THE INFLUENCE OF DRYLAND FARMING TECHNOLOGIES ON HOUSEHOLD FOOD SECURITY AMONG SMALL-SCALE FARMERS IN KYUSO SUB-COUNTY, KITUI COUNTY, KENYA

TITUS MASILA

A Thesis Submitted to the Board of Postgraduate Studies in Partial Fulfillment of the Requirements for the Award of the Master of Science Degree in Agricultural Extension of Egerton University

EGERTON UNIVERSITY

OCTOBER, 2015

DECLARATION AND RECOMMENDATION

Declaration

This thesis is my original work and has not been presented for award of any degree or diploma in this or any other University.

Signature……………………………………..Date:………………………….

Titus Masila
EM12/1654/06

Recommendation

This thesis has been submitted to the Board of Post Graduate Studies for examination with our approval as University Supervisors.

Signature…………………………………..Date:……………………..

Dr. Maurice O. Udoto
Department of Agricultural Education and Extension,
Egerton University

Signature…………………………………Date……………………..

Dr. James Obara
Department of Agricultural Education and Extension,
Egerton University

COPY RIGHT

DEDICATION

I dedicate this work to the glory of God and to my wife, Joyce, and my three sons Job, Sunday and Samuel.

ACKNOWLEDGEMENT

First and foremost I thank the Almighty God for giving me the strength and ability to go through the rigorous exercise of this study and research. I am grateful to Egerton University for having offered me the opportunity to study for Masters of Science in Agricultural Extension. This thesis would never have been possible without the concerted inputs and support of many people and organizations. I wish to express my sincere gratitude to everyone who contributed towards its success. Specifically, I wish to thank my supervisors Dr. M.O. Udoto and Dr. J. Obara for their hard work and guidance throughout all the phases of writing this thesis. Your support and encouragement kept me motivated to the very end. I will forever remain grateful. I am also grateful to the Government of Kenya for providing me the opportunity to study at Egerton University. I am particularly thankful to the Ministry of Agriculture staff, Kyuso Sub-County, for their invaluable support in typesetting, printing and binding of proposal manuscripts. Special appreciation goes to Regina Nderitu and Ambrose Ngétich for accepting to hold brief while I did consultation at the Egerton University. I also would like to extend my acknowledgements to my fellow colleagues, Joseph Mithamo and John Chege. Your input and moral support helped me to remain focused all through. Heartfelt gratitude goes to my wife, Joyce and my three sons, Job, Sunday and Samuel: you were patient and offered me encouragement. Because of you I am where I am.

ABSTRACT

Food insecurity remains a major challenge among the small-scale farmers in Kyuso Sub-County. Though the Ministry of Agriculture has been training small-scale farmers on various dryland farming technologies, Kyuso Sub-County has remained food insecure. This is evidenced by the fact that small-scale farmers in the Sub-County depend on food aid for their survival. The role played by the dryland farming technologies in ensuring household food security among the small-scale farmers has not been studied and documented. Consequently dryland farming technologies that could effectively help alleviate food insecurity in Kyuso Sub-County are not known. Agricultural productivity has thus continued to be low and since food aid availability is not guaranteed throughout the year, this exposes farmers to recurrent food insecurity. The purpose of this study was to identify dryland farming technologies that could be effectively used to alleviate food insecurity in Kyuso Sub-County. The study was carried out in Kamuongo Ward of Kyuso Sub-County. The ward had a population of 2,629 households. Proportionate and systematic random sampling procedures were used to select a sample of 140 respondents. Further samples of 12 farmers were selected purposively from each of the three villages in the study area, to participate in Focus Group Discussion (FGD). Thus the total sample size of 176 farmers participated in the study. Two instruments were used to collect data: a Focus Group Discussion Guide and a questionnaire. Validity of the instruments was ensured through examination by both experts and colleagues. Cronbach Alpha Reliability coefficient value of 0.795 was obtained after pilot testing the questionnaire. Data was analyzed by use of both descriptive and inferential statistics. The multiple linear regression model was used to test levels of influence among study variables at 0.05 level of significance. Results of the study showed that most of the farmers in the study area were female; most popular soil conservation technology was *fanya juu terraces*. Use of farmyard manure was found to be the most preferred method of soil fertility improvement. The level of millet and sorghum production was low with most farmers in the Sub-County due to high bird infestation. The results further revealed that soil and water conservation, rainwater harvesting, soil fertility improvement and production of drought tolerant crops (millet and sorghum) did not significantly influence household food security in Kyuso Sub-County.

TABLE OF CONTENTS

DECLARATION AND RECOMMENDATION ii
COPY RIGHT iii
DEDICATION iv
ACKNOWLEDGEMENT v
ABSTRACT vi
TABLE OF CONTENTS vii
LIST OF TABLES x
LIST OF FIGURES xi
LIST OF ABBREVIATIONS AND ACRONYMS xii
CHAPTER ONE
INTRODUCTION 1
1.1 Background of the Study 1
1.2 Statement of the Problem 5
1.3 Purpose of the Study 5
1.4 Objectives of the Study 5
1.5 Hypothesis of the Study 6
1.6 Significance of the Study 6
1.7 Scope of the Study 7
1.8 Limitations of the Study 7
1.9 Assumption of the Study 7
CHAPTER TWO
LITERATURE REVIEW 9
2.1 Introduction 9
2.2 Significance of Drylands in Household Food Security 9
2.3 Dryland Farming and Household Food Security 10
2.4 The Global Practice of Dryland Farming Technologies 12
2.5 Dryland Farming Technologies in Kenya 14
  2.5.1 Soil and water conservation 15
  2.5.2 Rainwater harvesting 17
  2.5.3 Soil fertility improvement 19

2.5.4 Crop and variety selection 21
2.6 Food Security 22
2.6.1 Agriculture and food security 23
2.6.2 Dryland farming technologies and food security 23
2.7 Theoretical Framework 24
2.8 Conceptual Framework 28
CHAPTER THREE
RESEARCH METHODOLOGY 30
3.1 Introduction 30
3.2 Research Design 30
3.3 Location of the Study 30
3.4 Target Population 31
3.5 Sampling Procedures and Sample Size 31
3.6 Instrumentation 33
3.7 Data Collection Procedures 34
3.8 Data Analysis 35
3.9 Ethical Considerations 35
CHAPTER FOUR
RESULTS AND DISCUSSION 37
4.1 Introduction 37
4.2 Demographic Characteristics of the Respondents 37
4.2.1 Gender of the respondents 37
4.2.2 Age of the respondents 38
4.2.3 Education level 39
4.2.4 Farming experience 41
4.2.5 Type of land ownership 42
4.2.6 Household heads' marital status 43
4.3 Soil and Water Conservation on Household Food Security 43
4.5 Rainwater Harvesting and Household Food Security 45
4.6 Soil Fertility Improvement and Household Food Security 47
4.7 Production of Drought Tolerant Crops 52
4.7.1 Farmers constraints in drought tolerant crop production 53

4.8 Thematic Analysis Results 55
4.8.1 Soil and water conservation technologies 56
4.8.2 Soil fertility improvement 56
4.8.3 Methods of rain water harvesting for crop production..........57
4.8.4 Drought tolerant crop production 58
4.8.5 Food Security..........58
CHAPTER FIVE
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS..........61
5.1 Introduction 61
5.2 Summary 61
5.3 Conclusion..........63
5.4 Recommendations..........64
5.5 Recommendations for Further Research..........64
REFERENCES 65
APPENDIX A:INVITATION LETTER TO FARMERS 78
APPENDIX B:FOCUS GROUP DISCUSSION GUIDE 79
APPENDIX C:QUESTIONNAIRE FOR HOUSEHOLD HEADS 81
APPENDIX D:MAP OF THE STUDY AREA 91
APPENDIX E:RESEARCH AUTHORIZATION 92
APPENDIX E:RESEARCH PERMIT IDENTITY CARD..........93
APPENDIX F:RELIABILITY ANALYSIS RESULTS..........94

LIST OF TABLES

Table 1. Population and Households per Village in Kamuongo Ward 31
Table 2. Proportionate Sample Size 33
Table 3. Age Distribution of Farmers...39
Table 4. Household Head's Marital Status...43
Table 5. Soil and Water Technologies...44
Table 6. Soil and Water Conservation Influence on Household Food Security 45
Table 7. Rain Water Harvesting Technologies 46
Table 8. Influence of Rain Water Harvesting on Household Food Security 46
Table 9. Methods of Soil Fertility Improvement 48
Table 10. Soil Fertility Improvement Frequency 48
Table 11. Rating of Soil Fertility Improvement Methods 49
Table 12. Constraints in Soil Fertility Improvement 50
Table 13. Influence of Soil Fertility Improvement on Household Food Security.............51
Table 14. Constraints in Millet and Sorghum Production 54
Table 15. Influence of Drought Tolerant Crops on Household Food Security.................55
Table 16. Drought Tolerant Crops Production per Acre 58

LIST OF FIGURES

Figure 1. The DFID Sustainable Livelihood Framework 27
Figure 2. Conceptual framework...29
Figure 3. Gender of the respondents...38
Figure 4. Level of education of the farmers...40
Figure 5. Farming experience 41
Figure 6. Distribution of types of land ownership..42
Figure 7. Percentage of farmers that face soil fertility challenges 47
Figure 8. Crops grown in the Sub-County...52
Figure 9. Mean crop production and consumption per household............................53

LIST OF ABBREVIATIONS AND ACRONYMS

ASAL	Arid and Semi- Arid Lands
ASDS	Agricultural Sector Development Strategy
DFID	Department for International Development
DLFT	Dry Land Farming Technologies
FAO	Food and Agriculture Organization
FIVIMS	Food Insecurity and Vulnerability Information and Mapping System
GDP	Gross Domestic Product
GOK	Republic of Kenya
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
ILO	International Labour Organization
KFSSG	Kenya Food Security Steering Group
Kg	Kilograms
KNBS	Kenya National Bureau of Statistics
MOA	Ministry of Agriculture
mm	Milimeters
NEMA	National Environmental Management Authority
NGO	Non-Governmental Organization
P/PET	Precipitation to Potential Evapotranspiration
SIDA	Sweden International Development Agency
SSA	Sub Saharan Africa
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
UNESCO	United Nations Educational Scientific and Cultural Organization
USDA	United States Department of Agriculture
WHO	World Health Organization
WFS	World Food Summit

CHAPTER ONE
INTRODUCTION

1.1 Background of the Study

Improved food security in the dry land areas of the world has become an important issue of concern both nationally and internationally (Witsenburg, 2012). This is because a large part of the surface of the world is arid, characterized as too dry for conventional rain fed agriculture. Yet, millions of people live in such regions. Trends in population increase indicate that there will soon be millions more. These people must eat, and the wisest course for them is to produce their own food (Creswell & Martin, 1998). Crop production in dryland areas must be improved to help meet the requirements of the growing world population. A major contribution to this improvement will be the capture and use of a greater portion of the limited and highly variable precipitation in dryland areas. Dryland farming technologies including water and soil conservation and management can increase water use efficiency, thus increasing yields and reducing the likelihood of crop failure (Food and Agriculture Organization (FAO), 2008a).

The majority of the population in sub-Saharan Africa make their living from rain-fed agriculture. They depend to a large extent on small-scale, subsistence farming for their food security. In Kenya 85 % of her population derive their livelihood from rain-fed subsistence agriculture (Rockström, 2000). More than three-quarters of Kenya's land is arid or semi-arid with 3.2 million food insecure affected marginal farmers and agro pastoralists living in the arid and semi-arid Sub-Counties of eastern Kenya (FAO, 2009*)*. Jan (2007) contends that even after decades of modern agricultural research, the small-scale farmer in most parts of Kenya is still poor. He adds that the small scale farmer still operates a largely traditional technology to meet subsistence needs. If agricultural research is to help the small-scale farmer, there must be a selective emphasis on technology appropriate for the typical small-farm situation of scarce financial resources and poor access to information (Jan, 2007).

Kenya’s agriculture in arid and semi-arid areas is predominantly small-scale. Production is carried out on farms averaging 0.2–3 ha and without irrigation. Farms are generally small, and in most cases are suffering from a degradation of resources and the environment. The small-scale farmers in Kyuso Sub-County can be described as being resource-poor and subsistence-based. Since these dryland comprise 84 % of Kenya's land mass (GOK, 2010) there is huge potential for increasing productivity for these farmers with adoption of modern farming practices including irrigation and dryland farming technologies (Ministry of Agriculture (MOA), 2009).

The major purpose of dryland farming technologies is to conserve soil, water and nutrients for the purposes of crop production (Gichuki, 2000). Soil erosion is the process of detachment of soil particles from the top soil and transportation of the detached soil particles by wind and / or water. The agents causing erosion are wind and water. The detaching agents are falling raindrop, channel flow and wind. The transporting agents are flowing water, rain splash and wind (Mutunga, Critchley, Lameck, Lwakuba, & Mburu, 2001). According to Douglas (1994) when land suffers from soil erosion and degradation, it loses its productivity. He explains soil degradation as the decline in the productive capacity of the soil as a result of soil erosion and changes in hydrological, biological, chemical and physical properties. Gichuki (2000) states that land degradation can result from inappropriate land use and poor land management. He adds that investments in soil management can be justified on the basis of sustaining and improving land productivity.

Soils in semi-arid areas are generally fragile and of low inherent producing capacity. The objectives of soil management are to maximise the limited water supply, maximise plant nutrient supply, minimise erosion, and maintain or improve soil fertility and soil physical conditions (Mati, 2006). Water and soil nutrient management form a critical component of agricultural production. In the drylands water and nutrient conservation are dictated by the need for water harvesting and conservation and the available technology (Mutunga, et al., 2001). Soil and water conservation technologies consist of activities that minimise water losses by runoff and evaporation, while at the same time maximizing soil moisture storage for crop production. On the other hand rain water harvesting is a deliberate effort made to transfer runoff water from a catchment to the desired area or storage structure (Mati, 2006).

Sorghum and millet have been noted as staple food grains in many arid and semi-arid lands of the world, particularly in Sub-Saharan Africa because of their good adaptation to hard environments and their good yield of production (Mukarumbwa, 2009). Taylor, Schober and Bean (2006) describe sorghum and millet as generally the most drought-tolerant cereal grain crops that require little input during growth and with increasing world populations and decreasing water supplies, represent important crops for future human use. There is an urgent need to promote drought tolerant crops that are relevant to the small-scale farmers and poor consumers in the semi-arid lands. This can be through the production of sorghum and millet because they are adaptable to these environments.

The food supply situation in Kenya has been a cause for concern. According to the Ministry of Agriculture (2009), over 10 million people suffer from chronic food insecurity and poor nutrition. It is estimated that at any one time, about two million people in the country require food assistance (MOA, 2009). The long rains season in Kenya (March-May), which normally accounts for 80 % of total annual food production, has been failing over the years leading to severe drought, and widespread crop failures in the arid and semi-arid areas of Eastern and North Eastern counties of Kenya (Kaloi, Tayebwa, & Bashaasha, 2005). Kyuso Sub-County lies in Kitui County in the drylands classified as arid and semiarid lands and receives low and unreliable rainfall of between 250 and 780 mm per year (Government of Kenya [GOK], 2009). The Sub-County suffers from food insecurity which is linked to declining agricultural productivity and general poverty. Drought as a natural cause is the main problem. Kyuso Sub-County has been under relief emergency operation from 2004 to date, with varying proportions of the population, as a result of either crop failure or low crop production. They are unable to sustain their households from one season to the next (Kenya Food Security Steering Group [KFSSG], 2011).

The agriculture sector remains the engine of growth of the Kyuso Sub-County economy. Over 85% of the Sub-County population is engaged in activities in the agriculture and livestock production subsector, making the sector the largest employer and by extension the largest contributor to household incomes. Specifically, an estimated 98% of households are engaged in crop farming in the Sub-County (GOK, 2012). The agriculture and livestock production activities in the Sub-County are dependent on rainfall, which is inadequate and unreliable, often resulting to droughts. This explains why the Sub-County has continued to be vulnerable due to climatic shocks, food insecure and characterized by high level of endemic poverty.

The World Food Summit of 1996 defined food security as existing “when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life” (FAO, 1996). Commonly, the concept of food security is defined as including both physical and economic access to food that meets people's dietary needs as well as their food preferences (World Health Organization [WHO], 2011). Food insecurity in a household is a combination of two distinct problems which includes acquirement and utilization. Acquirement refers to the ability of a household and its members to acquire enough food through production, exchange or transfer (International Fund for Agricultural Development [IFAD], 2007). Nearly 900 million people in 70 lower income countries are food insecure either temporary or chronic, and the situation could grow worse in the poorest countries. The broader reasons for it are poverty, population growth, environmental degradation, limited agricultural technology, ineffective policies, and disease (United States Department of Agriculture [USDA], 2010).

The Ministry of Agriculture has made efforts to promote dryland farming technologies in Kyuso Sub-County (MOA, 2011). These technologies include soil and water conservation, water harvesting, soil fertility improvement through compost and farmyard manure application and use of ecologically correct crop varieties (Mati, 2006). The crop varieties promoted in the Sub-County include: pearl millet, sorghum, green grams, cowpeas and pigeon peas (MOA, 2011). Reports by the Ministry of Agriculture (2011) indicate that while farmers have widely adopted the drought tolerant legumes, they have a problem with the cereals. Wide spread planting of maize crop which is not drought tolerant compared to millet and sorghum is believed to be one of the sources of household food insecurity in the Sub-County (KFSSG, 2011). Often farmers face acute food shortage due to failure to harvest in consecutive seasons during which period most farmers rely on relief food for sustenance. Whereas food aid has played a key role in saving lives in the Sub-County during times of extreme drought and famine, it has had a negative impact of creating a dependence syndrome among farmers (GOK, 2009). Dependency syndrome is known to limit creativity and hence maintain the status quo of food insecurity. Investments in dryland farming techniques in semi-arid regions lead to immediate and perceptible yield increases and contribute to reducing rural poverty (Reij & Steeds, 2003).

1.2 Statement of the Problem

In the arid and semiarid areas dryland farming technologies are key to achieving food security. The Government has implemented food security programmes promoting dryland farming technologies in Kyuso. Though the Ministry of Agriculture and other stakeholders have over the years been sensitizing and training small-scale farmers on various dryland farming technologies, Kyuso Sub-County has remained food insecure. This is evidenced by the fact that small scale farmers in the Sub-County depend on food aid for their survival. Agricultural productivity has thus continued to be low and since food aid availability is not guaranteed throughout the year, this exposes farmers to recurrent food insecurity. The influence of dryland farming technologies in alleviating food insecurity in the Sub-County has neither been studied nor documented. Therefore dryland farming technologies that may effectively help alleviate food insecurity are not known. This study aimed at bridging that gap.

1.3 Purpose of the Study

The purpose of the study was to identify dryland farming technologies that could be effectively used to alleviate household food insecurity of small-scale farmers in Kyuso Sub-County.

1.4 Objectives of the Study

The following objectives guided the study:-

(i) To determine the demographic characteristics of the small-scale farmers Kyuso Sub-County employing dryland farming technologies.

(ii) To examine the influence of soil and water conservation on household food security of small scale farmers in Kyuso Sub-County.

(iii) To assess the influence of rainwater harvesting on household food security of small-scale farmers in Kyuso Sub-County.

(iv) To establish influence of soil fertility improvement on household food security of small-scale farmers in Kyuso Sub-County.

(v) To establish the influence of growing drought tolerant crops on household food security of small- scale farmers in Kyuso Sub-County.

1.5 Hypothesis of the Study

The following null hypotheses were tested for their validity:-

Ho_1: There is no statistically significant influence of soil and water conservation on household food security among small-scale farmers in Kyuso Sub-County.

Ho_2: There is no statistically significant influence of rain water harvesting on household food security among small-scale farmers in Kyuso Sub-County.

Ho_3: There is no statistically significant influence of soil fertility improvement on household food security among small-scale farmers in Kyuso Sub-County.

Ho_4: There is no statistically significant influence of drought tolerant crops on household food security among small-scale farmers in Kyuso Sub-County.

1.6 Significance of the Study

This study investigated the contributions of different dryland farming technologies to household food security. The study would inform extension officers on the best dryland farming approaches to facilitate enhanced food security at household level. Implementation of the recommendations could enhance high food production by the small- scale farmers in the Sub-County therefore increasing household food security and higher incomes.

Findings may inform policy makers to adjust the on-going programs geared towards food security. Policy makers may be faced with the decision to avail improved, appropriate and affordable dryland farming technologies to ensure household food security for small-scale farmers. Since implementation of dryland farming technologies requires resources, policy makers may be faced with the requirement to expand both on and off-farm income activities for people living in rural areas. Agricultural technology development of these household may need to focus beyond yield enhancement and address other features that complement the household need to allocate labour to other off farm employment activities. Improved crop production not only ensures food security at household level but may also require marketing infrastructure to enable farmers to sell surplus produce.

1.7 Scope of the Study

The study was conducted in Kyuso Sub-County. It targeted small-scale farmers in Kamuongo Ward whose main economic activity is in agriculture and dependent on their farms as their main source of income. Dryland farming technologies namely soil and water conservation, rain water harvesting for crop production, soil fertility improvement and production of drought tolerant crops (sorghum and millet) were studied in relation to their influence on household food security.

1.8 Limitations of the Study

The following factors were identified as limitations to the study:-

(i) Most of the small-scale farmers did not keep proper records therefore information on cultivated land and yields were estimates and could have been affected by memory gap.

(ii) Since the study was confined to Kamuongo Ward, the findings from this research may only be generalized to wards with similar characteristics.

1.9 Assumption of the Study

The study was conducted under the following assumptions:-

(i) The respondents fully understood the questions they were asked.

(ii) Information provided by the small-scale farmers was accurate and reliable.

1.10 Definitions of Terms

Drylands: FAO (1989) classified Drylands as deserts, arid and semi- arid regions based on their annual precipitation sums as follows: - (i) Deserts with annual precipitation of less than 50mm and devoid of vegetation, (ii) Arid regions an annual precipitation sum of 50 – 250mm and sparse vegetation (iii) Semi-arid regions with an annual precipitation sum of 250-500mm. In this study drylands will means regions receiving an annual precipitation of 200-780mm.

Dryland Farming: This is the practice of growing crops without irrigation in areas which receive an annual rainfall of between 250 and 500 mm (Biamah, 2001). In this study dryland farming means the practice of growing crops without irrigation in areas which receive an annual rainfall of between 200 and 780 mm.

Dryland Farming Technologies: These are techniques and management practices used by farmers to continually adapt to the presence or lack of moisture in a given crop cycle (Creswell & Martin, 1998). In this study dryland farming technologies refer to the following practices: soil and water conservation, rain water harvesting for crop production, soil fertility improvement and growing of drought tolerant crop varieties

Food Security: Refers to a situation which 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, 2010). In this study a household is considered food secure if it has grain cereals (maize, millet or sorghum) and grain legumes (beans, cowpeas, pigeon peas or green grams) in store to last until the next harvest.

Household: This term is used within the definition by Lemba, (2009) as a social organization in which members live and sleep in the same place and share meals. In this study a household refers to a man, his wife and children who live together and share meals.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter offers a review of literature, which highlights the influence of dryland farming technologies on household food security and the existing gaps. The chapter starts by discussing generally what drylands are. It also highlights the constraints encountered in dryland farming and how to overcome them. Dryland farming technologies namely soil and water conservation, rain water harvesting, soil fertility management and production of drought tolerant crops are discussed in details. An overview of the food security situation in Kenya and Kyuso Sub-County is then provided. Views of different authors regarding the influence of dryland farming technologies on crop production and hence household food security for small-scale farmers in semi-arid regions are given. Finally the review discusses the theoretical framework on which this study is based and gives the conceptual framework.

2.2 Significance of Drylands in Household Food Security

Two of the most widely accepted definitions of drylands are those of FAO and the United Nations Convention to Combat Desertification (United Nations Convention to Combat Desertification [UNCCD], 2000). FAO has defined drylands as those areas with a length of growing period of 1–179 days (FAO, 2008); this includes regions classified climatically as arid, semi-arid and dry subhumid. The UNCCD classification employs a ratio of annual precipitation to potential evapotranspiration (AP/PET). This value indicates the maximum quantity of water capable of being lost, as water vapour, in a given climate, by a continuous stretch of vegetation covering the whole ground and well supplied with water. Thus, it includes evaporation from the soil and transpiration from the vegetation from a specific region in a given time interval (FAO, 2008a). Under the UNCCD classification, drylands are characterized by an AP/PET of between 0.05 and 0.65. While about 40 percent of the world's total land area is considered to be drylands, the extent of drylands in various regions ranges from about 20 percent to 90.

Drylands are inhabited by more than 2000 million people, nearly 40 percent of the world's population (White & Nackoney, 2003). The human populations of the drylands live in increasing food insecurity due to land degradation and desertification and as the productive land per capita diminish due to population pressure (United Nations Enviromental Programme [UNEP], 2000). These lands are also characterized by the following features: - uncertain, ill-.distributed and limited annual rainfall; occurrence of extensive climatic hazards like drought, flood; undulating soil surface; prevalence of mono-cropping; similarity in types of crops raised by almost all the farmers of a particular region; very low crop yield; poor market facility for the produce; poor economy of the farmers; and poor health of cattle as well as farmers (Creswell & Martin, 1998). For continued sustenance of human life sustainable management of drylands is essential to achieving food security and the conservation of biomass and biodiversity of global significance (UNEP, 2000). Investing in drylands has been underscored as millions of people live in such regions, and if current trends in population increase continue, there will soon be millions more. These people must eat, and the wisest course for them is to produce their own food.

In Kenya more than three-quarters of the country is arid or semi-arid receiving low and erratic rainfall with a range of 200-750 mm annually. Droughts are frequent and crops fail in one out of every three seasons (GOK, 2010). Farm enterprises comprise mixed crops and livestock. While there is ample land, farmers tend to grow crops that are not suitable for this rainfall regime or for the soils. These areas require better planning, careful selection of farm enterprises and greater investment in dryland farming technologies (GOK, 2010). In Kyuso 100% of the Sub-County is semi-arid with rainfall range of 250- 780 mm per year with 66% reliability (GOK, 2009).

2.3 Dryland Farming and Household Food Security

Dryland farming may be defined as the practice of growing profitable crops without irrigation in areas which receive an annual rainfall of 500 mm or even less (Creswell & Martin, 1998). In these areas lack of soil moisture limits crop production to part of the year. The low water supply may be caused by low rainfall, high runoff water losses or high evaporation. In dryland farming emphasis is on conservation of soil water for crop production.

Thus limited soil water supply and a serious erosion potential are the two most common characteristics in all dryland areas (FAO, 2008a)

According to Biamah (2001) the three broad areas of soil, water and nutrient management in drylands include: management of soil water; management of soil erosion; and the management of fertilization. He further states that just as less soil water leads to water stress, less fertilization leads to nutrient stress. Thus, the three major problems limiting dryland crop production are severe soil erosion, low soil fertility and low soil moisture (Biamah, 2001). Rainfall water use efficiency could be improved through: runoff water harvesting and conservation for crop production; crop rotation where deep rooted plants would use water in deeper soil horizons; surface residue mulching and cover cropping to decrease surface evaporation; enhancement of infiltration and reduction in surface runoff; and ultimately an increase in crop water use efficiency (Biamah & Nhlabathi, 2003)

In semi-arid Kenya, rainfall is bimodal and characterized as low, erratic and poorly distributed. The short and long rainy seasons receive about 55% and 45% of the total annual rainfall respectively. The short rains (October to December) are more reliable, evenly distributed and adequate for crop production. The long rains (March to May) are associated with most crop failures due to the poor distribution, unreliability and inadequacy for crop production (GOK, 2010).

Trials done in Machakos, Eastern Kenya, on zero tillage combined with subsoiling, pitting/ridgings and farmyard manure led to improved crop production (Biamah, 2001). Farmer experiences with conventional tillage practices in the trials showed that improvements in soil and crop productivity occur only when the soil erosion problem is minimized first through effective conservation structures. Thus conservation tillage practices are complimentary to erosion control and provide remedies to soil fertility, soil moisture and soil compaction problems. Thus conservation tillage is viewed as a viable land management option for improving soil moisture conservation for dryland crop production in semi-arid Kenya (Biamah, 2003).

2.4 The Global Practice of Dryland Farming Technologies

Dryland farming technologies are practised in various parts of the world. The specific practices vary because of differences in local conditions, both physical and social (FAO, 2008a). In Australia much of the agricultural income comes from the production of food and fibre on dryland farms (Squires, 1991). Squires (1991) adds that the Australia's, dryland-farming systems combine crops, pastures and fallow periods for the purpose of making efficient use of the limited water. Moisture is usually the deciding factor in the success of cereal cropping. Fallowing can be an important strategy to store and conserve water for the establishment and maturation of the crop.

In China arid and semi-arid lands cover 52 percent of the country (Shengxiu & Ling, 1992). In these lands rainfall is very variable. Annual rainfall totals average 300–500 mm. Shengxiu and Ling (1992) extensively reviewed the extent, characteristics, and management of the drylands in China. Management has focused on transforming desert and desertified lands, controlling erosion, and making efficient use of the precipitation. The basic tillage principle for conserving soil and water in China is to increase soil-surface roughness (Shengxiu & Ling, 1992). This is done mainly by building low earthen banks between fields, making ridges and furrows, or digging ditches in fields. Examples include: contour ploughing, contour planting, digging pits for seeding, contour plough furrows, and cultivation in pits or furrows.

Another important principle used in designing soil and water-conserving cropping systems in China is to increase plant cover. Narrow crop rows, intercropping and interplanting are widely used for this purpose. These practices increase the density of the crop canopy, which reduces raindrop impact on the soil surface and surface sealing, maintains soil permeability, and reduces or eliminates runoff and erosion. Fallowing has also been considered an important practice for restoring soil water and fertility in China. During the fallow period, weeds are controlled by cultivation. The fallow period differs depending on precipitation and soil fertility. The effect of a one-year fallow period on the subsequent crop production will last for at least 3 years (Shengxiu & Ling, 1992).

In the semi-arid zones of North America, in which water is the principal limiting factor, the experiences of the indigenous Seri, Pima, Papago and other indigenous groups offer local options for rainfed agriculture. Some of them have developed agricultural techniques, which utilize floodwater on a small scale, with hand-made canals, terraces, berms and diversions for the retention and utilization of rainwaters (Nabhan, 1982). Floodwater farming is the management of a sporadic flashfloods for crop production. It is an ancient technique in the southwestern regions of North America. Agronomically productive conditions have been developed by geomorphological alterations of the floodplain, including canals, terraces, grids, spreaders, and weirs. These environmental modifications serve to concentrate the runoff from a large watershed into a strategically located field, and break the erosive force of the incoming water (Nabhan, 1982).

In Sonoran Desert area where the mean annual rainfall is 150-350 mm, the Papago have traditionally irrigated their floodplain fields with the storm waters of intermittent water-courses (Nabhan, 1982). In the desert, there are usually no more than 3-15 substantial storm events during the year; of these, typically no more than 5-6 are sufficiently large to stimulate a spurt of plant production. In one Papago community, 100 families maintained 355 ha of crops on farms receiving storm water, organic matter and nutrients from 240 km of watershed. With a single intense storm, enough nitrogen-rich litter from leguminous tress, rodent feces and other decomposed detritus from the uplands, is shed onto the alluvial fans to add as much as 30 m^3 of organic material to each hectare (Altieri & Toledo, 2005).

Traditional agricultural systems in Sub- Saharan Africa (SSA) are characterized by slash-and-burn (or shifting cultivation) in which farmers use bush fallow and indigenous means to restore soil fertility (Drechsel, 1998). With increasing population, the pressure on agriculture to provide food and livelihoods is equally increasing. Each region in SSA has its own related challenges. While in the densely populated East African highlands, farm sizes are often too small to make a living, farmers in the Sahel have larger areas but face food shortage attributed to drought and very poor soil conditions. In these drier areas of SSA, erratic rainfall events and frequent long dry periods have created uncertainty for rainfed agricultural producers and livestock owners (Thiombiano, 2004). Given the ever growing population also in arid and semi-arid regions of SSA, and the decreasing possibilities to increase or change the cultivated area, standard recommendations across Africa's savannahs are to make the best use of rainwater and to maintain the productivity of the land. Emphasis has been put on the following strategies: conserving rainfall water in the rooting zone of crops (rainwater harvesting) and managing the field to use water more efficiently (soil & water conservation) (Altieri & Toledo, 2005).

In southern Tunisia as in most semi-arid ecosystems, crops have historically been at risk from physiological drought and so rain water must be collected, concentrated and transferred to cropped areas quickly to minimize losses via evaporation and runoff. Such macro catchment rain water harvesting has a long history in the Matmata Plateau. Using these methods, today, most farmers in Matmata practice agroforestry. They are able to grow relatively demanding trees such as olives, figs, almonds, pomegranates and peas, lentils and beans, and fodder crops such as alfalfa (Hill and Woodland, 2003).

In north-western Tanzania the Soil Conservation and Agroforestry Pilot Program established a program to make available conservation tillage systems for small farmers. The systems minimize the disturbance of the soil, but by using animal drawn rippers and subsoilers, farmers open part of the soil for rainfall infiltration and also a system of conservation farming using hand hoes to dig small planting pits (Mwalley & Rocktrom, 2003).

2.5 Dryland Farming Technologies in Kenya

Dryland farming builds upon knowledge of general agriculture but carries out its practices in the light of the significant probability that this year or next will be a drought. (FAO, 2008a). Dryland farming technologies refers to those agriculture practices that lead to sustainable land management in the dry lands. The technologies are many but can be broadly classified as those practices that seek to conserve rainfall water in the rooting zone of crops (rainwater harvesting),those that manage the field to use water more efficiently (soil & water conservation),and those that allow regeneration of the rangeland potential (rangeland restoration through fallow period). Choice of the right planting material (drought tolerant crop varieties) has also been identified as an important dryland farming technology (Altieri & Toledo, 2005).

2.5.1 Soil and water conservation

Soil and water conservation form part of the wider aim of conservation of natural resources, which covers also the conservation of other resources including water, forest, pasture and wildlife (Mollison, 2008). As the world's population grows; improving living standards without destroying the environment is a global challenge (Hinrichsen, 2000). In all arid regions a major challenge is to manage water appropriately. The purpose of such management is to obtain water, to conserve it, to use it efficiently, and to avoid damage to the soil (Creswell & Martin, 1998). Conservation of the environment and sustainable utilization of natural resources are major issues of concern within the international community (Li, Koskela & Luukkanen, 1999). Land degradation is a serious environmental problem worldwide and a major threat to the sustainability of agriculture and economic development (Xiao-Yan Li, 2000). Different systems of soil and water conservation are practiced both in Kenya and other parts of the world.

Since the economy of Kenya is heavily dependent on agriculture it is critical that soil and water resources are properly managed to sustain this important sector (GOK, 2010). Improving agricultural productivity is central to achieving Millennium Development Goals in the country. However wide spread land degradation, exemplified by erosion and declining soil fertility, which in turn leads to falling production remain a big challenge in the country (Swallow, Okono, Ong & Place, 2003).

Field investigations in the 1980s gave different estimates of the benefits of conservation on small-scale farms in Kenya. In Nandi Sub-County it was found that the average yield of maize and beans was 62% and 77% higher respectively on land where conservation had been done. Similar work done in Machakos, found that the yield of maize was on average 47% higher on terraced land than on non- terraced farms (Kimaru & Jama, 2005).

Early conservation programmes in the country emphasized building of physical barrier to control run off. These measures tended to target the symptoms of land degradation rather than the immediate underlying causes such as poor land management, overstocking and overgrazing which may themselves result from other factors (GOK, 2010). Good management of land under crop with improved practices are the best measures to reduce erosion on crop land. Good management practices such as contour cultivation, strip cropping, grass strips or building of terraces will break up the flow patterns and increase the infiltration rate. Clearing of steep slopes, above 12%, for crop cultivation without providing for erosion control measures greatly accelerates the erosion rates on these slopes (Biamah & Nhlabathi, 2003).

The line between soil and water conservation (SWC) and rainwater harvesting (RWH) technologies for crop production is very thin. SWC can be described as activities that reduce water losses by runoff and evaporation, while maximizing in-soil moisture storage for crop production, but the same could be said of RWH. The two are differentiated by the fact that under soil and water conservation, rainwater is conserved in-situ wherever it falls, whereas under water harvesting, a deliberate effort is made to transfer runoff water from a "catchment" to the desired area or storage structure (Mati, 2006). The important thing is that both systems complement each other, and under rain-fed agriculture in dry areas, both are necessary nearly all the time.

Indigenous and innovative technologies in SWC abound in Kenya (Reij & Steeds, 2003). In-situ soil and water conservation systems are by far the most common. From a development perspective the argument for the promotion of soil and water conservation measures have been to control soil erosion. This involves managing the negative side-effects of water (Mutunga *et al.*, 2001). The historic transition from top-down, imposed rural development approaches during the colonial period, to a progressive adoption of community based participatory approaches in the region, has been described by several authors (Rockström, 2000). This change has probably favoured the development of the diversified set of farming techniques present today in various farming systems in the country.

In Kenya the famous f*anya juu* terraces, which are made by digging a trench, normally along the contour, and throwing the soil upslope to form an embankment, has had a very significant effect on reducing soil erosion in semi-arid areas with relatively steep slopes (< 20 %) (Thomas, 1997). Tiffen, Mortimore and Gichuki, (1994) present evidence from Machakos Sub-County in Kenya suggesting that the adoption of *fanya juu* terraces played an important role in reducing land degradation over a period from the 1930s – 1990s when population increased more than fivefold. Similar widely spread techniques are the *fanya chini* (soil thrown downslope instead of upslope), stone bunds, and trashlines (successfully promoted through extension in dry areas of South-eastern Kenya) (Rockström, 2000).

In Kyuso Sub-County various soil conservation technologies have been promoted and adopted to varying degrees. Such SWC technologies include fanya juu terraces, retention ditches, cutoff drains, stone lines, trashlines, grass strips and agroforestry (MOA, 2011).

2.5.2 Rainwater harvesting

Rainwater harvesting can be traced back to the 9th and 10th Century (Global Research Development Center [GRDC], 2008). People in South and Southeast Asia collected rainwater from roofs and from simple dams constructed from brush. Rainwater has long been used in the Loess Plateau regions in China where between 1970 and 1974, about 40,000 well storage tanks of various forms were constructed (GRDC, 2008). A thin clay layer was generally laid on the bottom of the ponds to minimize seepage losses and trees were planted at the edges of the ponds to help minimize evaporation (UNEP, 1982).

According to Perrier and Salkini (1991) water harvesting could be defined as a water-management technique for growing crops in arid and semi-arid areas where rainfall is inadequate for rainfed production and irrigation water is lacking. Rainfall is collected from a modified or treated area to maximize runoff for use on a specific site such as a cultivated field. Siegert (1994) also defined rainwater harvesting as the collection of runoff from a catchment to the desired area or storage structure for productive use. Farmers in Yemen tend to use water-harvesting techniques where rainfall is not sufficient. Their approaches include: runoff agriculture, where runoff is concentrated on a smaller area, generally used for arable or perennial crops; and runoff storage, generally in small reservoirs, used to supplement rainfall – often in horticulture or for livestock or domestic use (FAO,2008a).

Interest in rain water harvesting is growing in Kenya, as more people are beginning to realize that surface runoff is a resource as important as the rain, and that it can be used for sustainable crop production and/or livestock watering. Consequently, there has been a major development in a diverse range of technologies in water harvesting and conservation

(Mati, 2006). This has been attributed, in part, to the transition from the imposed top-down rural development approaches to the more progressive adoption of community-based participatory approaches (Kimaru & Jama, 2005). These have probably favored the development of the diversified set of runoff farming techniques. Today, one can see these techniques being used in various farming systems in the country.

Rain water harvesting systems are also applicable over a wide range of conditions in areas where average annual rainfall is insufficient to meet the crop water requirement, with seasonal rainfall being as low as 100 to 350 mm (Mutisya, Zejiao & Juma, 2010). Innovations by progressive farmers seem common in the field of runoff farming (Kibwana, 2001). Farmers observe the flow of surface water through their own watersheds, and based on experimentation on trial and error basis, sophisticated runoff farming systems are developed. Some of the innovative ways according to Mati (2006) include the tapping of sheet flow from roads, diversion of sheet flow from rocky areas adjacent to the farmland, or diversion of surface runoff from footpaths.

Hai (1998) described rain water harvesting techniques as consisting of Micro-catchment and external-catchment systems. Micro-catchment systems are basins, pits, bunds and all other water harvesting systems that get their runoff from small areas. A portion of upslope land is allocated for runoff collection, which is harvested and directed to a cultivated area down slope. Micro-catchments are normally within-field systems (Reij & Steeds 2003). There are many types of micro-catchment techniques practiced in Kenya, such as zai pits, semi-circular bunds, negarims and earth bunds. Semi-circular earth bunds are found in arid and semi-arid areas for both rangeland rehabilitation and for annual crops on gently sloping lands (Thomas, 1997). For the establishment of fruit trees in arid and semi-arid regions, with seasonal rainfall as low as 150 mm, Negarim micro-catchments are often used. Negarims are regular square earth bunds turned 45 degrees from the contour to concentrate surface runoff at the lowest corner of the square (Hai, 1998). Similarly, large trapezoidal bunds, 120 m between upstream wings and 40 m at the base, have been tried in arid areas in Kenya, like Turkana, for sorghum, tree and grass growing (Thomas, 1997). In Kyuso zai pits and negarim techniques are taking root (MOA, 2011).

Road runoff harvesting systems vary from simple diversion structures directing surface water into crop fields, to deep trenches with check-dams in order to enable both flood and subsurface irrigation. Where surface conditions permit, storage in pans can be quite cost-effective, as has been demonstrated by farmers of Lare in the Nakuru Sub-County of Kenya. In a project where over 1,000 pans were dug to trap road runoff, the area was transformed from a food-aid recipient to a net exporter of food through this technology (Mati, 2006).

2.5.3 Soil fertility improvement

Soil fertility refers to the capacity of soil to produce crops by providing adequate supply of nutrients in correct proportions, resulting in sustained high crop yields (Bationo *et al*., 2006). Most drylands soils have been depleted in soil organic matter due to inappropriate cultivation, overgrazing and/or deforestation in the past, causing a decline in soil quality (Lal, 2002). In order for farmers in the ASAL areas to achieve food security they must embrace soil fertility management as an integral part of dryland agriculture.

Trials done in Arusha, Arumeru and Babati Sub-Countys of Tanzania on the performance of different dryland farming technologies showed that water harvesting alone does not give the strongest yield increase. It was only when soil fertility management is combined with water harvesting that the full effect of Conservation Farming felt (Benites, Vaneph, & Bot, 2002).

In Kenya, soil fertility depletion and soil degradation present the most serious problems. According to an FAO study (FAO 2001), Kenyan soils lose an annual average of 48 Kg/ha of nutrients, the equivalent of 100 Kg/year of fertilizer. To compensate for this loss, they receive an average of only 10 Kg of mineral fertilizer, compared with a global average of 90 Kg. In addition, soils in the arid and semi-arid areas are generally poor (Gichuru *et al*., 2003). According to Mati (2006) the declining per capita food production in Kenya is associated with declining soil fertility in small-scale farms. This is because nutrient capital is gradually depleted by crop harvest removal, leaching and soil erosion. The use of crop residues by farmers as fodder, and none or shorter fallow periods due to a shrinking land resource base, should be balanced by addition of chemical fertilizers and organic manure, which most small-scale farmers in the semi-arid areas cannot afford. There is, therefore, a need to develop appropriate soil nutrient and cropping systems that minimize the need for chemical fertilizers and also find ways to integrate livestock into the farming system (Mati, 2006).

Maintaining or increasing soil fertility is one of the most important things farmers have to do to increase output. Doing so, farmers have to know the characteristics and constraints of their soils and use sustainable agricultural practices and methods for conserving them and making them more fertile. These include fallowing, using compost, farm yard manure, crop residues, agroforestry, intercropping legumes with cereals and including the principles of conservation agriculture. Conservation agriculture includes crop rotation, ensuring permanent cover for the soil and no disturbing of the top soil layer. Soils have to be nourished and cared for, and allowed to rest from time to time (Gichuru, et al., 2003). In many small-scale farms, crop residues are harvested and fed to livestock, and very little is returned to the soil to replenish lost nutrients. The depletion of organic matter thus exacerbates this condition. Efficient farm management practices should result in greater stimulation of activities of soil organisms, nutrient additions to the soil, minimal nutrient exports from the soil and optimal nutrient recycling within the farming system (Mati, 2006).

Enhancement of soil productivity through the improvement of soil organic matter is essential for sustained agricultural production systems. This is particularly important in ASAL where rainfall is erratic and soils are low in most of the major nutrients needed by plants, and continuous cultivation with little or no external soil fertility inputs is a widespread practice (Bationo et al., 2006). A study done in Machang’a in Mbeere Sub-County, Kenya indicated that the annual manure application had positive response to crop dry matter (DM) production. Cumulative mean crop DM production after 20 seasons from 5 tons ha-1 and 10 tons ha-1 manure application did not differ significantly and therefore a recommendation was put forwards to ASAL farmers to apply 5 tons ha-1 manure in erosion free continuously cultivated lands (Micheni, Kihanda, & Irungu , n.d.).

In the sub-humid highlands of Kenya, soil fertility management among small-scale farmers is quite widespread. For instance, in Embu Sub-County, 99 percent of farmers use mineral fertilizers, 91 percent use farmyard manure and 74 percent do crop rotations, while in Vihiga, western Kenya, 75 percent use compost manure, 79 percent use green manure and cover crops, 91 percent use farmyard manure and 93 percent use crop residues (Amudavi, 2005). In ASAL areas use of farm yard manure in cereal farms is low. A study done in Mbeere Sub-County, Embu County Kenya, only 7% of farmers practice composting with the majority applying low quality manure directly from the cattle *boma* (Onduru *et al.*, 2008). In Kyuso Sub-County the most common methods of soil fertility improvement is through intercropping of cereals with legumes. Organic and inorganic fertilizers are also used but to a less extent (GOK, 2009).

2.5.4 Crop and variety selection

Choice of crop varieties is important. Varieties which have proven excellent in humid and sub-humid areas are generally unsuited for semi-arid conditions. Many attempts at dry land farming have failed, largely due to lack of recognition of the requirements for the variety selection (Creswell & Martin, 1998). Sorghum and millet have been noted as staple food grains in many semi-arid areas of the world, particularly in Sub-Saharan Africa (SSA) because of their good adaptation to harsh environments and their good yield of production (Mukarumbwa, 2009).

According to FAO (2008b) findings large parts of the SSA, including Kenya, are semi-arid with erratic rainfall and nutrient poor soils. While maize is the preferred staple food that is grown by most small-scale farmers, sorghum and millet were found to be important crops in these driest regions where rural farm households have limited production capacity and lowest incomes. Sorghum and millet being drought tolerant have a strong adaptive advantage and lower risk of failure than other cereals in such environments (Mukarumbwa, 2009). According to Hussein (2005) sorghum is more adapted to drought-prone areas, particularly the hot, semi-arid tropical environments with 400 to 600 mm rainfall and is too dry for most cereals. Millets grow well in arid and semi-arid environments, requiring less water compared to other cultivated grains. The two crops grow fast, do not need very much rain, resist drought and can be easily stored. Sorghum is the world's fifth most important cereal while millet is the seventh (Léder, 2004).

In the semi-arid parts of Kenya, sorghum and millet remain important crops for rural food security. Since many sorghum and millet producing areas still experience frequent food deficits, production must be increased in order to ensure food security is achieved (MOA, 2010). In a study that was conducted in semi-arid eastern Kenya by Sutherland, Irungu, Kang'ara, Mutamia, and Ouma (1999), it was found out that household food security was more stable for those households growing more adaptable crops such as millet and sorghum. However, because of unreliable rainfall, food insecurity was high for those households that grew crops, which were less adaptable to the environment such as maize and beans (Mukarumbwa, 2009).

The growing of drought tolerant crop varieties, such as sorghum and millet, in Kyuso Sub-County has been promoted by agricultural extension service as one of the ways of achieving household food security. However, adoption of the technologies associated with these varieties by small scale farmers is still low resulting, probably, in the low production of the crop. Farmers have been noted to have a higher preference for growing maize which is not as drought tolerant as sorghum and millet thereby occasioning frequent food insecurity due to due to crop failures (MOA, 2011).

2.6 Food Security

In May 2007, at the 33rd Session of the Committee on World Food Security, FAO issued a statement to reaffirm its vision of a food-secure world. FAO's vision of a world without hunger is one in which most people are able, by themselves, to obtain the food they need for an active and healthy life, and where social safety nets ensure that those who lack resources still get enough to eat (FAO, 2007). This vision has its roots in the definition of food security adopted at the World Food Summit (WFS) in November 1996: "Food security exists when all people at all times have physical or economic access to sufficient safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life"

2.6.1 Agriculture and food security

Agriculture is important for food security in two ways. It produces the food people eat. It also provides the primary source of livelihood for 36 percent of the world's total workforce. In the heavily populated countries of Asia and the Pacific, this share ranges from 40 to 50 percent, and in sub-Saharan Africa, two-thirds of the working population still make their living from agriculture (International Labour Organization [ILO], 2007). In Kenya agriculture sector employs 80% of the work force (MOA, 2009)

2.6.2 Dryland farming technologies and food security

Investments in dryland farming techniques in semi-arid regions lead to immediate and perceptible yield increases and contribute to reducing rural poverty (Reij & Steeds, 2003). Studies done in Nigeria in Borno State, show that, food security depends on weather, soil and water conservation and soil fertility management (Amaza, Abdoulaye, Kwaghe & Tegbaru, 2009). In Burkina Faso a multidonor funded study on the processes of environmental rehabilitation and agricultural intensification during the period 1980 – 2002 in an area with 500–700 mm annual rainfall concluded that when dryland farming technologies were implemented, millet and sorghum yields increased substantially, by about 50 %, since the mid-1980s (Reij & Steeds, 2003).

In Machakos Sub-County in Kenya, the results of a longitudinal study (1930–1990) on environmental recovery were published in 1994 (Tiffen et, al.,). One of the stunning finding was that despite a more than fivefold increase in the population between 1930 and 1989, land degradation that was a serious problem in 1930 had been reversed and significant improvement in household food security realised. Among the many factors that contributed to environmental recovery included technological change in agriculture accompanied by investment in soil and water conservation, enclosure of grazing land, planting of trees, and a wide range of other measures (FAO, 2008a).

According to Reij and Steeds, (2003) investments in dryland farming techniques in semi-arid regions lead to immediate and perceptible yield increases and contribute to reducing rural poverty. Experience shows clearly that investments in simple on-farm water harvesting techniques often produce immediate results. They contribute to restoring the productive capacity of degraded land and trigger other improvements in agricultural production systems. Examples from various trials in Kenya indicate that with modest slopes, yield increases of 30 to 50 percent are not uncommon. The multiplier effect of such increases is important. A 10 percent increase in crop yields leads to a 6 percent decrease in the percentage of those living on less than 1 $ a day (Reij &Steeds, 2003). A study conducted in Mwingi and Kyuso Districts in 2005 on food security status of households in the Districts found out that one of the key determinants of household food security was the farmers' involvement in food for work activities (Kaloi, et, al.,). These activities involve excavation of soil and water conservation structures mainly terraces and retention ditches and rain water harvesting structures especially tied ridges, zai pit and negarims. It can therefore be concluded that improvement in food security for these farmers could be due to their practice of dryland farming technologies (MOA, 2011).

2.7 Theoretical Framework

The main theory on which this study was based is the Sustainable Livelihoods Approach (SL). The sustainable livelihood approach was conceptualized in the work of Robert Chambers in the late 1980s and early 1990s. Robert Chambers was one of the strongest critics of the 'top down' approach, and emphasized on the need for enhanced focus on actors of development - the poor people themselves (Chambers 1983). The idea was to replace the 'top down' approach with action from below.

Chambers and Gordon (1992) defined sustainable livelihoods as the "capabilities, assets (stores, resources, claims and access) and activities required for a means of living". They call a livelihood sustainable when it "can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation; and which contributes net benefits to other livelihoods at the local and global levels and in the short and long-term"

The SL approach was adopted by the Brundtland World Commission on Environment and Development in 1987 as a way of linking socioeconomic and ecological considerations in a cohesive, policy-relevant structure. The 1992 United Nations Conference on Environment and Development expanded the concept, and advocated for the achievement of sustainable livelihoods as a broad goal for poverty eradication. It stated that sustainable livelihoods could serve as ‘an integrating factor that allows policies to address ‘development, sustainable resource management, and poverty eradication simultaneously’ (Krantz, 2001). The SL approach based on this framework supports poverty eradication by making enhancement of poor people’s livelihoods a central goal of development efforts (Scoones, 1998).

The asset base upon which people build their livelihoods includes a wider range of assets than are usually considered. The sustainable livelihoods framework suggests consideration of an asset portfolio of five different types of assets: Natural capital includes land, water, forests, marine resources, air quality, erosion protection, and biodiversity. Physical capital includes transportation, roads, buildings, shelter, water supply and sanitation, energy, technology, or communications. Financial capital includes savings (cash as well as liquid assets), credit (formal and informal), as well as inflows (state transfers and remittances). Human capital includes education, skills, knowledge, health, nutrition, and labour power. Social capital includes any networks that increase trust, ability to work together, access to opportunities, reciprocity; informal safety nets; and membership in organizations (Ashley & Carney, 1999).

The assumption is that people pursue a range of livelihood outcomes (including food security and income) by drawing on a range of assets to pursue a variety of activities. The activities they adopt and the way they reinvest in asset-building are driven in part by their own preferences and priorities. In this study the government through the Ministry of Agriculture and other stakeholders has trained farmers on the dryland farming technologies. These technologies include soil and water conservation, rain water harvesting for crop production and soil fertility improvement. These technologies seek to mitigate farmers’ vulnerability to drought resulting to food insecurity and poverty. They do so by increasing crop production despite possible shocks of drought, low rainfall and inherent poor soil fertility.

Figure 1, shows three ways in which agricultural technology can fit in by affecting the vulnerability context, through linkages to the asset base, or as part of policies, institutions, and processes. Agricultural technologies can reduce vulnerability, such as when terraces increases moisture availability to crops thus reducing susceptibility to moisture stress and subsequent crop failure, or pest control technologies reduce vulnerability to crop. The arrows between agricultural technologies and the vulnerability, assets and the policies, institutions, and processes point in both directions, because each of these domains have the potential to shape technologies (Adato & Dick, 2002).

Agricultural technologies interact with livelihood assets to produce desired livelihood outcome in this case food security. The overall conceptual framework for sustainable livelihoods is illustrated in Finger 1.

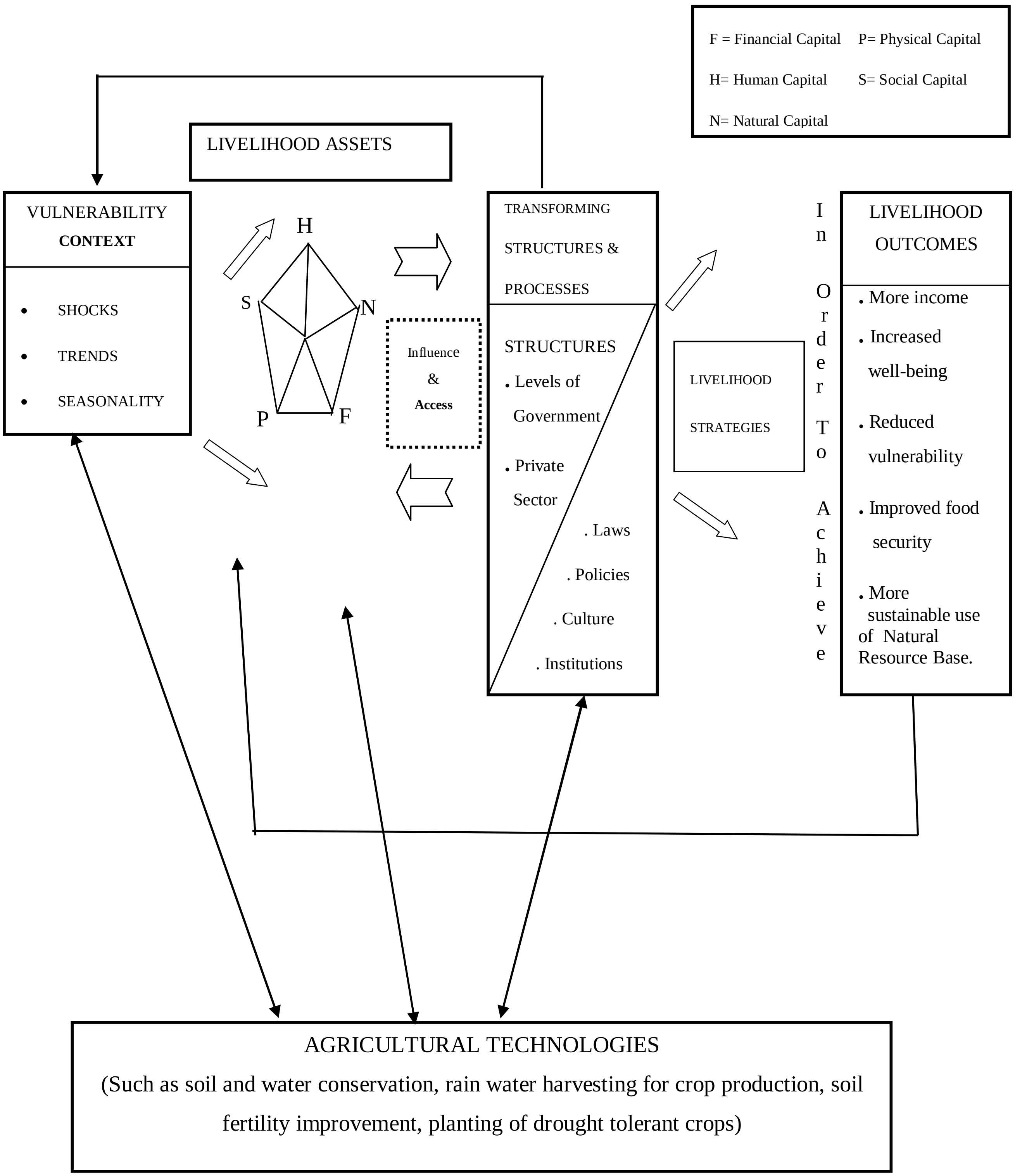


***Figure 1*. The DFID Sustainable Livelihood Framework (Adato & Dick, 2002)**

2.8 Conceptual Framework

In this study, the independent variables are dryland farming technologies which include soil and water conservation, rain water harvesting and soil fertility improvement and dependent variable is household food security. The study hypothesized that implementation of dryland farming technologies would result into improved food security in the study area. Food security at the household level was measured by food availability by looking at the amount of food crop produce of grain cereals and grain legumes in store, consumed or sold from farmer's own production and the available income to purchase these produce. Factors such as socio-economic status of the farmers (age, income, land size and level of education) and frequency of contact with agriculture extension workers may have had some influence on the household food security in the study area and thus were being treated as moderating variables. The influence of the moderating variables such as socioeconomic factors was controlled through random sampling and were also included as variables in the study.

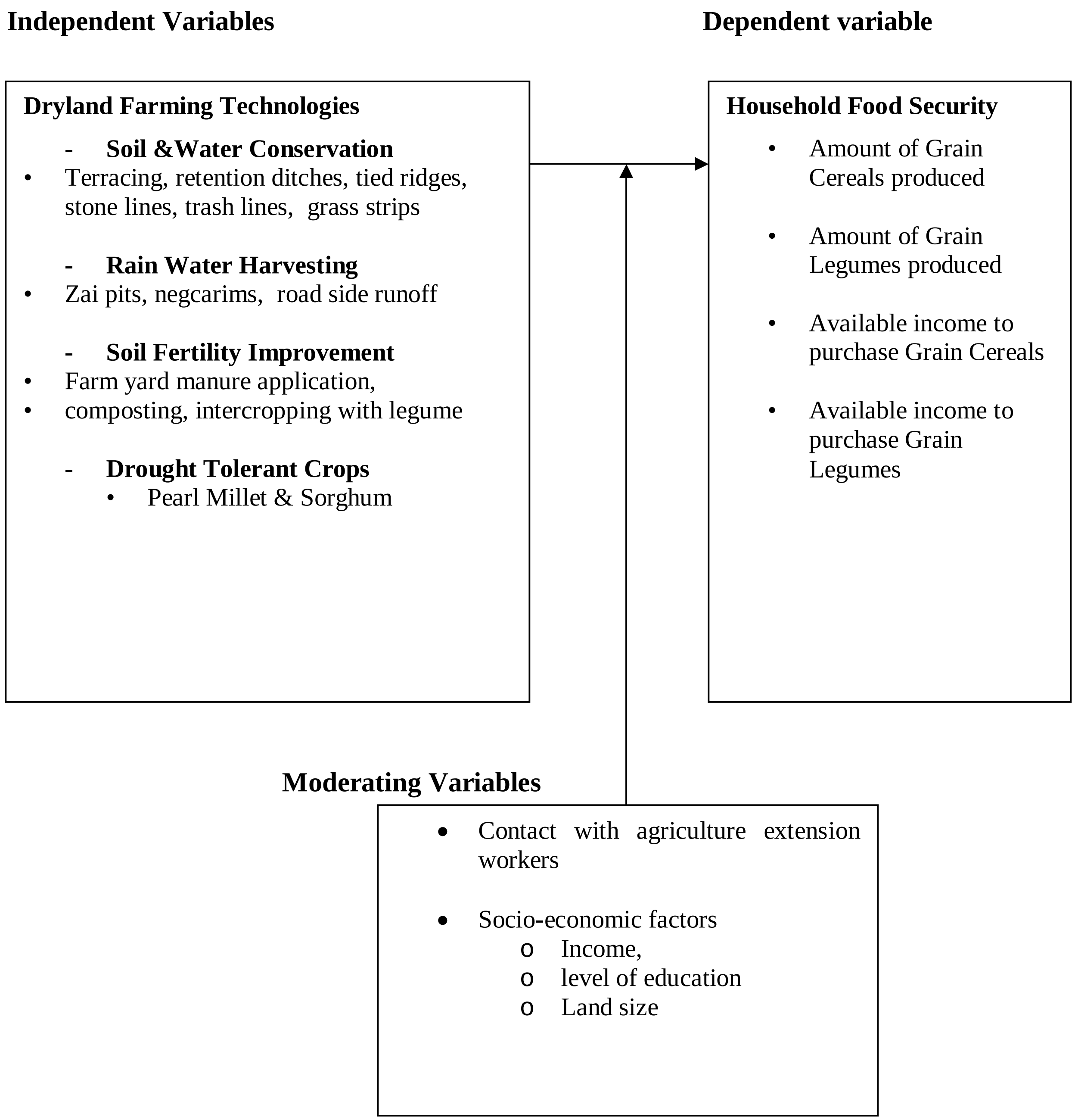


Figure 2. **Conceptual framework showing the relationship between dryland farming technologies and household food security which may have been influenced by some socio-economic factors and contact with extension workers**

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

This chapter gives an overview of the methods used for data collection and analysis. It also offers a description of the area of study where the research was conducted. The chapter commences by explaining the research design, describing the study area and the target population. The following subsections outline and explain sampling procedure and sample size, instrumentation, data collection and data analysis.

3.2 Research Design

This study adopted a descriptive survey design. This design was appropriate for this study because it enabled the description and exploration of the dryland farming technologies used by farmers in the selected study areas and determined the household food security in the Sub-County. The variables under the study were not manipulated.According to Mugenda and Mugenda (2003) this research design seeks to obtain information that discloses existing phenomena by asking individuals about their perceptions, attitudes, behavior or values. In addition descriptive surveys can be used for explaining or exploring the existing status of two or more variables at a given point in time. In this study the research indents to explore the dryland farming technologies, their level of implementation, status of crop production and determine their influence to achieving household food security of small-scale farmers in Kyuso Sub-County..

3.3 Location of the Study

This study was conducted in Kyuso Sub-County located in the Kitui County of Kenya. The Sub-County covers an area of 2,509 km^2 with a population of 64,224 people and 12,378 households (Kenya National Bureau of Statistics [KNBS], 2010). It is one of the arid and Semi-arid Sub-Counties in Kenya receiving average annual rainfall ranging from 250-780mm. The Sub-County experiences a bimodal type of rainfall. The long rains season starts from March and ends in May while short rains season starts in October and ends in December. The rainfall pattern is erratic with poor distribution and about 66% rainfall reliability (GOK, 2009.) Administratively the Sub-County is divided into 4 wards with 14 villages. Kamuongo Ward is one of the 4 wards in Kyuso Sub-County. This ward was be purposively sampled to host the study because the Ministry of Agriculture had promoted dryland farming technologies in the ward (MOA, 2011). The Ward covers an area of 179.7 km^2 and has 2,629 households (KNBS, 2010). The ward has three villages namely Itivanzou, Kamuw'ongo and Tyaakamuthale. The average farm holding is about 2ha. Mixed farming is mainly practiced where farmers keep goats, sheep and cattle and also plant crops such as maize, sorghum, pearl millet cowpeas and green grams (MOA, 2011).

3.4 Target Population

According to the Kenya National Bureau of Statistics (2010) Kyuso Sub-County had 12,378 households. This constituted the target population. The accessible population was composed of all the 2,629 households in Kamuongo Ward (KNBS, 2010). The ward had a population of 13,458 people out of which 6,057 were males and 7,401 were females (KNBS, 2010). The male to female ratio in the Ward was 1 to 1.2. Table 1 illustrates the distribution of the population in the study area.

Table 1

Population and Households per Village in Kamuongo Ward

Village	Total population	Number of Households
Itivanzou	4,526	882
Kamuongo	3,530	719
Tyaakamuthale	5,402	1,028
Total	**13,458**	**2,629**

Source: Kenya National Bureau of Statistics (2010)

3.5 Sampling Procedures and Sample Size

Kyuso Sub-County had 4 Wards. One Ward, Kamuongo, was selected purposively because the Ministry of Agriculture had in the past promoted dryland farming technologies in the Ward. There were 2,629 households in Kamuongo Ward. The sample size was determined by the coefficient of variation formula recommended by Nassiuma (2000) for determining sample size. Nassiuma (2000) asserts that in most surveys and even experiments, a coefficient of variation in the range of 21% to 30% and a standard error in the range 2% to 5% is usually acceptable. The Nassiuma's formula does not assume any probability distribution and is a stable measure of variability. Therefore, a coefficient variation of 23% and a standard error of 2% were used in this study. The lower limit for coefficient of variation and standard error were selected so as to ensure low variability in the sample and minimize the degree of error.

$$n = \frac{N C^2}{C^2 + (N-1) e^2}$$

Where n = the sample size

N = the population size

C = the Coefficient of Variation

e = standard error

Therefore, the sample size of respondents was:

$$n \text{ (respondents)} = \frac{2629 (0.23)^2}{(0.23)^2 + (2629-1)(0.02)^2}$$

$$= 130$$

To ensure balance of respondents across the three villages and take care of attrition and none response, the researcher revised the sample size upwards to 140.

Out of the four administrative Wards of Kyuso Sub-County, Kamuongo was purposively selected. This was because dryland farming technologies had been promoted in the Ward over time (MOA, 2011). It was thus a representative of the population. Ward and Village Extension Officers were used to draw a list of all the household heads in the study area.

Proportionate random sampling was used to determine the number of respondents for a given village while systematic random sampling was then used to obtain the actual respondents from the village. For each village the target population was divided by the proportionate sample size to obtain the sampling interval for the location. The sampling frame of each of the three villages was fed into the computer using Excell programme. The computer was commanded to generate a proportionate random sample. This yielded the size of 140 for the three villages

Table 2

Proportionate Sample Size and Number of Households per Village in Kamuongo Ward

Village	Number of households	Proportion	Household Heads
Itivanzou	882	0.34	47
Kamuongo	719	0.27	38
Tyaakamuthale	1028	0.39	55
Total	**2629**	**1.00**	**140**

Samples of 12 farmers were selected purposively from each village in the study area for participation in Focus Group Discussion (FGD) giving a total of 36 farmers. The criteria for their selection were gender, age, education, and marital status. One site per village was selected randomly to host the FGD. Thus the total sample size of 176 farmers participated in the study.

3.6 Instrumentation

Two instruments were used to collect data in the study area. A Focus Group Discussion Guide (Appendix B) was used to collect data about the dryland farming technologies (DLFT) practiced by the small scale farmers in Kamuongo Ward. It was also used to collect data on the status of food crop production as a result of these technologies, extent of household food insecurity among the small scale farmers and the DLFT that influence the small scale farmers' food security in the study area.

A questionnaire was used to collect data from household heads involved in the study. This instrument was chosen because of the ease of administration and scoring of the instruments besides being readily analyzed (Cohen, Manion, & Morrison, 2007). It was also useful in that the type of response to items facilitates consistency across the respondents (Denscombe, 2007). This type of instrument is useful in that it allows participation by illiterate people and allows clarification of any ambiguity in addition to minimizing discrimination of the less articulate (Kvale & Brinkmann, 2009). The instrument collected data on the dryland farming technologies practised by small-scale farmers in Kyuso Sub-County. It was also used to collect information on the crops grown and the food situation status. Challenges faced by farmers as they implement dryland farming technologies were explored.

3.6.1 Validity

The instrument was subjected to peer examination in the Department of Agricultural Education and Extension and colleagues in the Ministry of Agriculture. Secondly academic experts in the Department of Agricultural Education and Extension, Egerton University, looked at its contents and determined its ability to measure what it was intended to measure. For Focus Group Discussion Guide, validity was ensured by having colleagues and experts discuss it and ensure that all aspects of interest were covered.

3.6.2 Reliability

The structured interview schedule was pilot-tested in Kyuso Ward, Gai Village which had similar subjects, climatic and agroecological characteristics as the study location. Twenty households were surveyed during the pilot test. The piloting of the instrument helped to assess its appropriateness and aided in further refinement. The reliability of the instrument was estimated after the pilot study using the Cronbach's alpha procedure. A reliability coefficient of 0.795 was obtained which was above 0.7 adopted as the minimum threshold as recommend by Fraenkel and Wallen (2000) and Boermansab and Kattenbergb (2011). The tool was therefore good and was used for data collections.

3.7 Data Collection Procedures

A letter of approval was obtained from the Board of Post Graduate Studies of Egerton University and presented to the National Council of Science and Technology (NCST) to obtain a research permit. Arrangements were then made to visit Sub-County Agriculture Office Kyuso Sub-County for permission and authority to conduct research in the Sub-County. A visit to Kamuongo Ward Agriculture Office was made during which the sample frame for each village was drafted with the help of Ward extension officers and permission to work with the village personnel sought. With the assistance of the Ward Extension Officers, 12 household heads were selected for the FGD and letters of invitation to participate in the focus group discussion (Appendix A) sent. After the completion of FGDs the researcher, with the guidance of the village agriculture officer administered the structured interview schedule face-to-face to the 140 sampled household heads.

3.8 Data Analysis

The data collected from the focus groups was transcribed by the researcher, during this process the initial thoughts and ideas were noted down as this is considered an essential stage in analysis (Braun & Clarke, 2006). The transcribed data was then placed into themes. The researcher had developed a focus group discussion guide. This aided in placing the generated ideas into respective themes. Each theme was then clearly defined and accompanied by a detailed analysis. Considerations were made to ensure that the themes and the analysis related to the objectives of the study.

Data from the administered interview schedules was transcribed, coded and synthesized by study objectives. Data entry in the computer then followed after which analysis of quantitative data was done, using the statistical package for social sciences (SPSS).

Objectives (i), (ii), (iii), (iv) and (v) were analyzed using descriptive statistics namely percentages and frequencies. Except for objective (i) all the other objectives were translated into hypothesis (i), (ii), (iii) and (iv) respectively. Multiple linear regression was used to determine the influence of the independent variables on the dependent variables. Multiple linear regression was the most suited for analyzing data in this study because it attempts to determine whether a group of independent variables, dryland farming technologies in this case, together predict a given depended variable (household food security in this study). The hypotheses were tested at 5% level of significance.

3.9 Ethical Considerations

Ethical considerations ensure that ethical principles are taken into account when carrying out research. These ethical principles include justice, beneficence and respect for persons. The principle of justice requires that burdens and benefits of research be equally and fairly distributed such that particular groups do not bear the burden of research participation while other groups receive the benefits. This implies that the selection of research subjects needs to be scrutinized in order to determine whether some classes are being systematically selected simply because of their easy availability, their compromised position, or their manipulability (Lindorff, 2007).This study achieved that requirement through proper sampling procedures.

The second ethical principle is beneficence. It requires that researchers should make efforts to secure the well-being of participants. The principle views research as acceptable if it creates benefits and does not cause harm, or minimizes risks of harm or discomfort and maximizes possible benefits and the well-being of participants. Serious attention to the principle of beneficence requires that researchers assess the probability and magnitude of benefits and the many potential dimensions of harm, and ensure robust procedures that anticipate and confront possible harms (National Ethics Advisory Committee, 2012). This requirement was achieved by restricting Focus Group Discussions to two hours only. In addition refreshments (soft drinks and water) were served at the close of the meeting. The questionnaire was made in such a way that it was possible to fill within one hour or less to avoid tiring respondents.

The third core ethical principle in research is respect for persons. This is demonstrated by viewing individuals as autonomous agents, and protecting those with diminished autonomy. This principle operates on the foundation that individuals have rights such as for autonomy and privacy and these cannot be violated without causing harm. According to this principle research should show respect for the rights of individuals and organizations and it is the duty of the researcher to preserve and protect the privacy, dignity, well-being and freedom of research participants. This duty requires informed consent from all participants. Informed consent means explaining to potential participants the purposes and nature of the research so they can freely choose whether or not to become involved. Such explanations include warning of possible harm and providing explicit opportunities to refuse or participate and to terminate participation at any time (Mugenda, 2003; Lindorff, 2007; National Ethics Advisory Committee, 2012). This study fulfilled this condition by stating clearly in all the instruments that participation was voluntary and that a respondent drop out even in the middle of filling an instrument. Writing names in the interview schedules was optional. The respondents were also informed that the data collected was for the purposes of study and would not be used against them in any way.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents results and discussions of the findings of the study. Thematic analysis process was used for analysis of data from focus group discussions. Reports from this tool are presented as a contextual discussion. Findings from questionnaires are mainly presented in form of frequency tables, pie charts and bar graphs. The chapter analyses the demographic characteristics of the respondents and presents the results along the objectives of the study. The results are presented in the following order: demographic characteristics of the respondents influence of soil and water conservation, rain water harvesting, soil fertility improvement, and production of drought tolerant crops on household food security of small- scale farmers in Kyuso Sub-County.

4.2 Demographic Characteristics of the Respondents

This section presents a brief description of the demographic characteristics of the sampled respondents involved in the study. Such a description is considered to be very important in providing a better understanding of the respondents included in the study and therefore provide a good foundation for a detailed discussion of the results based on the stated objectives of the study. The demographic characteristics included gender, age, education, farming experience, land ownership and marital status.

4.2.1 Gender of the respondents

The study sought to find out the gender distribution among the respondents in Kyuso Sub-County. The respondents were asked to indicate their gender in the interview schedule. Figure 3 indicates that more than half of the farmers interviewed (61%) were female compared to 39% being male.

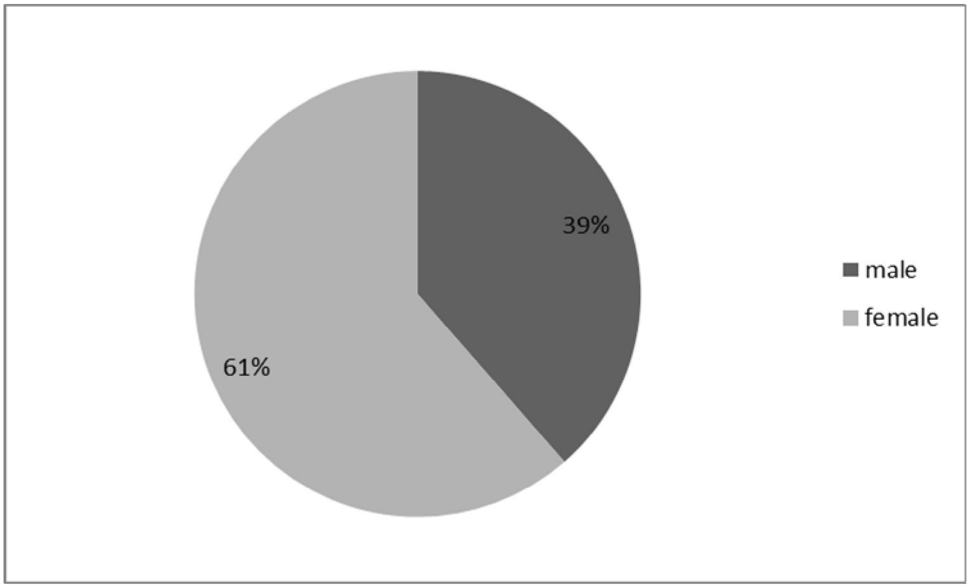


Figure 3. **Gender of the respondents**

Research has provided evidence that adoption and use of agricultural technology between female and male headed households is not the same (Meinenzen-Dick et al, 2010). It has also revealed that male-headed households are the greater adopters and users of modern agricultural technologies (Shiferaw, Kebede & You, 2008). Gender differences in technology use are usually caused by gender-linked differences in access to key inputs (Ndiritu, Kassie & Shiferaw, 2014). Women encounter barriers as far as access to new and improved technology and other productive assets is concerned Willy & Chiuri, 2010). In Kenya, women contribute the bulk of the farm labor needed for intensive activities such as weeding, and over half for the overall agricultural labor, but they have unequal opportunities and access to a range of productive resources, including land, education, information, and financial resources (Ndiritu et al, 2014).The fact that more women than men were available for interview was an showed that women handle most of the farm activities. This was an indication that the overall use of dryland farming technologies could have been low.

4.2.2 Age of the respondents

The study sought to find out the age brackets of the respondents in Kyuso Sub-County by asking them to state their age ranges. This was to help determine the age distribution for the respondents. The results are shown in Table 3. Among the respondents surveyed 32.1% were between the ages of 36-45 years. Another 22.9% were between the ages 26-35.

Table 3

Age Distribution of Farmers

Age bracket	Frequency	Percentage
under 25	3	2.1
26-35	32	22.9
36-45	45	32.1
46-55	22	15.7
over 55	38	27.1
Total	**140**	**100.0**

Table 3 shows that 22.9% of the farmers interviewed were in the age bracket of 26 -45 years and a further 32.1% and 15.5% were aged 36-45 and 46-55 respectively. Only 27.1% were aged above 55. This means that the majority of the farmers in Kyuso Sub-County were in their prime age and were expected to have been very active and ready to experiment on technologies. Age has been found to determine how active and productive the head of the household would be (Djomo & Fondo, 2012). Age is also said to affect the rate of household adoption of innovations, which in turn, affects household productivity and livelihood improvement strategies (Akpan, Nkanta & Essien, 2012). The predominance of active and productive heads of households in the study area means that able-bodied labor is available for use of dryland farming technologies for production.

4.2.3 Education level

Most of the interviewed farmers had got formal education up to primary level (68.6%) while 10 % had attained secondary school education. Those with post-secondary school level of education were 7.1%. However 14.3% had no formal education. Figure 4 presents the percentages of the levels of education of the farmers.

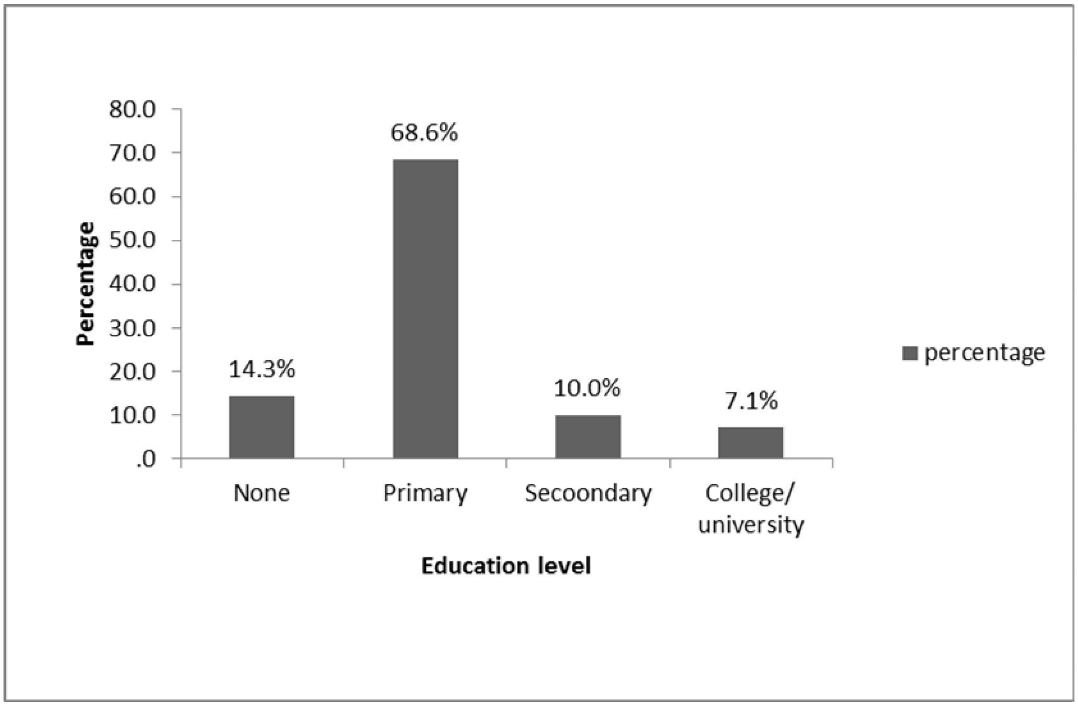


***Figure 4*. Level of education of the farmers**

Studies have revealed that the level of education helps farmers to use production information efficiently, as a more educated person acquires more information and, to that extent, is a better producer (Kinyangi, 2014)). The level of farmers' education is believed to influence the use of improved technology in agriculture and, hence, farm productivity. The level of education determines whether or not farmers adopt and integrate innovations into the household's survival strategies. It affects the level of exposure to new ideas and managerial capacity in production. Tenge (2004) states that, educated households are expected to understand farming technologies, have more access to dryland farming related information and hence be more food secure. On the other hand Mishra, Williams and Detre (2009) argue that education increases farmers' human capital and gives the more lucrative incentives for employment opportunities off the farm, which in turn decreases the manager ial time on the farm to implement new technologies and realize the expected results. That notwithstanding, it is generally agreed that education creates a favorable mental attitude for the acceptance of new practices especially of information-intensive and management-intensive technologies (Kinyangi, 2014).

4.2.4 Farming experience

The study sought to find out the farming experience of the respondents. This was aimed at determining the number of years the farmers has been in farming business and in turn know how much experience the respondents had been exposed to regarding the use of dryland farming technologies.

Majority of the farmers in the study area had farming experience of ten years and above (81.5%). Those with farming experience of 5 to 10 years were 15%. Only a small proportion, 3.6%, had experience of less than five years. Figure 5 presents the percentages of the levels of farming experience of the farmers.

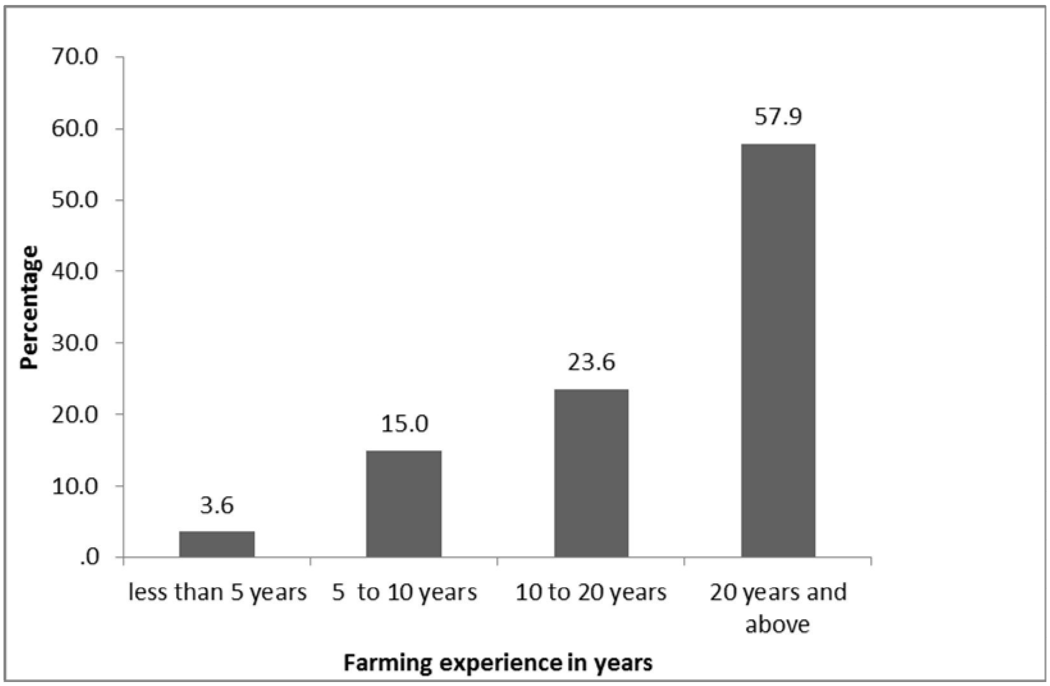


***Figure 5.* Farming experience**

This indicated that most respondents had the opportunity to acquire some experience, knowledge and skills to varying degrees to interact with dryland farming technologies promoted by extension officers and other stakeholders. Farming experience is an important factor determining both the productivity and the production level in farming. But the effect of farming experience on productivity and production may be positive or negative (Tankou, 2013). Generally, it would appear that up to a certain number of years, farming experience would have a positive effect; after that, the effect may become negative. The negative effect may be derived from aging or reluctance to change from old and familiar farm practices and techniques to those that are modern and improved (Amaza, et al., 2009). The farming experience of household heads in the study area varied widely, with a minimum of less than 5 years and a maximum of above 20 years (Figure 5). This shows that on average the household head had considerable experience in farming.

4.2.5 Type of land ownership

In the rural arid and semi- arid areas, land is considered to be the most important factor of production. This arises as a result of the low level of technology that accompanies agricultural production and other related problems of land tenure that are commonly found in the agriculture of developing economies. Figure 6 presents the typology of land tenure practiced in the study area.

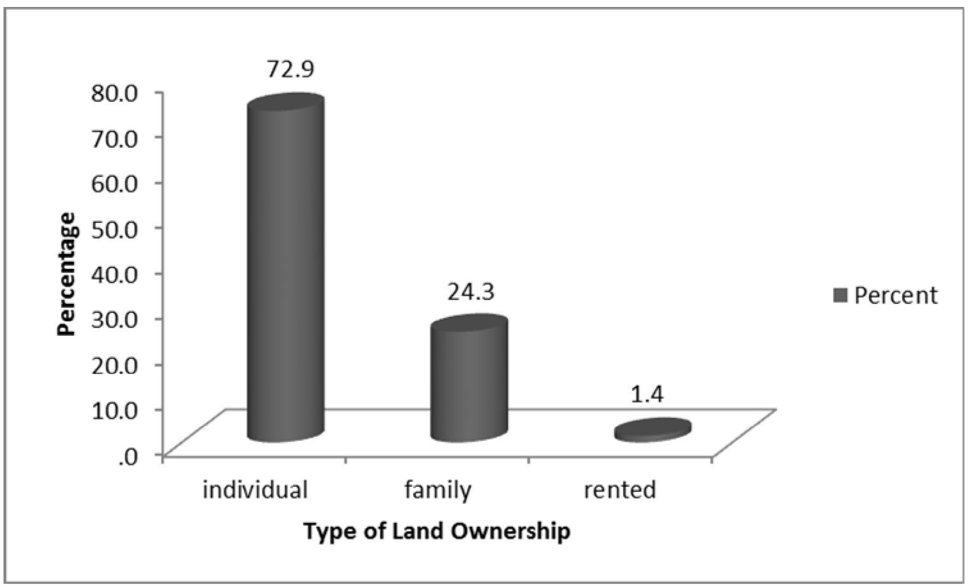


Figure 6. **Distribution of types of land ownership**

The most common type of land tenure was individual ownership by inheritance from family or direct purchase, accounting for 72.9%. This individual land ownership mode tends to promote security of tenure, as opposed to the other modes of land ownership. Hence, this factor is likely to provide an incentive for farmers to manage their land properly. Family land accounts for 24.3% of land ownership in the study area. Under this ownership mode, there could be fragmentation of land as a response to an increased number of family members, to give each family member a “fair” share of the right to land use. Rented land accounts for 1.4%. Studies show that types of land ownership affect the application of technologies for agricultural production. Secure land tenure such as individual ownership gives sufficient incentives to the farmers to increase their efficiencies in terms of productivity and ensure environmental sustainability (Shimelles, Islam & Parviainen, 2009).

4.2.6 Household heads' marital status

The significance of marital status on agricultural production can be explained in terms of the supply of agricultural family labor. It is expected that family labor would be more available where the household heads are married. Table 4 shows the distribution of the marital status of household heads in the study area.

Table 4

Household Head's Marital Status

Marital Status	Frequency	Percent
Married	121	86.4
Single	19	13.6
Total	**140**	**100.0**

The majority of household heads in the study area were married. On average, about 86.4% of all household heads in the study area were married. Only 13.6% were single. The majority of household heads in the study area being married, it is expected that enough labour force and resources would be available to implement dryland farming technologies within the study area (Sulo, Koech, Chumo & Chepng'eno, 2012).

4.3 The Influence of Soil and Water Conservation on Household Food Security

Soil erosion and absence of soil moisture could be a major constraint in crop production in the arid and semi-arid areas. Farmers overcome this change by using technologies that can conserve both soil and water. Table 5 shows soil and water technologies that farmers indicated they used in the study area:-

Table 5

Soil and Water Technologies

Technology practiced	Count	Column N %
Fanya chini/retention terraces	77	55.0
Fanya juu terraces	126	90.0
Log line	4	2.9
Stone line	9	6.4
Grass strip	19	13.6
Trash lines	46	32.9
Earth bunds	2	1.4

The most popular technology was *fanya juu* terraces whereby 90% of the respondents indicated that they use the technology. *Fanya chini* or retention ditches was the second most used technology with 55% of the farmers interviewed indicating that they practice the technology. The other technologies indicated by the respondents were trash lines (32.9%), grass strips (13.6%), stone lines (6.4%), log lines (2.9%) and earth bunds (1.4%). Farmers did not prefer earth bunds as a means of soil conservation because they were effective in one season only unlike the other methods like terraces which were both effective and longer lasting.

Ho_1: There is no statistically significant influence of soil and water conservation on household food security among small-scale farmers in Kyuso Sub-County.

The hypothesis was tested using multiple linear regression by running the model in the SPSS. The independent variables were soil and water conservation technologies while the dependent variable was household food security measured by grain cereal and grain legume production from one acre of land. Table 6 shows the regression results.

Table 6

Soil and Water Conservation Influence on Household Food Security

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.884	1.157		5.087	.000
	Soil and water conservation technology	-.386	.407	-.080	-.946	.346

Adj R^2= -.001**, F=** .896**, p=** .346

The hypothesis was tested at 0.05 level of significance. Since p = 0.346 which was greater than 0.05 the null hypothesis H_{01} was upheld. During focus group discussion farmers indicated that only about 20% of the households in the study area were regarded as being food secure. This was despite implementing soil and water conservation technologies at various levels. Reasons advanced were that there were frequent prolonged rainfall failures and poor agronomic practices. This agrees with Mati (2006), who observed that in arid and semi-arid areas, low productivity is usually associated with prolonged and recurrent drought and dry spells. The same results were obtained in India by Bouma and Scott (2006) who found out that in the semi-arid areas of India watershed development does not show a significant effect on dryland crop yields under prolonged drought conditions. Farmers indicated that they expect more benefits in good rainfall years.

4.5 Rainwater Harvesting and Household Food Security

Water harvesting is an important option for agricultural production in drylands. Water harvesting, which includes runoff farming and runoff storage can be less costly than irrigation and can be developed locally depending on rainfall and land conditions. Table 7 documents the water harvesting technologies practiced in the study area.

Table 7

Rain Water Harvesting Technologies N=140

Rainwater harvesting technology	Count	Column N %
Zai pits	33	23.6
Road side run - off water	19	13.6
Water pans	1	0.7

Table 7 shows that the most popular method of rain water harvesting was the zai pits where 23.6% of the farmers in the study area practiced it. This is followed by road side run-off water harvesting accounting for 13.6%. A negligible number, 0.7% used water pans as a method of water harvesting. Few farmers constructed water pans because the large financial outlay required to implement the technology.

Ho_2: There is no significant influence of rain water harvesting on household food security among small scale farmers in Kyuso Sub-County. The hypothesis was tested using multiple linear regression by running the model in the SPSS. The independent variables were rain water technologies while the dependent variable was household food security measured by grain cereal and grain legume production from one acre of land. Table 8 shows regression results of this hypothesis.

Table 8

Influence of Rain Water Harvesting on Household Food Security

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.957	.793		6.248	.000
	Methods of water haevesting	-.042	.233	-.015	-.179	.858

Adj R^2= -.007, **F=** .032, **p=** .858

The hypothesis was tested at 0.05 level of significance. The p obtained was 0.858, hence the null hypothesis H_{02} was upheld. This finding is contrary to expectations but agrees with Kaluli, Nganga, Home, Gathenya, Muriuki and Kihurani (2012) . While investigating the effect of rainwater harvesting and drip irrigation on soil moisture and crop performance in ASAL area of Kaiti water shed in Makueni County Kaluli, et al (2012) found that water harvesting technologies (zai pits and contour ridges) did not significantly increase soil moisture when compared to the control. The pits and contour ridges failed to collect and store rain water and provide adequate moisture to crops even after the rain had stopped. Because rainfall was insufficient during most of the study period, there was hardly any surface runoff even from the control and drip irrigated plots. Although Mati (2006) found that contour ridges and zai pits increased the yield of maize in semi–arid climate, in this study such increase did not significantly influence household food security at 5% level of significance.

4.6 Soil Fertility Improvement and Household Food Security

Poor soil fertility is an inherent problem in arid and semi-arid soils. When farmers were asked whether or not they faced problems with low soil fertility 95.7% said yes while only 4.3% said no. Figure 7 below gives the breakdown of the response:-

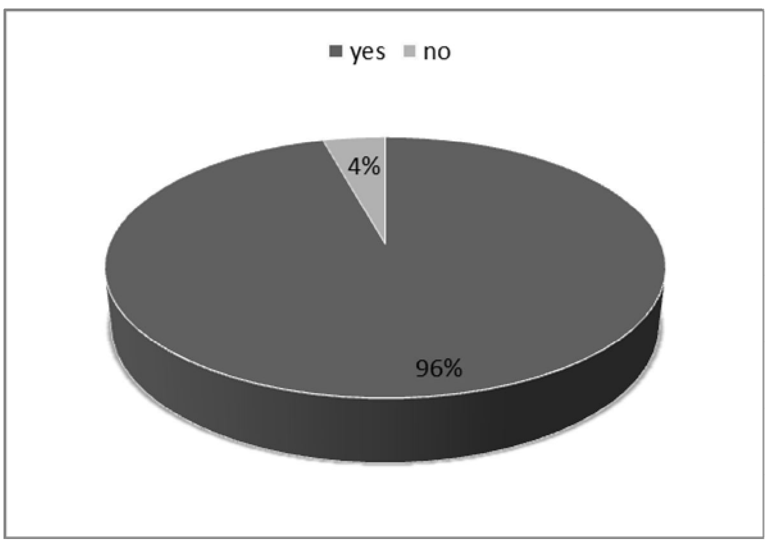


Figure 7. **Percentage of farmers that face soil fertility challenges**

Figure 7 above shows that most of the farmers in the Sub-County experience problems of low soil fertility. Making effort to improve farm soil fertility is essential in order improve crop production and hence household food security.

Table 9

Methods of Soil Fertility Improvement N=140

Soil Fertility Improvement Technology	Frequency	Percentage
Make and apply compost manure	9	6.4
Application of farm yard manure	100	71.4
Application of mineral fertilizers	2	1.4
Use of fallow method	7	5.0
Crop rotation	39	27.9
Crop residue	18	12.9
Tractor ploughing	1	0.7
Making terraces	4	2.9
Do nothing	17	12.1

The most popular method of soil fertility improvement in the Sub-County is farm yard manure. Out of 140 farmers interviewed 71.4% indicated that they apply farm yard manure as a way of improving soil fertility in their farms. The second most common method is crop rotation accounting for 39%. Use of crop residue incorporation in the soil is done by 12.9% while a paltry 1.4% applies mineral fertilizers. It is noteworthy that 12.1% of the respondents make no effort at all in improving soil fertility of their farms.

Table 10

Soil Fertility Improvement Frequency N=140

Method	Once a year	Twice a year	Not regular	Never
compost manure	2.20	0	0	97.80
Farmyard manure	58.70	15.90	1.40	23.90
Mineral fertilizer	0	2.90	0	97.10
Use of fallow	2.90	0	0	97.10
Crop rotation	13.90	19.00	0	67.20
Crop residue	5.30	21.20	5.30	68.40

Table 10 shows the frequency of application of the commonly used soil fertility improvement technologies. It is observed that most farmers in Kyuso Sub-County who use soil fertility improvement methods do so regularly either once or twice a year. Table 11 shows that 58.7% of the farmers who apply farm yard manure do so once a year while 15.9% apply farm yard manure in their farms twice a year.

Table 11

Rating of Soil Fertility Improvement Methods N=140

	Percentage Rating on technology effectiveness in improving production			
Technology	**Not Effective**	**Slightly Effective**	**Highly Effective**	**Very highly effective**
Compost manure	33.3	0.0	66.7	0.0
Farmyard manure	0.0	31.5	59.3	9.3
Mineral fertilizer	0.0	20.0	80.0	0.0
Use of fallow	0.0	60.0	40.0	0.0
Crop rotation	2.2	84.4	13.3	0.0
Crop residue	0.0	60.0	40.0	0.0

Table 11 above tabulates how farmers rated the effectiveness of selected soil fertility improvement technologies. The method accepted by most farmers and rated as being very highly effective and highly effective in improving farm production is farm yard manure at 9.3% and 59.3% respectively. Compost manure is quite similar to farm yard manure and 66.7% of those who had used the technology rated it as being very effective in improving farm production. Eight percent of farmers who had used mineral fertilizer rated it as being very effective in improving farm production. During focus group discussion farmers were asked why not many of them were using mineral fertilizers. Their response was that they feared their farms would become unproductive during the subsequent seasons.

Table 12

Constraints in Soil Fertility Improvement N=140

Constraint	Frequency	Percentage
Farm yard manure inadequate	88	62.9
Ferrying FYM too cumbersome	65	46.4
Shortage of labour	38	27.1
High cost of labour	44	31.4
Composting skills lacking	5	3.6
High cost of inorganic fertilizer	11	7.9
Not aware of inorganic fertilizer application	3	2.1
Soil erosion washing away applied nutrients	12	8.6
Lack of farm tools	8	5.7
Ignorance	6	4.3
Fear of weeds	5	4.3
Manure increase termites and chaffer grabs	2	1.4
Lack of knowledge on how to apply manure	2	1.4
Poor health	2	1.4
Farm too large	1	.7
Inadequate rainfall	1	.7
Trampling of farm by animals	1	.7

Whereas farmers agreed that farmyard manure application was important in improving crop production not many of them were applying to the maximum. When asked what constraints they faced 62.9% said they did not have adequate supplies to apply to their farms. Some 46.4% found it cumbersome to ferry and apply farm yard manure while 27.1% faced shortage of labour. 31.4% had problems with high cost of labour.

H_{03}: There is no significant influence of soil fertility improvement on household food security among small-scale farmers in Kyuso Sub-County

This hypothesis was tested using multiple linear regression by running the model in the SPSS. The independent variables were soil fertility improvement technologies while the dependent variable was household food security measured by grain cereal and grain legume production from one acre of land. Table 13 below shows the regression results.

Table 13

Influence of Soil Fertility Improvement on Household Food Security

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	4.154	.593		7.009	.000
	Soil fertility improvement Technologies	.877	.678	.109	1.293	.198

Adj R^2= .005 , **F=** 1.673, **p=** .198

At 0.05 level of significance, p was 0.198 which is greater than 0.05 and hence fail to reject the hypothesis. Observations during data collection showed that the farmers in the study area are agro-pastoralists. During focus group discussion farmers indicated that, after harvesting, livestock were allowed to graze freely in the farms. This production system greatly reduced availability of organic matter in the soil. Majority of farmers (98%) who applied farm yard manure did not improve quality through composting. 62.9 % of the farmer interviewed did not have adequate supplies of the farm yard manure. In his paper titled a search for strategies for sustainable dryland cropping in semi-arid eastern Kenya,

Probert (1992) observed that farmers in Kitui and Makueni Districts experience problems of declining yields due to low soil fertility. The same paper inferred that manure supplies were inevitably inadequate to prevent yield decline to a low-level equilibrium (Probert, 1992). Probert (1992) further found that farmers often had inadequate knowledge to prevent misapplication of farmyard manure. A similar study done in Mangwe District, Zibambwe, assessed the impact of conservation agriculture on food security and livelihoods. Key among the findings was that while conservation agriculture did improve yields per acreage, the improvement did not necessarily translate to improved food security. This was mainly due to climatic factors, including the poor rainfall experienced in the District (Tshuma, Maphosa, Ncube, Dube & Dube, 2012)

The inability of soil fertility improvement to positively influence household food security at 5% level of significance could be due to various reasons. Some of the reasons could be that farmers applied low quantities of poor quality manures, poor methods of manure application and poor rainfall regime experienced. This observation was made during focus group discussion and data collection.

4.7 Production of Drought Tolerant Crops

The major crops that were found to be grown in Kyuso Sub-County were maize, cow peas, green grams, sorghum, millet, beans, pigeon peas, dolichos, millet and sorghum. Figure 8 summarizes the major crops grown in the Sub-County. Almost all households amongst the sampled farmers in the study area were engaged in maize production (97.1%). The next two important crops in the Sub-County were cow peas and green grams. Millet and sorghum were also grown though they were relegated to fourth and fifth positions respectively.

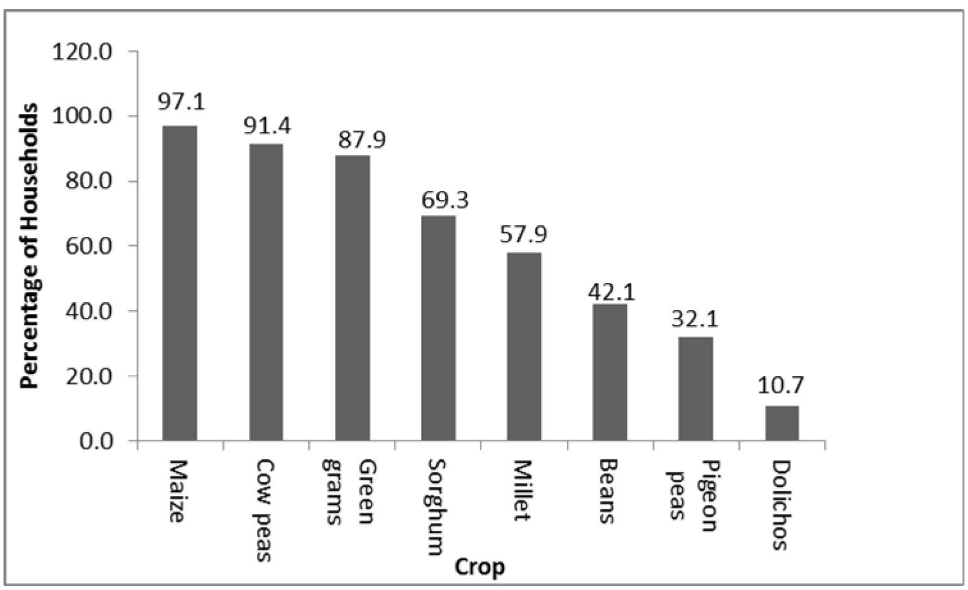


Figure 8. **Crops grown in the Sub-County**

The level of millet and sorghum production was found to be low with most farmers in the Sub-County. To this end 47% of the farmers interviewed rated their level of millet and sorghum production to be low, 29% rated as medium while on 24% felt that their production level was high. During focus group discussion farmers indicated that millet is grown for food while sorghum is grown as a cash crop having found a market with the Kenya Breweries Company.

Crop production was analysed in comparison to consumption. Farmers were asked to state their production and consumption over the previous one year. Figure 9 shows that consumption exceeded production for the following food crops: maize, sorghum, cowpeas and dolichos. Crops whose production per household exceeded consumption were millet, pigeon peas and beans.

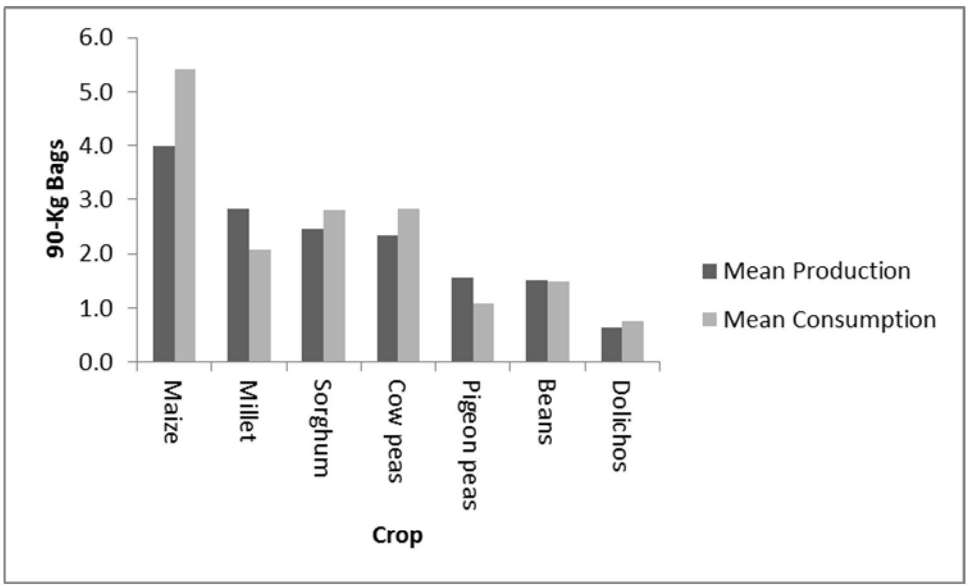


Figure 9. **Mean crop production and consumption per household**

This implies that farmers in the study area were not food secure. They had to rely on market purchase to top up their household food consumption.

4.7.1 Farmers constraints in drought tolerant crop production

Farmers were asked to indicate constraints in millet and sorghum production. Several possible constraints were provided and farmers were told to tick as many constraints as they were facing. They were also given an opportunity to list others which did not correspond to the one provided. Table 14 shows the farmers' response.

Table 14

Constraints in Millet and Sorghum Production N=140

Constraint	Count	Column N %
High bird infestation	69	49.3
Inadequate utillization skills	5	3.6
Lack of market for the produce	19	13.6
Lack of processing machines	0	.0
Crop is associated with backwardness	0	.0
Crop produce is not palatable	7	5.0
High labour requirement	26	18.6
Small farm size	4	2.9
Pest infestation	2	1.4
Belief that not a millet zone	1	.7
Produce not preferred	4	2.9
Varieties not productive as maize	3	2.1
Inadequate land	1	.7
Crop not preferred	4	2.9
Lack of draught animals	1	.7
Involvement in other activities (casual jobs)	1	.7
Low price for the produce	1	.7
Poor type of seeds	1	.7

As shown on Table 14 the most important challenge, which was highlighted by most farmers, was high bird infestation. Forty nine per cent of farmers in Kyuso Sub-County cited that they do not produce millet and sorghum because birds are a major menace and that they do not have enough time to scare off the birds. The farmers explained that this was the major reason why they end up shunning small grains for maize production. Furthermore, farmers indicated that the birds drastically reduced yields. In contrast, there were no birds attacking maize crop and this made production of small grains laborious and unattractive to farmers. High labour requirement in terms of bird scaring, harvesting and threshing followed next in the constraints reported by farmers. A total of 19% of farmers cited problem of high labour requirement. In the same way, 14% of farmers mentioned lack of market for the produce. This is because at times farmers reported that they like growing crops with high market value

Ho_4: There is no statistically significant influence of drought tolerant crops on household food security among small-scale farmers in Kyuso Sub-County. The hypothesis was tested using multiple linear regression by running the model in the SPSS. The independent variables were production of millet and sorghum representing drought tolerant crops while the dependent variable was household food security measured by grain production from one acre of land. Table 15 shows the regression results for this null hypothesis.

Table 15

Influence of Drought Tolerant Crops on Household Food Security

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.721	.672		7.029	.000
	Growing of millet and sorghum	.127	.744	.014	.170	.865

Adj R^2= -.007 , **F=** .029, **p=** .865

At 0.05 level of significance, p = 0.865 and hence the null hypothesis was upheld.

Challenges that prevent farmers from engaging in serious production of sorghum and millet have been identified. These include high bird infestation and high labour intensive compared to other crops like maize and green grams. Farmers who grew the crops were few and only small areas were put under the crop. Other reasons advanced were that there were frequent prolonged rainfall failures and poor agronomic practices. This agrees with Mati (2006), who observed that in arid and semi-arid areas, low productivity is usually associated with prolonged and recurrent drought and dry spells.

4.8 Thematic Analysis Results

During the course of the three focus groups discussions, participants gave their opinions and descriptions of dryland farming technologies, crop production and status of household food security.

They discussed and listed the soil and water conservation, rain water harvesting and soil fertility improvement technologies as practiced in their area. They also listed the drought tolerant crops grown together with their average annual yields. The participants gave their opinion of what food security is and made an assessment of the status of the household food security prevailing at that moment.

The following sections outline the main themes and subthemes emerging from analysis of the interview transcripts.

4.8.1 Soil and water conservation technologies

Soil and water conservation technologies refers to methods techniques that farmers apply in their farms to minimize loss of top soil and ensure soil moisture is retained in the soil for a longer time. The following open ended question was posed to the participants of the focus group discussion:

"Which are the main soil and water conservation technologies you practiced in your area?" The participants listed the technologies as here below:-

(i) Stone lines

(ii) Trash lines (drawn from millet, sorghum, maize stovers or grass).

(iii) Log lines – usually in newly opened land

(iv) Grass strips

(v) Excavation of terraces

(vi) Stabilizing terraces by planting sorghum on the embankment

(vii) Contour ploughing

(viii) Hand digging

(ix) Water pond/pan construction

(x) Ploughing in stover

(xi) Planting grass in fallow land.

4.8.2 Soil fertility improvement

Soil fertility improvement refers to the actions, materials and methods that farmers employ to ensure that the soil in their farms has the ability to supply nutrients that support optimum crop growth and production. The FGD participants were asked, *"Which methods do you use to improve soil fertility of your farms?"* They listed the technologies as:-

(i) Farm yard manure application

(ii) Composting

(iii) Incorporating crop residue in to the soil during land preparation

(iv) Green manuring using pearl millet as the green manure

(v) Intercropping legumes with cereals

(vi) Crop rotation

(vii) Keeping livestock off the farm by fencing.

At this point one participant explained that, "we keep livestock, goats and cattle to be specific. During dry period when we have harvested crops we allow livestock to graze freely in the farms. This is interfering with the fertility of our farms". Another participant while supporting the idea said, "I have fenced off my farm. I neither allow livestock in nor do I carry crop residue out of my farm. The farm has remained fertile and supports a good harvest".

4.8.3 Methods of rain water harvesting for crop production

These are techniques that when implemented harvest run-off and direct it to the root zone of crops. They also refer to structures that are excavated or constructed to store run-off or rain water for the purpose of supplementary irrigation to bring crops to maturity in the event rainfall is inadequate. Participants of the FGD were asked, *"How do you harvest water for crop production?"* To this question the following responses were given:-

(i) Construct / excavate water pans

(ii) Ridging while digging using oxen plough

(iii) Diverting run-off water from paths/roads in the farms

(iv) Zai pits

(v) Retention ditches

(vi) Irrigation.

Some participants had this clarification to make, "road side run-off water harvesting is not practiced by many farmers. They fear that diverting water in the farms could lead to accelerated erosion of their farms. Others are just not aware of the technology".

4.8.4 Drought tolerant crop production

Some crops and varieties require less water than others once they are established. They possess greater resilience to agricultural production under drought stress and escape drought through early maturity. Farmers participating in the FGD asked, "*which drought tolerant crops do you grow and what is the production from one acre piece of land?"* The response was tabulated as follows:-

Table 16

Drought Tolerant Crops Production per Acre

Crop	Production per acre
Maize	4 bags
Millet	3 bags
Sorghum	4 bags
Beans	4 bags
Cow peas	4 bags
Green grams	3 bags
Green grams	3 bags
Pigeon peas	5 bags
Dolichos	6 bags

Participants made certain comments concerning the crops and their production potential. One participant said, "maize is popular and is grown by most farmers but almost always leads to crop failure except in very good seasons". Another participant commented, "sorghum and millet are not popular as they demand bird scaring, have no demand in the market and are not preferred for home consumption".

4.8.5 Food Security

The FGD participants were asked to define food security the question, "*What do you understand by food security?"* Their response was, "*a* situation where a household has harvested enough produce (cereals and pulses) to last for one year i.e., from one harvest to the next harvest". The researcher wanted to the approximate quantities in the farmers' opinion that constitute food security. To get that information the researcher asked the participants, "*How much food stuff does a household need per year to be considered food secure?"* One participant replied, "it depends on the family size but in our locality on average the following apply:- cereals (maize, sorghum, millet) 7-10 bags and pulses (beans, cow peas, pigeon peas, green grams, dolichos): 3-6 bags". All the other participants were in agreement.

The researcher was interested in finding out the farmers' opinion about the household food situation in the study area and their perceived reasons. To this end the following questions were asked and responses obtained from the participants. "*In your opinion do you consider farmers in your area food secure?"* There was unanimous agreement that the farmers in the area were not food secure. The researcher further asked, "*what do you think could be the causes of food insecurity in some households even after a good rain season?"* The following reasons were given by participants as some of the causes of household food insecurity in the study area:-

(i) Failure to construct terraces
(ii) Lack of farm preparedness for the planting season
(iii) Late planting
(iv) Planting inappropriate crop/seed variety
(v) Selling farm produce soon after harvesting
(vi) Lack of agroforestry trees
(vii) Wrong inter crops e.g. intercropping maize with millet of sorghum
(viii) Incorrect spacing/ plant population
(ix) Lack of seeds at planting season
(x) Grazing in the farm after harvesting
(xi) Very small farms
(xii) Rocky/small farms
(xiii) Lack of enough soil conservation structures
(xiv) Poor soil fertility

The researcher also wanted to know a quantified figure of food security situation as per the farmers' opinion. In that connection the researcher asked, "*What could be the current food situation in your area? (Out of ten households how many would you consider as being food securer:* The response was: food secure, 2 out of 10, food insecure, 8 out of 10

The researcher wanted to find out what the farmer perceived as the best options for attaining food security in Kyuso Sub-County. To achieve that the researcher asked, "*in your opinion, which farming technologies if embraced can eradicate food insecurity and poverty in your area?* The participants deliberated and gave the following responses in order of priority:-

(i) Farmer training on good agricultural practices

(ii) Terracing

(iii) Early land preparation

(iv) Compost/farm yard manure application

(v) Water harvesting (zai pits, retention ditches, water pans)

(vi) Early farmer preparedness e.g. acquisition of necessary inputs

(vii) Optimum plant population

(viii) Crop pest and disease control through spraying

(ix) Practice conservation agriculture/ fence off the farms to keep livestock out of the farm

(x) Proper post- harvest management through dusting and storage of farm produce.

(xi) Crop rotation

CHAPTER FIVE
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents a summary of the study objectives, conclusion drawn from the findings of the study and recommendations for possible action and areas of further research. The chapter also reaffirms the purpose of the study.

5.2 Summary

This study was carried out in Kyuso Sub-County of Kitui County. The purpose of the study was to identify dryland farming technologies that could be effectively used to alleviate household food insecurity of small-scale farmers in Kyuso Sub-County.

The independent variables in the study were dryland farming technologies while dependent variable was household food security measured by the amount of grain cereal and grain legumes produced. This study adopted a descriptive survey design. A Focus Group Discussion Guide and a questionnaire were the two instruments used to collect data from a sample of 176 respondents. Data from 36 farmers in three Focus Group Discussions was transcribed and analyzed using thematic analysis technique. Qualitative data from the administered questionnaires were analyzed using descriptive statistics namely percentages and frequencies. Multiple linear regression was used to determine the influence of the independent variables on the dependent variables at 0.05 level of significance.

Objective one sought to determine the demographic characteristics of the small-scale farmers Kyuso Sub-County. The demographic characteristics examined were gender, age, education level, farming experience and the type of land ownership. The study found that most of the respondents were female (61%), the most predominant age bracket was 36-45 (32.1%). A majority of the respondents had attained primary school education (68.6%). The majority of the farmers in the study area had a long farming experience of over 20 years (57.9%) with a further 23.6% with between 10 and 20 years of experience. Individual land ownership was the most predominant land tenure system in the area (72.9%). This offered incentive for investment in dryland farming technologies.

Objective two examined the influence of soil and water conservation on household food security of small scale farmers in Kyuso Sub-County. The study found that soil and water conservation technologies practiced by small scale farmers in Kyuso sub-county were found to be *fanya chini* / retention ditches, *fanya juu* terraces, log lines, stone lines, grass strips, trash lines and earth bunds. The most popular technology is *fanya juu terraces* followed by *Fanya chini* or retention ditches. The least utilized technology according the study results was earth bunds. The influence of soil and water conservation on household food security among small-scale farmers in Kyuso Sub-County was found to be insignificant at 5% level of significance ($p > 0.05$).

Objective three sought to investigate the influence of rain water harvesting on household food security of small-scale farmers in Kyuso Sub-County. The study found that Water harvesting technologies practiced by small-scale farmers in Kuyso sub-county were road side run-off, Zai pits and water pans. The most popular method of rainwater harvesting were the zai pits. The influence of rain water harvesting on household food security among small scale farmers in Kyuso Sub-County was found to be insignificant at 5% level of significance ($p>0.05$).

Objective four was to establish the influence of soil fertility improvement on household food security of small-scale farmers in Kyuso Sub-County. The study found that poor soil fertility was a serious problem in Kyuso Sub-County. About 95.7% of farmers interviewed indicated that they were having the problem of low soil fertility. Methods used by the small-scale farmers to improve soil fertility in Kyuso Sub-County were found to be compost manure, application of farm yard manure, application of mineral fertilizers, use of fallow method, crop rotation and crop residue. Use of farmyard manure was found to be the most preferred method of soil fertility improvement among the small-scale farmers in Kyuso Sub-County. Application of mineral fertilizers was found to be extremely low because farmers feared their farms would become unproductive during the subsequent seasons. Inadequate supply was the major constraint that prevented farmer applying adequate farmyard manure to their farms. The influence of soil fertility improvement on household food security among small-scale farmers in Kyuso Sub-County was found to be statistically insignificant at 5% level of significance ($p>0.05$).

Objective five sought to assess the influence of growing drought tolerant crops on household food security of small- scale farmers in Kyuso Sub-County. The study found that the level of millet and sorghum production was low with most farmers in the Sub-County. High bird infestation was the main reason why most farmers did not plant millet and sorghum. The other two reasons were found to be high labour requirement and lack of market for the produce. The influence of drought tolerant crops (millet and sorghum) on household food security among small-scale farmers in Kyuso was insignificant at 5% level of significance.

5.3 Conclusion

The findings of this study led to the following conclusions:-

(i) Demographic characteristic of the small-scale farmers that could have affected the outcome of the study was gender since there was gender imbalance in the community in dryland farming in the study area.

(ii) Soil and water conservation technologies alone do not necessarily ensure household food security.

(iii) Frequent prolonged rainfall failures and poor agronomic practices are some of the important factors that deny farmers the full benefits of soil and water conservation technologies.

(iv) Maintaining good soil cover through retaining organic matter after harvesting could be crucial in enhancing the function of soil fertility improvement technologies.

(v) Improved yields per unit area due to soil fertility improvement technologies do not necessarily translate to improved food security.

(vi) Certain constraints such as high bird infestation, high labour requirement and lack of market for the produce made production of sorghum and millet so low that it could not ensure food security at household level of small-scale farmers in Kyuso Sub-County.

5.4 Recommendations

(i). The County Government should come up with programmes that empower women since majority of people involved in agricultural activities in the ASAL areas are women.

(ii). The County Government should promote other agronomic practices that support effectiveness of soil conservation structures.

(iii). The County Government and other stakeholders should invest in irrigation so that during seasons of inadequate rainfall supplementary irrigation is done in order to bring crops to maturity and thus prevent crop failure.

(iv). The County Government through the Ministry of Agriculture should train farmers on how to improve the quality of organic manures through composting and the correct methods of application. Farmers should also be taught about the correct quantities and combination of manures that can influence household food security.

(v).The Government should formulate policies that encourage production and consumption, marketing of millet and sorghum.

5.5 Recommendations for Further Research

Based on the outcome of this study it is recommended that an in-depth study be carried out to investigate the conditions under which the dryland farming technologies will positively influence household food security among small-scale farmers in the arid and semi-arid areas.

REFERENCES

Adato, M., & Dick, R.M. (2002 ,March). *Assessing the Impact of Agricultural Research on Poverty Using the Sustainable Livelihoods Framework.* (FCND discussion paper No. 128). International Food Policy Research Institute. Washington, D.C., U.S.A.

Amaza, P., Tahirou, A., Patrick, K., & Amare, T. (2009). *Changes In Household Food Security And Poverty Status In PROSAB Areas Of Southern Borno State, Nigeria. Promoting Sustainable Agriculture in Borno State (PROSAB)*. International Institute of Tropical Agriculture, Ibadan, Nigeria.

Amudavi, D.M. (2005). *The Contribution of Farmer Group Participation to Improved Natural Resource Management Practices*. USAID BASIS Policy Brief No. 7. Retrieved March 31, 2012 From Http:// dyson.cornell.educ /special _programs/afsnrm/basis/document/briefs/2005/amudavibrief7.pdf.

Altieri, M.A., & Toledo, V.M. (2005). Natural Resource Management Among Small-scale Farmers in Semi-arid Lands. Building on Traditional Knowledge and Agroecology, *Annals of Arid Zone* ,44(3&4), 365-38.

Ashley, C., & Carney, D. (1999). *Sustainable Livelihoods: Lessons From Early Experience*. London: Department for International Development.

Bationo, A., Hartemick, A., Lungu, O., Naimi, M., Okoth, p., Smaling, E., & Thiombiano, L. (2006, June). *African Soils: Their Productivity and Profitability of Fertilizer Use Background*. (Paper Prepared for the African Fertilizer Summit June 9-13, 2006). Abuja, Nigeria.

Biamah, E.K. (2001). *Seasonal Conservation Tillage Reports (1999-2001) For Iiuni Conservation Tillage Trials Site, Machakos, Kenya.* RELMA/Sida Report, Nairobi, Kenya.

Biamah, E.K., & Nhlabathi, N. (2003). *Conservation Tillage Practices For Dryland Crop Production In Semi Arid Kenya: Promotion of Conservation Tillage Techniques for Improving Household Food Security in Iiuni, Machakos, Kenya*. p 45-50. In: Beukes, D., de Villiers, M., Mkhize, S., Sally, H., and van Rensburg, L. (eds.), Water Conservation Technologies for Sustainable Dryland Agriculture in Sub-Saharan Africa (WCT), Proceedings of The WCT Symposium and Workshop. 8-11 April, 2003. Bloemfontein, South Africa.

Boermansab, M, A., & Kattenbergb, M.A.C. (2011). Estimating reliability coefficients with heterogeneous item weightings using Stata: A factor based approach. *Tjalling C. Koopmans Research Institute. Discussion Paper Series No. 11-19. Retrieved on March 20, 2012 From, http:// www.uu.nl/rebo/economie/discussionpapers*

Bouma, J. & Scott, C. 2006. *The possibilities for dryland crop yield improvement in India's semiarid regions: Observations from the field*. Comprehensive Assessment discussion paper no. 3. Colombo, Sri Lanka: Comprehensive Assessment Secretariat.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3, 77-101.*

Chambers, R., Conway, G., (1992). *Sustainable Livelihoods: Practical Concepts For The 21st Century.* IDS Discussion Paper 296, University of Sussex, London: Institute of Development Studies.

Chambers, R. (1983). *Rural Development: Putting the Last First.*: Harlow, UK: Longman Scientific and Technical, Essex.

Cohen, L., Manion, L., & Morrison, K. (2007). *Research Methods in Education (6th ed)*. Oxford, UK : Routledge Publishers.

Creswell R., & Martin, F.W. (1998). *Dryland Farming. Crops and Techniques For Arid Regions*. (2nd ed). USA: Echo Staff.

Denscombe, M. (2007). *The Good Research Guide for small-scale social research projects* . McGraw-Hill Education. McGraw-Hill House, England: Open University Press.

Douglas, M. (1994). Sustainable Use of Agricultural Soils: A Review of The Prerequisites for Success or Failure, *Development and Environment Report No. 11.* Group for Development and Environment, Institute of Geography. Switzerland: University of Berne.

Djomo J.M. N., & Fondo S. (2012). *The Effects of Human Capital on Agricultural Productivity and Farmer's Income in Cameroon:* International Business Research Vol. 5, No. 4; April 2012

Drechsel, P., Olaleye, A., Adeoti, A., Thiombiano, L., Barry, B. & Vohland, K. (2004). *FAO Adoption Driver and Constraints of Resource Conservation Technologies in Sub-Saharan Africa.* . Accra, Ghana: FAO Regional Office for Africa,

FAO. (1989). *The Arid Environments.* Retrieved on February 8, 2012 From http:// www.fao.org/docrep/T0122E/ t0 122e03.htm.

FAO. (1996). *Rome Declaration and World Food Summit Plan of Action. Rome.* Retrieved on February 8, From http:// www. fao.org /docrep /003/X8346E/x8346e02.htm#P1_10.

FAO. (2001). *Soil Fertility Management in Support of Food Security in Sub-Saharan Africa.* Food and Agriculture Organization. Rome, Italy : Food and Agriculture Organization.

FAO. (2003). *Conceptual Framework for National, Agricultural, Rural Development, and Food Security Strategies and Policies, by K. Stamoulis and A. Zezza.* Rome: Earthscan press.

FAO. (2007). *National Programmes for Food Security: FAO's Vision of a World Without Hunger*. Rome, Italy: Food and Agriculture Organization.

FAO. (2008a).*Water and Cereals in Drylands.* The Food and Agriculture Organization of the United Nations and Earthscan. Malta: Gutenberg Press Ltd,

FAO. (2008b, June). *Special Report; Crop and Food Supply Assessment Mission to Zimbabwe* 18 June 2008. Retrieved on March 30, 2012 From: http://www.fao.org/docrep/010/ai469e/ai469e00.htm

FAO. (2010). *The State of Food Insecurity in the World; Addressing food insecurity in protracted crises*. Rome, Italy: Food and Agriculture Organization.

Fraenkel, J.R., & Wallen, N.E. (2000). *How to Design and Evaluate Research in Education*, New York: N.Y. McGraw-Hill Publishing Co.

Gichuru, M.P., Bationo, A., Bekunda, M.A., Goma, H.C., Mafongonya, P.L., Mugendi, D.N., Murwira, H.M., Nandwa, S.M., Nyathi, P. & Swift, M.J. (2003). *Soil Fertility Management in Africa: A Regional Perspective*. Nairobi: Academy Science Publishers.

Gichuki, F.N., (2000). Makueni Sub-County Profile: Soil Management and Conservation, 1989-1998', *Drylands Research Working Paper 4***.** United Kingdom, Drylands Research ,Crewkerne.

GOK. (2009). *Kyuso District Development Plan, 2008-2012. Kenya Vision 2030 , towards a globally competitive and prosperous Kenya.* Nairobi: Government printer.

GOK. (2010). *Agricultural Sector Development Strategy 2010–2020* Nairobi: Government printer.

Global Research Development Center. **(**2008). *An Introduction to Rainwater Harvesting*. Kobe, Japan. Global Research Development Center. Retrieved on November 4, 2012 from http://www.gdrc.org/uem/water/rainwater/ introduction.html

Hai, M. (1998). *Water Harvesting – An illustrative Manual for Development of Microcatchment Techniques for Crop Production in Dry Areas.* Nairobi: Regional Land Management Unit.

Hinrichsen, D. (2000). *Requiem for a Dying Sea, People and Planet.* Retrieved on August 2, 2011 From http://www.peopleandplanet.net/doc.php?id=384

Hussein, A.E. (2005, April-May). *Similarities in the World of the Indian Ocean: Interaction of Cultures – Roots and Routes.* Canadian Association of African Studies Annual Conference April 27 – May 1, 2005, Montreal, Quebec.

International Fund for Agricultural Development. (2007). *Food, poverty and women. Lessons from rural Asia.* Retrieved on May 10, 2011 From http:// http:www.ifad.org

International Food Policy Research Institute. (2001). *Pilot Analysis of Global Ecosystems (PAGE) Agro-ecosystems*, Washington, DC.

International Labour Organization. (2007). *Employment by Sector. in Key indicators of the Labour Market (KILM)*, (5^{th} Ed). Chapter 4. Retrieved on May 10, 2011 From http:// www.ilo.org/public/English/employment/strat/kilm/download/kilm04.pd

Jan, B.P. (2007). *Agricultural Research to Help The Small-Scale Farmer in Developing Countries.* Taiwan ROC. Food and Fertilizer Technology Center for the ASPAC Region Taipei.

Kenya Food Security Steering Group. (2011). *Mwingi Sub-County Short Rains 2010 Assessment Report (17^{th} –21^{st} January 2011).* Nairobi: Kenya Food Security Steering Group.

Kaloi, E., Tayebwa, B., & Bashaasha, B. (2005). Food security status of households in Mwingi Sub-County, Kenya. *African Crop Science Society*. African Crop Science Conference proceedings, Vol. 7. pp. 867-873.

Kaluli J.W., Nganga K., Home P.G., Gathenya J.M., Muriuki A.W., & Kihurani A.W. (2012) . Effect of Rain Water Harvesting and Drip Irrigation on Crop Performance in an Arid and Semi-Arid Environment. *Jagst vol. 14(2) 2012*

Kathuri, N. J., & Pals, D.A. (1993). *Introduction to Educational Research*. Egerton University, Njoro, Education Materials Center.

Kenya National Bureau of Statistics. (2010). 2009 *Kenya Population and Housing Census Volume1a, Population Distribution by Administrative Units.* Nairobi: Government printer.

Kibwana, O. T. (2001). *Forging Partnerships Between Farmers, Extension and Research in Tanzania. In Farmer Innovation in Africa. A Source of Inspiration For Agricultural Development*. London: Earthscan.

Kimaru G., & Jama, B. (2005). *Improving Land Management in Eastern and Southern Africa: A Review of Practices and Policies*. ICRAF Working Paper No. 18. Nairobi: World Agro-Forestry Centre.

Kinyangi, A.A. (2014). Factors influencing the Adoption of Agricultural Technology Among Smallholder Farmers in Kakamega North Sub-County, Kenya. *University of Nairobi, Digital Repository, 2014 URI: http://hdl.handle.net/11295/76086*

Krantz, L. (2001). *The Sustainable Livelihood Approach to Poverty Reduction. An Introduction*. Stockholm, Sweden: Swedish International Development Cooperation Agency.

Kvale, S. & Brinkmann, S. (2009) *Interviews: Learning the Craft of Qualitative Research Interviewing*, Los Angeles, California: Sage printing press.

Lal, R., (2002). Carbon Sequestration in Dryland Ecosystems in West Asia and North Africa. *Land Degradation and Development* 13:45-59.

Lemba, J.K. (2009). *Intervention Model for Sustainable Household Food Security in the Drylands of Kenya: Case Study of Makueni Sub-County,* (Doctoral Dissertation). Ghent University, Belgium.

Léder, I. (2004). *Sorghum and Millets, in Cultivated Plants, Primarily as Food Sources* , [Ed. György Füleky], in Encyclopedia of Life Support Systems (EOLSS),Developed under the Auspices of the UNESCO, Eolss Publishers, Oxford ,UK, [http://www.eolss.net]

Leung, W.C. (2001). *How to Conduct a Survey. University of East Anglia*. Retrieved on January 24, 2012 http://www.archive.student.bmj.com/back_issues/0601/education/187.html.

Li, C.Y., Koskela, J., & Luukkanen, O. (1999). Protective Forest System in China: Current Status, Problems and Perspectives. *Ambio* 28(4): 341-345.

Lindorff M (2007). The Ethical Impact of Business and Organisational Research: the Forgotten Methodological Issue? *The Electronic Journal of Business Research Methods Volume 5 Issue 1, pp 21 - 28, available online at www.ejbrm.com*

Mati, B. M. (2006). *Overview of Water and Soil Nutrient Management Under Smallholder Rainfed Agriculture in East Africa,* (Working Paper 105). Colombo, Sri Lanka: International Water Management Institute (IWMI).

Meinzen-Dick, R., Quisumbing, A., Behrman, J., Biermayr-Jenzano, P., Wilde, V.,Noordeloos, M., Ragasa, C., Beintema, N.(2010). *Engendering Agricultural Research. IFPRI Discussion Paper 973*. International Food Policy Research Institute, Washington, DC. <www.ifpri.org/publication/engenderingagricultural-research>.

Micheni, A., Kihanda, F. & Irungu, J.(n.d). *Soil Organic Matter (SOM): The Basis for Improved Crop Production in Arid and Semi-Arid Climates of Eastern Kenya*. Embu : Kenya Agricultural Research Institute, (Research report). Retrieved on

January 26, 2012 from: http://webapp.ciat.cgiar.org/tsbf_inistitute/managing…/AfnetCh.17.pdf

MOA. (2009). *Ministry of agriculture strategic plan 2008-2012*. Nairobi: Government printer.

MOA. (2010). *Economic Review of Agriculture 2010*. Nairobi: Government printer.

MOA. (2011). *Kyuso Sub-County 2011 Annual Report.* Unpublished.

Mishra, A.K., Williams, & Detre ,J.D.(2009). "Internet Access and Internet Purchasing Patterns of Farm Households." *Agricultural and Resource Economics Review 38(2):240-257.*

Mollison, B. (2008). *Soil Conservation*. Retrieved on January 26, 2012 from http:en. wikipendia .org /wiki /soil conservation.

Mugenda, O.M., Mugenda, A.G, (2003). *Research Methods. Quantitative and Qualitative Approaches*. Nairobi: Acts Press.

Mukarumbwa , P. (2009). *Potential of Sorghum and Finger Millet to Enhance Household Food Security in Zimbabwe's Semi-Arid Regions: A Case Study of Communal Areas in Masvingo Province* (M.Sc. Thesis) University of Fort Hare , Alice Zimbambwe.

Mutai B.K. (2000). *How to Write a Quality Research Proposal: A Complete and Simplified Recipe*, New York, NY :Thelley Publications

Mutisya, T. W., Zejiao, L., & Juma, N. (2010). Soil and Water Conservation in Kenya-Operations, Achievements and Challenges of the National Agriculture and Livestock Extension Programme (NALEP) . *Journal of American Science*, 6(3) 7-15. Retrieved on January 8, 2012 From http://www.americanscience.org

Mutunga, K.; Critchley, W.; Lameck, P.; Lwakuba, A.; & Mburu, C. (2001). *Farmers' Initiatives in Land Husbandry. Promising Technologies for the Drier Areas of East Africa*. Technical Report No. 27.Nairobi: RELMA.

Mwalley, J. & Rockstrom, J. (2003). Soil Management in Semi-Arid Savannas. *Leisa Magazine,* 19, 8-10.

Nabhan, G.P. (1982). *The Desert Smells Like Rain: A Naturalist in Papago Indian Country*. Berkeley, California: North Point Press.

Nassiuma, D.K. (2000). *Survey Sampling; Theory and Methods.* Nairobi: Nairobi University Press.

National Ethics Advisory Committee. (2012). *Ethical Guidelines for Observational Studies : Observational research, audits and related activities .Revised edition* . Wellington: Ministry of Health

Ndiritu, S.W, Kassie, M .,& Shiferaw, B. (2014). Are there systematic gender differences in the adoption of sustainable agricultural intensification practices? Evidence from Kenya, *Food Policy 49 (2014) 117–127*

Onduru, D.O., Snijder, P., Muchena, F.N., Wouters, B., De Jegar, A., Gachimbi,L. & Gachini, G.N. (2008). Manure and Fertility Management in Sub-Humid and Semi-Arid Farming Systems of Sub-Saharan Africa: Experiences From Kenya. *International Journal of Agricultural Research* 3 (3):166-187. Nairobi, Kenya.

Perrier, E.R. & Salkini, A.B. (1991). *Introduction*. *In* E.R. Perrier & A.B. Salkini, eds. *Supplemental Irrigation in the Near East and North Africa,* pp. 1–14. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Probert, M.E., ed. (1992). *A Search For Strategies For Sustainable Dryland Cropping In Semi-Arid Eastern Kenya*. Proceedings Of A Symposium Held in Nairobi, Kenya, 1~11 December 1990. ACIAR Proceedings No. 41,138 p.

Reij ,C., & Steeds, D. (2003). *Success Stories in Africa's Drylands: Supporting Advocates and Answering Sceptics:* A paper commissioned by the Global Mechanism of the Convention to Combat Desertification: CIS / Centre for International Cooperation; Vrije Universiteit Amsterdam.

Rockström, J. (2000). Water Resources Management in Smallholder Farms in Eastern and Southern Africa: An Overview. *Phys. Chem. Earth* (b), 25(3), 275 – 283.

Siegert, K. (1994). I*ntroduction to Water Harvesting: Some Basic Principles for Planning, Design, and Monitoring. In: Water Harvesting For Improved Agricultural Production.* Proceedings of the FAO expert consultation, Cairo, Egypt, 21 – 25 Nov., 1993, pp 9 – 23. FAO, Rome. Shengxiu, L., & Ling, X. (1992). Distribution and Management of Drylands in the People's Republic of China. *Advanced Soil Science.,* 18: 148–302.

Shengxiu, L., & Ling, X. (1992). Distribution and Management of Drylands in the People's Republic of China. *Advanced Soil Science.,* 18: 148–302.

Shiferaw, B., Kebede, T.A., You, Z.(2008). Technology adoption under seed access constraints and the economic impacts of improved pigeon pea varieties in Tanzania. *Agric. Econom. 39, 1–15*

Shimelles T.,Islam K.M.Z.,& Parviainen T. (2009). Effects of land tenure and property rights on agricultural productivity in Ethiopia, Namibia and Bangladesh. *University of Helsinki, Department of Economics and Management, Discussion Papers n:o 33, Helsinki 2009.*

Squires, V.R. **(**1991). A Systems Approach to Agriculture. *In* V. Squires & P. Tow, Eds. *Dryland Farming: A Systems Approach*, pp. 3–15. Sydney, Australia: Sydney University Press.

Sulo T., Koech P. Chumo C. & Chepng'eno W. (2012).Socioeconomic Factors Affecting the Adoption of Improved Agricultural Technologies among Women in Marakwet

County. *Kenya Journal of Emerging Trends in Economics and Management Sciences (JETEMS) 3(4): 312-317 © Scholarlink Research Institute Journals, 2012 (ISSN: 2141-7024)*

Sutherland, A. J., Irungu, J. W., Kang'ara, J., Mutamia, J., & Ouma, J. (1999). Household Food Security in Semi-Arid Africa: The Contribution of Participatory Adaptive Research and Development to Rural Livelihoods in Eastern Kenya. *Food Policy,* 24 (4): 363-390.

Swallow, B., Okono, A., Ong, C., & Place, P. (2003). *Transvic: Improved Land Management Across The Lake Victoria Basin*.Nairobi: International Centre Reaseach In Agroforestry.

Tankou, C.M. (2013).*The Interactions Of Human Mobility And Farming Systems And Impacts On Biodiversity And Soil Quality In The Western Highlands Of Cameroon*. Department of Conservation Biology, Institute of Environmental Sciences, Faculty of Science, Leiden University. 2013

Taylor, J.R, Schober, T.J, & Bean, S., (2006). Novel and Non-Food Uses for Sorghum and Millets. *Journal of Cereal Science,* 44: 252-271.

Thomas (Ed.), D.B. (1997). *Soil And Water Conservation Manual for Kenya. Soil and Water Conservation Branch, Ministry of Agriculture, Livestock Development and Marketing.* Nairobi: English Press.

Thiombiano, L. 2004. Overview of Best Practices For Farmland Restoration And Conservation In West Africa. IWMI, FAO, Workshop On Restoration Of African Farm-And Rangelands Accra, 23 To 25th August 2004. Accra, Ghana: IWMI.

Tiffen, M., Mortimore, M., & Gichuki, F. (1994). *More People, Less Erosion – Environmental Recovery in Kenya.* Nairobi: Actspress.

Tenge, A.J.M. (2004). Social and economic factors affecting the adoption of soil and water conservation in West Usambara highlands, Tanzania. *Land Degradation and Development.march.2004*

Tshuma N., Maphosa M., Ncube G., Dube T. & Dube Z.L. (2012).The Impact of Conservation Agriculture on Food Security and Livelihoods in Mangwe District. *Journal of Sustainable Development in Africa (volume 14, no.5, 2012). issn: 1520-5509* Clarion University of Pennsylvania, Clarion, Pennsylvania

United Nations Convention to Combat Desertification. **(**2000). *An Introduction to The United Nations Convention to Combat Desertification. Retrieved on May 18, 2011 From* http://www.unccd.Int.

United Nations Environmental Programme**. (**1982). *Rain and Storm Water Harvesting in Rural Areas*. United Nations Environment Programme. Tycooly, Dublin: International Publishing Ltd.

United Nations Environmental Programme. (2000). *Sourcebook of Alternative Technologies For Freshwater Augmentation in West Asia. Retrieved on April 20, 2011 From httpp://*www.unep.Org.jp

United States Department of Agriculture. (2010). *Food Security Assessment, 2010-20 A Report From The Economic Research Service GFA-21. Retrieved on April 20, 2011* from http:// www.ers.usda.gov

White, R.P., & Nackoney, J. (2003). *Drylands, People, And Ecosystem Goods and Services*: A Web-Based Geospatial Analysis. Retrieved April 23, 2011 from http://pubs.wri.org

Willy, D.K., Chiuri, W. (2010). New common ground in pastoral and settled agricultural communities in Kenya: renegotiated institutions and the gender implications. *Euro. J. Dev. Res. 22 (5), 733–750.*

Witsenburg, K. (2012). *Food Security in Dry Lands: How Can We Manage Our Land to Achieve Food Security?* Both ENDS Amsterdam, 2012. Retrieved from www.desireproject.eu/disclaimer on 6th August 2015.

World Health Organization. (2011). *Trade, Foreign Policy and Health – Glossary of Globalization Trade and Health Terms (Paper)*. Retrieved on April 23, 2011from htpp://www.Who.Int/Trade/Glossary/Story028/En/

Xiao-Yan L. (2000). Soil and Water Conservation in Arid and Semiarid Areas: The Chinese Experience : Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences, Lanzhou 730000, P.R.China ;*Annals Of Arid Zone*, 39(4),1-18

APPENDIX A

INVITATION LETTER TO FARMERS

Dear_______________________________________

You are invited to take part in a discussion on dryland farming technologies and the influence they have on household food security. You have been identified on the basis of being a knowledgeable farmer in the location. This is part of data collection process for my post graduate studies in Agricultural Extension at Egerton University.

The discussion is scheduled to take place on ________ and the venue will be at __________.

The discussion is scheduled to start at _________________ exactly.

Your presence and active participation will contribute highly to the process of understanding the dryland farming technologies practiced in your area, their challenges and ways of improving household food security in the location.

Thank you.

Yours sincerely,

TITUS MASILA

APPENDIX B
FOCUS GROUP DISCUSSION GUIDE

Introduction

My name is Titus Masila, a Master of Science in Agricultural Extension student at Egerton University. As part of my studies, I am carrying out a survey on the influence of dryland farming technologies on household food security of small-scale farmers in Kyuso Sub-County. Your contribution will be useful not only in this study but also in future planning and improvements of agricultural extension in your area. Your responses are highly valued and will be treated with utmost confidentiality. Your participation is optional and you may wish to withdraw.

Purpose of the FGD

1. To identify the dryland farming technologies (DFT) practiced by the small scale farmers in Kyuso Sub-County.
2. To determine the crops grown and the yields achieved.
3. To determine the Status of the farmers household food security.
4. To collate the views of participants on food security status of households using different DLFT.

Participants

The FGD participants will be drawn from the sub villages of the sampled area. Care will be taken to balance both gender and age.

Materials

Flip charts, field note books, markers of different colours, biro pens and cards.

Time

About 2 hours.

Outputs

1. Types and status of DLFT practiced.
2. Crops grown and yield level.
3. Crops consumed and their sources.

4. Farmers opinion on status of their food security.
5. Farmers recommendation for improvement
6. Written notes of the exercise.

Key Guiding Questions

1. What are the main on-farm soil conservation technologies practiced in this area?
2. What are the main methods of soil fertility improvement practiced?
3. What is your experience with rain water/run off water harvesting for crop production?
4. What food crops do you grow and how much do you harvest?
5. What food substances do you consume and where do you get them from?
6. What is your general understanding of food security?
7. What food stuffs and how much of them does one need to have per year to be considered food secure?
8. In your opinion do you consider farmers in your locality food secure or insecure? Explain.
9. What do you think are the causes of food insecurity in some households even after a good rain season?
10. Currently can you assess out of 10 the level of household food insecurity?
11. In your experience which farming technologies if embraced by all in your locality can eradicate food insecurity and poverty? Rank these technologies from most effective to least effective.

APPENDIX C

QUESTIONNAIRE FOR HOUSEHOLD HEADS

My name is Titus Masila, a Master of Science in Agricultural Extension student at Egerton University. As part of my studies, I am carrying out a survey on the influence of dryland farming technologies on household food security of small-scale farmers in Kyuso Sub-County. Your contribution will be useful not only in this study but also in future planning and improvements of agricultural extension in your area. Your responses are highly valued and will be treated with utmost confidentiality. Your participation is optional and you may wish to withdraw.

Structured interview schedule on the influence of dryland farming technologies on household food security of small-scale farmers in Kyuso Sub-County

SECTION A: DEMOGRAPHIC INFORMATION

1. Serial Number…………………………………………………..
2. Ward…………………………………………………………
3. Location ……………………………………………………..
4. Sublocation …………………………………………………
5. Date of interview…………………………………………….
6. Gender of the respondent

   Male ☐

   Female ☐
7. Age

   Under 25 ☐

   26-35 ☐

   36-45 ☐

   46-55 ☐

   Over 55 ☐

8. What is your highest educational qualification?

   (i) None ☐

(ii) Primary ☐

(iii) Secondary ☐

(iv) College / University ☐

9. Marital status:

a. Married ☐

b. Single ☐

10. If single, tick the one that best describes your condition

a. Divorced ☐

b. Widowed ☐

c. Separated ☐

d. Single parent ☐

SECTION B: SOIL FERTILITY MANAGEMENT

11. For how long have you been farming?

a. Less than 5 years ☐

b. 5 to 10 years ☐

c. 10 to 20 years ☐

d. 20 years and above. ☐

12. Please indicate the ownership type of the land you cultivate.

a. Individual ☐

b. Family ☐

c. Rented ☐

d. Community ☐

13. Kindly tell us the total size of land cultivated by your household :……..…..(Acres).

14. Do you face any problems with declining soil fertility?

a. Yes ☐ b. No ☐

15. Which method/methods do you use to improve soil fertility in your farm? Tick one or more.

a. Make and apply compost manure ☐
b. Application of cattle boma (farm yard) manure ☐
c. Application of mineral fertilizers ☐
e. Use fallow method ☐
f. Crop rotation ☐
g. Do nothing ☐
h. Any other, state

16. For the soil fertility method indicated in question 5, how often do you use the method.

	Method	**Frequency of use** 1 = Once per year, 2 = Twice per year, 3 = Never
a.	Compost manure (Made in compost pits by farmer)	
b.	Cattle boma manure (FYM)	
c.	Mineral fertilizer (e.g. DAP,CAN, etc)	
d.	Use fallow method	
e.	Crop rotation	
f.	Do nothing	
g.	Any other, state	

17. For the soil fertility improvement methods you have used how do you rate their influence in improving crop production yields?

1= Not effective ; 2=Slightly effective; 3=Highly effective; 4= Very highly effective.

	Method	**Influence in improving crop production yields** 1= Not effective; 2=Slightly effective; 3=Highly effective; 4= Very highly effective; 5= Method not applied
a.	Compost manure	
b.	Cattle boma manure (FYM)	
c.	Mineral fertilizer	

d.	Use fallow method	
e.	Crop rotation	

18. What constraints do you face in your attempt to manage soil fertility in your farm? Tick as many as are applicable to your case.

a. Cattle boma manure/Farm yard manure inadequate. ☐
b. Ferrying FYM to the farm is very cumbersome ☐
c. Shortage of labour ☐
d. High cost of labour ☐
e. Composting knowledge lacking ☐
f. High cost of inorganic fertilizer ☐
g. Not aware of inorganic fertilizer application ☐
h. Soil erosion washing away applied nutrients ☐
i. Others, state

SECTION C: SOIL CONSERVATION AND WATER HARVESTING

19. Of the following dryland farming technologies, which ones do you practice in your farm and what is your level of implementation. Give your responses in the table below:

	Dry land faming technology	Do you practice this technology? Yes or No	What proportion of your farm do you apply this technology? (Estimate %)
1.	**Soil and water conservation**		
	Fanya chini/retention ditch terraces		
	Diversion ditches/ Cut-off drain		
	Fanya ‘juu’ terraces		
	Log lines		
	Stone lines		
	Grass strips		

	Others, state		
2.	**Rain water harvesting**		
	Zai pits		
	Road side run off water harvesting		
	Water pans		
	Others, state		

20. In your opinion are soil conservation structures useful in increasing crop yield in your farm?

Yes. ☐ No. ☐

21. What challenges make you not construct as many soil conservation structures as your farm may require? (Retention ditches, fanya juu terraces, cut off drains, zai pits, stone lines, grass strip)

Tick as many as are applicable.

a. Free grazing destroying structures ☐
b. Land tenure insecurity ☐
c. High labour requirement ☐
d. Land size limitation ☐
e. High cost incurred. ☐
f. Any other, state

SECTION D: DROUGHT TOLERANT CROP PRODUCTION

22. For the following crops, indicate acreages grown in your farm annually and their production.

		No. of acres grown	**Production per acre**	**Total annual production in 90kg bags**
a.	Maize			
b.	Millet			
c.	Sorghum			
d.	Beans			

e.	Pigeon peas			
f.	Green grams			
g.	Cow peas			
h.	Dolichos lab lab			

23. On an annual basis, how long does your production take your family?

	Crop produce	**Length of time (months) family takes to subsist on produce**
a.	Maize	
b.	Millet	
c.	Sorghum	
d.	Beans	
e.	Pigeon peas	
f.	Green grams	
g.	Cow peas	
h.	Dolichos lab lab	

24. If your farm produce cannot feed your family throughout the year (12 months or more) what could be the possible reasons for this? You can tick more than one.

a. Farm produce is sold soon after harvesting ☐

b. Lack of income from off-farm activities ☐

c. Low farm produce in comparison to family size ☐

d. Small farm size ☐

e. Lack of soil conservation structures in the farm ☐

f. Farm yard manure not adequately applied in the farm ☐

g. Late planting leading to crop failure ☐

h. Planting crop varieties that are not ecologically suited ☐

i. Any other, state

25. If you are able to feed your family on farm produce for more than 12 months after harvesting, what reasons do you have for this

a. Farm is well terraced ☐

b. Road side water is harvested into the farm ☐

c. Farm yard manure is adequately applied ☐

d. Early land preparation before the rains ☐

e. Early planting before the rains ☐

f. Has income from off-farm employment ☐

g. Any other, state

26. Do you practice pure stand or mixed cropping in your farm? Tick below as appropriate.

a. Pure stand ☐

b. Mixed cropping ☐

c. Both ☐

27. If you practice pure stand, which crops do you grow as pure stand.

a. Maize ☐

b. Millet ☐

c. Sorghum ☐

d. Beans ☐

e. Green grams ☐

f. Cow peas ☐

g. Pigeon peas ☐

h. Pure stand not practiced ☐

28. Indicate the mixed cropping combination of food crops practiced in your farm.

a. Maize and Pigeon peas ☐

b. Maize and Beans ☐

c. Maize and Cow peas ☐

d. Maize and Green grams ☐

e. Millet and Pigeon peas ☐

f. Millet/Beans ☐

g. Millet/Cow peas ☐

h. Millet/Green grams ☐

i. Sorghum/Beans ☐

j. Sorghum/Cow peas ☐

k. Sorghum/Pigeon peas ☐

l. Sorghum/Green grams ☐

m. Others, state

29. How would you rate your level of production of millet/sorghum?

    a. Low ☐

    b. Moderate ☐

    c. High ☐

30. If you rate your production of millet/sorghum as low what are the contributing factors?

    a. High bird infestation ☐
    b. Inadequate utilization skills ☐
    c. Lack of market for the produce ☐
    d. Lack of processing machines ☐
    e. Crop is associated with backwardness ☐
    f. Crop produce not palatable ☐
    g. High labour requirement. ☐
    h. Any other, state

SECTION E: HOUSEHOLD FOOD SECURITY

31. Kindly indicate the number of your household members who fall in the following age group?

Age group (in years)	**Number of males**	**Number of females**	**Total**
0–1			
2-3			
4-6			
7-9			
10-12			
13-15			

16-19			
20 and above			
Total			

32. What is your (household head) primary occupation?

a. Crop farming ☐

b. Business ☐

c. Livestock farming ☐

d. salaried job ☐

e. Others, state

33. Secondary occupations (Tick as appropriate)

a. Farming ☐

b. Trading ☐

c. Salaried job ☐

d. Crafts and artisans ☐

e. Others, state

34. How much does your household earn from the following sources of income annually?

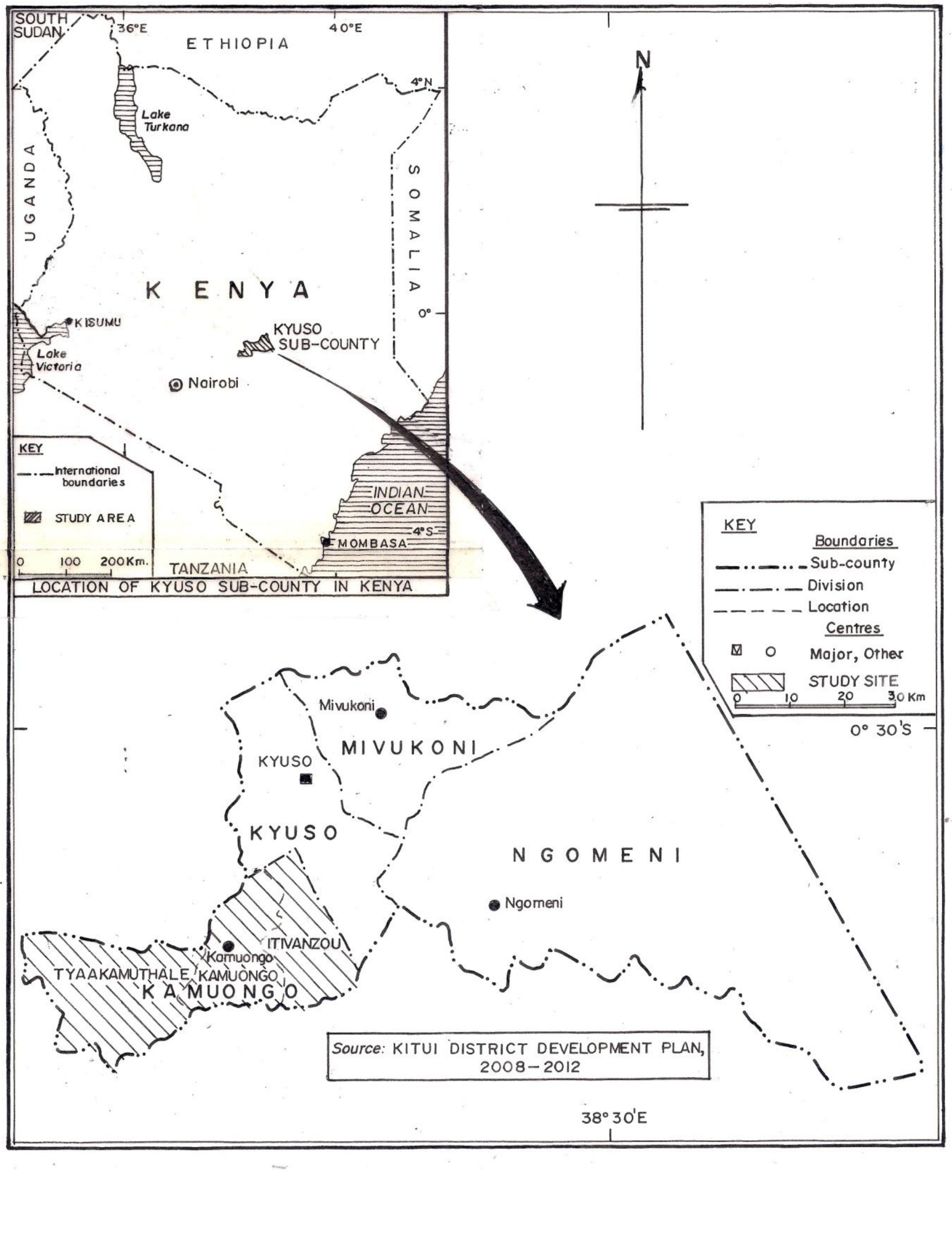
S/NO.	Income source	Amount in KSh.
a.	Self-employment (trading, business, tailoring, carpentry, barber's work, shoe cobbling, repairing of bicycles and motorcycles, etc.)	
b.	Salaried employment	
c.	Money earned from interest on capital lent out and rent on building or dividend on shares, etc.	
d.	Remittances (money sent by children and relatives)	
e.	Sale of livestock (poultry, sh	

35. Kindly provide information on the following crops (only on those you have purchased or produced).

Food Item	Item purchased last season for household consumption		Amount produced last cropping season (90kg bags)	Amount consumed from last season's production (90kg bags)
	Quantity In Kg/90kg bags	Price paid per kg/90kg bag		
Cereals				
a. Maize				
b. Sorghum				
c. Millet				
Total				
Legumes				
a. Beans				
b. Cowpeas				
c. Pigeon peas				
Total				

APPENDIX D

MAP OF THE STUDY AREA



APPENDIX E

RESEARCH AUTHORIZATION

REPUBLIC OF KENYA

NATIONAL COUNCIL FOR SCIENCE AND TECHNOLOGY

Telephone: 254-020-2213471, 2241349, 254-020-2673550
Mobile: 0713 788 787 , 0735 404 245
Fax: 254-020-2213215
When replying please quote
secretary@ncst.go.ke

P.O. Box 30623-00100
NAIROBI-KENYA
Website: www.ncst.go.ke

Our Ref: **NCST/RCD/10/013/30**

Date: **11th June 2013**

Titus Masila
Egerton University
P.O Box 536-20115
Egerton.

RE: RESEARCH AUTHORIZATION

Following your application dated **4th June, 2013** for authority to carry out research on "***The influence of dryland farming technologies on household food security of small-scale farmers in Kyuso District, Kitui County, Kenya.***" I am pleased to inform you that you have been authorized to undertake research in **Kyuso District** for a period ending **31st December, 2013.**

You are advised to report to **the District Commissioner, District Education Officer and District Agricultural Officer, Kyuso District** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

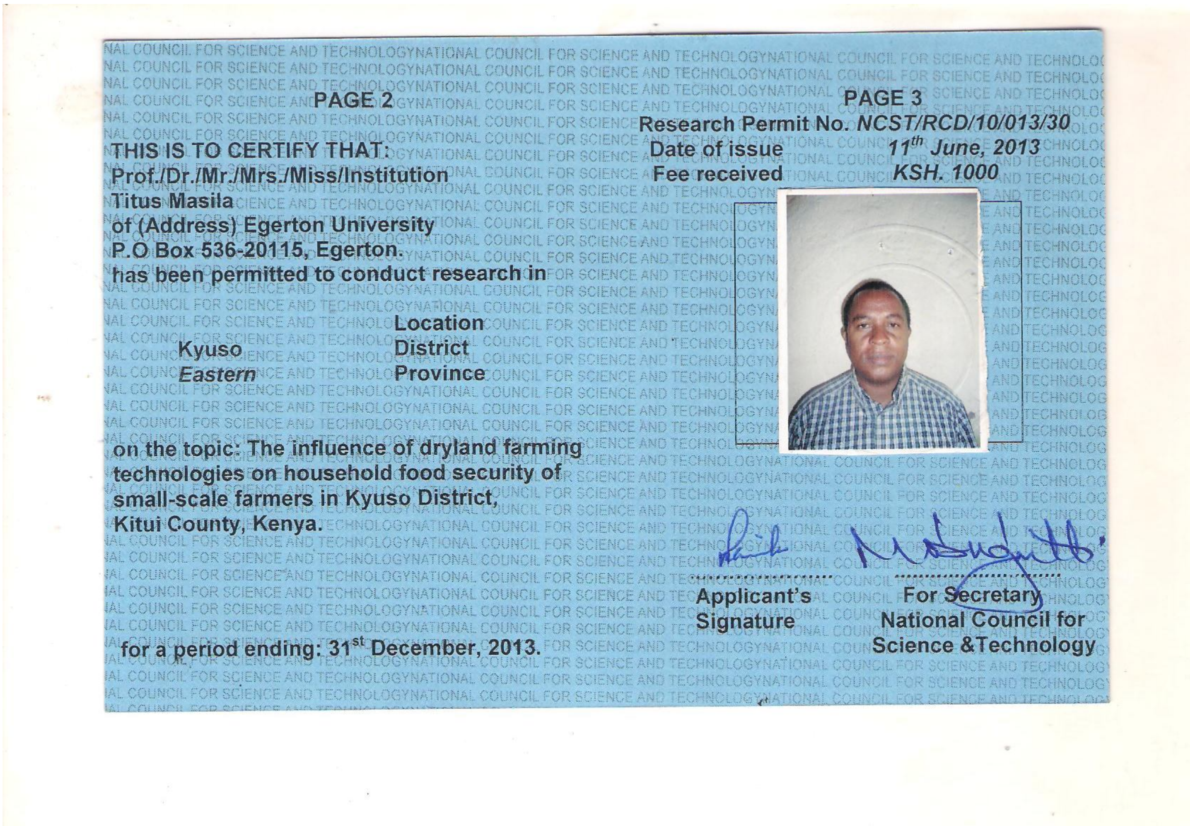
DR. M. K. RUGUTT, PhD, HSC.
DEPUTY COUNCIL SECRETARY

Copy to:
The District Commissioner
The District Education Officer
The District Agricultural Officer
Kyuso District.

"The National Council for Science and Technology is Committed to the Promotion of Science and Technology for National Development".

APPENDIX E

RESEARCH PERMIT IDENTITY CARD



PAGE 2

THIS IS TO CERTIFY THAT:
Prof./Dr./Mr./Mrs./Miss/Institution
Titus Masila
of (Address) Egerton University
P.O Box 536-20115, Egerton.
has been permitted to conduct research in

	Location
Kyuso	District
Eastern	Province

on the topic: The influence of dryland farming technologies on household food security of small-scale farmers in Kyuso District, Kitui County, Kenya.

for a period ending: 31st December, 2013.

PAGE 3

Research Permit No. *NCST/RCD/10/013/30*
Date of issue *11th June, 2013*
Fee received *KSH. 1000*

Applicant's Signature

For Secretary
National Council for
Science &Technology

APPENDIX F

RELIABILITY ANALYSIS RESULTS

Scale: All variables

Case Processing Summary

		N	%
Cases	Valid	19	95.0
	Excluded[a]	1	5.0
	Total	20	100.0

a. Listwise deletion based on all variables in the procedure.

This is the reliability coefficient 0.795. The minimum accepted is 0.7
So the tool is good.

Reliability Statistics

Cronbach's Alpha	N of Items
0.795	212