming [ ]
Worker's compensation [ ]
Pensions/Seniors/ benefits [ ]
Other (specify)…….[ ]

9) Level of Income in Kshs per month

Less than 20,000 [ ] 20,001 – 30,000 [ ]
31,001 – 40,000 [ ] 51,000 – 60,000 [ ]
61,000 – 70,000 [ ] Above 70,000 [ ]

10) To what extent does household income affect household food security in MirigaMieru East Division?

To a very great extent [ ] To a great extent [ ]
To a moderate extent [ ] To a little extent [ ]
To no extent [ ]

11) What is the extent to which the following aspects of household income affect your household food security?

	Very great extent	Great extent	Moderate extent	Low extent	Not at all
Revenue per month					
Access to credit					
Employment status and education					
Access to capital/					

Cost of the irrigation systems

12) To what extent does cost of the irrigation systems affect household food security in MirigaMieru East Division?

To a very great extent [ ]
To a great extent [ ]
To a moderate extent [ ]
To a little extent [ ]
To no extent [ ]

13) What is the extent to which the following cost of the irrigation systems affect your household food security?

	Very great extent	Great extent	Moderate extent	Low extent	Not at all
Cost of the systems					
Equipment and machines					
Electricity					
Maintenance cost					
Labour cost					

Household food security

14) What is the trend of the following in the last five years?

	Greatly Improved	Improved	Constant	Decreasing	Greatly decreased
Food availability/accessibility					
Food supply consistency					
Food self-sufficiency					

15) What other practices do you incorporate alongside irrigation to enhance food security?

……

……..……

……

……

NB: Likert scale (very great extent = 5, great extent= 4, moderate extent = 3, low extent = 2 and not at all = 1).

THANK YOU

Appendix 3: Interview Schedule for Extension Officers and Committee Members

1. What are the types of crops grown in MirigaMieru East Division under irrigation?
2. How do these type of crop grown affect household food security in MirigaMieru East Division?
3. How do these type of crop grown affect food security in MirigaMieru East Division?
4. How do the level of household income affect household food security in MirigaMieru East Division?
5. What is the effect of cost of the irrigation systems on household food security in MirigaMieru East Division? Explain.
6. In your view, what should be done to enhance household food security in MirigaMieru East Division?