THE INFLUENCE OF HOUSEHOLD CHARACTERISTICS AND AGRICULTURAL PRACTICES ON FOOD SECURITY IN SEMI ARID AGRO-ECOLOGICAL ZONES OF NYAKACH SUB-COUNTY, KISUMU COUNTY, KENYA

BY

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MASENO UNIVERSITY

DECLARATION

Declaration by the student

I hereby declare that this thesis is my original work and has never been presented for the award of a certificate, diploma or degree in any other university

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DEDICATION

This thesis is dedicated to my late dad Jakwath Johnson Obuoyo K'awino whose pride in me and support towards this course was overwhelming. May your soul rest in eternal peace Baba…..till we meet at Jesus' feet.

ABSTRACT

The world is facing decreasing food production from agriculture, especially in Africa where smallholder farming provides most of the food. The importance of agriculture in food provision at household and national levels is now universally accepted. However, in as much as smallholder production feeds majority of rural households, the available global data only exist on well-established food systems and not on the smallholder systems. In Kenya, over 85% of farmers are smallholder mixed farmers. Further, many researchers and policy-makers have not considered household characteristics and agricultural practices as determinants to household food security hence the nexus between them has received little attention resulting in limited comprehensive data linking them. This study was carried out in the semi-arid Agro-ecological zones of Nyakach where agriculture is the main source of food and food poverty level is 65.0%. Agricultural practices that the smallholder farmers engage in could be a fundamental factor influencing household food security. Studies on food security in Nyakach Sub-County have, however, concentrated on Economic Partnership Agreements and commercial agriculture. There was therefore need to determine the influence of agricultural practices by smallholder farmers on household food security. The study adds to the existing body of knowledge and forms a basis for further research and policy analysis on agriculture and food security in semi-arid environments. The broad objective of the study was to assess the influence of agricultural practices on food security. The specific objectives were: to determine the influence of demographic and socio-economic household characteristics on food security; to examine the influence of crop farming practices on household food security; to examine the influence of livestock farming on household food security. The study population was 9,331 households. The sample size was 384 households selected using Proportionate Stratified sampling method. Purposive sampling was used to identify key informants. The study adopted cross-sectional social survey research design. Primary data on household characteristics; crop and livestock farming practices and household food security were collected through field observations; questionnaires; key informant interviews and focus group discussions. Pearson's Correlation Coefficient (r) was used to assess the relationships between household characteristics; farming practices and household food security. Logistic regression Analysis was conducted to establish significance of relationships between size of acreage; household income and expenditure; annual crop yields; livestock numbers and household food security. Chi-Square test was used to show the association between categorical and continuous variables and household food security. Multivariate analysis was done to establish the relationship between all crop farming practices and food security. Qualitative data on household size; type of crop and livestock; food coping strategies and quality of food consumed in household was transcribed and analyzed by creating relational themes. Household Socio-demographic and economic characteristics that most significantly influenced food security were family size (0.000), consumption of own-produced food (0.000), total number of livestock owned (0.002) and off-farm employment (0.003). Choice of seeds and crop varieties, use of inorganic fertilizer, organic manure, mulching and composting; irrigation, improved fallow practices and construction of anti-erosion hedges are crop farming practices that influenced household food security. Also, Livestock type, ownership, housing and veterinary services are significant determinants of household food security. The study concludes that the household is the basis of achieving food security hence the farmer and farming practices must be prioritized. The study recommends that smallholder farmers' sensitization programs and extension and veterinary services should be encouraged so as to protect household food security in semi-arid lands.

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LIST OF ABBREVIATIONS AND ACRONYMS

AEZ	Agro-Ecological Zone
AGDP	Agricultural Gross Domestic Product
ASFs	Animal Source Foods
CIG	Common Interest Group
CGIAR	Consultative Group on International Agricultural Research
EMCA	Environmental Management Co-ordination Act
FAO	Food and Agricultural Organization
FEWS	Famine Early Warning Systems
GDP	Gross Domestic Product
GIS	Geographic Information System
GLASOD	Global Assessment of Soil Degradation
GNP	Gross National Product
GoK	Government of Kenya
HFIAS	Household Food Insecurity Access Scale
HYV	High-Yielding Varieties
ICRAF	International Centre for Research in Agroforestry
IFPRI	International Food Policy Research Institute
IMPACT	International Model for Policy Analysis of Agricultural Commodities and Trade
ISRIC	International Soil Research and Information Centre
K	Potassium
KCDP	Kisumu County Development Profile
LEIT	Low External Input Technology
MOARD	Ministry of Agriculture and Rural Development
N	Nitrogen
NALEP	National Agriculture and Livestock Extension Program
NEAP	National Environmental Action Plan
NEPAD	New Partnership for Africa's Development
P	Phosphorus
SARD	Sustainable Agricultural and Rural Development
SCuAF	Soil Conservation under Agroforestry
UNDP	United Nations Development Program
UNEP	United Nations Environmental Program
WCED	World Commission on Environment and Development
WRI	World Resources International

OPERATIONAL DEFINITION OF TERMS

Agricultural practices

These are multifunctional systems of crop and livestock farming activities.

Agro-Ecological zones (AEZs)

These are geographical areas exhibiting similar climatic conditions that determine their ability to support agriculture.

LM3 Agro-ecological Zone.

This is a warm and semi-arid AEZ that exhibits climatic conditions that are good to fair for cotton crop and fair for maize crop.

LM4 Agro-ecological Zone

This is a very warm and semi-arid AEZ that exhibits climatic condition that is fair to poor for cotton and maize crops, fair for pigeon pea and good for sisal.

Farmers / Family farmers

These terms are used interchangeably to mean the smallholder crop and livestock farmers.

Food Security

This is the availability, access, stability, and utilization of food at household level.

Food availability

This is the average and sufficient food supplies available to meet household consumption needs.

Food access

This is having the resources to produce or purchase the food required.

Food utilization

This is the way a household consumes the available food.

Food stability

This refers to minimizing the probability of food supply, access and consumption falling below consumption requirements.

Poverty

This is a situation where condition of life if below definition of human decency. People whose annual consumption is between US$275 to US$370 per person a year are POOR, and those whose annual consumption is less than US$275 per person a year are EXTREMELY POOR.

Food Poverty

This is a condition in which a household or individual cannot access the food they would like to eat or eat what they can afford, not what they prefer.

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CHAPTER ONE: INTRODUCTION

1.1 Background to the Study

Agricultural practices can determine food security status of farming households because the practices influence health and productivity of family farm (Pimbert, *et al*. 2006). The ultimate result of inappropriate agricultural practices is little or no production from the soil (Shepherd and Soul, 1998). Juma and Ojwang' (1996) agree with Pimbert, *et al*. (2006) that the soil becomes less able to support plant growth as there is a decline in levels of available moisture, available nutrients, and biological activity. According to world Commission on Environment and Development (WCED, 1987a), it has been estimated that the degraded area of the world's arable land increased from 10% in the early 1970s to about 40% in the early 1990s due to unsustainable agricultural practices. Smale, Cohen and Nagarajan, (2009) points out that the greatest need for remedy is in developing regions of the world, where the rate of loss of agriculturally usable land has been estimated at 0.3% per year.

Mixed farming systems are inherent characteristics of semi-arid areas where rainfall is low and erratic, ranging between 150mm and 600mm (Buckle, 1996). The probability of drought occurrence in semi-arid areas is 40-60%. Semi-arid areas occupy about 17% of Africa, 30 percent of Central America and Caribbean, 39% of Oceania and 7% of Europe (Stewart, 2005). The semi-arid areas are inhabited by about 16% of the global population (Dobie, 2001) who mainly engage in marginal small-scale mixed agriculture (Oteng'i, 1995; Ribot, *et al*. 1996). Small-scale mixed farming is practiced in small holdings where farmers grow crops and at the same time keep livestock. Small-scale farming, however, may not provide substantial contribution to the world economies but produce enough food for households' survival (William and Balling, 1996).

Agriculture in much of Africa is grounded in small-scale farming (EuropAfrica, 2013). According to the Food and Agricultural Organization (FAO), Africa has 33 million family farms of less than 2 hectares, which make up 80% of all farms in the continent (FAO, 2009c). Family farms exist in various forms in different countries, meeting distinct needs, but altogether across the continent family farming provides most of the food and most livelihoods in Africa, supporting resilient social structures in rural areas (Williams, *et al*., 2004). Most governments and institutions recognize, at least in words, the need to support small-scale farmers as key actors in achieving food security (Wodon, *et al*., 2008) and they acknowledge the role of sustainable small-scale farming as compared with commercial agriculture, in creating employment, stimulating local economies and providing environmental services (Fischer, *et al*, 2009). In practice, however, most governments and institutions attribute increased agricultural productivity to industrial technologies as they factor in attaining food security. They tend to view small-scale farming as an archaic mode of production, incapable of feeding Africa's population, that needs to be 'modernized' through a transition to market-led industrial agri-food systems (World Economic Forum, 2011).

The importance of crop and livestock production toward food provision at household and national levels cannot be overemphasized (Rabbinge, 1995). As Smaling, *et al*. (1997) points out, the problem encountered however, is that data only exist on well-developed and well established food systems of the World. The FAO (2010) further concurs with the New Partnership for Africa's Development (NEPAD, 2013a). that, in the case of Africa, it has been established that statistics only exist about commercial commodity and export food markets, export crops, export livestock products, formalized large scale food traders and value chains for food products This paucity of knowledge is particularly alarming given that the crops grown and animals kept in

small scale food systems are produced, processed, traded and consumed in both urban and rural areas. Crop and livestock farming by subsistence farmers thus make up the majority of the diet of many people in the sub-Saharan Africa (Swanepoel, Stroebel and Moyo, 2010). It is therefore important to investigate the relationship between crop and livestock farming practices and household food security. The problem of unsustainable use of agricultural land is the key area of concern relating to food deficit in Africa (Agassi, 1996). During the 1996 World Food Summit, it was reported that Sub-Saharan Africa is the only remaining region in the world with decreasing food production per capita (FAO, 1997). Many reasons have been advanced including mismanagement of land resource base; lack of appropriate technology and the inability of the farmers in the region to use the available know-how correctly (World Bank, 1997). Massive crop and animal failure and extreme poverty are direct consequences of unsustainable use of agricultural land that results in large-scale nutrient depletion (FAO, 1997; Buresh and Tian, 1997. International Assessment on Agriculture knowledge, science and Technology for Development (IAASTD), 2011). This situation has resulted in enormous nutrient depletion in Africa (Norton, Alwang and Masters, 2010).

According to FAO (2014), the number of East African food crises per year has tripled from the 1980s to 2000s, yet agricultural practices which is a major factor in food production has not been assessed. Gill (2002) points out that most of the world's hungry are smallholder farmers who depend on agriculture to make a living and feed their families. According to FAO (2015) nearly 75% of the food poor people in developing countries live in rural areas. It further explains that growth in the agriculture sector is on average, twice as effective in reducing food poverty as growth in other sectors of economy. Investing in smallholder farmers is therefore important in order to feed a population expected to grow to 9.15 billion people by 2050 (United Nations

Population Department, 2008). The world will have to double its current food production even with increase in droughts and less predictable rains due to climate change (FAO, 2010; Fosu and Nico, 2011). It is increasingly becoming important to monitor the number of undernourished people who are at risk of food insecurity and the factors that create this risk (FAO, 2010). This effort will guide action toward ensuring household food security. Much of the effort to date has focused on finding ways to identify specific geographic areas where vulnerable and food-insecure people are most likely to be found, but in the end it is the condition of the people that counts (FAO, 2009a; Sebastian, 2014). Agricultural practices carried out by households within the Lake Victoria Basin are of major concern for the livelihood and food security of the rapidly expanding population (Gill, 2002). The World Commission on Environment and Development (WCED) and other studies agree that the Lake Victoria Basin experiences some of the most severe problems of agricultural stagnation and inadequate food production, (WCED, 1987a; Braun *et al*. 1997; Mugo, 2000).

Out of the over billion undernourished people in the world today, 265 million live in Sub-Saharan Africa. Three-quarters of the hungry are the rural farming families (LEISA Magazine, 2009). A significant number of African countries depend on basic food imports to meet their consumption needs. African continent imported about US$ 3 billion more food than was exported in 2006, and this rose during the price spike of 2008 and early 2009. However, not everyone can afford to buy food, and the recent food price hikes deepened this problem even more. In fact, just over half of the sub-Saharan population lives on less than USD1.25 per day (FAO, 2010). Most governments and institutions have recognized the imperative of food security, the need to increase investment in agriculture, to increase domestic food production especially in food deficit countries, to address risk and issues such as climate change and price

volatility that impact negatively on food security (FAO, 2010; International Institute for Environment and Development, 2011, World Economic Forum 2011, FAO, 2012; Mecheo, 2013). However, the different strategies being proposed to meet these goals have been and are intended to be successful among the commercial farmers (Delgado, *et al*., 2010). This ignores the evidence that the small scale African farmers are already meeting up to 80% of Africa's food needs, despite the fact that they are receiving little or no policy and program support (Dixon, Boffa, and Garrity, 2014; FAO, 2014). Studies conducted in rural areas of Tanzania (Ellis and Mdoe, 2003), Ethiopia (Bogale and Shimelis, 2009) and Nigeria (Idrisa, Ogunbameru, and Amaza, 2010) concur with the FAO report (FAO, 2014) that farmers' practices are influenced by their socio-economic characteristics at household level. In Kenya, however, the relationship between these characteristics and food security has been given little attention. In order to fill this knowledge gap, this study aims at identifying demographic, social and economic household characteristics that influence farmers' practices hence household food security.

Since the idea of producing food as an industrial product to maximize profit was introduced, corporations and governments have accelerated the race to control many aspects of the food system, including land, water, seeds, and markets (Gill, 2002). Industrial agriculture is driven to maximize what it can extract from the soil, at literally any cost. Soils are becoming starved, and addicted to chemicals fertilizers and inputs, destroying biodiversity and resilience (Davies, 2006). It is therefore vital to provide farmers and policy makers with hard evidence on the short and long-term consequences of agricultural practices on food security. It is also important to demonstrate that opportunities for productive and sustainable agricultural land management, as well as feeding the world's population exist with the small-scale food producers and the local ecological systems of food production (GoK, 1997b; Garrity, *et al*., 2012).

The issue of agricultural policy investment is a key one in Africa. How and where these investments are directed is of considerable concern to African smallholder farmers and their organizations (FAO, 2015). From Comprehensive Africa Agriculture Development Program (CAADP) pillar 3 to the renewed Committee on World Food Security, enhanced policy investment for food security is at the top of the agenda (NEPAD, 2009). There is now a commitment on the part of multilateral institutions and of a number of donors to give greater priority to supporting small-scale farmers (IFPRI, 2007). However, a number of questions need to be explored in depth in order to ensure that the support proposed in these policies is what is wanted by Africa's smallholder farmers, and is potentially beneficial to them and their sustainable food systems (Dorward, *et al.,* 2008; Mecheo, 2013). The International Food and Agriculture Development (IFAD, 2011) asserts that the questions that need to be asked about food security are "what policy investment for what systems of food production, for what food products, for what markets, and to whose benefit." These concerns prompt this study to make policy recommendations on agricultural practices in Semi-arid lands of Kenya, and how the transmission, knowledge and adoption of these policies influence rural household food security.

Agriculture is the most important form of livelihood for the people of Kenya and it is the backbone of Kenya's economy (GoK, 2012c). The dominance of Agriculture is indicated by several factors including contributing 27% of Gross Domestic Product (GDP); generating over 60% of foreign exchange earnings; providing employment to over 75% of the country's population; providing raw materials to about 70% of all industries and providing over 45% of the annual government budget (GoK, 2012b). There are three major agricultural categories, namely crop cultivation, livestock farming and fisheries production. The overall mean yield productivity of Kenya's agricultural land has declined drastically over the years due to various factors ranging

from inadequate utilization of inputs, inappropriate agricultural practices and unfavorable weather conditions (IFPRI, 2013a). In order to raise production and productivity, there is need to address the prevailing constraints. The agricultural sector in Kenya is characterized by small holder farmers, 85% of who own and farm less than two hectares of land. This number accounts for 75% of the agricultural output and 50% of the marketed surplus in both crops and livestock (Government of Kenya, 2008c). This category of farmers retain significant amounts of their production for home consumption as more than half of the food consumed is from own farm produce (UNICEF, 2008). Households that cannot produce enough food have to purchase it from the markets. On average, households in Kenya spend 54% (56% in rural and 41% in urban areas) of their budget on food (Government of Kenya, 2012a).

Current demographic mapping indicate that about 80% of Kenya's population live in the rural areas and derive their livelihood from agriculture and related activities (GoK, 2012b). The agricultural sector is therefore key in addressing poverty and food security challenges. These facts suggest that for any strategy to address poverty and food insecurity successfully, it must embrace broad-based development of the agricultural sector (NEPAD, 2013a) and by extension that of rural Kenya. Excessive poverty in rural areas leads to poor crop farming practices (Goita, *et al*., 2013). Such strategies must therefore focus on activities aimed at improving crops and livestock and to safeguard real farm incomes, with a view of ensuring availability, access, stability and utilization of enough and quality food (FAO, 2014; 2015). Studies conducted in West Africa (Williams, *et al*., 2004) and in South Africa (Tshediso, 2013) agree that it is important to transform subsistence crop farming by farmers engaging in appropriate crop farming practices to ensure improved food production on farm.

The NEPAD (2013a; 2013b) agree that this would encourage food security as envisioned in the Vision 2030 Strategy. However, this relationship between agricultural practices and household food security has not been explored in semi-arid Nyakach. It was therefore necessary to conduct this study on the influence of crop farming practices on household food security. Global demand for livestock products and animal-source foods (ASFs) is on the increase (Delgado, 2005). This increasing demand continues to be a key opportunity for food poverty reduction and economic growth (Dijkman, 2009), although the evidence of the last 15 years suggests that only a few countries have taken advantage of this opportunity effectively (FAO, 2014). In sub-Saharan Africa, this demand is determined by factors such as rapid human population growth (1.2% per year); unprecedented urban growth (United Nations Population Fund, 2008) and income growth (Delgado, 2010). This has considerable impact on patterns of food consumption in general and on demand for livestock products in particular (FAO, 2014). These factors, however, could continue to be an important impediment to achieving improvements in food security in some countries (FAO, 2015) The resultant trends in meat and milk consumption in developing countries show that food demand for livestock products will nearly double in sub-Saharan Africa and South Asia, from 200 kcal per person per day in the year 2000 to around 400 kcal per person per day in 2050 (Wiggins, 2009).

Elzaki, (2005) states that meeting the substantial increases in demand for food will have profound implications for livestock production systems over the coming decades. Gura, (2008) and Rosegrant, *et al*., (2009) agree that smallholder livestock producers currently are critical to food security for the vast majority of the rural poor households in Asia, and this role is not likely to change significantly in the future, particularly in sub-Saharan Africa (Rosegrant, *et al*., 2009). Findings of the study conducted in rural White Nile state in Ethiopia by Feleke, Kilmer and

Gladwin (2005) and Elzaki, *et al*. (2011) indicate that livestock production has a positive role to play in household food security. However, (Wiggins, 2009) intimate that what is in store for the humankind's association with domesticated animals during the coming decades is not clear, and that it is suffering stress and upheaval on several fronts. The association is still critical to the wellbeing of millions of people. In many developing countries' food supply, currently livestock has no known viable substitute (Elzaki, *et al* 2011). The FAO also notes that increasing industrialization of livestock production may mean that smallholders continue to miss out on the undoubted opportunities that exist toward provision of household food security (FAO, 2014). Studies done in semi-arid Nyakach, however, have concentrated on agricultural land-use changes and conversion of wetlands into agricultural and settlement land, which have led to significant changes in the structure and composition of natural vegetation (KCDP, 2013) with little attention on influence of livestock practices on food security. It is important to note that these livestock production systems are determined by livestock farming practices which could then influence household food security. Therefore the study aimed at examining the influence of livestock farming practices on household food security in semi-arid Nyakach.

1.2 Statement of the Problem

Despite food insecurity in Africa, particularly in Kenya, studies done on food systems have focused on effect of rainfall variations, climate change and commercial farming on food security. Further, most global studies on food security have concentrated at national and regional levels, neglecting the household which is the basic unit for food production. Smallholder agriculture is the backbone of the economy of the semi-arid agro-ecological zones of Nyakach. Hence the agricultural practices that the farmers engage in could be a fundamental factor in improving and sustaining household food security. The absolute poverty in semi-arid Nyakach is 60.1% against

the mean national poverty level of 45.9%, while the food poverty level is at 65.0 % compared to the national food poverty level of 60.5% (KCDP, 2013). Farmers may be engaging in farming practices which aside from other economic activities could influence household food security status hence help reduce this food poverty level. Despite all these facts, most studies conducted in semi-arid Nyakach have focused on the influence of Economic Partnership Agreements and commercial agriculture on food security with little attention on the nexus between agricultural practices and food security. Whereas food security is in the hands of the small scale farmers, farming practices may also be influenced by household characteristics which may consequently determine household food security status. Therefore this study set out to determine the influence of socio-demographic and economic characteristics of households on food security.

The rural poor depend on continuous seasonal cropping for subsistence, a practice that results in overuse of soil nutrients. Continuous cropping could influence the amount of yields, which could then influence household food security. Hence the need to examine the influence of crop farming practices on household food security in semi-arid Agro Ecological Zones of Nyakach. About 65.0% of the population of semi-arid Nyakach is food poor. And yet 98% of households are engaged in livestock husbandry (KCDP, 2013). This high percentage could be involved in livestock farming practices that could then influence household food status so as to reduce the food poverty level. Consequently, there was need to examine the influence of livestock farming practices on household food security. Therefore the purpose of this study was to assess the influence of household characteristics and agricultural practices on food security in semi-arid agro-ecological zones of Nyakach.

1.3 Objective of the Study

The broad objective of the study was to assess the influence of household characteristics and agricultural practices on food security in semi-arid agro-ecological zones of Nyakach Sub-County, Kisumu County, Kenya.

The specific objectives were:

1. To determine the influence of socio-demographic and economic characteristics of households on food security.
2. To examine the influence of crop farming practices on household food security.
3. To examine the influence of livestock farming practices on household food security.

1.4 Research Questions

The study addressed the following research questions.

1. What are the household socio-demographic and economic characteristics that influence food security?
2. What is the influence of crop farming practices on household food security?
3. What is the influence of livestock farming practices on household food security?

1.5 Justification of the Study

Smith, *et al*., (2000) observed that the geographical location determine food security in developing countries due to climatic and soil conditions. The natural conditions of semi-arid Nyakach therefore could have an influence on food security. SIDA (1999) established that engaging in appropriate agricultural practices is one of the strategies of ensuring sustainable food security in the Lake Victoria Region. It is therefore possible that agricultural practices that household engage in could lead to food security. Mecheo (2013) further reports that building on the household characteristics and experiences of African family farmers with regard to agricultural practices would lead to realization of sustainable food security. In addition, Feleke, Kilmer and Gladwin (2005) note that if food security is defined as "...access to enough food for

an active healthy life" livestock can make a major contribution since achieving food security in this case is largely determined by an assumption of minimum nutritional need. Swanepoel, *et al*. (2010) further agree that livestock production enhance food security in developing communities due to its multi-functionality. This may imply that socio-demographic and economic characteristics of households may determine household food security. The semi-arid Nyakach was selected for this study because 47% of the population is employed in agriculture sector, providing 48% of households' income. Over 89% of households engage in smallholder mixed farming as their source of food and livelihood, yet food poverty level stands at 65.0%. Since the backbone of the study area is agriculture then agricultural practices by the farmers could have a relationship with food security of households. Since this relationship has not been explored, this study assessed the possible scenario that crop farming practices and livestock farming practices could have an influence on household food security in the study area.

1.6 Significance of the Study

The study yielded information on socio-demographic and economic household characteristics and agricultural practices that influence household food security in semi-arid agro-ecological zones of Nyakach Sub-County. This data is useful for creating awareness in rural communities and among other stakeholders about proper planning and decision-making in regard to sustainable utilization of semi-arid agricultural land for food production and provision. Also, information yielded from the study may help in developing strategies for improving farmers' knowledge, skills, attitude and perceptions toward appropriate practices so as to ensure household food security. It may also be of benefit to economic planners to find out alternative ways of helping subsistence mixed farmers in adapting to and mitigating the impact of food insecurity. Further, it provides an understanding of household food security parameters that may

help agricultural extension officers and farmers to plan appropriate food coping strategies, improve crop and livestock production and achieve household food security. The study adds to the existing body of knowledge and forms a basis for further research on agriculture and food security in semi-arid environments and this will help other researchers in this area of specialization. The study also forms a basis for further research in agriculture and food policy analysis. The results and recommendations of this study generate new ideas on better and more effective agricultural practices in semi-arid areas of Kenya. This could be applied in other semi-arid rural areas of the globe experiencing threatened food security.

1.7 Scope and Limitations of the Study

1.7.1 Scope of the Study

This study focused on the relationship between household characteristics, agricultural practices and household food security. Other variables which may also influence food security in the study area were not within the scope of this study. Mechanization was not explored because it is not widely adopted in the study area. Calorie-intake (biological utilization of food) which is a variable used mostly by nutritionists to measure food security was not incorporated in this study. The study examined smallholder mixed farming system since it is the main source of the rural households' food. All farming households in the semi-arid Nyakach grow crops while 72.8% of the households keep livestock. In assessing the influence of agricultural practices on food security, the study used maize, sorghum, rice and bean crops since the four crops are regarded as subsistence staple foods and are grown by most households. The influence of livestock on food security was assessed against the number of livestock owned, annual milk production and annual income from the sale of milk and live animals.

1.7.2 Limitations of the Study

The major limitation of this study was its localization to semi-arid agro-ecological zones of Nyakach Sub-County, which is relatively a small geographical area so the results may not necessarily be applicable in some parts of the world hence could lower the study's generalizability to other populations outside these zones. Ideally, the study should have been conducted in a wider area such as all the semi-arid zones of Kisumu County and the sample selected from this larger geographical area. However, financial and other resource constraints dictated a smaller Study area. The findings will nonetheless be useful for creating awareness among stakeholders, exemplification and for beginning of debate on the relationship between agricultural practices and household food security in semi-arid environments. Moreover, the study could be replicated elsewhere in semi-arid environments where food insecurity is a problem. Further, most of the households in semi-arid Nyakach did not have title deeds for their farm holdings, therefore may not have been accurate about the acreages that they owned. This was remedied by actual measuring of the parcels, which slowed down primary data collection.

1.8 Assumption of the Study

The study made assumptions that:

1. All households were rural smallholder hence practiced mixed farming.

1.9 Outline of Chapters

Having introduced the study in Chapter 1, the researcher proceeded to review related literature in Chapter 2 as guided by the main and specific objectives of the study. Literature was therefore reviewed on agricultural practices and food security globally, in sub Saharan Africa and in Kenya. Further, literature related to Specific objective 1: to determine the influence of socio-

demographic and economic characteristics on household food security; Specific Objective 2: to examine the influence of crop farming practices on household food security and specific objective 3: to examine the influence of livestock farming practices on household food security were reviewed. Both the theoretical and conceptual frameworks were also explained under Chapter 2. Further, Chapter 3 addressed Research Methodology, under which the study area is well described, the research design adopted by the study is explained, the study population, sample size and sampling techniques, sources of data, data collection instruments and data analysis procedures, reliability and validity of research instruments and research ethics considerations are all explained. Results for specific objective 1 which aimed at determining the influence of socio-demographic and economic characteristics of households on food security is presentation, interpreted and discussed in Chapter 4. Under Chapter 5, results for Objective 2 which examined the influence of crop farming practices on household food security are presented, interpreted and discussed. Results for Objective 3 that examined the influence of livestock on household food security are presented, interpreted and discussed in Chapter 6. Chapter 7 entails summary, conclusion and recommendations of the study on the basis of the specific objectives of the study. It also suggests possible areas that further research could be conducted. The last section of the thesis includes the references and appendices.

CHAPTER TWO: REVIEW OF RELATED LITERATURE

2.1 Introduction

This chapter reviews literature that is related to the assessment of the influence of agricultural practices on household food security. It particularly focuses on establishing the relationship between agriculture and food security status of the semi-arid agro-ecological areas of sub-Saharan Africa; assessment of the influence of household socio-demographic and economic factors on household food security; the role of crop farming practices of household food security and the role of livestock farming practices on household food security. These were considered the main aspects of the study and hence reviewed topically.

2.2 The Concept of Food Security

The concept of food security has gradually evolved from the original term that emphasized the availability of food at the World Food Conference of 1974, to an emphasis on access to food (FAO, 1983) to today's definition stressing the four dimensions viz: the availability of food; access to food; utilization of food; and the stability of food (Figure2.1). The latest concept was adopted at the World Food Summit in 1996, which defined food security as "A situation when all people, at all times, have physical and economic access to enough, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO, 1997).The aspect of food security most commonly studied is that of food availability (supply). However, increased food supply alone does not guarantee food security. The concept of food security builds strongly on central aspects of sustainability such as equitable access, stability and utilization of food (FAO, 2008; 2010).

Food security is defined at global, national, regional, household and at individual levels (Figure 2.1). Ultimately, food security concerns the individual or family unit and its principal

determinant is purchasing power and income adjusted for the cost of the food that income could buy (FAO, 2010). Similarly, purchasing power at the national level, the amount of foreign exchange available to pay for necessary food imports, is a key determinant of national food security (Andersen, *et al*. 1999). However, for the purpose of this study, food security only applies to "household food security", which is the situation in which a household has the availability of, stability of and accessibility to adequate and well-balanced diet at all times and the household being at no risk of losing such availability, stability and access (FAO, 2010).

Food availability refers to the physical availability of food which is a function of both home production and imports, that is, through national food stocks and commercial food import, farming, community gardens and harvesting (own production and reserves), purchasing (the market), hunting wild food and fishing and food handouts (Renzaho and Mellor, 2009). However, this study concentrates more on domestically produced food. Increased food production will have to come from more efficient use of land already under cultivation as opposed to significant expansion of cultivated land which is not an economically or environmentally feasible option in semi-arid parts of the world (Pinstrup-Andersen and Pandya-Lorch, 1997; Mollel, 2010). Food security on its food supply or availability component implies adoption of best agricultural practices that have potential to increase productivity as a result of efficient and environmentally friendly agricultural practices (Sebastian, 2014). Therefore from a food availability perspective, increased food security occurs when the producer price of food rises, conventional factor input prices fall, improved agriculture technology prices fall, user costs of infrastructural services fall, weather conditions improved in food-producing areas, the world market price of food falls, national domestic income rises, international interest rates fall, the volume of food aids increases, and the domestic interest rates fall (Fosu and Nico, 2011). Food

access is actualized at the household and individual levels. Food access refers to the capability to obtain the needed food, either from own production or purchasing from the market (Bahiigwa, 2002). Access to food depends on the purchasing power of the households but also on what portion of income they spend on food. Within the households, full income is used not only for achieving food security but also for accessing other basic needs such as basic education, health care and housing (Maxwell, *et al*., 1999). This means that in the household, food access is influenced by intra-household food distribution decisions (FAO, 2009a, FAO, 2010).

Food utilization occurs in two forms: physical utilization and biological utilization. The physical utilization is the ability of a household to have all the physical means to use food available. This may include cooking utensils, culturally regulated feeding hierarchies, cuisine patterns, adequate housing, caretaker behavior, knowledge, family structure, and workload while the biological utilization is concerned with the ability of the body to effectively use the nutrients once the food is consumed (Renzaho and Mellor, 2010). To this point, food security has been correlated accordingly with the status of malnutrition prevalence, dietary energy balance or supply and prevalence of absolute poverty (Smith, *et al*., 2000). In order to be food-secure, adequate supply and access to food by an individual, a household or a community must be met at all times. If there is inadequate access to food due to sudden political shocks like conflict, economic shocks like high food prices or climatic shocks like droughts then there is food insecurity (Kendal, *et al*., 1996). Some temporal man made or natural disasters may affect food security and hence cause transitory food insecurity (Hartwig and Gunter, 2006). Figure 2.1 illustrates the concept of food security as a multi-sectorial and multi-dimensional phenomenon.

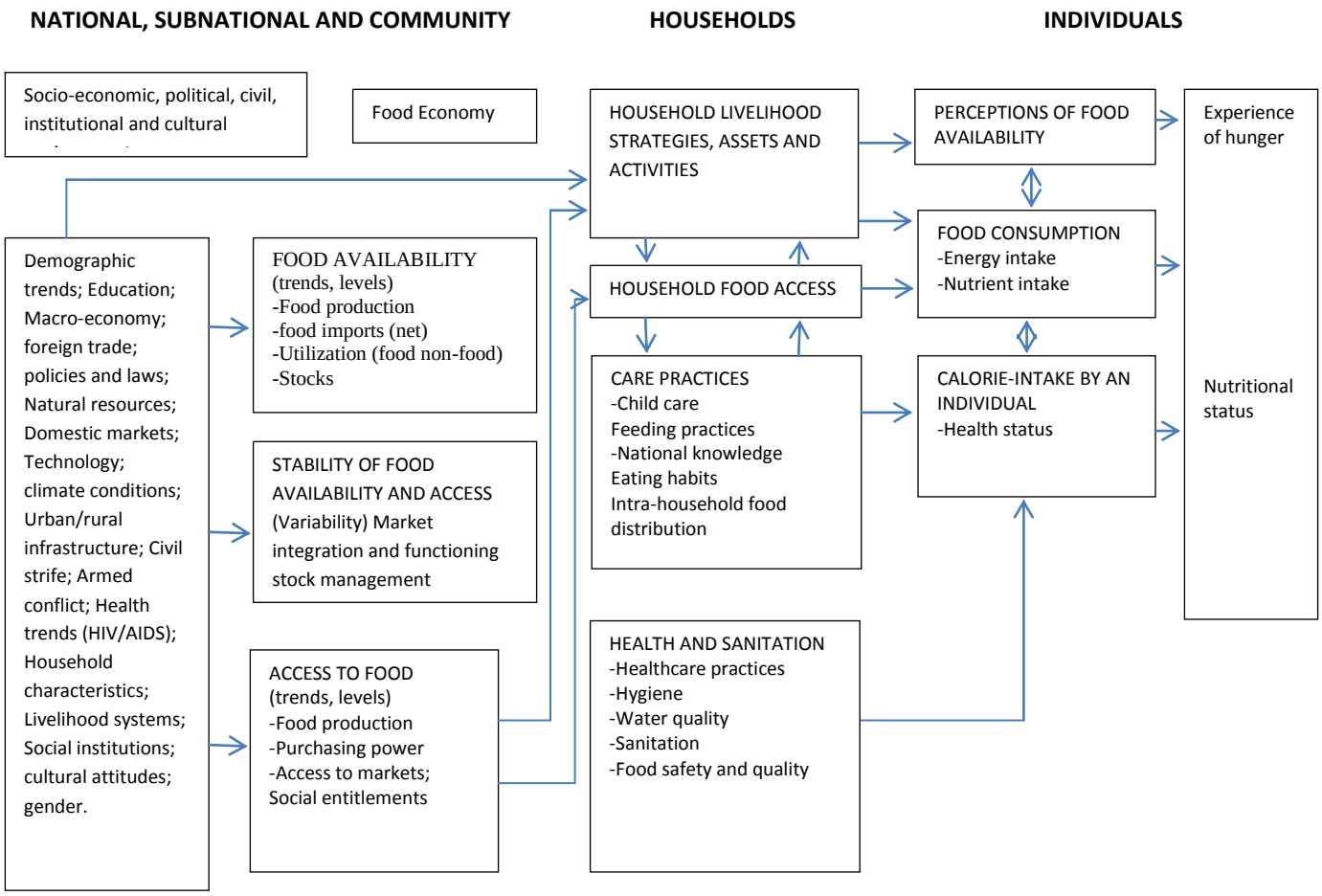


Figure 2.1: Food security analysis framework
Source: NEPAD, 2009

Critical to the understanding of food security is recognizing that it hinges as much on low purchasing power and entitlement as on variable production and supply. This implies that, to ensure food security requires long-term solutions taking account of socio-economic, environmental and political factors (Kiess, *et al*., 2001). What is important for households and individuals is the availability and adequacy of food intake, that is, whether their consumption requirements match the amount actually consumed (Shackleton, *et al*., 2001).

This intake can be produced or procured. Since production and prices fluctuate, consumption gap then results. One answer is provided by national carryover stocks, but these are not always

adequate. Relief can also come through food aid, which is, however, only a palliative. At all levels- household, domestic or international-fluctuations in prices will often affect food security. For household members, food is not available as needed either because they are unable to produce enough or because they cannot buy it. This may be because there is shortage of food in the market or limited funds to purchase their share from the market (Slack and Haddad, 1998; von Grebmer, *et al*., 2013). Production, access, the functioning of the market, the existence of early warning systems, famine prevention and relief measures come into play at this point. Chronic food insecurity causes famine, and the recurrence of famine and near-famine perpetuates food insecurity by destabilizing social relations and eroding the capacity of households to absorb the shock (Onianwa and Wheelock, 2006; Omotesho, *et al*., 2007; Wodon, *et al*., 2008).

2.3 Global Food Security Status

The latest FAO estimates indicate that the trend in global hunger reduction continues (FAO, 2015). About 805 million people were estimated to be chronically undernourished in 2012–14, down by more than 100 million over the last decade and by 209 million since 1990–92. However, about one in every nine people in the world still has insufficient food for an active and healthy life (FAO, 2014). The vast majority of these undernourished people live in developing countries, where an estimated 791 million were chronically hungry in 2012–14 (Azzarri, *et al*., 2012; FAO, 2014; 2015). Although developing countries also account for most of the improvements over the last two decades – with an overall reduction of 203 million undernourished people since 1990–92 – about one in eight people in these regions, or 13.5% of the overall population, remain chronically underfed (FAO, 2014; 2015). The decline in the share of hungry people has been more impressive than the reduction in absolute numbers. Between 1990–92 and 2012–14, the prevalence of undernourishment has fallen from 18.7% to 11.3%

globally, and from 23.4% to 13.5% in developing countries (FAO, 2014). If the current trend of a reduction of about 0.5% per year since 1990–92 continues, the prevalence of undernourishment in developing regions would reach 12.8% in 2015 – 1.1% points above the MDG target of 11.7%. With greater efforts, particularly in sub-Saharan Africa and Southern and Western Asia, the trend in hunger reduction can be accelerated to meet the MDG hunger target (FAO, 2014).

While the MDG hunger target seemed to be within reach globally (DFID, 2002), the World Food Summit (WFS) target of *halving the number* of undernourished people by 2015 was not achieved (FAO, 2015). Despite the progress in developing regions, large differences remain across particular regions. In Africa, there has been insufficient progress towards international hunger targets, especially in the sub-Saharan region, where more than one in four people remain undernourished – the highest prevalence of any region in the world (FAO, 2014). Nevertheless, the prevalence of undernourishment in sub-Saharan Africa has declined from 33.3% in 1990– 92 (FAO, 1997; 1999; Clover, 2003) to 23.8% in 2012–14 (FAO, 2014). Growing political commitment to promote food security in Africa is being transformed into concrete results. Strong economic growth (7 of the 10 fast-growing economies in the world are in Africa) is improving the living conditions of its growing population. There is greater recognition of the importance of ensuring peace and stability, the lack of which has been both cause and consequence of conflict that risks thwarting efforts to fight hunger in many countries in Africa (von Grebmer, *et al*., 2013; FAO, 2014). The situation is different in Northern Africa, with a far lower hunger burden, with the prevalence of undernourishment consistently less than 5% since 1990 (FAO, 2014).

Asia has a prevalence of undernourishment of 12.7%, corresponding to 526 million people, or an eighth of the region's population, chronically lacking access to enough food (FAO, 2014; 2015). As the most populous region in the world, Asia is home to two out of three of the world's

undernourished people. Overall, it is close to attaining the MDG 1c hunger target, but there are large differences across its sub-regions. Eastern and South-Eastern Asia have already met the target, having cut their undernutrition rates by more than half and more than two-thirds respectively (FAO, 2014). The Caucasus and Central Asia are also on track to reach the goal by 2015, while lack of progress in Southern and Western Asia makes it unlikely that these regions can achieve MDG 1c. Hunger continues to take its largest toll in Southern Asia, where population growth is high. The estimate of 276 million chronically undernourished people in 2012–14 is only marginally lower than the number at the beginning of the MDG process. Although the prevalence of undernourishment has declined from 24.0% in 1990–92 to 15.8% in 2012–14, progress is still too slow to allow Southern Asia to reach the MDG target by 2015 (FAO, 2014). The situation is worse in Western Asia, where the prevalence of undernourishment actually increased from 6.3% in 1990–92 to 8.7% in 2012–14, largely owing to political instability and the deterioration in overall economic conditions during recent years (IFPRI, 2013b; FAO, 2014).

To date, Latin America and the Caribbean – the first region to publicly commit to eradicate hunger by 2025 – has the most successful developing region record in increasing food security (FAO, 2014). It has already met the MDG target by a comfortable margin and is close to the WFS summit target. Much of the success results from rapid hunger reduction in Latin America, which has reached the WFS target, while the Caribbean has seen slower progress in fighting undernourishment so far (FAO, 2015). For the region as a whole, the prevalence of undernourishment has declined to 6.1%, representing little more than one-third of its hunger burden in the early 1990s (FAO, 1999). Of all the developing regions, Oceania currently has the lowest number of undernourished people (FAO, 2015). However, despite the low overall burden

of hunger in the region, this number has increased over the last two decades, while the prevalence of undernourishment has only registered a very modest reduction. Estimates place undernourishment at 14.0% in 2012–14, only 1.7% points below the level for 1990–92 (FAO, 2014). An additional cause for concern is that rising undernourishment in Oceania has been accompanied by a growing burden of overweight and obesity, exposing the region to a significant double burden of malnutrition (FAO, 2014).

2.4 Food Security Status in Sub-Saharan Africa

The severity of hunger in Africa is categorized ranging from "Low" to "Extremely alarming". These categories are associated with Global Hunger Index (GHI) scores. Higher scores indicate greater hunger; the lower the score, the better a country's situation (Holt-Gimenez, 2010). Of the 19 countries worldwide with alarming or extremely alarming levels of hunger, 15 are in Africa south of the Sahara (FAO, 2012). Despite the progress in developing regions as a whole, large differences remain across regions. In Africa, there has been insufficient progress towards international hunger targets, especially in the sub- Saharan region, where more than one in four people remain undernourished – the highest prevalence of any region in the world (FAO, 2014; 2015). Nevertheless, the prevalence of undernourishment in sub-Saharan Africa has declined from 33.3% in 1990– 92 (FAO, 1997; 1999; Clover, 2003) to 23.8% in 2012–14 (FAO, 2014).

The current state of food security in Kenya is paradoxical. Severity of hunger in Kenya is categorized as "Serious", while food shortage in semi-arid Kenya is categorized as "alarming". Overall, from the 1990 GHI to the 2013 GHI, six countries in Africa were able to reduce their scores by 50 percent or more. Twenty countries made modest progress, reducing their GHI scores by 25.0 to 49.9%, and 17 countries decreased their GHI scores by 0.0 to 24.9%. Kenya falls within the last category, a fact partly attributed to the HIV and AIDS epidemic, along with

high unemployment and adverse macroeconomic conditions, as the likely factors that undermined food security in the country (FAO, 2015; von Grebmer, *et al*. 2013). According to the Integrated Food Security Phase Classification, the majority of Kenyan households experiencing problems with food security are in the second 'borderline' food insecure phase. By the autumn of 2012 up to 10% of the population had reached the 'crisis' phase (FAO, 2012).

The International Food Policy Research Institute (IFPRI) publishes an annual report on hunger in the world called the "Global Hunger Index". This index reflects the share of the undernourished population, the share of underweight children under the age of five years and child mortality. Kenya ranked fiftieth out of eighty-one countries in 2011 (IFPRI, 2011). In 2012 the country fell to fifty-fourth place on the list (IFPRI, 2012). Hunger in Kenya is assessed as a 'serious problem'. Kenya does not even meet the requirements for reducing malnutrition as part of the first United Nations Millennium Development Goal One (MDG lc) (IFPRI, 2012). In response to some of the food security challenges facing by the smallholder farming households in sub-Saharan Africa, there is consensus that support and appropriate technologies requiring low inputs would significantly improve the take-up of subsistence production (Tripp, 2006; World Bank, 2006; CAADP, 2010). Examples of some of these technologies include rainwater harvesting and soil and water conservation practices, indigenous technologies and organic inputs (Dorward, *et al*., 2008). The technologies have been shown to increase yields significantly and reduce risks of crop failure (Botha, *et al*., 2003; Bogale and Shimelis, 2009). Furthermore, the uptake of farming by poor households will significantly reduce their dependence on purchasing food from the market and thus release some income for other household uses. However, this will require appropriate and targeted support to ensure the success of the efforts to improve subsistence production among the poor and food-insecure households (NEPAD, 2013a).

2.5 Socio-Demographic and Economic Household Characteristics and Food Security

Measures to ensure sustainable food security should consider not only climatic and edaphic factors but also management, demographic and socio-economic aspects of the farming household (Alamgir and Arora, 1991). While mixed farming still remains an important source of food for rural households, farmers in Kwarwa State, Nigeria are looking for diverse opportunities to increase and stabilize their incomes (Omotesho, *et al*. 2007). Therefore rural livelihoods are based not solely on agriculture but on a diverse array of activities and enterprises (Chapman and Tripp, 2004). The extent of dependence on non-farm income sources varies across countries and regions. Evidence from a sample of rural villages in Tanzania as illustrated by Ellis and Mdoe, 2003; Chapman and Tripp, 2004 show that on average, half of household income came from crops and livestock and the other half from non-farm wage employment, self-employment and remittances. The proportion of non-farm income was higher for upper income groups than for the lowest income groups. The poorest households were therefore more reliant on agriculture, a reliance which decreased as non-farm activities increased (Idrisa, *et al*., 2010).

In a study of 11 Latin American countries, Reardon, *et al*. (2001) found that non-farm income accounted for 40% of rural household incomes. The extent to which rural households are able to feed themselves depends on non-farm income as well as on their own agricultural production (Chapman and Tripp, 2004) since non-farm income is used by many households to purchase their staple grain. Subsistence agriculture and food security should therefore be understood in this context of diversified income sources (Goita, *et al*., 2013). According to Bryceson (2000; 2002), based on a case study of seven countries (Nigeria, Ethiopia, Tanzania, Congo-Brazzaville, Malawi, Zimbabwe and South Africa), the countries were all undergoing "de-agrarianisation" and "depeasantisation". This was driven mostly by restrictions on access to land (South Africa),

urbanization (Congo-Brazzaville and Nigeria) and the removal of agricultural subsidies with the enforcement of structural adjustment policies in the other four countries. During this period, peasant agriculture, with its subsistence orientation and relatively low yields, was discouraged in favor of agro-industrial production that involved off-farm sources of income (Bryceson, 2000).

According to Jayne, *et al*. (1999), 61% of maize-growing households in Kenya were found to be net buyers of maize. Such households may be more interested in lower food prices than in investments to increase subsistence production. However, surpluses from off-farm income may provide farmers with the financial security that would enable greater on-farm innovation (World Bank, 2006). This is largely dependent on whether the households diversified out of agriculture due to a lack of opportunities for on-farm innovation or whether they are exploiting a particularly high demand for their labor off-farm (Chapman and Tripp, 2004). Furthermore, Doss (2006) agrees that on-farm investment is likely to occur when non-farm work is of short duration and the household farm has not been neglected.

Despite the above mentioned changes in food accessibility, African rural-dwellers value the pursuit of small-scale mixed farming activities (Bryceson, 2002) thus subsistence production of food is still a major component of livelihoods in sub-Saharan Africa. The use of improved input packages is declining since effective input packages have not yet been developed, especially for the semi-arid parts of the region. In addition, the input packages that exist for the higher rainfall areas need to be supplemented with expansion of intermediate and appropriate technology to improve returns to labour (World Bank, 2006; CAADP, 2009). Small-scale farmers have the potential to play an important role in reducing sub-Saharan Africa's food deficit. Subsistence production complemented by off-farm sources of livelihood can increase food supplies and

accessibility thus cushioning households from food price shocks, thereby improving household food security (Matata, *et al*., 2008).

2.6 Agriculture and Household Food Security in Semi-Arid Environments

Semi-arid regions occupy about 18% of the earth's land and are home to approximately 16 percent of the global population (Dobie, 2001). The semi-arid regions are prone to food insecurity in varying severities (Clover, 2003). Oteng'i (1995) observes that farmers in semi-arid areas of Laikipia District, Kenya practice cropping systems mainly centered on small-scale farming. Under small-scale farming, agricultural production rely on rainfall performance and land-use practices, therefore deficiency in annual and seasonal rainfall and inappropriate practices lead to crop wilting, crop yield loss, total crop failures, reduction in crop yield, inadequate pastures and livestock mortality hence food insecurity (Claeys, 2013). Most African farmers, particularly in semi-arid tropical areas, rely on rain-fed agriculture with very limited use of inputs such as fertilizers (Dixon, Bofa and Garitty, 2014, Dorward, *et al*., 2008). This means that the land's agricultural production depends almost solely on the agro-ecological (AEZ) context. In Africa, where most agriculture is rain-fed, crop growth is limited by water availability. Rainfall variability during a growing season generally translates into variability in crop production. The spatial distribution of Africa's dominant farming systems is, therefore, closely aligned with the regional pattern of AEZs (Mollel, 2010). Local agro-ecological conditions not only influence the range of feasible agricultural enterprise options in an area but also often strongly predict the feasibility and effectiveness of improved technologies and production practices. For this reason agriculture research and development planners are keen to understand the nature and extent of agro-ecological variation in the areas where they work (Thornton and Herrero, 2010). There is also growing interest in the potential consequences of

agro-ecological change. Slack and Haddad, (1998) intimates that change might be brought about by mitigating local agro-ecological constraints through, for example, investments in irrigation or improved soil-water management practices.

External factors such as climate change may also drive agro-ecological change (Blench and Marriage, 1999). The likely negative economic and social implications of shifting agro-ecological patterns in Africa due to climate change are priorities for emerging research and policy research. Over the past three decades, extreme poverty has fallen substantially in many regions of the world, especially in East Asia, the Pacific and South Asia. In sub-Saharan Africa, however, little progress has been made and almost half the population is extremely poor (NEPAD, 2013b). Extreme poverty is disproportionately concentrated in rural areas of sub-Saharan Africa where households rely on agriculture for food than urban households (Omotesho, *et al*., 2010). The reliance of rural households on agriculture for their livelihoods and the high share of expenditure on food makes agriculture key to poverty and hunger alleviation interventions in the rural areas (FAO, 2015).

Semi-arid environments of Kenya experience nearly all of the major impediments to improved food production (Mwangi, 2000). These impediments are such as high cost of agricultural inputs, lack of processing facilities, inaccessibility of markets, lack of extension services, poor agricultural technology, low and erratic rainfall, increased livestock diseases, lack of irrigation canals, floods and lack of dams, high population growth rate leading to over subdivision and over utilization of land and lack of title deeds (Swallow and Wangila, 2002). The semi-arid Nyakach is characterized by 60% absolute poverty, 65% food poverty level, disease and destitution (KCDP, 2013). These further worsen the problem of food insecurity. It is important that particular governments encourage agricultural production so as to increase national and

household food security (McIntyre, *et al*., 2009). In South Africa, the government has initiated programs to assist farming households with sustainable access to inputs. The programs are planned in a way that households are able to generate enough cash to continue to acquire these inputs beyond an initial period of government support (shackleton, *et al*., 2001).

Appropriate inputs for sustainable and intensified agricultural production include fertilizer, animal traction, organic inputs, and water and soil conservation technologies. An estimated four million people in South Africa engage in smallholder agriculture so as to procure 'an extra source of food'. In addition, the number of people engaged in agriculture as a 'main source of food' is increasing over time (Seti, 2003). However, there are no credible, long-term national data that establish the contribution of the subsistence/smallholder agricultural sector to food security. Household survey data indicate that black households with access to agricultural land reported that agriculture contributes 15% of the total household income, but for the poorest quintile the contribution stands at 35% (Aliber, 2005). While the contribution of agriculture to household income is small, evidence from case studies indicates that agriculture in the former homelands is undergoing a decline. The commonly cited reason for this decline is the removal of support that farmers in former homelands used to receive from pre-1994 governments (Sierbert, *et al*., 2010). An example is Thaba Nchu in the Free State where with the removal of government subsidies, farmers stopped cultivating communal lands because they could not afford the necessary inputs.

In order to eradicate hunger the food-insecure households need better control over resources, access to opportunities, and improved governance (FAO, 2009a). In addition to the foregoing factors, the threat of climate change and global warming has become pertinent to agriculture and food security in recent years (Nelson, *et al*., 2014). Based on findings of the Intergovernmental

Panel for Climate Change (IPCC), climate change is anticipated to have severe effects on food security, environmental sustainability and equity, possibly increasing the number of hungry people from 100 million to 380 million by 2080 (Easterling,, *et al*. 2007). The estimated rise in temperature is in the range of 2°C to 4.5°C (Meehl *et al*., 2012) with a most likely value of about 3°C. More recent findings emphasize the possibility of abrupt changes and suggest that climate sensitivity ranges from 2.5 to 6.0°C (Monastersky, 2009; Nelson, *et al*., 2014). Sub-Saharan Africa is especially vulnerable to these climatic changes and to the resulting agricultural production response (Jayne, *et al*., 2003). According to projections, climate change impacts on SSA are considerable; even a 1°C to 2°C warming would lead to high yield losses in arid and semi-arid areas (30-50% by 2050). Projections related to climate change are subject to huge uncertainties for smaller geographical areas, so effects may vary by region (Nelson, *et al*., 2014). Food and agricultural reforms are necessary in developing countries. This includes more equitable access to productive assets such as land, livestock and water, as well as all the inputs and services needed to make the land more productive (WCED, 1987; NEPAD, 2009; FAO, 2015). A prerequisite for this is a broad-based land reform, increased equity and the creation of new rural power structures. In countries where land reform has occurred such as Eastern Europe, China, Japan, Korea, Taiwan, India, Pakistan and Cuba, the aims of increasing food security through enhanced agricultural production have been largely achieved (Ruel, *et al*., 1998; Frayne and Pendleton, 2009). These successful land reforms have been complemented with the institutions and policies that promote production, equity and productive accumulation.

The creation of a balanced system of incentives at the individual, sectoral and country levels is also crucial to the success of such reforms (NEPAD, 2013; FAO, 2015). Increased subsistence food production has the potential to improve the food security of poor households in both rural

and urban areas by increasing food supply, and by reducing dependence on purchasing food in a context of high food price inflation in developing countries (Ruel, *et al*., 1998, IFPRI, 2012, USAID, 2014). There is a general consensus that households access food mainly through three sources. These are the markets, subsistence production and transfers from public programs or other households (Ruel, *et al*., 1998). These sources are entitlements categories that entail production, exchange (barter or purchase) and transfers (Sen, 1982; Holt-Gimenez, 2010). Historically, rural households produced most of their own food, whereas urban households purchased most of their food (von Braun, *et al*., 1993). Recent studies in the Czech Republic, however have shown substantial increases in dependence on market purchases of food by both urban and rural households (Maritz, 2013). As a result food expenditures of low-income households in developing countries are as much as 60-80% of their total income (Lee, 2007; Bickel, *et al*. 2000, CAADP, 2012). A similar case scenario may replicate in semi-arid Nyakach. Subsistence agriculture currently supports about 25 million people in the Lake Victoria Basin (EuropAfrica, 2013) with average incomes in the range of US$ 90-270 per annum (World Bank, 2014). The Welfare Monitoring Survey done in Kenya in 2012 shows that the incidence of "hard-core" poverty in Kisumu County is 60%. Hard-core poverty was defined as total expenditure of less than Ksh.703 per adult equivalent per month (Kenya National Bureau of Statistics, 2014). With this pervasive poverty among the farming communities in the basin, the use of inorganic fertilizer is limited and primary productivity is wholly linked to the inherent productive capacity of the soil (Banderembako, 2006). Inappropriate agricultural land use has resulted in soil erosion in the order of 5-10 tons per hectare per year (KCDP, 2013), and this is associated with substantial losses in soil nutrients that contribute significantly to negative farm

nitrogen, phosphorus and potassium balance hence low agricultural production (Jama and Pizarro, 2001; Omotesho, *et al*., 2010).

2.6.1 Crop Farming and Household Food Security

Cropland covers approximately 7% of the African continent. High concentrations of cropland (60≤ percent) are found along the arid and semi-arid Mediterranean coast in the Nile Valley, Nigeria, the Ethiopian highlands, the Rift Valley north and the Lake Victoria Basin (FAO, 2012). Due to uncertainty in food production from the agriculture sector, the small scale resource-poor farmers in semi-arid environments have resorted to mixed farming so as to minimize risks of either crop or animal failure (Bryceson, 2000; CAADP, 2010). Spreading the risk between several crops, whether subsistence or commercial crops, also minimizes the risk related to unstable or declining prospects in local, regional or national markets as the risk of all crop markets failing simultaneously is smaller than on the risk of a single main crop failing (Ellis and Mdoe, 2003). Furthermore indigenous crops are more resistant to climatic irregularities than exotic crops and can cope with little rainfall. Similarly, a flexible production schedule can adjust to variations in rainfall patterns and protect against total seed loss from, for example, mid-season droughts (Braun, *et al*. 1997). The protection this affords is only partial, however, as severe weather conditions such as drought and flashfloods are likely to damage all crops (Ellis and Mdoe, 2003). Following this line of thought, the same can be said for crop pests and diseases.

To survive the negative effects of crop farming practices on food security, Clover (2003) and Davies (2006) note that inhabitants of the Malian Sahel have evolved a form of existence which enables them to live with the harsh climatic conditions and food insecurity. Among the mixed farmers, diversification of crops and animals has been the major adaptive strategy against the effects of land-use practices and food insecurity. A mix of different crop types planted together

ensures that the farmers obtain some harvests from at least one type that is less affected by the drought (Davies, 2006). In Danbatta district in Nigeria, Ribot, *et al*. (1996) observes that farmers cultivate larger portions of land after a given drought in order to compensate for low yields and also practice small-scale irrigation to enhance their agricultural productivity. Morris, *et al*., (2007) notes that mixed farmers in Sukumaland, Tanzania, plant drought-resistant crops and practice regular weeding of their planted fields so as to reduce competition for moisture between crops and weeds. (Wang'ati, 1996; Mburu, 2011).

A better understanding of current and evolving ways to increase productivity of cropland should aid in tailoring more pragmatic solutions for smallholder farmers in arid environments of sub Saharan Africa (Otte, *et al*., 2012) where conversion from natural vegetation (forest, grassland or woodland) to cropland represents a process level change in quality and quantity of litter inputs and conditions of soil organic carbon formation and mineralization (Dixon, *et al*., 2014). Results from ongoing studies in semi-arid parts of Kisumu County show the effects of conversion of grassland to cropland whereby average litter in cultivated land is only 11% as high as litter cover of the grassland (mean of 8.6 tons/ha in the forest versus a mean of 0.9 tons/ha in cultivated land. (World Agroforestry Centre, 2004). The absence of soil cover and reduced litter makes the soil surface more compact and less permeable. Surface and sub-surface infiltrations rates are significantly lower in cropland than in the grassland. The overall result of cultivation is the disturbance of nutrient cycles and accelerated loss of soil organic carbon through Volatilization, leaching or water erosion, (Tewodros and Subaro, 2013).

Solution to food crisis due to decreasing crop production in semi-arid areas of the world requires an integrated approach by all stakeholders (Dovie, *et al* 2003). Problems of soil fertility loss and declining productivity have to be addressed without eroding the natural resource base over the

long term. (World Agroforestry Centre, 2004). While subsistence crop production has been shown to be important for household food security, the productivity of smallholder agricultural production is quite low and in some cases is given as the reason for the abandonment of agricultural production by rural households and their reliance on non-farm sources of income (Doss, 2006). According to the Rockefeller Foundation (2006), this is a consequence mostly of the non-use of high-yielding crop varieties that are widely used in other parts of the world. As a result, increasing yields depends mostly on increasing the area cultivated. If better seeds and technologies could reach the farmers, the inefficiency and food shortage risks could be significantly reduced (Dorward, *et al*., 2008). It is possible to deliver these inputs and assist farmers to use them more effectively (Rockefeller Foundation, 2006). Hence studies by Obuoyo, (2005) noted that it is also important that farmers in the dry agro-ecological zones of Siaya District in Western Kenya should stop growing exotic varieties of crops and revert to the practice of growing indigenous crops, which are tolerant to moisture deficit, relatively high air temperatures and poor soil conditions. This would result in increased food production hence availability. The above studies agree that smallholder crop production in semi-arid areas is low hence the need for diversification of crop farming practices so as to enhance household food security. Therefore there was need to provide adequate information on the influence of crop farming practices on household food security.

2.6.2 Improved Fallow Agro-Forestry System and Household Food Security

Agroforestry is an important land-use practice that ensures increased and sustainable food production by smallholders in western Kenya (Waithaka, *et al*., 2007). In agroforestry systems, one or more tree crops are combined with one or more food crops or animal farming on the same plot of land in spatial or temporal combinations (Jama and Pizarro, 2001). If the different crops

are well selected, they reinforce each other (Yila and Thapa, 2008) and the total food production is greater than in separate food growing systems (Renhazo and Mellor, 2009). The International Centre for Soil Fertility and Agricultural Development (2007) points out that especially good results can be achieved by the use of multi-purpose trees in such improved fallow agroforestry systems. Some tree species, such as *Acacia albida* can fix nitrogen and, consequently, fertilize the soil; some fruits are edible, while others are used as medicine; some leaves are used as animal fodder; and branches can be chopped off to provide firewood or to be used in basket making (Tripp, 2006).

Although the term is relatively recent, "agroforestry" has been practiced by traditional farmers everywhere (Garrity, *et al*., 2012). The challenge today is to revive the old methods and adapt them to the new conditions, in addition to developing new methods. Agroforestry practices can significantly reduce deforestation since they reduce the need to convert forest land into agricultural land and pastures (Place, *et al*., 2003) and provide farmers with the means of producing their own food, firewood, timber, fertilizer, fodder, building poles and other forest products (Tripp, 2006; Waithaka *et al*., 2007). Natural fallows for one to two seasons generally do not improve soil fertility and crop yields significantly in the arid and semi-arid areas although this effect is likely to be site and fallow-specific (Place, *et al*., 2004).

Natural fallows can however be improved by introduction and planting of fast-growing leguminous trees and shrubs. Improved fallows of leguminous trees and shrubs accumulate Nitrogen in their biomass through biological Nitrogen-2 fixation, capture of sub soil nitrogen unutilized by crops, and interception of nitrogen leached beyond the crop rooting zone (Buresh and Tian, 1997; Waithaka, *et al*., 2007). Leguminous trees and shrubs such as Sesbania have been reported to fix large quantities of nitrogen (Rao, *et al*., 1990; Tripp, 2006). This nitrogen

(N) can benefit crops through the recycling of tree leaf and root litter, nutrients captured by trees from below the rooting zone of annual crops can also become an input when transferred to surface soil in the form of leaf litter, roots and prunings of tree leaves and branches (Schroth, 1995; Morris, *et al*., 2007). In addition, tree fallows can increase large fractions of soil organic matter, which supply nutrients to crops after fallows (Beddington, 2010). Overcoming soil fertility depletion is fundamental to increasing maize and other cereals yield.

2.6.3 Livestock Farming and Household Food Security

One quarter of the world's estimated 752 million small-scale livestock keepers live in Africa south of the Sahara (SSA), where more than 85 % of them live in extreme food poverty (Otte, *et al*., 2012, Sebastian, 2014). Agricu1tural productivity gains and diversification into high-value products such as livestock products are essential ways of raising rural incomes and improving rural household food security in such areas, where keeping of small herds of livestock such as cattle, sheep, goats and poultry is practiced alongside crop farming (Feleke, *et al*., 2005). Studies by Elzaki, *et al*., (2011) concur that livestock production is an important contributor to sustainable food security for many nations, particularly in low-income areas and marginal habitats such as the arid and semi-arid environments of the rural White Nile State of Sudan that are unsuitable for crop production. These households keep livestock to ensure continuity in food availability during droughts and crop failure since animals are less affected than crops.

Pastureland covers one-quarter of the African continent and dominates the semi-arid landscapes in the Sahel and Sudano-Sahelian regions, the Maghreb, much of eastern and southern Africa, and western Madagascar (Elzaki, 2005). Livestock production constitutes a very important component of the agricultural economy of developing countries, a contribution that goes beyond direct food production to include multipurpose uses, such as skins, fibre, manure and fuel, as

well as capital accumulation that could be spent on purchase of food (Swanepoel, *et al*., 2010). Furthermore, livestock are closely linked to the social and cultural lives of several million resource-poor farmers for whom animal ownership ensures varying degrees of sustainable farming and economic stability (FAO, 2015a). Official global statistics have underestimated or ignored the multipurpose role that livestock play in food and agricultural production, as well as in the social life of smallholder farmers in developing countries (Smith, *et al*.; 2000; Kassa, *et al*.; 2002;). Instead, the overriding considerations in livestock production have been the availability and efficient use of local natural resources. Further, a successful livestock development strategy requires the formulation of resource management plans that complement the wider economic, ecological and sociological objectives (Swanepoel, *et al*., 2010). Particular attention needs to be given to land-use systems and to the natural resources required for improved livestock production (Elzaki, *et al*., 2011). The strategy will also need to consider the social, cultural, political and institutional elements that affect the management of natural resources. On the policy side, issues relating to land use, common property, legislation, price policies, subsidies, levies, national priorities for livestock development and research capacity have to be addressed (Fosu and Nico, 2011). Finally, the implementation of action programs requires both technical and institutional support and equally important, government commitment (World Forum for Food Security, 2007; Praskova, 2013).

Further, the World Vision International, Burundi (2003) asserts that food security of each country is naturally closely tied to the production of food from livestock sector, a fact that is supported by findings of Kassa (2002). According to a study by the Intergovernmental Authority on Development (IGAD), animal products make up 43% of the agricultural GDP of Kenya. Three-quarters of this amount is milk production (IGAD, 2012; Otte, *et al*., 2012). In Kenya,

William and Balling (1996), Davies (2006) and GoK (2012a) confirm that distribution of livestock among households in different ecological zones to avoid loss of entire stock, keeping stock of mixed species and feeding requirements such as a mixture of grazers and browsers, subdivision of livestock into grazers and browsers during drought in order to exploit different microhabitats, keeping of indigenous stock species better adapted to tolerate drought conditions and food shortages are the common drought coping strategies in pastoral and mixed-farming communities. Blench and Marriage (1999) observes that cattle-raiding is also a survival strategy of restocking livestock after droughts in arid and semi-arid areas of East Africa and Madagascar. The current global food crisis has brought to the mainstream of public policy and development planning, alongside being matters of academics, the need to take measures to promote the management and sustainable use of livestock enterprises (FAO, 2003; Maxwell and Slater, 2003; Oriola, 2009). Since 1970s countries have been formulating policies and laws as well as establishing various institutional arrangements to deal with global and local food problems. World Forum for Food Security (2007) however asserts that despite these efforts, food insecurity, particularly due to low agricultural production, continues. This situation threatens humanity's future by undermining the socio-economic base of most societies (FAO, 2009a). The world is faced by inadequate demonstration of how livestock can play a key role in the development of sustainable agriculture and food security in different agro-ecosystems, and the failure to transfer appropriate technologies (NEPAD, 2009).

The FAO (2009b) concurs that in particular, most of the increase in animal products has come from an increase in animal numbers rather than from an increase in individual-animal productivity, a fact that erodes further the ability of semi-arid lands to produce more animal source foods. Many of the problems associated with livestock production in arid and semi-arid

lands are a result of the inability to identify appropriate technologies and define strategies for livestock development that are applicable to individual agro-ecosystems (FAO, 2015). Often, technology is transferred from developed countries unmodified, rather than generating appropriate technologies within the developing countries themselves (Yila and Thapa, 2008). Imported technologies have almost always failed to overcome the constraints imposed on local farming systems or to meet the socio-economic requirements of the local farmers (Zeller, *et al*., 2014). Careful analysis and assessment are required so that livestock development strategies can be reoriented towards better use of local resources, contribute more effectively to food security, improve the living standards of poor farmers and ensure sustainable animal agriculture development (Otte, *et al*., 2012). The determining factors of this overall strategy include: improved capacity and commitment of national and international agricultural centres and non-governmental organizations (NGOs) to implement strategies that contribute to the development of livestock production within specific agro-ecosystems/ecoregions (Fischer, *et al*., 2009; FAO, 2015). The above studies indicate that the livestock sector has contributed positively in improving food availability but the sector is neglected. Many of the problems associated with livestock production in arid and semi-arid lands, therefore, are a result of the neglect. Therefore, the study examined livestock farming practices on household food security.

2.7 Theoretical Framework

Theoretical framework has been prepared as a mapping strategy for the presentation of the research study. The Sustainable Agricultural and Rural Development (SARD) approach was adapted and modified so as to explain the relationship between demographic and socio-economic attributes of the farmer, sustainable agricultural practices and food security. The term Sustainable Agricultural and Rural Development (SARD) is here defined as a process, which entails the

following elements. First, it ensures that the basic nutritional requirements of present and future generations are met, while providing a number of other agricultural products. Second, such process provides durable employment and sufficient income for all those engaged in agricultural production. Third, that process maintains and, where possible, enhances the productive capacity of the natural resource base as a whole, and the regenerative capacity of renewable resources, without disrupting the functioning of basic ecological cycles and natural balances, destroying the socio-cultural attributes of rural communities, or causing contamination of the environment. Finally, that process is presumed to reduce the vulnerability of the agricultural sector to adverse natural and socio-economic factors and other risks, and strengthens self-reliance and food security (FAO 1999). It was also noted that the SARD approach has been further elaborated and operationalized by other scholars such as Rabbinge (1995); Bouma, *et al*. (2007), Rotter, *et al*. (2007), and in the International Assessment of Agricultural Science and Technology for Development (IAASTD,2011; www.agassessment.org), including for instance, equity aspects. The multi-functional character of agriculture and land use (commonly referred to as MFCAL framework) also builds on SARD (FAO, 1999). The theoretical framework of the link between rural development, sustainable agricultural practices, poverty alleviation and food security that this study has adapted is presented in Figure 2.2.

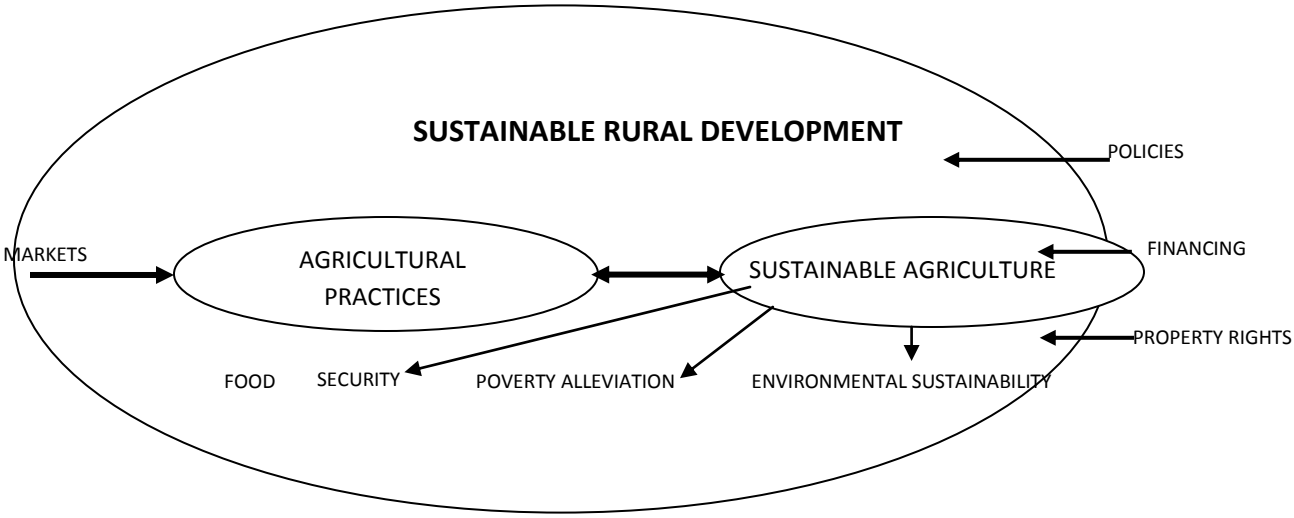


Figure 2.2: Theoretical framework
Source: Modified from Sumelius, *et al*., 2009).

Agricultural sustainability influences food security, poverty alleviation, environmental sustainability and agricultural productivity. Policies, financing possibilities, property rights and markets are in turn important instruments that partly directly influence sustainable agriculture and also the possibilities to improve food security and to decrease poverty. Sustainable rural development relies on agricultural practices and sustainable utilization of natural resources such as vegetation and soil. It is a development that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987, pg. 43). Sustainable rural development is a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are all in harmony and enhance the current and future potential to meet needs and aspirations (*ibid*, pg. 46). Appropriate agricultural practices result in sustainable agriculture, which then contribute positively to alleviating poverty, environmental sustainability and food security.

Agricultural policies, financing, property rights and markets are also determinant factors that influence sustainable rural development, which is not attainable unless the community is food secure. This owes to the fact that a food insecure people will definitely mismanage the physical environment from where they get their food. It therefore becomes a cycle of inappropriate agricultural practices- unsustainable agriculture- food insecurity- unsustainable rural development. Sustainable agriculture and rural development (SARD) practices have the potential to reduce hunger and poverty while sustaining the ecosystems that poor rural people rely on for their livelihoods. Farmers and local communities have developed many valuable approaches to SARD that could benefit other groups, but limited resources or political and social constraints have often hampered the uptake of exemplary practices or the sharing of lessons learned. From the year 2007 to date, The International Institute for Sustainable development (IISD) and Agriculture and Agri-Food Canada have been working in collaboration with the Food and Agriculture Organization (FAO) under the Sustainable Agriculture and Rural Development (SARD) Initiative, to help civil society organizations and governments identify local successes in SARD and build capacities, particularly of the poorest and most disadvantaged groups, such as the small scale mixed farming households in developing countries to adopt, replicate and scale up good farming practices so as to upscale food security.

This is part of the process to develop the Sustainable Development Goals (SDGs), which was expected to be implemented by 2015, the end of the implementation period for the Millennium Development Goals (MDGs). Agriculture in the hands of small scale mixed farmers provides three key outputs: food for consumption and exchange; enhanced livelihoods through sale of food and other agricultural produce, stimulated rural economies; social and environmental sustainability, with better use of soils, water and agricultural biodiversity, and strong local

institutions. This enhances sustainable rural development. Small scale farmers are the basis of Africa's food system thus developing and protecting the resource base of farming families are essential to achieving a sustainable food system in Africa. The family farm exists to support the welfare and livelihoods of the members, both through the production of food to be consumed within the household, supporting food security, and also through sale of produce and value addition (Jan Douwe van der Ploeg, 2005).

The Study adapted the Sustainable Agricultural and Rural Development (SARD) approach so as to explain the relationship between social, demographic and economic attributes of the farmer (intervening variables), sustainable agricultural practices (independent variable) and food security (dependent variable), as illustrated in the conceptual framework. The SARD provides the link between sustainable rural development, agricultural practices and sustainable Agriculture, which influence household food security through improved agricultural productivity. Therefore in this study the researcher focused on household socio-demographic and economic characteristics, crop farming practices, livestock farming practices and their influence on household food security as illustrated in the conceptual framework.

2.8 Conceptual Framework

Based on the literature reviewed and theoretical framework, problems of poverty, farmers' demographic and socio-economic attributes, agricultural practices and food security are large closely-related. The concepts that emerge are the linkages between sustainable agricultural practices and poverty alleviation, food security and practices and sustainable rural development. It becomes increasingly important to find out the influence of agricultural practices on food security in semi-arid lands. This study focuses on the agricultural practices and the extent to

which the use of agricultural land in the study area has contributed towards food availability, accessibility, stability and utilization in semi- arid Nyakach.

Figure 2.3 is a summary of the relationship between household characteristics, agricultural practices and food security. Crop farming and livestock farming relate to food security. Practices such as continuous cropping, intercropping, agroforestry, and animal health and husbandry may influence the food security in the study area. In order to address the menace of food crisis in the study area therefore, this study aims to establish the socio-demographic and economic characteristics that influence household food security, identify various agricultural practices and examine how they may have influenced household food security.

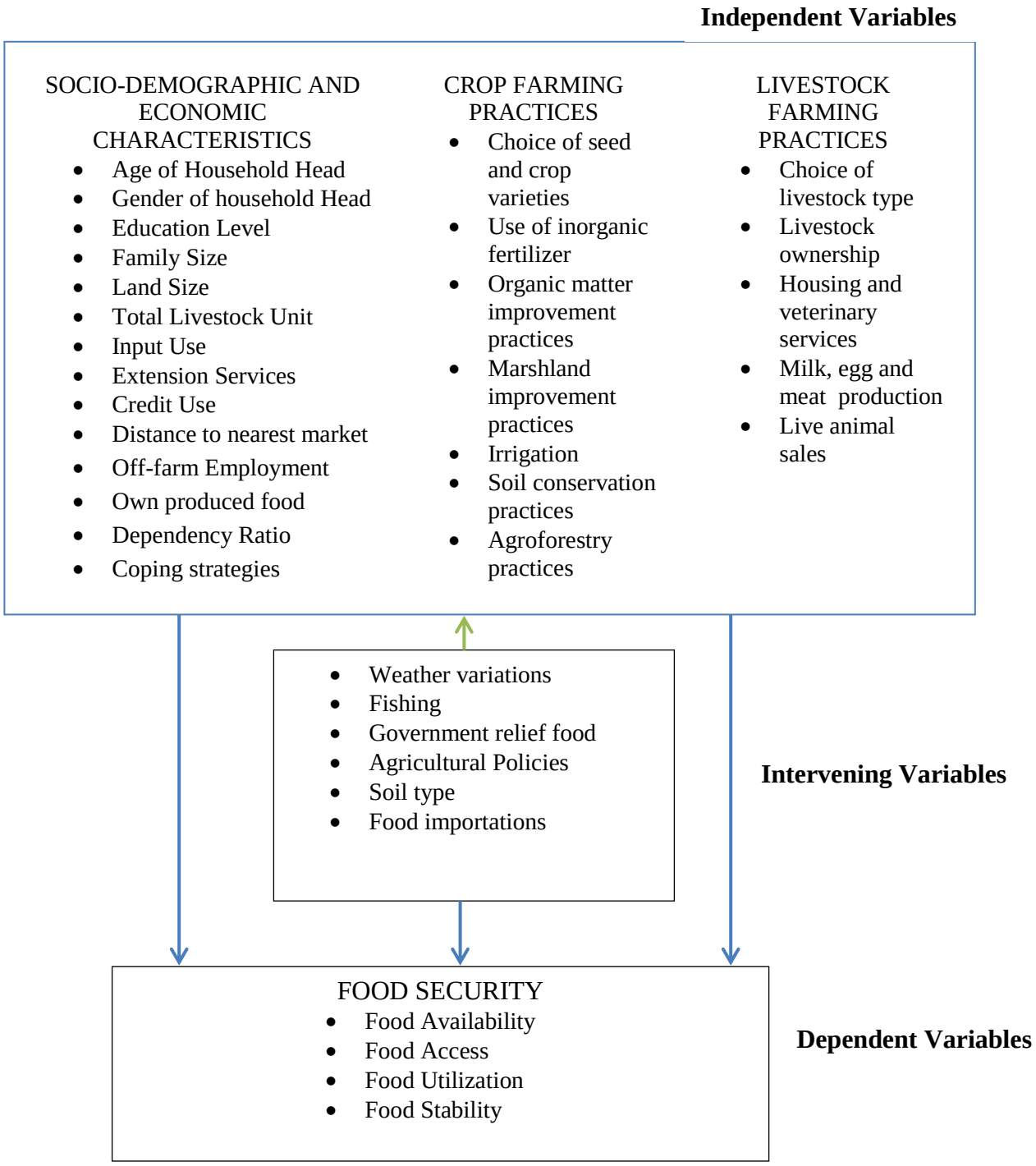


Figure 2.3: Conceptual framework of household characteristics and agricultural practices on food security

Source: Researcher, 2015

In the conceptual framework, the independent variables are social, demographic and economic characteristics of households and agricultural practices. Social, demographic and economic variables include age of the household head, gender of household head, household head's level of education, family size, land size, household total livestock unit, input use, household contact with extension services, credit use, distance of a household to the nearest market, off-farm employment, household's consumption of own produced food, household dependency ratio and household food coping strategies.

Crop farming practices include choice of seed and crop varieties, use of inorganic fertilizer, organic matter improvement practices, marshland improvement practices, irrigation, soil conservation practices and agroforestry practices. Livestock farming practices include choice of livestock type and ownership, housing and veterinary services, sale of livestock products and sale of live animals. The intervening variables include weather variations like droughts and floods, fishing activity, relief food from the government and agricultural policies. The dependent variable is food security that includes food availability, access, stability and utilization.

In summary, chapter two entails Review of related literature, theoretical and conceptual frameworks, in line with the specific objectives of the study. Literature shows that socio-demographic and economic household characteristics could influence farming practices which may then contribute to household food security. Therefore, there was need to investigate the influence of socio-demographic and economic characteristics of households on food security. Also, the studies agree that smallholder crop production in semi-arid areas is low hence the need for diversification of crop farming practices so as to enhance household food security. Therefore there was need to provide adequate information on the influence of crop farming practices on household food security. Further, the above studies indicate that the livestock sector has

contributed positively in improving food availability but the sector is neglected. Many of the problems associated with livestock production in arid and semi-arid lands, therefore, are a result of the neglect. Therefore, the study examined livestock farming practices on household food security in semi-arid Nyakach.

Having reviewed related literature and explained the relationship between the theoretical and conceptual frameworks in Chapter two, the study proceeds to Chapter 3, which describes the study area, research design used in the study, the study population, sample size and sampling techniques used. Sources of data, data collection methods and analysis techniques are also explained. The research methodology in Chapter 3 is aimed at generating the most reliable, valid and authentic results from the data collected so as to address the study gaps under each specific objective as identified in the cited literature.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents detailed description of the study area, research design, population sample and sampling techniques, sources of data, data collection instruments, data analysis procedures and ethical considerations. Data on agricultural land use practices and household food security were collected using different approaches including structured questionnaires, interviews, personal observation and literature search. Stratified simple random sampling and Purposive Sampling techniques were used to select household respondents and key informants respectively.

3.2 Study Area

This sub-section describes the study area in terms of its location and size, agro-ecological zones, climate, topography and drainage, soils, vegetation, population and settlement, land use, socio-economic activities and food security status.

3.2.1 Location and Size

The study was conducted in semi-arid Agro-Ecological Zones of Nyakach Sub-County in western region of Kenya. It lies between latitude $0^0$11'59" to $0^0$23'40" South and longitude $34^0$45'08" East and $35^0$03'33" East. Nyakach Sub-County is bordered by Homabay County to the South, Nyando Sub-County to the North, Kericho County to the East, Kisumu East Sub-County to the North West and Lake Victoria to the West (Figure 3.1). It is one of the 6 Sub-Counties that comprise Kisumu County. The study area covers 243km^2, 68% of 357.3km^2 that comprise Nyakach Sub-County.

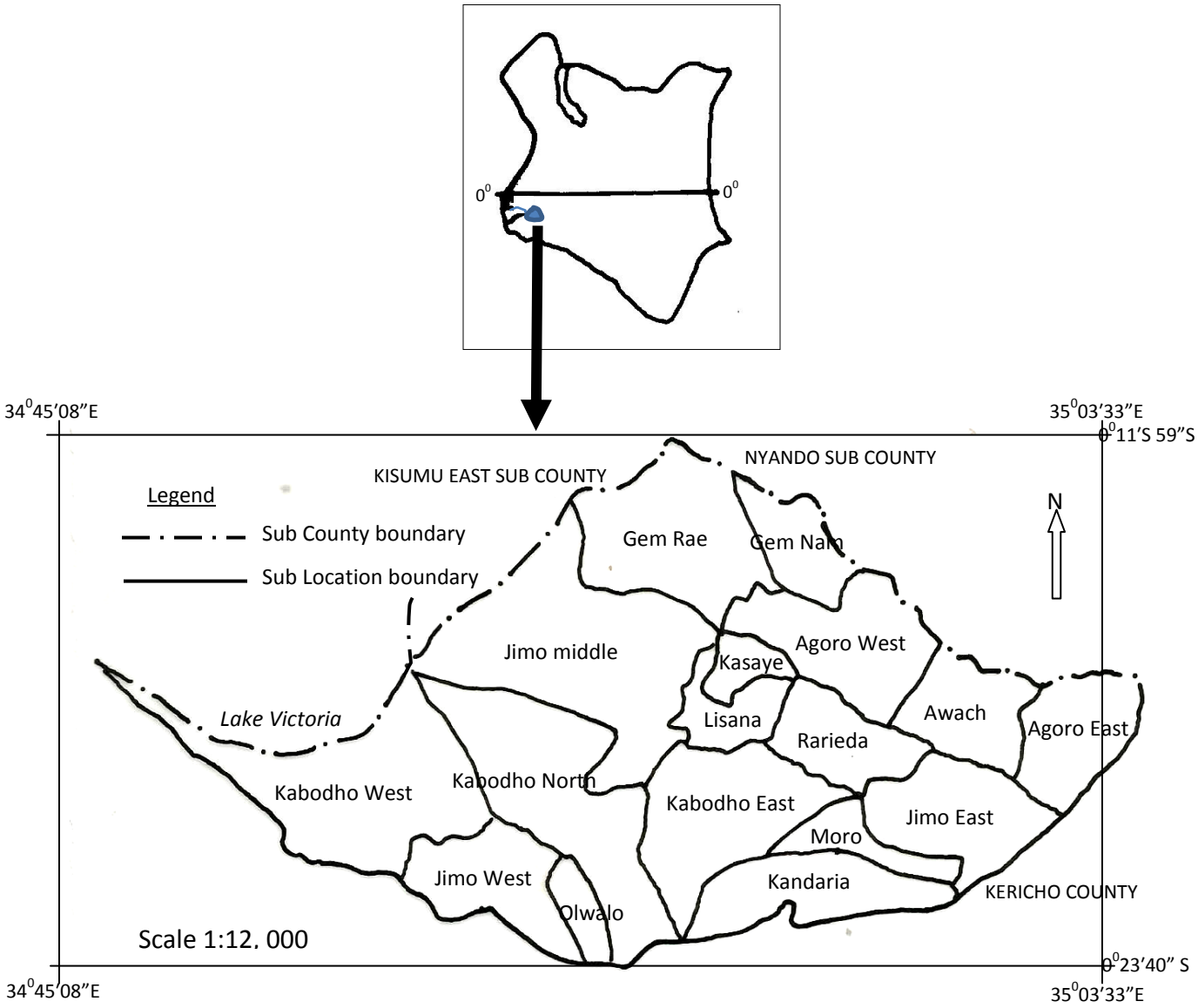


Figure 3.1: Map of the study area
Source: Jaetzold and Schmidt, 1983

3.2.2 Agro-Ecological Zones

Agro-ecological zones (AEZs) are geographical areas exhibiting similar climatic conditions that determine their ability to support agriculture. AEZs are influenced by latitude, elevation, and temperature, seasonality of rainfall, rainfall amounts and distribution during the crops growing season (Fischer, *et al* 2009). The study area spreads across two Agro-Ecological Zones: LM3 and LM4, which are low and dry zones receiving very unreliable rainfall varying from 150mm

during the short rains to 700mm during the long rains. It receives mean annual rainfall of 420mm and sometimes less. LM3 is the Lower Midland Cotton Zone. It is warm and semi-arid. Its annual average precipitation is 50-65 percent of potential evapotranspiration. Its climatic conditions are good to fair for cotton crop and fair for maize crop. The best preferred cereal for LM3 is the early maturing dwarf sorghum like Serena and Seredo varieties. LM4 is the Marginal Cotton Zone/ Middle Sisal Zone. The climatic condition of LM4 is fair to poor for cotton and maize crops, fair for pigeon pea and good for sisal. It is warm and transitional zone. Its annual average precipitation is 40-50 percent of potential evapotranspiration. It is better and less risky with the early maturing maize varieties but their yield capacities are lower.

3.2.3 Climate

Semi-arid Nyakach is classified as 50-85% arid (GoK, 2012c). The study area receives convectional type of rainfall due to its proximity to the Lake Victoria. The mean annual rainfall varies between 500mm to 600mm. The area has a bimodal rainfall pattern. The long rains fall between March and May with the peak in April. The short rains are less pronounced, poorly distributed and unreliable falling between September and November with the peak in October. The long and short rainy seasons are separated by a not very dry period in December and February. The dry season starts in June and ends in August. Farmers in the study area have adopted one cropping season during the long rains making it appear as if there is a single rainfall season. The average of daily sunshine is 8-10 hours. The mean minimum temperature is 20^0C while the mean maximum temperature is 35^0c. Humidity is relatively high with mean evaporation rate ranging between 1800mm and 2000mm per annum.

3.2.4 Topography and Drainage

Semi-arid Nyakach lies on an altitude of 1134m above sea level. It is a lowland area with flat topography. The land is poorly drained hence prone to flooding. It is drained by River Awach that flows from North East into Lake Victoria, Agembo, Atooyieng'o and Onguo seasonal streams. River Awach flows along the border of Nyakach and Nyando Sub-Counties and is particularly important for watering livestock. There are permanent and seasonal swamps found near the Lake shore. These drainage systems attract farmers who practice small-scale horticultural and rice farming along River Awach and the lake during dry seasons of the year.

3.2.5 Soils

Figure 3.2 illustrates the soil types and fertility levels. The study area has two soil types; the Black Cotton Clay soils (vertisols) that occupies 71% of the total coverage of the study area and sandy clay loam soils that occupy the remaining 29%. The vertisols exhibit variable fertility ranging from low to moderate, poor drainage and are prone to flooding. The vertisols do not allow quick infiltration of surface water into the ground and this compounds the problem of drainage since surface drainage is already impeded by the flat gradient. The sandy clay loam soils are derived from granite parent material characterized by moderate to high natural fertility and a relatively high moisture holding capacity (8-11mm/10cm) and good potential for agricultural activities (KCDP, 2013).

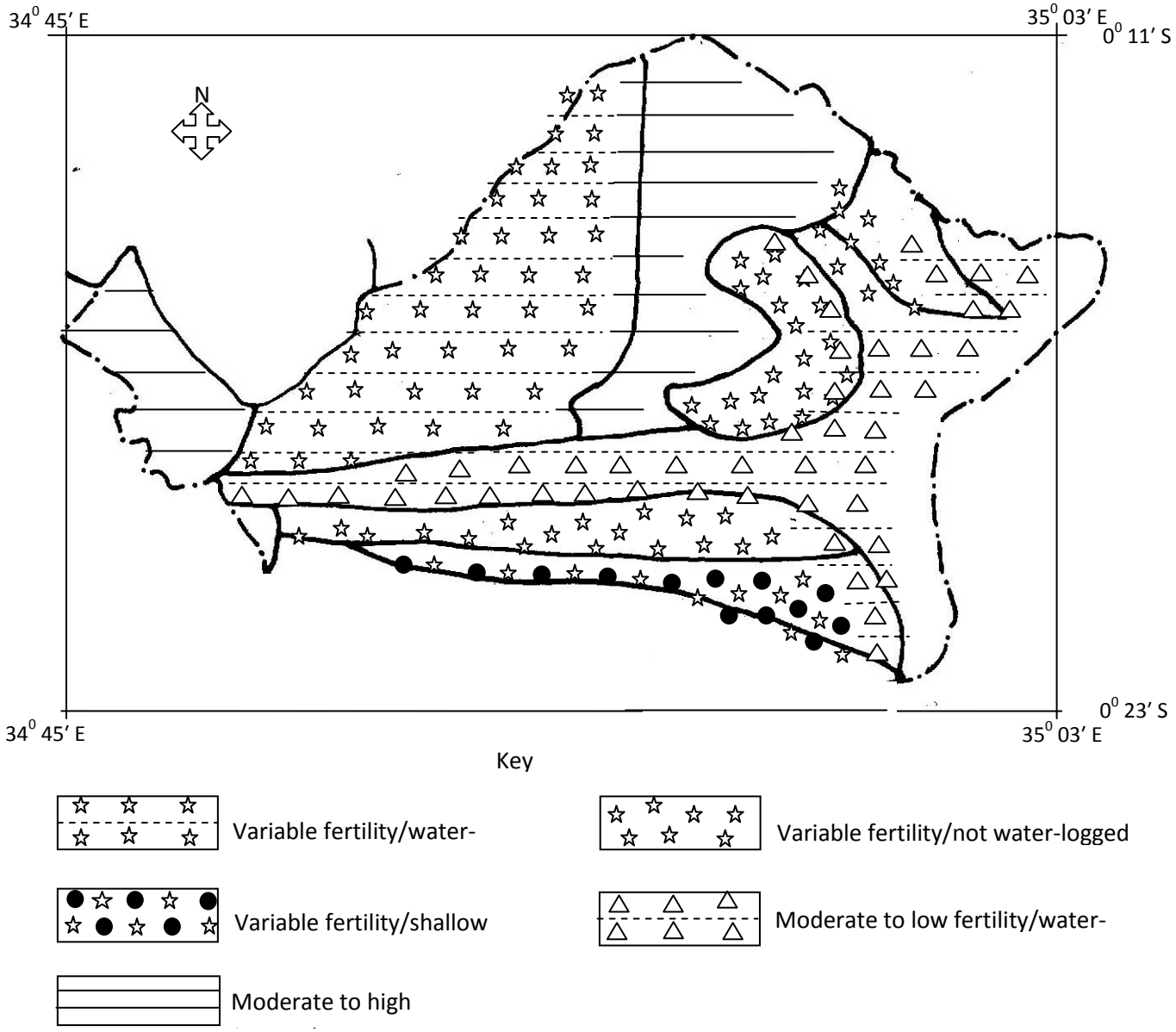


Figure 3.2: Soil map of the semi-arid Nyakach showing soil types and soil fertility.
Source: Jaetzold and Schmidt, 1983

3.2.6 Vegetation

The semi-arid Nyakach is characterized by tree vegetation, a variety of grasses, bushes and wetland vegetation around the swampy areas of Gem-Nam and Awach. The tree vegetation is sparsely distributed with most presence in individual households, homesteads and enclosures where the trees are mainly used for fencing purposes, provision of shade and firewood. Bushes and grasses are mainly found on unoccupied spaces, undeveloped and private fallow lands.

Reliable sources of grass with high productivity are small and widely scattered. Isolated blocks of hills and river floodplains are particularly important as grazing areas for livestock and collection of firewood for domestic use during dry seasons. Along the shores of Lake Victoria the vegetation is a wetland type such as papyrus and reeds that is mostly harvested for economic purposes by the local community.

3.2.7 Human Population Characteristics

During the Population and Housing Census of 2009 the total population of semi-arid Nyakach was 133,041 comprising of 69,353 females and 63,828 males. It has 9,331 farming households. The total population was projected to 153,974 by the year 2015 and 160,674 by 2017 (KCDP, 2013). The average population density is 396 persons km^{-2} and is projected to be 440 persons km^{-2} by the year 2017 (KNBS, 2014). It has a child rich population, where 0-114 year olds constitute 47% of the total population. However, it is at the onset of a fertility decline as 42% of households have 0-3 household members. The total population and households formed the basis for the sampling during the primary data collection.

3.2.8 Land Use

The land use is mainly pasture and farm that includes small-scale rain-fed mixed cropping and small-scale livestock keeping and settlement infrastructure. However, agriculture does not provide enough livelihood support due to frequent droughts alternating with severe floods and poorly drained intractable soils (KCDP, 2013). According to NEMA, (2005), it is estimated that total agricultural potential area is 231 km^2, which accounts for 95 per cent of the total land area, while 87.5 km^2, which accounts for 36% is currently utilized. The subsistence farmers grow food crops such as maize, beans, sorghum, cowpeas; and rear livestock. Livestock kept are of

traditional breeds, and serve as source of income for the farmers. These include cattle, sheep, poultry, donkey and goat. The average household farm size is 0.99 hectare.

3.2.9 Socio-Economic Activities

Agriculture is the major economic activity engaged in by over 95% of the population (KCDP, 2013).Most households practice subsistence mixed farming on small land holdings. Livestock keeping is practiced in enclosures, open fields and fallow land where grass is dominant (Nyongesa, 2008). The crops grown are maize, beans, green grams, sorghum and rice. Individuals also engage in small businesses such as running kiosks, sale of illicit brew, firewood, hair platting, water vending, carpentry, petty trade, artisan, fishing, masonry, sand-harvesting and sale of mats made from papyrus to generate income for their households. A few men and women are formally employed.

3.2.10 Food Security Status

Food security is one of the major development challenges in the study area. The area depends primarily on agriculture that contributes 47% of household income. Most farmers grow food crops on small scale during one season per year. The harvests are low resulting in households facing hunger and malnutrition. The food poverty rate is 65%, which is above Kenya's Food Poverty index, which of 60.5%. This confirms that the study area is not self-sufficient in food production. The percentage of the population living under extreme poverty is 60 percent, against the national poverty level of 45.9% (KNBS, 2014). This indicates high poverty incidence.

3.3 Research Design

The study used cross-sectional social survey research design as an overall strategy whereby data was collected at one point in time to depict the current situation of farming practices and food

security in the study area. A research design is a plan or an overall strategy for conducting a research (Oso and Onen, 2009). The cross sectional survey research design was deemed appropriate for this study because surveys are concerned with describing, recording, analyzing and interpreting the current situation (Mugenda and Mugenda, 2003). Surveys generally explain events, relationships and influences that are evident. Thus Cohen and Lewis (1987) also agrees that a survey is the best design when a researcher wants to describe events or opinions without manipulating variables, while enabling the researcher to collect data within the shortest time possible thereby reducing operation costs. The data collected were used to analyze the influence of agricultural practices on food security in semi-arid Nyakach. The household was the unit of analysis of which household heads were sampled and interviewed because these are the persons responsible for availability, accessibility and utilization of daily food by the household members.

3.4 Population of the Study

According to the 2009 Population and Housing Census Nyakach Sub-County had a total population of 133,041 people that comprised of 13,997 farming households (GoK, 2009). The target population comprised 9,331 households that were within the semi-arid agro-ecological zones of Nyakach Sub-County (Kisumu County Development Profile, 2013). A household questionnaire and was administered to each of the 384 households, which were clustered into administrative Locations of Central Nyakach (1091); Pap-Onditi (1232); Nyalunya (1350); East Nyakach (1434); Asao (787); North East Nyakach (1332); Rangul (789) and North Nyakach (1316) as shown in Table 3.1 (KCDP, 2013). The following key informants were also included in the target population and were issued with the Key Informant questionnaire: 1 Sub-county Agricultural Officer; 3 Extension Officers in the Sub-County; 1 Officer from the VI-Agroforestry Project and 1 Officer from the World Vision- Kenya, which are NGOs working

with households in the Sub-County to improve their food security status. This was the target population from which the study sample was drawn.

3.5 Sample and Sampling Techniques

3.5.1 Sample Size

The sample consisted of 384 households selected from all clusters of semi-arid agro-ecological zones of Nyakach Sub-County. Key informants included 1 Agricultural Officer, 3 sub-county Agricultural Extension Officers; 1 officer from VI-Agroforestry Project and 1 officer from the World Vision-Kenya. This sample size was determined according to Israel's (2009) sample size formula. This is because the sample size formula assumes that the respondents are selected randomly and it is very appropriate when the sample size is small relative to the population size. That is, when the sample size is less than 10% of the population size (Mugenda and Mugenda, 2003). The sample size formula is expressed as below:

$$n = \frac{t^2 .p(1-p)}{m^2}$$

Where: n = required sample size
t = confidence level at 96% (standard value of 1.96)
p = estimated proportion of the attribute of interest present in the study population
m = margin of error at 5% (standard value of 0.05)

$$n = \frac{1.96^2 .0.5(1-0.5)}{0.05^2}$$

$$n = \frac{0.9604}{0.0025}$$

$$n = 384.14 \cong 384$$

The number of responses compared to the sample size was at a 95% level of confidence; within a precision level of ± 5 at significance level of 5%. Thus, authenticated the data collected from the households and key informants (Kothari, 2004). Based on these recommendations, the study selected a sample size of 384 households and 6 key informants in lieu of those conditions. The sample provided information on agricultural practices and household food security status.

Table 3.1: Sample size distribution

Stratum	Cluster/Administrative location	Households	Sample size
LM3	Central Nyakach	1091	45
	Nyalunya	1350	56
	East Nyakach	1434	59
	Asao	787	32
LM4	Pap Onditi	1232	51
	North East Nyakach	1332	55
	Rangul	789	32
	North Nyakach	1316	54
	Total	**9331**	**384**

Source: The researcher, 2015

3.5.2 Sampling Techniques

This study adopted proportionate stratified sampling and purposive sampling techniques. Stratified sampling technique was used to determine the proportions of each cluster of households to be included in the sample. Stratified sampling is used in heterogeneous populations to create homogeneous subsets that share similar characteristics (Krathwohl, 1993). Since households in semi-arid agro-ecological zones of Nyakach are mutually and exclusively divided into LM3 and LM4 strata, it was necessary to determine the proportions of each cluster of LM3 and LM4 so as to capture the household characteristics of each stratum in the sample. This could only be guaranteed through stratified sampling. For each cluster under the two strata, the sub-sample size was determined as:

$$\textbf{Cluster sample size} = \left(\frac{\textbf{cluster population}}{\textbf{total population}}\right)\textbf{required sample size}$$

For instance, the sample size of Central Nyakach sub-stratum of LM3 was determined as:

$$\textbf{Central Nyakach} = \left(\frac{1091}{9331}\right) \times 384 = 45$$

The same procedure was followed for all the clusters and the weights were given in proportion to the size of stratum. Sample sizes shown in Table 3.1 were obtained. Stratified sampling ensured that the agro-ecological zones were divided into homogeneous strata, and each stratum was represented in the sample in proportions equivalent to its size in the target population, and that each subgroup characteristics were accounted for.

Total sample size for LM3 stratum was determined as:

Samples for (Central Nyakach+ Nyalunya+ East Nyakach+ Asao)

$= (45 + 56 + 59 + 32) = 192$

Total sample size for LM4 stratum was determined as:

Samples for (Pap Onditi+North East Nyakach+Rangul+North Nyakach)

$= (51 + 55 + 32 + 54) = 192$

Once the size of each stratum was determined, the individual households for each agro-ecological zone were selected through a simple random procedure using a sample frame of households obtained from Nyakach Sub-County agricultural office. Simple random sampling is the selection of a group of subjects (a sample) from a larger group (a population) for a study. Each household was chosen entirely by chance and each member of the population had an equal and independent chance of being included in the sample. This equal and independent chances property ensured that the sample was random, and a fair representation of the population of households in the LM3 and LM4 agro-ecological zones of Nyakach with regard to agricultural

practices and food security. The random selection was done using random numbers technique, from a sampling frame constructed from a list of households obtained from the sub-County agricultural office.

Purposive sampling technique was used to access other stakeholders in the agricultural sector that were not household heads. Purposive sampling is the selection of a group of subjects (a sample) from a larger group (a population) for study based on the judgment of the researcher as to which subjects best fit the criteria of the study. Purposive sampling was used in selecting the key informants who included the Sub-County Agricultural Officer, 3 Sub-County Agricultural Extension officers, 1 officer from the VI-Agroforestry project and 1 officer from the World Vision-Kenya (WVK), which are NGOs that had worked with the farming households on livelihood improvement and food security programs. Purposive sampling technique was also used for selection of community members for the Focus Group Discussions (FGDs). Members of the FGDs included men, women, youth and officers from the Sub-County Agriculture and Livestock office, Agricultural Extension Office, WVK and VI-Agroforestry. According to Mugenda and Mugenda (2003), purposive sampling technique refers to where a researcher targets a group of people believed to be typical or average or group of people specially picked for some unique purpose. It allows the researcher to use cases that have the required information with respect to the objectives of the study. The key informants and members of FGDs identified using this technique provided focused information on crop and livestock practices in the study area and socio-economic factors influencing land use practices and food security.

3.6 Sources of Data

Data for the study were obtained from both secondary and primary sources.

3.6.1 Secondary Sources

Documented data on agricultural land-use practices and food security was obtained from published and unpublished reports including government reports, text books, newsletters, and papers from professional and academic journals. This involved reviewing of the available literature on agricultural land-use practices and its contribution towards food security in the semi-arid areas of the world in general and in Kenya in specific. The resource centres below were visited so as to obtain the secondary data: Maseno University library in Kenya, Nyakach Sub-County documentation centre, Kisumu County documentation Centre, Centre for Training and Integrated Research in Arid and Semi-arid Development (CETRAD) library, World Agroforestry Centre (WAC) library in Kisumu, Kenya and the internet. The information obtained from the secondary sources gave background information on indigenous and contemporary crop and livestock practices in the semi-arid agro-ecological zones of the world and the contribution of agricultural land-use practices on household food security status in semi-arid AEZs.

3.6.2 Primary Sources

Primary data on crop and livestock production practices and performance, household socio-demographic and economic characteristics and household food security status was collected. This was done by collecting information from households and key informants. This information was collected to complement secondary data. Key informant interviews were administered to elicit data which served to confirm some of the information collected from household heads.

3.7 Data Collection Instruments and Procedures

Questionnaires, interviews, field observation, Focus Group Discussions (FGDs) and document analysis as the instruments of collecting data that were used. The researcher was concerned with knowledge, skills, views, perceptions, opinions, attitudes and behaviors of the respondents. Such

information could be best collected using the given instruments (Bell, 1999; Cauvery, *et al*., 2007; Oso & Onen, 2005).

3.7.1 Questionnaire

Questionnaire was the main instrument because it was used in administering all research questions to respondents. Both open and closed-ended household (Appendix I) and HFIAS (Appendix IV) questionnaires were used to collect information from 384 household heads. The advantage of using questionnaire is that it was administered by the researcher to respondents in their own private settings. The household questionnaire collected data about the household crop framing practices, livestock farming practices, socio-demographic characteristics, economic characteristics, household food security status, challenges faced by households with regard to food security and household food coping strategies.

Data obtained were used in explaining the influence of agricultural practices on food security and the influence of household socio-demographic and economic characteristics on food security. Both qualitative and quantitative data were collected. Quantitative data collected was on size of acreage per household, acreage under crop production and livestock production, household livestock numbers, total crop yields per cropping season and mean annual crop yields, amount of milk production, prices of livestock and livestock products, total household yearly income from crops and livestock, total yearly expenditure on food and non-food requirements, amount of food available and accessible by households. Household socio-demographic information such as age of household head, gender of household head, level of education of the household head, and the household dependency ratio were also collected using questionnaire. Qualitative data collected was on opinions of the household heads on their household food security status, household size, type of crop grown, type of livestock kept, quality of food consumed by household, household

food coping strategies and suggestions on how food security could be realized in the study area. Data obtained from the use of questionnaires was used in analyzing the relationship between agricultural practices and food availability, access, stability and utilization.

The Household Food Insecurity Access Scale (HFIAS) Questionnaire (Appendix IV) was administered to household heads. The HFIAS is a tool that was used to assess whether households had experienced problems in food access in the preceding 30 days (Coates, *et al*., 2006 and D'Haese *et al*., 2010). HFIAS is composed of nine questions that ask about modifications made by households in their diet due to limited resources to acquire food. It measured the severity of food insecurity in the past 30 days as reported by the households themselves (Coates, et al, 2006). Reactions and responses made by household's experience of food insecurity were captured, quantified and summarized in a scale. The HFIAS questions were based on three different aspects of food insecurity that were: anxiety and uncertainty about the household food supply; insufficient quality including variety and preferences of the types of food and insufficient food intake; and its physical consequences (Coates *et al*, 2006). For each question four response options ranging from 0 to 3 represent frequencies of occurrence of the condition (never (0), rarely (1), sometimes (2), and often (3) in the past 30 days.

Radimer/Cornell Hunger and food insecurity questionnaire (Appendix V) was administered to the household heads so as to verify and complement the data that had been collected on food security using the HFIAS questions. This is a qualitative food security measure that incorporates as essential elements the perceptions of food insecurity and hunger by the people affected. It monitors the prevalence and severity of hunger and food insecurity .It explored the relationship between food security and income, the association between household food expenditures and both the quantity and quality of food, the relationship between the food security measure and

other measures known to affect food security; these included household food expenditures, absolute income and income relative to poverty, and household report of food sufficiency. The questions in the food security module were intended to measure four underlying conditions or behaviors in the households: (1) anxiety about the food budget or food supply; (2) perceptions that food is inadequate in either quantity or quality; (3) reduced food intake in adults; and (4) reduced food intake in children. Taken together, the 18 questions capture a wide range of severity of food insecurity as experienced in households, ranging from light (worrying about running out of food) to quite severe (child going the entire day without food). The 18 individual scale items are fairly evenly spaced across the full range of severity captured by the set of items as a whole (one characteristic of a strong measure). The scale thus enabled successive ranges of food insecurity to be measured and distinguished. It also enabled prevalence to be determined for each of these distinct severity levels.

3.7.2 In-depth Interviews

Both structured and unstructured questions were used to collect qualitative data from Sub-County Agricultural Officer, Agricultural Extension Officers (Appendix IIA) and officers from World Vision Kenya and VI-Agroforestry Program (Appendix IIB). The researcher administered face to face interviews to the key informants from their places of work. The data collected was on socio-demographic and economic characteristics of the households, crop farming practices, livestock farming practices, and household food security of the semi-arid Nyakach. The interviews explored the efforts made by the government and NGOs toward ensuring food security. Data obtained from the interviews were used in identifying crop and animal practices that had a relationship with food security. The key informants were targeted because of their experience of working with the households and they had information about the study area.

3.7.3 Observation

Direct observation was used in identifying the various types of crops grown, the dominant crops grown, cropping patterns, methods of farming employed by the farmers, grazing patterns, types of livestock kept, number of animals kept and types of livestock farming practices. During the survey the researcher observed specific cropped fields and livestock at homesteads and in the grazing fields. Data obtained through direct field observation supplemented the information given by the household heads and key informants on crop and livestock practices. It particularly helped in identifying and documenting conditions of crops and livestock.

3.7.4 Focus Group Discussions (FGDs)

Eight (8) focus group discussions were conducted, one from each cluster (administrative Location). The researcher selected 8-10 community members from each cluster, who included men, women and youths in equal ratio to form a focus group. Each FGD consisted of 8-10 participants guided by a moderator/facilitator, who ensured equal representation, more polished data and orderly discussions about themes considered important to the research through creating a forum for respondents to critique each other's views. (Appendix III). The researcher noted down key issues emerging from the discussions and other factors which might have influenced interpretation of information. Non-verbal communication was noted and interpreted about the feelings that individuals and members of each focus group felt about the issues of discussion. Writing materials and recording equipment were the supporting materials used. Data collected through FGDs was about farmers understanding of food security characteristics, challenges to food security, efforts by the government and NGOs to ensure food security and identification of food coping strategies adopted by households. Focus group discussions enabled the researcher to capture the stories behind respondents' experiences that could not be directly observed nor

captured in questionnaires. The information collected from FGDs was used to complement (put flesh on the bones of) the data that was collected from individual household heads through questionnaires and key informants through interviews.

3.7.5 Document Analysis

Documents objectively written about agricultural practices and food security in semi-arid environments were reviewed and analyzed. Secondary data was obtained through review of relevant information from journals, reports, websites and books. Documentary review provided literature on the relationship between crop farming practices, livestock farming practices and household socio-demographic and economic characteristics and food security. Crop and livestock yields and prices were obtained from the documentation in the Sub-County Agriculture and Livestock Office. This information helped in the identification of knowledge gaps and supplemented data collected through questionnaires, interviews and FGDs.

3.8 Data Analysis Procedures

Both the quantitative and qualitative data was analyzed and presented as subsequently indicated.

3.8.1 Quantitative Data analysis Procedures

Statistical procedures used to analyze quantitative data included descriptive statistics such as frequency distribution, percentages, means and standard deviation. Inferential statistics used were Pearson's correlation and Least Square Regression Analyses.

The Mean was used in calculating the mean annual crop yields and milk production. Mean is calculated as below:

$$\bar{x} = \frac{\sum x}{n}$$

Where $\bar{x}$ = Mean
x = Observed variables
n = Total number of observed variables

Standard deviation was used in calculating the spread of annual crop and milk yields around the mean and was computed using the following formula:

$$\sigma = \sqrt{\frac{\sum(x - \bar{x})^2}{n}}$$

Where σ = Standard deviation
$\bar{x}$ = Observed variables
n = Total number of observed variables

Pearson's Correlation (r) was performed to identify the significant variables such as household size and income level and to assess the relationship between household socio-demographic and economic characteristics, crop and livestock farming practices and household food security. A significance level below 0.05 showed that there was a statistical significance between the variables compared, while a significance level above 0.05 indicated that there was no statistical significance between the variables compared. It was used to show the association between socio-demographic and economic characteristics of farmers and food security; the association between crop farming practices and food security and the association between livestock farming practices and food security. The relationships were positive where socio-demographic and economic characteristics of households led to agricultural practices that increased food security. The relationships were negative where agricultural practices led to decrease in crop yields, milk production, livestock numbers and livestock prices. The relationships were positive where agricultural practices resulted in increase in crop yields, milk production, livestock numbers and livestock prices. Pearson's correlation was computed using the following expression:

$$r = \frac{n\sum xy - (\sum x)(\sum y)}{\sqrt{n\sum x^2 - (\sum x)^2 \times n\sum y^2 - (\sum y)^2}}$$

Where: r = Correlation coefficient
x = Observed variable x
y = Observed variable y
n = Total number of variables

Chi-square ($\chi 2$) test for goodness-of-fit was used to analyze the frequencies in line with the research questions (Kothari, 2004; Oso and Onen, 2005). According to Kothari (2004), it was an important non-parametric test and as such no rigid assumptions were necessary in respect of the type of population. Only the degrees of freedom for using the tests were prerequisite, for this case the degree of freedom depending on a particular case was determined. It was used to compare the differences between categories frequencies when data was categorical and drawn from a population with a homogeneous distribution in which all alternative responses were equally likely. The test was done to compare the food secure and food insecure households on the basis of demographic, socioeconomic, expenditure and coping strategy variables. Households experiencing household and individual food insecurity as well as child hunger were categorized as food insecure households. Chi-square analysis was utilized for comparison of categorical and continuous variables between the food secure and food insecure households. The two categories: food secure and food insecure households were also used in the logistic regression analysis.

T-test was used to test if there were any significant relationship between monthly expenditure of food secure and food insecure households on food, utilities, child education, loan repayment and transportation in given the households' total incomes; comparison of group mean differences and percentages of households within two categories of food secure and food insecure households, exhibiting particular socio-demographic and economic characteristics; establishing if there were

significant relationships between consumption of animal source foods (ASFs) in households where women owned or did not own various livestock species; and to compare months per year that households had adequate food with respect to women owning or not owning various livestock species.

Logistic Regression Analysis was conducted to identify the variables that contributed to food security and to establish the significance of relationships between the independent and dependent variables. Four logistic regression models were estimated using the various subsets of variables from the three main groups of variables (demographic and socioeconomic, expenditures and coping strategies) - (i) demographic and socioeconomic variables alone (ii) demographic, socioeconomic and expenditure variables (iii) demographic, socioeconomic and coping strategy variables (iv) demographic, socioeconomic, expenditure and coping strategy variables. The inclusion of variables into the logistic models was based on the combination of variables that were significantly different between food secure and food insecure households and variables with unadjusted odds ratios significant at $p<0.05$. However, in the variable selection procedures, various adjustments were made. Income per capita was not included in any of the model as the variable was operationalized as both household income and household size. In models which include expenditure variables, household income was excluded, total expenditure was operationalized as a proportion of total household income and food, child and loan expenditures were included as a proportion of total expenditures; for income stability, trends in household income were included in the models even though the variables were not risk factors for food insecurity or not significantly different between the two types of households. The results from the final logistic regression model were expressed as odds ratios with 95% confidence intervals.

3.8.2 Qualitative data analysis

The qualitative data obtained from questionnaires, Key Informant Interviews and FGDs was analyzed by transcription and creation of relational themes. The data was coded and organized into themes and sub-themes. Qualitative data analyzed were responses on household size, types of crop grown, types of livestock kept, quality of food consumed in a household and household food coping strategies. The available data was evaluated on the basis of its usefulness in answering the research questions. Qualitative data analysis carried out was about detection and involved the tasks of defining, categorizing, theorizing, explaining, exploring and mapping. The methods used for qualitative analysis therefore facilitated such detection and allowed various functions such as understanding internal structures of the households in the study area, mapping the range, nature and dynamics of the household social, demographic and economic characteristics, agricultural practices and food security. Further, the analysis involved seeking explanations from the respondents and categorizing different types of attitudes, behaviors and motivations of the households.

3.9 Results Presentation

The results were presented in the form of description, maps, graphs, tables, bar charts and pie charts. Tables were used in presenting respondents' responses on demographic and socio-economic characteristics of food secure and food insecure households, household food coping strategies, crop yields, milk production, the number of livestock, livestock prices and household food security status. Maps were used in presenting the location and size of the study area the agro-ecological zones and soil types. Graphs and pie-charts were used in presenting information on demographic and socio-economic characteristics of the respondents, crop farming practices and livestock farming practices.

3.10 Reliability and Validity of the Instruments

3.10.1 Reliability

To ensure reliability of instruments used in this study, pre-testing was done. According to Ary, *et al*. (1996) pre-testing is the best way to minimize ambiguity, enhance clarity and ascertain responses to the style and content of the questions. In this case the test conditions were not different so the test-retest approach was the appropriate choice of the researcher (Mugenda and Mugenda, 2003). Test-re-test technique of measuring reliability was used whereby questionnaire was administered to 10% sample of farming households that were not included in the study sample. This involved administering the questionnaire to the pilot respondents twice, with a break of three weeks, and then the correlation coefficient (r) was calculated for the two tests by using Pearson's Correlation. After computing the responses, a correlation coefficient (r) of 0.83 was obtained. According to Mugenda and Mugenda (2003), a correlation of 0.8 is considered to have high degree of reliability. Therefore, the questionnaire was accepted as reliable.

3.10.2 Validity

Validity means the extent to which the concept one wishes to measure is actually being measured by a particular scale or index (Creswell, 2003). To measure validity of instruments used in this study, content validity was tested. Mugenda and Mugenda (2003) define content validity as the measure of the degree to which data collected using a particular instrument represents a specific domain of indicators or content of a particular concept, that is, an instrument should provide adequate coverage of a topic. Expert opinions and pre-testing of instruments helps to establish content validity (Wilkinson, 1991; Mugenda and Mugenda, 2003). The instruments for data collection were edited and approved by the supervisors whose expert judgment helped to improve content validity. These instruments for data collection were also pre-tested during the

pilot survey. Moreover, data was collected from various categories of respondents which included household heads and key informants. Also secondary data were collected from Nyakach Sub-County Agriculture and Livestock office. These helped in maximizing data validity.

On transferability, a belief that everything was context bound, detailed descriptive data was collected using questionnaires (refer to the questionnaires and interview questions on appendices 1 and 2). Dependability and stability of the data was done by establishing an "audit trail" where a colleague in the discipline of Geography audited the written description of each process undertaken which included original field notes. Conformability and neutrality or objectivity of the data collected was ascertained by triangulation of the various methods especially questionnaires, interview, observation and documentary analysis (Vogt, 2007; Gomm, 2008; Gay, *et al*. 2009).

3.11 Research Ethics Consideration

During this study ethical considerations such as privacy and confidentiality of the respondents were taken into account. The researcher conducted the study in a manner that upheld research ethics. Information provided by the respondents was used for academic purpose only. The research process was free, fair and open, not insulting the private, religious, cultural and social life of the respondents. The respondents were at liberty to freely ignore any questions or concerns they did not wish to respond to. The researcher assisted the farmers in understanding the questions so that information collected was relevant.

The principle of justice was adhered to. The respondents were Household Heads of the sample population. This ensured that the study recognized the ability of all members of the community and that risks if any and benefits of the study were equally distributed among all individuals in

the community. It also ensured that the subjects were not discriminated on the basis of gender, age and socio-economic backgrounds.

The moral obligation of the study was to ensure that the respondents were not harmed in the process of carrying out the study or after completion of the study and that the possibilities of the respondents benefiting from the study were maximized. Counseling was offered to the subjects in regard to their privacy, confidentiality and linking their behavior to all the procedures involved in the study. This aimed at addressing any psychological effects, social stigma and cultural effects that may have been be associated with the study. It also informed the respondents that there were no any political and economic implications due to this study.

Consent was sought from the study participants so as to protect their human and constitutional rights. All the respondents were adult Household Heads above the age of consent, which is 18 years in Kenya. The respondents were invited to participate in answering questions in the questionnaires about crop and livestock farming practices that they engaged in, their socio demographic and economic characteristics and their household food security status. The respondents were made aware of the risks and benefits of the study. Confidentiality of the information collected from the respondents and privacy of the respondents were upheld by not revealing the names of the respondents. Each respondent was accorded the rights to inquire on any part of the questionnaire deemed not clear and to unconditionally withdraw from the research process at any point in time, before or after the data analysis without any prejudices. Secondary sources of data were cited and acknowledged by the researcher.

Data limitations arose when using household questionnaire during data collection, whereby some households could not remember amount of yields harvested during previous seasons they gave

estimate figures, which were then corroborated and confirmed by information from key informants and Focus group discussions. Also the study faced limitations when using the Logistic Regression Analysis. Four logistic regression models were estimated using the various subsets of variables from the three main groups of variables used to measure specific Objective 1 (social, demographic and economic variables) within the food secure and food insecure households. (i) demographic and socioeconomic variables alone (ii) demographic, socioeconomic and expenditure variables (iii) demographic, socioeconomic and coping strategy variables (iv) demographic, socioeconomic, expenditure and coping strategy variables were estimated.

The inclusion of variables into the logistic models was based on the combination of variables that were significantly different between food secure and food insecure households and variables with unadjusted odds ratios significant at $p<0.05$, which was a challenge. However, in the variable selection procedures, various adjustments were made to overcome this limitation. Income per capita was not included in any of the model as the variable was operationalized as both household income and household size. In models which include expenditure variables, household income was excluded, total expenditure was operationalized as a proportion of total household income and food, child and loan expenditures were included as a proportion of total expenditures; for income stability, trends in household income were included in the models even though the variables were not risk factors for food security or not significantly different between the two types of households.

CHAPTER FOUR: RESULTS AND DISCUSSION

SOCIO-DEMOGRAPHIC AND ECONOMIC CHARACTERISTICS OF HOUSEHOLDS AND FOOD SECURITY

4.1 Introduction

The results presented and discussed in this chapter were in the light of the fact that household socio-demographic and economic variables could negatively or positively influence sustainability of households' agricultural practices. These practices could then influence household food security. The study investigated the relationship between thirteen socio-demographic and economic characteristics. The socio-demographic variables investigated were: age of the household head, gender of the household head, family size, dependency ratio, source of labor, formal level of education of the household head. Economic characteristics include father's and mother's employment status and incomes, access to credit, farm size and ownership. The households were classified as either food secure or food insecure for ease of analysis.

4.2 Socio-Demographic and Economic Characteristics and Household Food Security

This section contains an analysis of socio-demographic and economic characteristics of the households and the occupational operations and conditions of household heads. Table 4.1 shows the Binary logistic estimates of socio-demographic and economic factors that are relevant to household food security. Thirteen (13) independent variables were explored by the survey. These were: gender of the household head; age of the household head; family size; level of formal education of household head; size of land owned by households; total number of livestock owned; input use by households; household contact with extension service; household access to credit; distance of the farmer to the nearest market; household head's engagement in off-farm

and non-farm (secondary) employment; value of own food production and consumption; and household dependency ratio.

Table 4.1: Binary Logistic estimates of socio-demographic and economic characteristics on household food security

				Sample size = 384	
Variables	**Beta Coefficient**	**S.E**	**Wald test**	**Sig.**	**Exp(B)**
Age of Household Head	-0.154	0.06	6.63	0.010**	0.858
Gender of Household Head	-0.197	0.286	0.04	0.008`***	0.822
Education Level	-0.795	0.514	2.394	0.024**	0.452
Family Size	1.799	0.44	16.703	0.000***	6.041
Land Size	-0.815	1.054	0.598	0.439	0.443
Total Livestock Unit	-0.915	0.289	10.062	0.002***	0.400
Input Use	-2.313	1.008	5.26	0.022**	10.101
Extension Services	-1.283	1.0	1.645	0.2	0.277
Credit Use	-1.708	0.888	3.696	0.055*	0.181
Distance to Nearest Market	-0.206	0.169	1.483	0.223	0.814
Off-farm Employment	-3.827	1.273	9.044	0.003***	0.022
Consumption of Own food	-0.004	0.001	17.805	0.000***	0.996
Dependancy Ratio	3.558	1.852	3.689	0.055*	0.029
Constant	7.511	3.015	6.205	0.013	1828.3
Pearson Chi-square			92.404***		
Sensitivity			93.9		
Specificity			81.6		
Percent correctly predicted (Count R2)			90		

***Significant at less than 1% probability level; **Significant at less than 5% probability level; *Significant at less than 10% probability level

Binary logistic estimation revealed that ten (10) of these household characteristics were statistically significant to household food security (Table 4.1). Econometric results show that gender of the household head, age of household head; family size; level of education of the household head; number of livestock; input use; credit use and off farm (secondary) employment, the value of own food production and consumption and dependency ratio are significant in explaining the likelihood of a household being food secure. The factors presented in Table 4.1 are hereafter discussed as given.

4.2.1 Age of Household Head

The comparative age distribution of both male and female household heads was calculated. The data analysis shows that about three quarter (74.2%) of respondents were in the aged 41-50 years. This informs that the household heads are relatively young. Studies have shown that household heads whose ages are below 50 years prefer growing exotic varieties of crops such as green grams, maize, kales and beans as opposed to indigenous crops such as sorghum, millet and ground nuts (Smith, *et al*., 2000; Obuoyo, 2005; Renhazo and Mellor, 2009). Given the weather variations and edaphic conditions of the semi-arid Nyakach the exotic varieties of crops fail more often than not, a fact that has contributed to decreased food production among the younger farmers' households. The respondents had reasons for their preference of exotic to indigenous crops, which included; 72% or respondents attributing indigenous crops to backwardness and as foods left for the old. As if to prove their allegation, the older household heads, aged above 50 years preferred growing indigenous crops. Almost all (97%) of the older household heads were conservative in their food production patterns and consumption habits. They are still attached to their culture and this includes the foods that they consume. They also asserted the fact that indigenous varieties of crops and animals were adapted to the weather conditions of the study area and gave higher and sustainable yields as opposed to exotic varieties.

The above assertion was confirmed by data in Table 4.1, which revealed that the age of the household head was a significant variable at 5% probability level in explaining food security. The sign of the coefficient of change in age of the household head showed a negative relationship with food insecurity. This shows that as the age of the household head increased the likelihood of being food insecure decreased by 0.858. This indicates that farming of indigenous food crops, keeping indigenous livestock such as the zebu, and household asset ownership

increased with age. Furthermore, the field data calculation based on the same population sample showed that the mean age of the household head growing indigenous crops and rearing indigenous livestock was 62.8 years and that of household heads growing exotic crops was 40.2 years. The above figures give the mean age of all household heads in semi-arid Nyakach to be about 51.5 years, a fact that could help explain the food security status of households. These findings are consistent with the average age of a farming household head in Asia and Latin America, estimated to be 48.0 and 47.4 years respectively and explained as a factor that would have caused household food insecurity in the regions save for the use of agrochemicals and irrigation (IFPRI, 2007; 2013b).

Possibly because of the western culture and civilization, which have brought with it tastier foods like rice, wheat, beans and maize the younger generations born after the year 1970 are not willing to embrace the rather heavier and "not-appetizing" traditional foods. This attitude of household heads needs to change because the prevailing agro-ecological conditions of semi-arid Nyakach cannot support the growth of exotic crop species and rearing of exotic livestock hence dictate that the farmers improve on indigenous varieties, production so as to realize higher yields hence more food availability and access.

4.2.2 Family Size

Results in Table 4.2 revealed that more than half (60.9%) of the respondents had between 5 and 8 dependants with mean Family Size of 6.80 people per household. This could be regarded as large family size. The implication of this finding is that the quantity of food intake and dependency ratio was affected negatively. The larger the family size, the lesser food availability to each person within the household. A large family size also affects the nutritional status negatively. Results on Table 4.1 show that the coefficient for family size has a positive sign

(1.799) and statistically different from zero at 1% level of probability (0.000), indicating that this variable was a cause of food insecurity. This therefore means that other factors held constant, the odds ratio in favor of food insecurity increases by a factor of 6.041 as household size increases by one person. This shows that as the number of family size increased, family food demand also increased and access to food decreased.

4.2.3 Dependency Ratio

Table 4.1 also shows that the higher the number of the dependants in a household, the higher the probability of the household being food insecure. A unit change in dependency ratio increased the chance of households to be food insecure by a factor of 0.029, keeping other factors constant. This supports the argument by Shackleton, *et al*. (2001) that population pressure somewhere is a threat to food security elsewhere. Relevant findings on dependency ratio and food security show that in a household where adults or productive age groups were higher than the non-productive age groups, the probability of the household to be food secure would be higher, provided that the area provided good working atmosphere and agricultural production potential (Watts and Bohle, 1993; NEPAD, 2009; Nelson, *et al*., 2014; USAID, 2014). Contrary to expectation, size of land holding did not seem to be a factor influencing household food security. An explanation for this may lie on the importance of the quality of land and or lack of complementary agricultural inputs. Moreover, there was no much difference between households with respect to land size holding because the average household farm size was 0.99 hectares.

4.2.4 Level of Education of Household Head

The respondents' education level according to Figures 4.1 and 4.2, respectively, shows that more than quarter (32%) of the female respondents and 18% of male respondents did not have any formal education. In essence, three quarters (60%) of the household heads were educated. This

shows that majority of respondents were literate, a fact that would be expected to enhance the food security status through adoption of sustainable and improved farm practices. This would be expected to improve household farm production and off-farm sources of food. However, this is not the case here because primary level of education which accounts for more than quarter of the respondents are basically unskilled and at most semi-skilled hence have limited choices of work for skilled jobs. They need sensitization and support so as to involve in on-farm and off-farm practices that would improve food security status of their households.

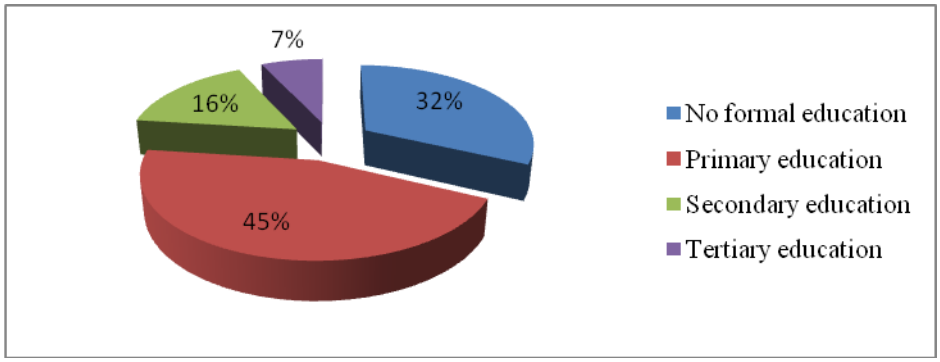


Figure 4.1: Female respondents by Level of Education.
Source: Field data, 2015

Figure 4.1 also illustrates that 45% of female household heads have primary level of formal education; 16% and 7% have secondary and tertiary levels of formal education. Further, the male respondents education levels in Figure 4.2 indicate that 18%, 51%; 21% and 10% of male respondents had no formal education; primary; secondary and tertiary levels of formal education respectively. This shows that on average 46% of households attained basic education, which would not translate to them acquiring the best knowledge, skills and attitude to engage in farming practices that would enhance food security. The education that the household heads attained had not exposed them to modern technology and the behavior of markets beyond their

geographical horizons. This resulted in low agricultural production due to farmers not having technical know-how and expertise in farming.

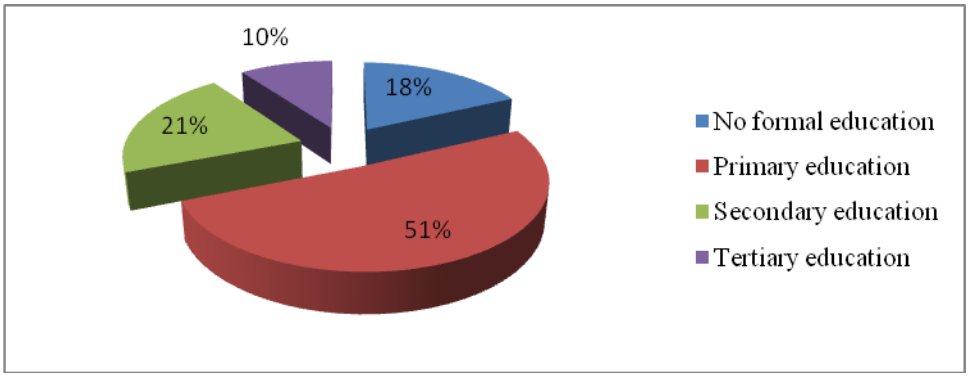


Figure 4.2: Male respondents by Level of Education
Source: Field data, 2015

Various studies have informed that formal education to women is important towards attaining sustainable household food security because women with formal education and income-earning capability have more autonomy in household decision making that translates to better health and nutrition of the women's households and their children (Fartahun *et al*., 2007; Hindin, 2006; Myntti, 1993; Pfeiffer, *et al*., 2001).

Coping with food insecurity in the rural and urban areas rests with farm households who are the main food producers (FAO, 2010). Education opportunities should therefore be opened up to them. This is especially true with women who make up 71% of the illiterate farmers in the area of study. Numerous studies underscore the social costs of rural women's lack of education and assets, linking it directly to high rates of under-nutrition, infant mortality and in some countries HIV/AIDS infection (FAO, 2015a). There are also high economic costs that are associated with wasted human capital and low labor productivity that stifle rural development and progress in agriculture and ultimately threaten food security when both women and men are not well

educated. That is why formal education to all farmers has become central to FAO's new and core strategy for agriculture and rural development (FAO, 2009; 2012; 2015c).

4.2.5 Gender of the Household Head.

Results in Table 4.1 reveal that gender of the household head was significant at less than 1% probability level. Gender of the household head and members of the household is an important factor that influences household food security, which includes the role that men and women play in food production, processing, distribution and consumption. The study established that women produced 76% of food while male respondents produced 24% of food in semi-arid Nyakach. This percentage contribution to food production by the household heads by gender confirms that women played a critical role in food production. This was manifested in areas of cultivation, seed selection, weeding, harvesting and yield storage. Hence household food production, provision and consumption depended on women. It is recognized that in developing countries, women play an important role in achieving household food and nutrition security (Pfeiffer, Gloyd and Ramirez, 2001). They are involved in household food production, participate in economic activities so as to supplement household incomes and are responsible for the care of the household members with regard to food supply (Quisumbing, 1996).

Table 4.3 further demonstrates that slightly over half (52.4%) of women in the food secure households were income-earners while only 24.1% of women in the food insecure households were employed hence being a housewife was a significant factor associated with household food insecurity. Studies by Maxwell, *et al*. (1998), Fartahun, *et al*. (2007) and FAO (2015a) agree that the combination of women's working experience (socialization with other people) and ability to generate and control financial resources in the households allow them to provide enough food for

family members, manage income and food resources efficiently and be innovative in spending the household income and coping with household food insufficiency.

Men owned over three quarter (81%) of family assets in terms of land and movables such as livestock and household goods. The extent to which they made decisions on the use of the assets, the products from the assets and the income derived from these assets influenced household food security. Women's decision-making on how much of the products to sell and how much to keep for domestic consumption was not tolerated by men in over 76% of the male-headed households. Men therefore engaged in practices that were not sustainable in the sense of increasing household food security. Practices such as leasing and renting out family land (23%); selling livestock to purchase food items during famines (41%) and selling family land to buy food and other household utilities (16%) were decisions that were made by male respondents. These practices curtailed household food availability, access, utilization and stability. Such practices only relieved the households of hunger for a limited period of time after which they would experience food shortage again. Such households remained in food poverty as opposed to households (24%) where decision-making with regard to food supply and consumption involved women.

Evidence from relevant studies has shown that women typically had fewer assets than men (Rotter, *et al*., 2007; Smale, *et al*., 2009). Further, Tshediso (2013) established that rural women had less access than men to productive resources, services and opportunities such as land, livestock, financial services and education. These studies agree with FAO (2015a), that the assets owned by women are used mostly toward provision of food, and that increasing women's control over assets mainly land and livestock has positive effects on food security, child nutrition, and education, as well as women's own well-being. Despite their important role in ecological and agricultural rehabilitation and ensuring food security, they do not have direct rights to land and

their access to it is being curtailed by titles being provided to men (FAO, 2015a). Despite these facts, Smith, *et al*. (2000) and Tshediso (2009) noted that women form about 19% of those smallholder farmers who receive training in modern methods, their traditional knowledge regarding farming is rarely sought and built upon and they are not consulted regarding community forestry which is also a source of food in semi-arid environments.

In semi-arid Nyakach, the males are not actively involved in farming except at the stage of land preparation, after which they laze around in homes and shopping centres, leaving the bulk of the farm work like planting, weeding, harvesting and storage to women (Sub-County Agricultural Office, 2015). This is could be understood to have greatly contributed to household food insecurity in the study area. Since men are more physically and economically able than women they need to be more involved in farming activities so that larger portions of land are put under food production hence realizing more yields compared to when only women get more involved.

4.2.6 Number of Livestock Owned by Household

Livestock holding was negatively and significantly related to the probability of a household being food insecure (Table 4.1). This translates to a positive relationship with household food security, which is explained by the fact that households with large herd size have better chance to earn more income from livestock production through sale of live animals and animal products such as milk, eggs, hide and skin. This in turn enabled households to purchase food when they were in short of food stock, and invested in purchase of farm inputs such as animal feeds, improved seeds and fertilizer that increased food production, and thus ensured food security at household level. The implication is that the probability of being food insecure decreased by a factor of 0.400 for households owning livestock. Field observations however showed that livestock numbers were severely limited due to lack of grazing facilities, as land was extensively

used for crop production which provided the staple foods necessary for family subsistence. This finding fits well with the sentiments of Dixon, Boffa and Garrity (2014) that while crop production growth in sub-Saharan Africa will come mostly from yield increases rather than from area expansion, the increases in livestock production will come about more as a result of expansion in livestock numbers in developing countries. However, FAO (2015) points out that bioenergy demand is projected to compete with land and water resources, and this will exacerbate competition for land from increasing demands for feed resources. This view is true because growing scarcities of water and land will require substantially increased resource use efficiencies in livestock production to avoid adverse impacts on food security

This finding is also in tandem with the views of Gryseels (1988), Asamenew (1991) and Omiti (1995) who conducted studies in small scale crop-livestock systems in the Ethiopian highlands. They established that livestock accounted for 34-87% of total cash income from the systems. Whereas crops were more often a subsistence enterprise, the livestock share in cash income was higher in those villages where total cash income was higher, indicating that increased cash income came primarily from livestock. This finding also concurs with Debrah and Sissoko (1990) that in semi-arid parts of Mali, livestock contributed 78% of cash income from smallholder crops and livestock mixed farms. In both Ethiopia and Mali, a major part of livestock cash income was spent on food and medicines. In some crop-livestock systems, such as in semi-arid areas of Botswana, self-sufficiency in food crop production may not be a major goal. Most food crops may be purchased by income generated by livestock. It should be understood from the basis of this finding, and as pointed out by other studies, that livestock integration with crop farming provides sustainable household food security as opposed to crop-

only systems that may provide actual food consumed by members of the household, but more often without surplus for sale.

4.2.7 Farm Inputs

The use of inputs such as improved seeds, animal feeds, manure and fertilizer had a significant and negative influence on the probability of households being food insecure as shown in Table 4.1., hence positively influenced household food security. The possible explanation is that the households that used inputs were more likely to be food secure than those who had no access to it. It therefore follows that if other factors were kept constant, the odds ratio in favor of being food secure increased by a factor of 10.101 as a household used more units of inputs. However, only quarter (24.8%) of the respondents could afford small amounts of fertilizer, feeds and certified seeds. This was the case because the remaining 75.2% lacked the cash income needed to purchase inputs. Among agricultural inputs labor occupied 17% while 9% was spent on improved seed and the remaining 2% and 1%, respectively, was allocated to land rental and fertilizer inputs. The share of expenditure on pesticides was very small at 1%.

In view of the low productivity of agriculture in Africa, many studies assert that long-term food security on the continent can be improved by encouraging farmers to pursue sustainable intensification of production through the use of improved inputs (Reardon, *et al*., 1996; Gill, 2002; Rockefeller Foundation, 2006; World Bank, 2006; Smale, *et al*., 2009). This will require a dramatic increase in the use of fertilizer, organic inputs, animal feeds and conservation investments (Dorward, *et al*., 2008).

4.2.8 Household's Access to Credit Facilities

Participating in credit use by the respondents according to data on Table 4.1 contributed in increasing the probability of being food secure by a factor of 0.181. This implies that credit utilization enhanced the capacity of households to access labor and input for productivity improvement or food when the need arose. Moreover, credit is an important source of investment on off and non-farm activities that generate income used to purchase food for farm households.

Further, there is a need to increase household access to assets, as household assets are the major determinants of these farmers' ability to participate in agricultural production and markets and to secure livelihoods through subsistence agriculture (Jayne, *et al*., 2003). The lack of assets for agricultural production is predominant in sub-Saharan Africa because households cannot access credit that would enable them secure such assets (FAO, 2012). This is evidenced by unsustainably small and decreasing farm sizes and poor-quality land, and the fact that investment in irrigation and farm inputs is negligible. Jayne *et al*. (1999) and World Bank (2008) propose that commercial and subsistence smallholder farming can be made more productive and sustainable by among other measures improving access to financial services and reducing risks.

4.2.9 Off-farm Employment

Among the respondents there were those who had wage employment alongside farming activities. Off-farm employment included permanent employment like teaching, nursing; casual jobs and petty trade in nearby shopping centres and fishing activities at landing beaches of Lake Victoria. Most (85.8%) of the respondents with wage employment engaged in crop and animal farming on part-time basis while 14.2% engaged in agriculture on full-time basis. This was an indication that majority of the respondents were not serious with farming. The findings

established that 95.2% of respondents with off-farm employment engaged in agriculture as their minor source of income while only 4.8% practiced agriculture as their major source of income.

From results in Table 4.1, it was evident that household heads who engaged in off-farm employment were less likely to be food insecure since off-farm employment negatively correlated with the probability of being food insecure (-3.827) hence such employment improved the likelihood of a household being food secure. The findings of Reardon, *et al*. (2001) and Aliber (2005) agreed that due to decline in soil fertility and consequent reduction in farm productivity and income, farming households were more reliant on off- farm activities to provide food and income. Further, the FAO (2015a) concured that wage income from non-farm employment and from other income-generating opportunities is of particular importance for rural households' food security. The current study established that off-farm employment created an opportunity to raise household's income positively influenced household food security.

4.2.10 Household Consumption of own Produced Food

Results on Table 4.1 indicate that the value of foods from the household's own production and own consumption had a negative relation (-0.004) with the probability of being food insecure at less than 1 percent probability level. This implies that keeping other factors constant, a unit positive change in the amount of household own food production and consumption reduced the probability of food insecurity by a factor of 0.996. Among the ten variables, households own food production and consumption (0.000***) and Family size(0.000***) most significantly influenced household food security, followed by total livestock Unit (0.002) then off-farm employment (0.003); while Land size least influenced household food security (0.439). This could be interpreted that households that depended on their own farm produce had yields that could last them longer than households that bought from the market. Moreover, households with

fewer members(less than 7) were more food secure since food intake was less. The sign of coefficient of change in family size showed a positive relationship with food insecurity (1.799). This shows that as the size of the family increased, family food demand also increased hence food availability, access and utilization decreased. In addition, keeping other factors constant, a unit change in the value of household own production and consumption reduced the probability of food insecurity by a factor of 0.996. Contrary to expectation, Size of land, distance to the nearest market and contact to extension services did not seem to be factors influencing household food security. This could be due to the fact that households in the study area own an average farm size of 0.99 hectares (KCDP, 2013) hence it's the quality and utilization of the farm which would determine the amount of yields harvested.

Further, the study established that on average both food secure and food insecure households allocated 56% of their total expenditure on food purchase (Table 4.4), which is relatively high and reveals limited food production for intra-household consumption. The high proportion of households' expenditure on food purchase shows that the households were not able to satisfy their food needs through their own production hence they still needed to purchase food because they did not produce enough food to sustain them to the next harvest. This finding agrees with that of Chambers and Conway (1992) and FAO (2015d) that farmer's own produce had a significant contribution toward achieving food security at household level.

4.3 Households by Food Security Status

Households were classified into food secure and food insecure groups based on expenditure value of meeting recommended daily allowance (RDA) of 2200 kcal. This classification was based on recommendations and standards set by IFPRI (2007) and the FAO (2008). Accordingly, the cost of basic need food poverty line was constructed based on data from the lowest income

quartile of Ksh.703 per adult equivalent (AE) per month. This line was then used as a threshold in which the aforementioned values declared success of food security and food insecurity otherwise as presented in Table 4.2.

Table 4.2: Households by food security status

n=384; Average household size = 6.8		
Number of dependants		
	Number of households	Percentage
0-3	57	14.8
4-7	307	80.0
More than 7	20	5.2
Household food security status		
Food secure	134	34.9
Low food secure	200	52.08
Very low food secure	50	13.02
Child hunger	169	44.01

Source: Field data, 2015

Results in Table 4.2 show that 34.9% of households were food secure, 52.08% had low food security and 13.02% had very low food security. Food secure households had access, at all times, to enough food for an active, healthy life for all household members. The low food secure households obtained enough food to avoid substantially disrupting their eating patterns or reducing food intake by using a variety of coping strategies, such as eating less varied diets, eating little food per meal, or getting emergency food from government. In the very low food secure households, normal eating patterns of one or more household members were disrupted and food intake was reduced at times during the year because they had insufficient money or other resources for food. Food insecure households include those with low food security and very low food security because at times during the year, these households were uncertain of having, or unable to acquire enough food to meet the food needs of all their members.

Further, results in Table 4.2 indicate that the average household size was 6.8 persons and 65.1% of households experienced food insecurity, with 44% reporting child hunger (Table.4.2). Further, 80% of households had between 4-7 dependants. These results further supported the fact that rural households in semi-arid environments experience food poverty (Dixon, *et al*., 2001; GoK, 2003a; FAO, 2015b). Also, it shows that the more individuals there were in a household, the more a household was likely to be less food secure. Studies by Clover (2003), Dorward, *et al*. (2008) and FAO (2015b) agree that in rural sub-Saharan Africa population pressure has a significant correlation with national and regional food security. In closing, the current study established that household size negatively influenced household food security.

On the basis of socio-demographic and economic characteristics, the food secure and food insecure households differed significantly on most of the independent variables as summarized in Table 4.3.

Table 4.3: Socio-demographic and economic characteristics of food secure and food Insecure households

Characteristics	Food secure n= 134 Mean	(SD)	Food insecure n =250 Mean	(SD)	P value+
Household size	6.8	(1.6)	6.8	(1.9)	<0.01
Number of children	3.8	(1.4	4.6	(1.8)	<0.01
Number of schooling children	2.2	(1.2)	3.2	(1.6)	<0.01
Years of schooling					
Father	7.6	(2.6)	6.4	(2.3)	<0.01
Mother	7.6	(2.6)	5.1	(2.5)	ns
Father's income (Ksh.)	15,466	(9,785)	14,469	(6,774)	<0.001
Mother's income (Ksh)	6,365	(9,329)	2,594	(5,386)	<0.001
Household income (Ksh)	23,864	(16,635)	16,597	(11,001)	<0.001
Income per capita (Ksh)	5,035	(3,487)	3,012	(2,366)	<0.001
(SD) n %					
<1,425[a]	2	(1.2)	20	(7.8)	
1,425 ~ 2,755[b]	28	(21.4)	129	(51.7)	
>2,755	104	(77.4)	101	(40.5)	
Employment status (Father) n (%)					
Employed	94	(69.9)	168	(67.2)	ns
Self employed	40	(30.1)	82	(32.8)	
Employment status (Mother) n (%)					
Working	70	(52.4)	60	(24.1)	<0.001
Housewife	62	(47.6)	190	(76.0)	
Savings n (%)	126	(94.0)	201	(80.2)	<0.01
Own Land n (%)	29	(21.4)	32	(12.9)	ns
Household income decreases from one year to another	51	(38.1)	110	(44.0)	ns
Household income for this year is less than last year	61	(45.2)	125	(50.0)	ns
Household income is not the same for every month n (%)	78	(58.3)	168	(67.2)	ns
Household income this month is less than last month n (%)	59	(44.0)	127	(50.9)	ns

Note.[a] – hardcore poor; [b] – poor; Ksh.95 = 1USD; + P value is based on t-test and chi-square analysis for comparison of group mean differences and percentages of households within each group with such characteristics respectively.

Table 4.3 shows that the food insecure households were characterized by larger household size, more children and school-going children and mothers who were housewives. Results in Table 4.3 further reveal that in light of the dependency pressure, 22.6% and 59.5% of the food secure households and the food insecure households, respectively, lived below the international poverty

line of USD1 per day with slightly more than half (51.7%) being poor households and 7.8% categorized as hard-core poor households (USD 0.33 per day) (Table 4.3). Further, results in Table 4.3 show that the respondents from the food insecure households reported short and long term income instability. Almost half (44.0%) of the food insecure households reported decrease in household income from one year to another; half (50.0%) of the food insecure households reported lesser household income in the year that the study was conducted than in the previous year; 67.2% reported fluctuation in monthly income and a further 50.9% intimated that their household income for the month during which the study was conducted was lesser than the previous month's income. These food insecure households' yearly (long term) instability in income was not very different from the responses of the food secure households that reported 38.1% and 45.2% respectively. However, the monthly (short-term) instability in household income between the two categories differed significantly, as the food secure households reported 58.3% and 44.0%, respectively. The common reasons that the respondents gave for this continued household income instability and decrease were fluctuations in prices for agricultural commodity items such as staple foods, milk, and live animals; little rainfall which resulted in crop and livestock failure; too much rain that resulted in flooding and difficulty to do odd jobs or secure secondary employment to supplement household income.

Logistic regression was performed between each socio-demographic and economic variable (independent variables) shown on Table 4.3 and household food security status Households with larger household size (OR=1.29, CI=1.09, 1.53) more number of children (OR=1.33, CI=1.11, 1.60) more school going children (OR=1.37, CI=1.10, 1.69), mothers as housewives (OR=2.89, CI=1.58, 4.29) and with no savings (OR=3.91, CI=1.42, 10.76) or land ownership (OR=1.84, CI=1.12, 3.90) were more likely to be food insecure. Households with wage earning mothers

(OR=0.998, CI=0.997, 0.999), fathers with higher years of schooling (OR=0.84, CI=0.74, 0.95) and higher per capita income (OR=0.993, CI=0.989, 0.996) were more food secure.

Cristofar and Basiotis, (1992) noted that household wealth assets are important to lessen financial burden of households during events that stress household budgets (Home owners and households with savings have been reported to be less likely to experience food insecurity (Rose, *et al*., 1995; Olson, *et al*., 2008). This study established that land ownership had two valuable features. The land is utilized for agricultural production activities or houses are built for rent, both of which are sources of income to the households. It is also noteworthy that 38% and 52% of the food secure and insecure households respectively owned livestock. However, food secure households reared livestock mainly for their own consumption while food insecure households reared livestock mainly for sale. Land ownership per se was not an important predictor of food security but its sustainable utilization was protective against household food insecurity.

Results in Table 4.4 show expenditures incurred by households. For both types of households, major expenditures were on foods, utilities, child education, loans and transport. The food insecure households spent 97.7% of their total incomes compared to food secure households that spent 83.9% of their total incomes on these items (Table 4.4). Some of the food insecure households had total expenditures which exceeded their monthly incomes. They realized this over expenditure by using their savings, borrowing money from various sources and using a system in the community whereby the villagers could take food and non-food items from the grocery or small shops *(kiosks)* and pay at the end of the month or later.

Table 4.4: Monthly expenditures by food secure and food insecure households

Characteristics	Food secure (n = 134) Mean (SD)	Food insecure (n = 250) Mean (SD)	P value +
Total expenditure	16,730 (10,222)	13,433 (5,453)	<0.01
Total expenditure (% total income)	83.9 (34.5)	97.7 (24)	<0.001
Types of major expenditures (% total expenditure)			
Food (Ksh)	8,123 (2,423)	7,097 (1,967)	<0.01
% total expenditure	52 (47)	60 (16)	<0.05
Utilities (Ksh)	1378 (1,102)	1,074 (846)	ns
% total expenditure	7 (7)	7.9 (4)	ns
Children education (Ksh)	1,349 (2,138)	1,739 (1,891)	ns
% total expenditure	7.9 (17)	12.5 (12)	<0.05
Loan (Ksh)	2,366 (2,537)	1,330 (1,938)	<0.05
% total expenditure	8.7 (14)	9.1 (12)	ns
Transport (Ksh)	1387 (0-7,496)	1,112 (0-22,496)	ns
% total expenditure	8.3 (14)	8.2 (5)	ns

+ P value is based on t-test analysis; USD 1 = Ksh.95

Among expenditure variables, total expenditures as proportion of household income (OR=7.09, CI=2.08, 14.17) and percentage of expenditure on food (OR=1.91, CI=1.11, 3.46) are higher for food insecure households. Mothers from food insecure households were also more likely to cook whatever was available at their homes for meals (OR=3.45, CI=1.42, 6.08) while strategies like borrowing money to buy food (OR=0.39, CI=0.20, 0.79), reducing number of meals (OR=0.996, CI=0.993, 0.999) and selling valuable materials (OR=0.46, CI=0.24, 0.90) contributed to household food security.

Results in Table 4.4 show that the food secure households spent 52% of the total income on food; 7% on utilities; 7.9% on child education; 8.9% on loan repayment and 8.3% on transport costs. The food insecure households on the other hand spent 60% of their total incomes on food; 7.9% on utilities; 12.5% on child education; 9.1% on loan repayment and 8.2% on transport. This qualifies the fact that food security hinges on household's purchasing power and entitlement

(accessibility to food) as it does on household's own food production (food availability) (Slack and Haddad, 1998; Odoemenem and Obinne, 2010). The results further reveal the importance of off-farm income that would help households to purchase food that they do not produce, a fact that has been established by many studies (Sen, 1982; Pimbert, *et al*., 2006; FAO, 2015d).

4.4 Household Food Security Coping Strategies

Results in Table 4.5 show that in the households' attempt to minimize food insecurity, several coping strategies were significantly different between the food secure and food insecure households. Results from households and FGDs concurred that three quarter (81%) of the food secure households adopted the strategies of selling valuable materials while 83% borrowed money to purchase food. On the other hand 67% and 72% of the food insecure households sold valuable materials and borrowed money, respectively. The food secure households had higher mean income, assets and properties that they sold or mortgaged during periods of economic hardship and food shortage. The food insecure households used food-related coping mechanisms like cooking whatever food was available at home; borrowed money to buy food; used less expensive food; consumed home-prepared meals; decreased frequency and quantity of food intake; compromised food quality and preference; sold assets to buy food; received relief food from the government and borrowed food and money to buy food during periods of food shortage. There are several advantages of using coping strategies to measure food insecurity such as the procedures are simple, low cost and comprehensible by many locals, can be used in combination with other measures of food insecurity and capture some elements of vulnerability and complexity related to food insecurity.

The food insecure households had more school-going children and reducing expenditures on children's education was an important coping strategy which included taking a school textbook loan, reducing children's pocket money and reducing expenditures on school needs and activities.

4.5: Coping strategies by food secure and food insecure households

Coping strategy	Food secure n = 134 N (%)		Food insecure n= 250 N (%)		P value +
Income and expenditure	Yes	**No**	Yes	**No**	
Reduce daily/ monthly spending	123 (92)	**11 (8)**	240 (96)	**10 (4)**	ns
Use savings	114 (85)	**20 (15)**	205 (82)	**45 (18)**	ns
Borrow money	110 (82)	**24 (18)**	180 (72)	**70 (18)**	<0.05
Sell valuables e.g. land, animals	109 (81)	**25 (19)**	168 (67)	**82 (33)**	<0.05
Have a second job (off or non-farm)	111 (83)	**23 (17)**	205 (82)	**45 (18)**	ns
Reduce spending on children's education	110 (82)	**24 (18)**	230 (92)	**20 (8)**	<0.05
Get cheaper treatment for illnesses	115 (86)	**19 (14)**	235 (94)	**15 (6)**	<0.05
Get medical treatment only when illnesses get worse	115 (86)	**19 (14)**	230 (93)	**20 (7)**	ns
Maintain status quo	122 (91)	**12 (8)**	230 (92)	**20 (8)**	ns
Food					
Reduce foods eaten outside home	126 (94)	**8 (6)**	240 (96)	**10 (4)**	ns
Cook whatever food is available at home	110 (82)	**24 (18)**	245 (98)	**5 (2)**	<0.01
Reduce amount of food cooked every meal	117 (87)	**17 (13)**	218 (87)	**32 (13)**	ns
Borrow money to buy food	111 (83)	**23 (17)**	168 (67)	**82 (33)**	<0.01
Reduce amount of food intake	111 (83)	**23 (17)**	198 (79)	**52 (21)**	ns
Reduce variety of food prepared	111 (83)	**23 (17)**	198 (79)	**52 (21)**	ns
Reduce food variations every meal	106 (79)	**28 (21)**	210 (84)	**40 (16)**	ns
Reduce fruit and vegetable intakes	105 (78)	**29 (22)**	183 (73)	**67 (27)**	ns
Reduce number of meals per day	105 (78)	**29 (22)**	168 (67)	**82 (33)**	<0.05
Receive food gifts from relatives, neighbors, friends	99 (73)	**35 (27)**	160 (64)	**90 (38)**	<0.05
Receive relief food from government	111 (83)	**23 (17)**	198 (79)	**52 (21)**	ns

+P value is based on chi square analysis

Further, 73% of food secure households received foods from family, friends, relatives and neighbors as a way of cushioning their households from experiencing food insufficiency (Table 4.5). Most (98.0%) of the food insecure households adopted the strategy of cooking whatever

food was available at home, including the use of herbs, plant shoots, wild vegetables, porridge, cassava, boiled maize or vegetables grown by the households, poultry and other domestic animals such as rabbits, goats, cows and sheep reared for own consumption or cash, and fishing from river Awach and Lake Victoria. In other words, these strategies did not require the food insecure households to use money to purchase food. The strategies on reducing amount of foods cooked per meal, total amount of food intake, food variations in meals and consumption of fruits and vegetables did not differ significantly between the two categories of households. However, reduction in the number of meals was adopted by 78% of food secure households and 67% of the food insecure households. Typically, direct observation in the field established that either breakfast or lunch was the meal skipped by these households.

The use of strategies to cope with short-term and long-term changes in household income and food insufficiency as direct indicators has been documented in many studies. De Garine, 1993; Watts & Bohle, 1993; Eele, 1994; Maxwell, 1996; indicated that in both rural and urban settings, four categories of coping strategies related to dietary change, food-seeking behaviors, household structure and rationing are commonly adopted by households experiencing food insufficiency. However, Maxwell *et al*. (1999) and Frakenberger and Coyle (2003) noted that the specific coping strategies within each category may vary across socio-economic settings. Due to different environmental circumstances such as cost of living; rural versus urban culture; education and employment status of women; the urban low-income households may utilize different specific coping mechanisms to deal with income and food insufficiency compared to rural households. Similarly, Adugna and Wagayehu (2012) has suggested that various aspects of coping behaviors, that is, definition, sequence of importance, severity, short-term versus long-term changes, may differ between locations for instance urban versus rural and within a location for instance fishing

versus agricultural communities in a rural area. Further, Table 4.6 shows the models of measuring food insecurity using the various subsets of variables from the three categories of demographic and socio-economic, expenditure and coping strategy variables. The Receiver operating characteristics (ROC) area represents the probability that the model correctly orders pairs of food secure and food insecure households. The area under the ROC curve is similar to R^2 in the Logistic regression analysis. The combination of demographic, socioeconomic and coping strategy variables yielded the area under the ROC curve as 0.86 and with all the three groups of variables combined, the value remained the same (0.86).

Table 4.6: Variance of food security explained by various subsets of household variables

Subset of variables	Food insecurity area under ROC + curve
Demographic and socioeconomic variables [a]	0.79
Demographic, socio-economic and expenditure variables [b]	0.79
Demographic, socio-economic and coping strategy variables [c]	0.86
Demographic, socio-economic, expenditure and coping strategy variables [d]	0.86

Key:

+ Receiver operating characteristics
a Number of children, father's income, mother's employment status, land ownership
b Number of children, father's income, mother's employment status, land ownership, percentage of expenditure on food
c Number of children, father's income, mother's employment status, land ownership, cook whatever is available at home, borrow money to buy food.
d Number of children, father's income, mother's employment status, land ownership, percentage of expenditure on food, cook whatever food is available at home, borrow money to buy food.

Logistic regression was performed for the combination of the various subsets of variables in Table 4.6 as factors contributing to household food insecurity. Results revealed that the food insecure households were more likely to have more children (OR=1.37, CI=1.10, 1.71), non-working mothers (OR=5.15, CI=3.76, 6.15), did not own land for agriculture (OR=2.41, CI=1.60, 3.18) and adopted strategy of food preparation based on whatever was available at

home (OR=3.84, CI=2.25, 4.33). However, households with mothers who reported having to borrow money to purchase food (OR=0.63, CI=0.22, 0.84) and households having fathers with higher incomes (OR=0.997, CI=0.996, 0.998) were more likely to be food secure. These results agree with findings of Davies (2006) and Idrisa, *et al*. (2010) that demographic characteristics, socio-economic characteristics and coping strategies of households are determinants of the households' food security status.

The current study has established that household food security is influenced by the following demographic, social and economic factors namely age, gender, level of education, land size, total number of livestock, input use, credit use, off-farm employment, the value of own food production and consumption and dependency ratio. Among the ten variables the study confirmed that households own food production and consumption (0.000***) and Family size (0.000***) most significantly influenced household food security, followed by total livestock Unit (0.002) then off-farm employment (0.003). This could be interpreted that households that depended on their own farm produce had yields that could last them longer than households that bought from the market. Moreover, as the size of the family increased, family food demand also increased hence food security decreased. Further, food coping strategies are determinants of the households' food security. Contrary to expectation, Size of Land (0.439), Distance to the nearest market (0.223) and Contact to extension services (0.2) did not seem to be factors influencing household food security. This could be due to the fact that households in the study area own an average farm size of 0.99 hectares (KCDP, 2013) hence it's the quality and utilization of the farm which would determine the amount of yields harvested. This suggests that own food production and consumption is a key determinant of household food security.

CHAPTER FIVE: CROP FARMING PRACTICES AND FOOD SECURITY

5.1 Introduction

Crop farming in semi-arid Nyakach comprised crops such as maize, sorghum, beans, green grams, kales (*sukuma wiki*) among others. Subsistence farming was the dominant system of crop production. Cultivation was done mainly using hoe, oxen-drawn plough while a few farmers used tractor. Crop farming was characterized by low inputs hence yields and profit margins were below the optimum. Majority of the households were resource-poor hence they adopted multiple cropping systems as risk diversification strategy. Crop farming practices studied included choice of seeds and crop varieties; soil enrichment practices, soil organic matter improvement practices, water conservation practices, soil conservation practices and agroforestry practices.

5.2 Choice of Seeds and Crop Varieties

Results in Table 5.1 show that households obtained seeds from different sources. Almost half (46%) of the respondents got their seeds from their own stocks of previous harvests and 2% of respondents bought seeds from input (agrovet) shops. Further, 49% of respondents sourced seeds from the open-air markets, while farmers' cooperatives and extension services provided seeds for 3% of the respondents.

Table 5.1: Sources of seeds by households and percent respondents

Source of seeds	Number of households	Percentage of respondents (%)
Farmers' own production	177	46
Input shops	8	2
Open air markets	188	49
Farmers' cooperatives and Extension services	11	3
Total	**384**	**100**

Source: Field data: 2015

The most common source of seeds for the respondents was the open-air markets, followed by the households' own production from previous harvests, cooperatives and extension services and input shops respectively, which revealed weakness in extension services in promoting food security in semi-arid Nyakach. The low percentage of households accessing seeds from agrovet shops, cooperatives and extension services could be attributed to the fact seeds could be more expensive from these sources and that cooperatives are few and extension may not be reaching farmers for awareness and incentives. Cooperatives are ideally the appropriate channels for disseminating extension services and all information on incentives to households. Further, FGDs revealed that seeds sourced from the open-air markets or from the households' own yields were not of the best quality since the seeds were not certified thus resulting in low crop yields. Sourcing of certified seeds from input (agrovet) shops by 2% of the respondents is negligible, meaning only these few households accessed high-yielding seed varieties. The inadequate food security experienced in the study area could therefore be attributed to low crop production due to 95% of households planting uncertified seeds, which may not be suitable for the area hence realizing low yields.

More than three quarter (86%) of the respondents preferred not to sow in line as they cited sowing in line as cumbersome and labor intensive. Sowing in line is a practice which facilitates efficiency in agricultural inputs use with respect to labor efficiency, seeding and returns for labor. The study indicated that less than quarter (14%) of the respondents used sowing in line as an improved farming practice. The low up-take of modern cropping practices may be explained by the fact that the households were not aware of the advantage of this practice in terms of labor efficiency and low production costs except for it being labor intensive at planting.

5.3 Soil Enrichment Practices

Practices that focused on soil health included use of inorganic fertilizers, herbicides, pesticides and organic matter improvement practices. These practices played an important role in protecting crops from insects, diseases pests, and increasing soil fertility. Table 5.2 shows that the level of use of each of the chemical products was still very low in the study area.

Table 5.2: Use of agrochemicals by percent adopters (N=384)

Product	Percent adopters of the products (%)
Inorganic fertilizer (Urea, CAN, DAP, MAP and NPK)	19
Herbicide (Gramoxone, Aurora turbo SG, Linagan 50 WP, Kalif 480 EC)	2
Pesticides (Insecticides e.g. furadan 5G, Acletic, Dipterex); Fungicides e.g. Dithane/Sancozab, Antracol, Ambush CY) and Chlorofenviphos	4

Source: Field data, 2015

Inorganic fertilizer was the most commonly used chemical product by a larger proportion of the respondents at 19%, pesticides were used by 4% of the respondents while herbicides was used by 2% of the households. The remaining 75% of households did not apply agro-chemicals on their farms. There were widespread attacks of stalk borer (*Buseola sp.* Lepidoptera), aphids (*Aphidae sp.* Homoptera), cutworm (*Agrotis sp*. Lepidoptera), termites and weeds on maize and sorghum crops and blights on bean crop. However, the households mostly applied pesticides on vegetables, water melon and rice crops under irrigation. The staples such as sorghum, beans, green gram and maize were least considered for pesticide application. As shown on the Table 5.3, households sourced agrochemicals from the private sector, farmers' cooperatives, open-air markets and extension services.

Table 5.3: Sources of inorganic fertilizer and pesticide supply by percent respondents (N=384)

Source of chemical products	Fertilizer (%)	Pesticide (%)
Private sector	1	1
Open air markets and input shops	35	75
Farmers' cooperatives	1	4
Extension services	11	4

Source; Field data, 2015

The open air markets and input shops was the major source of inorganic fertilizer for the respondents, with a proportion of 35% of the respondents buying fertilizer from these markets. A proportion of 11% of the respondents confirmed that they got fertilizer from extension services. Cooperatives and the private sector provided 1% of fertilizer to the respondents each, respectively. However, a proportion of 52% of the respondents did not use any of the given sources of inorganic fertilizers. Further, the source of pesticides were the local markets which was the most important source (75%) Extension services, cooperatives and farmers' associations were sources of 4%, 4% and 1% of pesticides used by the respondents, respectively.

5.3.1 Use of Inorganic Fertilizer

Table 5.4 illustrates that the factors that commonly influenced a household's adoption of use of any modern technology were: acreage owned; Extension services received; the number of trainings that a farmer engaged in; household head's access to credit facilities and the household head's belonging to a cooperative.

Table 5.4: Factors determining adoption of inorganic fertilizer use

Determinant factor	B	S.E	Significance	Exp (B)	Lower	Upper
Constant	-1.687	0.313	0.000	0.185		
Number of plots owned	0.154	0.040	0.000**	0.166	1.078	1.262
No. of visits per month by Extension officer	0.245	0.133	0.066*	1.277	0.984	1.659
Number of trainings per season	0.253	0.230	0.271	1.287	0.821	2.019
Access to credit (1)	0.114	0.380	0.765	1.120	0.532	2.359
Member of cooperative (1)	0.533	0.231	0.021**	1.704	1.084	2.680
Farm size (ha)	0.060	0.093	0.517	1.062	0.885	1.274

Chi-square value = 40.003; 95% Confidence. Interval for EXP (B); P value = 0

Source: Field data, 2015

The results of the binary logistic regression from Table 5.4 show that the total number of plots, the number of visits per month by extension workers and membership of farmers' to cooperatives influenced positively the use of inorganic fertilizer. A one unit increase in the number of visits per month by extension workers increased the log of the odds of fertilizer use by a factor of 0.245, all factors held constant. This is logical because knowledge exchange between extension workers and farmers on the one hand and sensitization about the benefit of using inorganic fertilizer for productivity growth on the other hand could help farmers to improve their way of combining assets to improve their methods of production including inorganic fertilizer use. Furthermore with extension workers' visits, farmers are exposed to information which reduces their subjective uncertainty and increases their chance of improved level of uptake of technologies, inorganic fertilizers included (Asiabaka, *et al*., 2001; Agwu, 2004).

Further, results on Table 5.4 show that the number of trainings attended by a farmer per season and farm size; had no statistically significant influence on the adoption of inorganic fertilizer at 10% significance level. Although it is a fact that the use of fertilizer requires capital, the results indicate that access to credit has no significant influence on the adoption of fertilizer-use in semi-arid Nyakach. This could be explained by the fact that only a few households had access to credit

and therefore access to credit was not so determining a factor. Further, 98% of the households lacked the land titles or other acceptable security for collateral required by financing institutions. Another reason may be that the procedures for obtaining credit were too complicated and time consuming for household heads that needed credit.

In addition, the results from the analysis illustrate that household heads who were members of cooperatives are more likely to use inorganic fertilizer than non-members of cooperatives. This is probably due to the fact that farmers' cooperatives have more access to agricultural information and credit and therefore their members have a better ability to adopt innovations, inorganic fertilizer-use included, than non-members of cooperatives. Bahiigwa (2002) and Clover (2003) agree that when it comes to agricultural support provision, farmers' cooperatives reduce the transaction costs and have high potential to remediate on the issue of imperfect information and uncertainty of agricultural inputs. In addition, the total farm size had a significant positive influence on the use of inorganic fertilizer whereby households having larger farm sizes were more likely to use inorganic fertilizer than households with smaller farms.

Analyses of the results indicate that the model chi-square is 40.003 with a p-value of 0.000. This indicates that the model is significant, that there is a significant relationship between inorganic fertilizer use and the set of dependent variables of food availability, access, utilization and stability. The Cox & Snell R^2 for the model is 0.108 and the Nagelkerke R^2 is 0.144 which show that there is some association between the dependent and independent variables. The Hosmer and Lemeshow, which is the goodness-of-fit measure had a value of 7.138 and P-value of 0.522 which means that the predicted values are not significantly different from the observed values.

From the Table 5.4, the model used was:

Logit (p) = log $\left(\frac{p}{1-p}\right)$ = Z = -1.687-0.154*X^1 + 0.245*X^2 + 0.253*X^3 + 0.114*X^4 + 0.533*X^5 + 0.060*X^6

Where: X^1 = total no. of plots; X^2 = No. of visits per month by extension workers; X^3 = No. of trainings attended per season; X^4 = Access to credit; X^5 = member of cooperative, X^6 = farm size (ha)

The following equation estimates the odds: $\frac{p}{1-p} = e^z$

Finally, the probability of inorganic fertilizer adoption (p) is obtained by applying the logistic transformation: $P = \frac{e^z}{1+e^z}$

Figure 5.1 illustrates that the probability of inorganic fertilizer use increased by a factor of 0.14 when the household head was a member of cooperative compared to the reference. This probability increased by a factor of 0.04 when the size of farm increased by one unit and by a factor of 0.03 when the number of visits increased by one unit.

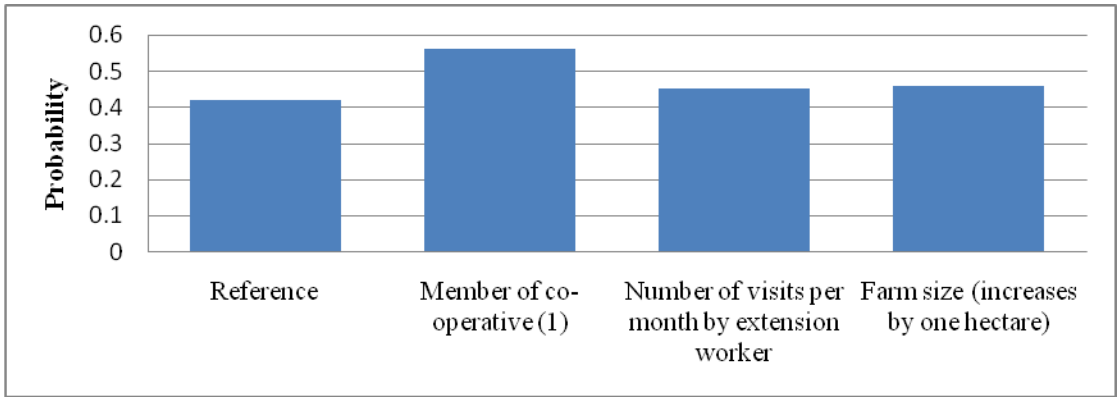


Figure 5.1: Single bar graph showing the Probability of household use of inorganic fertilizer by access to information and farm size
Source: Field data, 2015

In summary the results of this analysis concludes that membership to cooperatives; number of visits per month by extension workers and the size of farm per household are major factors determining inorganic fertilizer use in Nyakach sub-County. This result concurs with the findings of Morris, *et al*. (2007) and that exchange between extension workers and farmers and sensitization about the benefit of inorganic fertilizer use for improved productivity could help farmers to improve their way of combining assets to improve their methods of production including inorganic fertilizer use. Further, Cavane (2009) intimates that extension officers' visits enlighten farmers and reduces their subjective uncertainties thus increases adoption rate of modern technologies including fertilizers application. Results in Table 5.5 show the influence of inorganic fertilizer on crop yield by comparing the mean crop yield of the main food crops among users and non-users of the practice.

Table 5.5: Crop yield by users and non-users of inorganic fertilizer

	Users (n=173)		Non-users (n=211)			
Mean crop yield	Mean	SD	Mean	SD	t-test	P-value
Rice	92.8	188.5	68.6	196.2	-1.2	0.236
Maize	92.8	197.6	32.2	71.6	-3.7	0.000
Beans	195.3	200.1	115	155.8	-4.1	0.000
Sorghum	175.1	364	61.3	187.2	-3.6	0.000

Source: Field data, 2015

Table 5.5 further shows the results of t-test which provide evidence that there is no statistically significant difference in mean production of rice between inorganic fertilizer users and non-users (p-value of 0.236). However, there is a statistically significant difference between fertilizer users and non-users in mean production of Maize, beans and sorghum, which all have p-values of 0.000. This is an indication that inorganic fertilizer use led to increased production of maize, beans and sorghum hence increase in food availability among households.

This result agrees with the findings of Mwangi (1997) and FAO (2006) that the positive effect of crop farming on food production requires intensive agriculture based on modern technologies due to shortage of land.

5.3.2 Soil Organic Matter Improvement Practices

Practices that improved organic matter content and amelioration included use of organic manure, composting, mulching, landfill and application of crop residues to the soil (Table 5.6).

Table 5.6: Soil organic matter improvement practices by adopters (N=384)

Soil organic matter improvement practice	Percent Adopters of the practice
Organic manure	62
Composting	71
Mulching	76
Landfill	92
Application of crop residues	23

Source: Field data, 2015

As indicated on table 5.6, most (92%) of respondents affirmed the use of landfill practices, followed by mulching with 76% of the respondents. Composting and organic manure were also used by 71% and 62% of households respectively. Application of crop residues to the soil was however low at 23% because most farmers fed the residues to livestock. If the use of organic soil fertility management practices is compared with the chemical fertilizer (46%) it is evident that the uptake is much higher for the use of organic manure than the uptake of chemical fertilizer use. A possible reason for preferring manure over chemical fertilizers is its lower cost.

Further, results in Table 5.7 shows the influence of manure on crop yield by comparing the mean crop yield of the main food crops among users and non-users of the practice.

Table 5.7: Crop yield by users and non-users organic manure

	Users of manure (n=238)		Non-users of manure (n=146)			
Mean yield	Mean	SD	Mean	SD	t-test	P-value
Rice	111.6	229.2	27.9	89.2	-4.8	0.000
Maize	76.6	173.3	33.3	82.6	-3.1	0.002
Beans	181	185.5	106.2	165.8	-3.9	0.000
Sorghum	160	338.9	38.5	149.5	-4.6	0.000

Source: Field data, 2015

Results in Table 5.7 show that there is a statistically significant difference in mean production of rice, maize, beans, and sorghum between users and non-users of organic manure. For all crops the mean production was higher for organic manure users compared to non-users. This shows that when the farmers used manure then household food availability increased. This is interpreted that manure use increased yields of rice, maize, beans and sorghum thus increasing household food availability. These results are in support of findings of FAO (2006) that organic matter improves the soil structure, diminishes soil erosion, and helps to accumulate moisture, and that manure use contributes to releasing nutrients to the soil slowly and helps to make organic matter with long -term benefits (Place, *et al.*, 2003).

5.4 Water Conservation Practices

5.4.1 Marshland Improvement Practices

Drainage was the most widely adopted marshland improvement practice in the study area, adopted by 78%of households. This was because semi-arid Nyakach is located on a flat terrain and dominated by vertisols, which is poorly drained. Hard pan had mostly formed at 0.5 feet below the ground surface and this impeded water penetration and retention capacity of the soil.

These conditions exposed the study area to perennial flooding during rainy seasons that necessitated digging water channels, constructing dykes, building gabions and digging rills in homesteads and farmlands that lead water out. Also, drainage was a simple practice of regulating the water flow on farmland and was done by the active household members including children without necessitating paid labor. However, irrigation practices were not well adopted by the respondents, as about 9% of the respondents residing in Gem Rae, Gem Nam and Agoro West sub locations, near River Awach had adopted irrigation. These farmers practiced small scale traditional ways of abstracting water from the rivers using portable pipes and buckets for irrigation of vegetables and water melon. About 8% of households produced rice under irrigation at the local small-scale Gem-Nam irrigation project.

5.4.2 Irrigation

Table 5.8 illustrates the influence of irrigation on food security as was examined by comparing mean production of selected food crops between adopters and non-adopters of the practice Irrigation. Irrigation was practiced mainly on the wetlands for rice production. However, a few households near river Awach and Lake Victoria irrigated other crops such as maize, water melon and vegetables based on affordability of the practice.

Table 5.8: Crop yield by users and non-users of irrigation

	Adopters of irrigation (n=34)		Non adopters of irrigation (n=350)			
Mean crop yield (tons)	Mean	SD	Mean	SD	t-test	P-value
Rice	147.3	251.3	73.2	185.3	-2.0	0.038
Maize	137.6	304.5	52.5	119.5	1.5	0.127
Beans	181.2	182.1	149.7	181.7	-0.9	0.351
Sorghum	181.4	314.8	107.1	285	-1.3	0.164

Source: Field data, 2015

Table 5.8 shows that a dismal 8.9% of the respondents practiced irrigation while 91.1% had not adopted the practice. This low adoption of irrigation could be as a result of the cost involved or ignorance. Further, the results illustrate that there was significant difference in yields of rice and no significant difference in yields of maize, beans and sorghum between adopters and non-adopters of irrigation. This can be explained by the fact that rice was the only food crop mostly produced under irrigation in the study area. This finding explains the dismal performance of crops in semi-arid Nyakach and agrees with Dabour (2002) that irrigated agriculture is attributed to be of greater importance in increasing food production in semi-arid lands of the sub-Saharan Africa than rain-fed agriculture. It should be noted that whereas the study area experienced low and unreliable rainfall, farmers greatly depended on rain-fed agriculture, with irrigation being adopted by 8.9% of households. It is worthy to note that this low adoption of irrigation in the semi-arid environment, therefore, could have resulted in low crop yields experienced hence reduced household food security.

Table 5.8 further illustrates that there was a statistically significant difference in mean production for rice between adopters and non-adopters of irrigation. Nevertheless there is no statistically significant difference in mean production of maize, beans and sorghum between adopters and non-adopters of irrigation. The lack of significance for other crops other than rice can be explained by the fact that irrigation was practiced on wetland and in most cases rice is the only food crop under study that was produced under irrigation. This finding agrees with Dabour (2002) that irrigated agriculture is of importance in increasing food production in semi-arid lands of the sub-Saharan Africa than rain-fed agriculture. It should be noted that whereas the study area experienced low and unreliable rainfall, farmers greatly depended on rain-fed agriculture, with irrigation being adopted by 8.9% of households. It is worthy to note that this low adoption

of irrigation in the semi-arid environment, therefore, could have resulted in low crop yields experienced hence reduced household food security.

5.5 Soil Conservation Practices

5.5.1 Anti-Erosion Hedges

Table 5.9 indicates that the total acreage owned by household; extension services received; the number of trainings that a household head engaged in; farmer's access to credit facilities and the farmer's belonging to a cooperative were chosen by the study as possible factors that influenced household's adoption of anti-erosion hedges. These factors were selected because trainings were conducted by extension officers, World Vision-Kenya and Vi-Agroforestry project on erosion control measures; there were two cooperative organizations dealing with rice production and households had varied sizes of land for agricultural production.

Table 5.9: Factors determining adoption of anti-erosion hedges

Determinant factor	B	SD	Sig.	EXP(B)	Lower	Upper
Constant	-1.568	0.335	0	0.208		
No. of visits per month by extension Officer	0.24	0.127	0.059**	1.272	0.991	1.631
Number of trainings per season	0.248	0.215	0.248	1.281	0.842	1.951
Member of cooperative (1)	0.52	0.231	0.025**	1.682	1.069	2.646
Household size	0.095	0.053	0.072*	1.099	0.999	1.219
Farm size	1.188	0.091	0.038**	1.206	1.01	1.441

Significance level: ** = 0.05 significance level; 95% C.I for EXP (B); Chi-square = 28.761; P value= 0
Source: Field data, 2015

Binary logistic regression results presented in Table 5.9 show that the numbers of visits per month by extension workers; household head being a member of a cooperative; household size and farm size had a significant positive influence on the adoption of anti-erosion hedges. Hence household heads who were members of cooperatives were more likely to adopt anti-erosion hedges compared to those that were not members of cooperatives. This implies that cooperatives and extension services provided necessary technical information and benefits of anti-erosion

hedges, a fact that may have reduced farmers' resistance to change and resulted in increased adoption rate of the practice. Further, the results indicate that larger households are more likely to adopt anti-erosion hedges. In addition, a one unit (ha) increase in the farm size increases the log of the odds of adopting anti-erosion by a factor of 1.188, keeping other variables constant. This can be understood that if one extra hectare of land is available, a household is likely to adopt anti-erosion hedges because in that case the household does not fear competition for land between crops and the anti-erosion hedges. Also, ownership of a larger farm size is likely to result in tenure security which may cause the owner to invest on his/her farmland through various ways including anti-erosion hedgerows so as to ensure sustainable crop production. However, there is no significant influence of the number of trainings attended by farmers per season on the adoption of anti-erosion hedges.

Analyses were done on the data in Table 5.9 and the results showed that the model chi-square is 28.761 with a P-value of 0.000. This indicates that the model is significant, that variables in the model other than the intercept are useful in explaining anti-erosion adoption. The Cox & Snell R^2 for the model is 0.079 and the Nagelkerke R^2 is 0.107 which leads us to believe that there is at least some association between the dependent and independent variables .The goodness-of-fit measure (Hosmer and Lemeshow) has a value of 11.046 and P-value of 0.199 which means that the predicted values are not significantly different from the observed values.

Further, Figure 5.2 illustrates that the probability of adopting anti-erosion hedges increases by a factor of 0.12 when the household head is a member of cooperative compared to if the household head is not a member of any cooperative. When the number of visits per month by extension workers increased by one unit, the probability of farmers adopting anti-erosion hedges increased by a factor of 0.02. At the same time a one unit increase in farm size increased the probability of

adopting the use of anti-erosion hedges by a factor of 0.24. Reference is a situation when the household head is not a member of a cooperative is not visited by extension worker and has a farm size of 0.99 hectares which is the average household farm size in the study area.

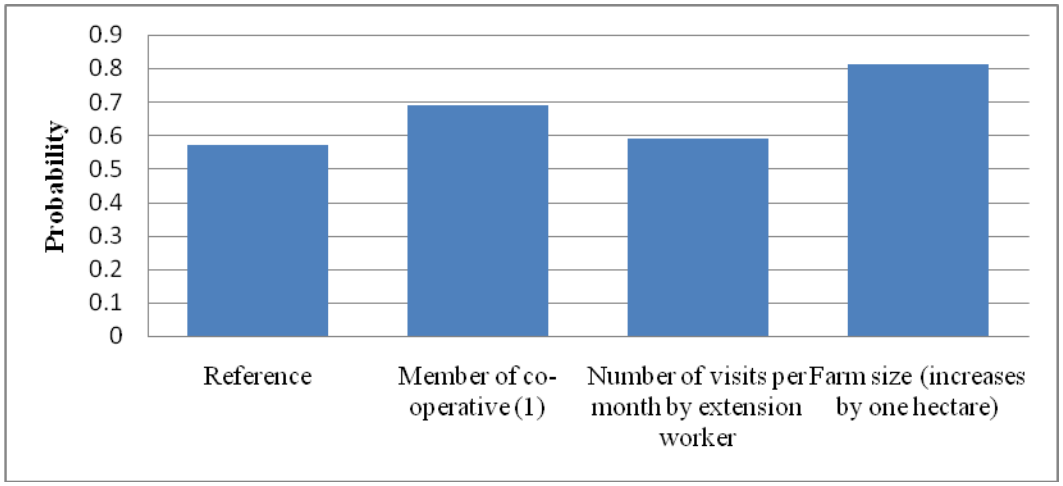


Figure 5.2: Probability of Household adoption of anti-erosion hedges
Source: Field data, 2015

Also, discussions with FGDs indicated that anti-erosion hedges contributed to the protection of soil against erosion especially in the areas of flat topography prone to flooding during rainy seasons. The importance of anti-erosion hedges is shown by comparing the mean production of selected crops between adopters and non-adopters as presented. Results show that 60.9% of the respondents constructed anti-erosion hedges while 39.1% did not adopt the practice.

Table 5.10: Crop yield by users and non-users of anti-erosion hedges

	Adopters of anti-erosion hedges (n=150)		Non adopters of anti-erosion hedges (n=234)			
Mean crop yield (tons)	Mean	SD	Mean	SD	t-test	P-value
Rice	108.9	247.3	61	145	-2.1	0.038
Maize	80.5	175.7	47	123.7	-1.9	0.005
Beans	189.9	194.5	128	169.1	-3.1	0.002
Sorghum	124.8	236.1	106.6	317.3	-0.5	0.561

Source: Field data, 2015

The results of t-test in Table 5.10 show that there is no statistically significant difference between harvests of adopters and non-adopters of anti-erosion hedges in mean production of sorghum, which is an indigenous crop of the study area. Results show that 39.1% of the respondents constructed anti-erosion hedges while 60.9% did not adopt the practice. Probably, the low level of adoption could be due to lack of awareness of the importance of anti-erosion hedges in improving soil conservation. Further, t-test results showed that there was no significant difference in mean production of sorghum (indigenous) but there was a significant difference in mean production of rice, maize, and beans between adopters and non-adopters of anti-erosion hedges. This indicates that the practice had a positive influence on food production of rice, maize and beans (exotic) in the semi-arid Nyakach.

This finding confirms to the households in the study area, that indigenous crops are still the key to sustainable crop production. This result supports the findings of Obuoyo (2005) and McIntyre, *et al* (2009) that communities of dry lands should revert to growing traditional crops so as to ensure food security, a fact they attribute to the weather and edaphic conditions of these geographical areas. It is however difficult to compare productivity among adopters and non-adopters of the above practices because with a mixed cropping system, it is difficult to know how much hectares of each crop are planted per season.

5.6 Agroforestry Practices

Improved Fallow technology was the most viable agroforestry practice carried out in the study area because it was applicable and yielded results fast. The study revealed that crops yields were low and declining in the semi-arid Nyakach due to low soil fertility and productivity. Further, the study was informed by the Sub-County Agricultural Officer that soils in the study area were deficient mainly in nitrogen and phosphorus but in some areas, potassium so that Maize, which

was the staple food crop of the study area yielded less than 0.8 ton ha^{-1} per season. Odoemenem and Obinne, (2010) supports the sentiments of the officer, that with declining soil nitrogen, the build-up of *Striga hermonthica* - a parasitic weed of many cereals including maize, increases and this decreases yields. The net effect of all this was the decline in production of crops and food shortages. The improved fallow of fast-growing leguminous species such as *Sesbania sesban, Crotalaria grahamiana, Tephrosia vogelii* and *Cajanus cajan* was explored and evaluated as a technology that could restore soil fertility and improve soil productivity hence increase food production. It was the best alternative to the commonly practiced natural fallows.

These evaluations were conducted in two types of trials: Type 1 (researcher designed and farmer-managed), Type 2 (farmer-designed and farmer-managed). From these trials, improved/planted fallows of fast-growing leguminous species emerged as a technology that improved soil fertility and crop yields remarkably. While improved fallows can improve crop yields in Nitrogen-limited soil, its effects are little in Phosphorus-limited soils that cover a large area of the study area (Braun, *et al*., 1997). Consequently, the annual nutrient deficits on such small holdings are estimated at 100 kg N ha^{-1} and 10 kg P ha^{-1} (Place, Noordin and Jama, 2004). Unlike Nitrogen, trees do not obtain Phosphorus from the air. Phosphorus-deficient soils, therefore needed input of phosphorus so as to integrate with improved fallows technology for improved crop yields.

5.6.1 Improved fallows, Natural fallow and Continuous Cropping

The choice of the species for planted fallows and systems depends on adaptation of the species to the biophysical and socio-economic conditions of a given site. The species adapted in this study area were *Sesbania sesban, Tephrosia vogelii, Crotalaria grahamiana and Cajanus cajan*. Sesbania was not new in the area, though, and was particularly popular with the farmers because of its soil fertility improving properties and for firewood. The other species were relay-sown in

standing maize and millet during the long rains of the year (May 2014), 4-5 weeks after sowing. Relay cropping minimizes negative effects of the trees on the crop and allows the trees to benefit from crop husbandry practices such as fertilizer application and weeding. It also permits tree growth to be extended for two seasons. When the crops were harvested at the end of the first season (July-August 2014), the trees were left to grow during the second season (six-month long) until they were cut in January or February 2015 and the cropping cycle repeated. Once the trees were cut, wood was removed and the leaf and small twigs were left on the field and incorporated into the soil during land preparation in September 2015. Depending on how much weed control was achieved during the fallow period, it was possible to plant the crop with no or minimum tillage when the fallow were cut.

In one on-farm of Researcher-designed, Farmer-Managed study (type 1 trial) at an NPK-deficient site (Figure 5.3), a six-month fallow of *Sesbania sesban*, *Tephrosia,Crotalaria* and *Cajanus cajan* increased amounts of maize yield by about 35% to 128% compared with continuous maize with no fertilizer application. This had good prospects for many farmers in the area with fewer other options for improving crop yields. Maize yield was highest after fallows of Tephrosia at 3.6t ha^{-1}; Sesbania followed at 3.5t ha^{-1} while Crotalaria, Cajanus and natural fallows performed poorest at 2.7t ha^{-1} each. Maize yield was lowest for the continuous cropping systems, at 2.0t ha^{-1} although it was higher than the typical yield of 1.0 t ha^{-1} or less for such a system in semi-arid environments (Swinkels, *et al*., 1997). The fallows showed considerable residual effects on the subsequent crops, which were harvested in July-August 2015 which ranged from 36% for natural fallow to 44% with *Sesbania sesban*.

This could have important implications on the economic evaluation of the technology, but that is left for further research by Agricultural economists.

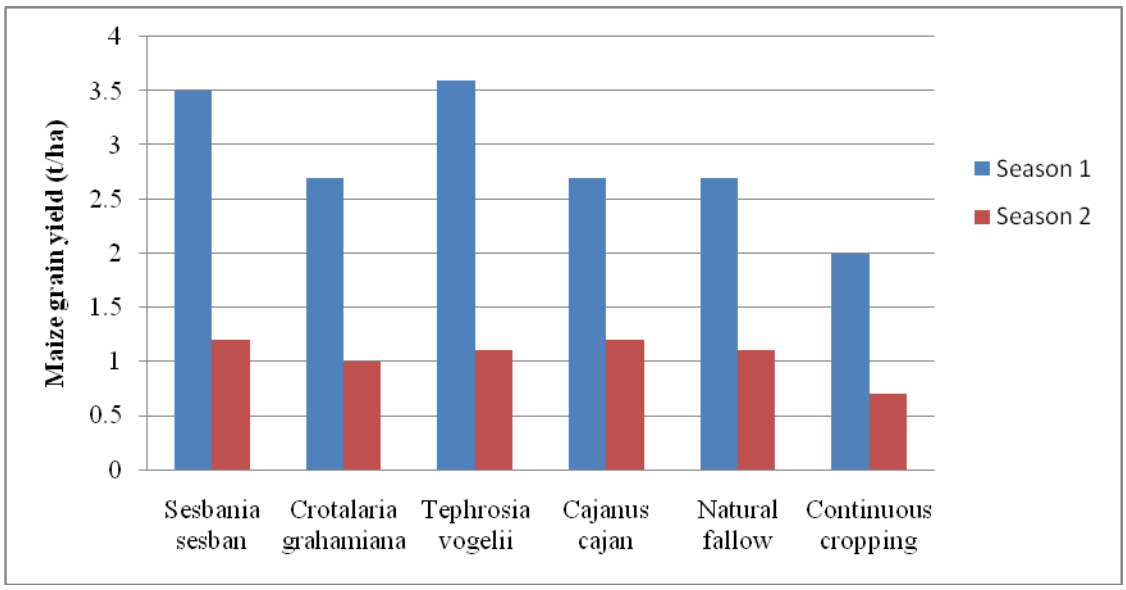
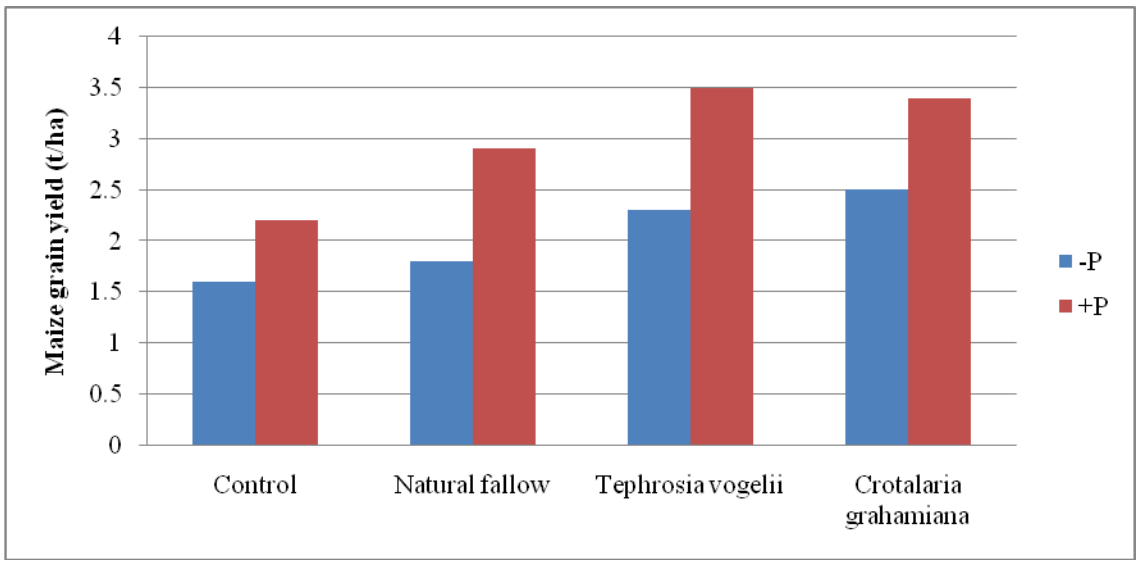


Figure 5.3: Comparative bar graph of Six-month improved fallows, natural fallow and continuous cropping on maize yield.
Source: Field data, 2015.

Figure 5.4 shows the results on the potential of short-duration improved fallows that were assessed on farm, under farmer' own designed and managed conditions (Type 2 trials) in a study on Nitrogen and Phosphorus-deficient sites. The six-month fallows of *Crotalaria grahamiana* and *Tephrosia vogelii* increased maize yields by 31% to 36% compared with continuous cropping without the addition of Nitrogen and Phosphorus. Maize yield from non-phosphorus addition soil was similar for that from *Crotalaria grahamiana* and *Tephrosia* vogelii fallows, which were 2.5tha^{-1} and 2.3 t ha^{-1} respectively, but higher than the farmers' no-input control fallow, which yielded 1.6t ha^{-1}. With the addition of Phosphorus as Tripple superphosphate (TSP) at the rate of 20kg ha^{-1}, maize yield of all systems increased considerably for Crotalaria at 0.9 ton ha^{-1}; for Tephrosia at 1.2 ton ha^{-1} and for the control at 0.6 ton ha^{-1} compared to non-Phosphorus addition.



-P: without fertilizer; +P: with phosphorus

Figure 5.4: Comparative bar graph of maize yield with and without Phosphorus application on farmer-managed improved fallows

Source: Field data, 2015

5.6.2 Economic Benefits of Improved Fallows

Economic returns of short-duration planted fallows were attractive under both trials 1 and 2 conditions. This was evident from the results of the on-station study as indicated on Table 5.11.

Table 5.11: Comparative Economic analysis of six-month Continuous Maize cropping, Natural fallow and *Sesbania sesban* Improved fallow systems

System	Returns to land (Ksh./ha)		Returns to labour (Ksh./day worked)	
	+P	-P	+P	-P
Continuous maize	-3520	-11840	24	24
Natural fallow	-5840	-8400	24	16
Sesbania fallow (Firewood valued)	30,400	28,240	112	112
Sesbania fallow (Firewood NOT valued)	24,320	22,240	96	96

Source: Field data, 2015

The study compared the effects of a six-month Sesbania fallow (direct seeded at the rate of 20,000 plants per hectare) with a six-month natural fallow and continuous maize. The plots were established at the end of the fallow period and Phosphorus was applied at the rate of 20 kg ha^{-1} to only the first of four maize crops after the fallow period. Net benefits, expressed in terms of returns to land or labour per day worked, of Sesbania were positive and higher than those of the other two systems, whether Sesbania firewood was valued or not. Net benefits of Sesbania increased slightly with the application of Phosphorus compared with non- P addition, at Ksh. 32,000 ha^{-1} and Ksh. 29,840 ha^{-1} respectively. The small increase with Phosphorus was attributed to the low amount of P added.

In a nearby locality with Phosphorus deficient soils, researchers with Vi-Agroforestry project carrying out research in collaboration with the farmers, found application of high rates of Phosphorus, at 200 kg ha^{-1} after an 18-month *Sesbania sesban* fallow increased considerably both maize yields and economic benefits. (Jama, *et al*., 1998). Because of the low value of 6-month Sesbania wood, its valuation did not affect much the net benefits.

Economic assessment of improved fallows under twenty (20) farmer-designed and managed conditions in the study area also revealed positive results. They demonstrated that the break-even maize yield, that is, the yield increase required over continuous maize to cover the cost associated with planted fallows, for a one year long Sesbania fallow as 21% of 0.6 t ha^{-1}, which is a typical yield for nutrient-depleted soils with no fertilizer inputs. Improved fallow effects are usually more than 21% (Jama and Pizarro, 2001). The main reasons for positive economic returns of improved fallows are increased crop yields, low labour cost and other crop inputs saved during the fallow period, residual effects of fallows extending beyond the first crop after and; firewood from fallow which is limiting in many areas of the semi-arid Nyakach.

Phosphorus deficiency was widespread in the study area. 86% of the farms were severely deficient in phosphorus (Sub-County Agricultural Office). High yields require large Phosphorus applications- at least over 100kg ha^{-1} (Jama and Pizarro, 2008). Phosphorus input is therefore a must in order to improve yields meaningfully. The options of P inputs are phosphorus fertilizers and phosphate rock (PR). Considering cost effectiveness, the latter was more recommended for the resource-poor farm households of the study area.

It is evident that the level of uptake of various crop farming practices in semi-arid Nyakach largely depended on the financial capability of the farmers to afford the production cost. This is confirmed by the fact that the findings revealed that the adoption rate is higher for the practices that did not require much external resources and inputs and precisely those that could easily be technically implemented by family labor. Some crop farming practices had significant correlation with food security. This created sufficient grounds to suspect that household food security could be predicted from crop farming practices. This condition informed the need for regression analysis.

5.7 Bivariate Relationship between Crop Farming Practices and Food Security

Having ascertained that there are significant associations between some crop farming practices and food security in semi-arid agro-ecological zones of Nyakach, the researcher proceeded to predict and ascertain the individual relationships between each practice and household food security by conducting a bivariate analysis. The practices selected for the purpose of the study were inorganic fertilizer use, organic manure application, anti-erosion structures and irrigation because they were most applicable in the study area as presented in Table 5.12.

Table 5.12: Bivariate relationship between crop farming practices and food security

Food secure	Use of inorganic fertilizer			Use of organic manure			Anti- erosion hedges			Irrigation		
	No	Yes	Total	No	Yes	Total	No	Yes	Total	No	Yes	Total
No respondents	195	154	349	143	206	349	213	136	349	321	28	349
(%)	56	44	100	41	59	100	61	39	100	92	8	100
Yes respondents	18	37	55	3	52	55	30	25	55	45	10	55
(%)	32	68	100	6	94	100	55	45	100	81	19	100
Total respondents	207	177	384	146	238	384	234	150	384	349	35	384
(%)	54	46	100	38	62	100	61	39	100	91	9	100
	Chi-square=6.387 P-value=0.011			Chi-square=4.372 P-value=0.000			Chi-square=0.512 P-value=0.474			Chi-square=4.588 P-value=0.032		

Source: Field data, 2015

Table 5.12 shows the relationship between selected crop farming practices and food security. In each case the first row is the number of respondents and the second row are percentages of respondents engaging in the various crop farming practices and their household food security status. A positive relationship occurred between food secure households and inorganic fertilizer use, organic manure application, and irrigation. At 5% significance level, there is a strong positive correlation between use of organic manure and food security as the P-value is 0.000. This suggests that the use of organic manure for improving soil fertility and productivity is very important because it results in increased food production hence availability. The findings reinforce the calling for farmers not to rely exclusively on inorganic fertilizers because manure has greater potential of improving soil fertility and most importantly while sustainably preserving the soil minerals. This view is in agreement with FAO (2006; 2015) that the application of manure contributes to the supply of plant nutrient and replenishes soil organic matter sustainably.

Similar significance was found with irrigation at P-value of 0.032. Even though not adopted by many farmers because of the high cost factor, irrigation has a great potential to improve food security because of the less dependency on rain-fed food production, and given that the study area experiences drought more often than not, and that there are water rivers and the Lake Victoria that the locals could source water for irrigation. With irrigation, drought is not a problem and hence food is produced throughout the whole yearly cycle.

5.8 Multivariate Relationship between Crop Farming Practices and Food Security

Having determined the relationships between each crop farming practice and food security, the researcher investigated the relationships between all the practices taken together and household food security. This was necessary since the practices were presumed to influence food security, and as already suggested in literature, it is not possible that each practice could influence food security in isolation. This being a social study, and crop farming practices being social variables in social arena, there was high possibility that the crop farming practices could have a combined influence on food security, and it was necessary to establish the extent to which this was true hence the need for a multiple relationship between all the practices and food security. Hence Multivariate analysis was conducted to examine the relationship between several independent variables simultaneously and food security. Table 4.13 shows the practices that were analyzed by this study as: use of inorganic fertilizer, use of manure, composting, mulching, irrigation, use of anti-erosion hedges and farm size.

Table 5.13: Multivariate relationship between crop farming practices and food security

Crop farming practices	B	SD	Significance	Exp (B)	Lower	Upper
Constant	1.592	0.444	0	4.912	-	-
Use of inorganic fertilizer	-0.484	0.243	0.047**	0.616	0.383	0.993
Use of manure	-0.788	0.274	0.004**	0.455	0.266	0.778
Composting	-0.217	0.327	0.507	0.805	0.425	1.527
Mulching	-0.311	0.284	0.274	1.364	0.782	2.378
Irrigation	-0.472	0.400	0.238	0.624	0.285	1.366
Anti-erosion hedges	0.075	0.250	0.763	1.078	0.661	1.759
Farm size (ha)	-0.347	0.117	0.003**	0.707	0.562	0.889

** Significance level=0.05; 95% Confidence Interval; chi-square value=47.769; P-value= 0
Source: Field data, 2015

Regression results on Table 5.13 reveal that there is no statistically significant influence of individual practices such as mulching, composting, irrigation of marshland, and anti-erosion hedges on severe food insecurity in semi-arid Nyakach at 5% significance level. Checking for multicollinearity the results revealed that there is a weak correlation between different crop farming practices and food security. Further, the results from Multiple Regression analysis show a significant negative influence of inorganic fertilizer use and organic manure use on the likelihood of a household being food insecure at the 5% significance level. The log of the odds of being food insecure decreased by a factor of 0.484 when households used inorganic fertilizer compared to households that did not use inorganic fertilizer, all factors held constant.

Similar result is observed in the case of organic manure application where the log of the odds of being severely food insecure decreased by a factor of 0.788 when households used organic manure compared to households not using manure, all factors held constant. This means that households that used organic manure were less likely to be food insecure than households that did not use manure. The results show also that households with a smaller farm size were more likely to be food insecure compared to households with larger farm size.

This is confirmed by statistically significant negative coefficient of the variable which shows that for a one unit (ha) increase in farm size, the log of the odds of being food insecure decreased by a factor of 0.347, all factors held constant. In the study area the average farm size is shrinking and the land: man ratio is reducing as population growth continues to increase. This may result in reduced farm yield, income and expenditure levels which in turn will worsen the food status of the households leading to food insecurity.

The results in Table 5.13 also show that the model chi-square is 47.769 with a p-value of 0.000. This indicates that the model is significant, that variables in the model other than the intercept are useful in explaining severe food insecurity. The Cox & Snell R^2 for the model is 0.125 which leads us to believe that there is some association between the dependent and independent variables. Figure 5.5 shows the probability of a household being food insecure by use of soil fertility improvement practices and size of household farm.

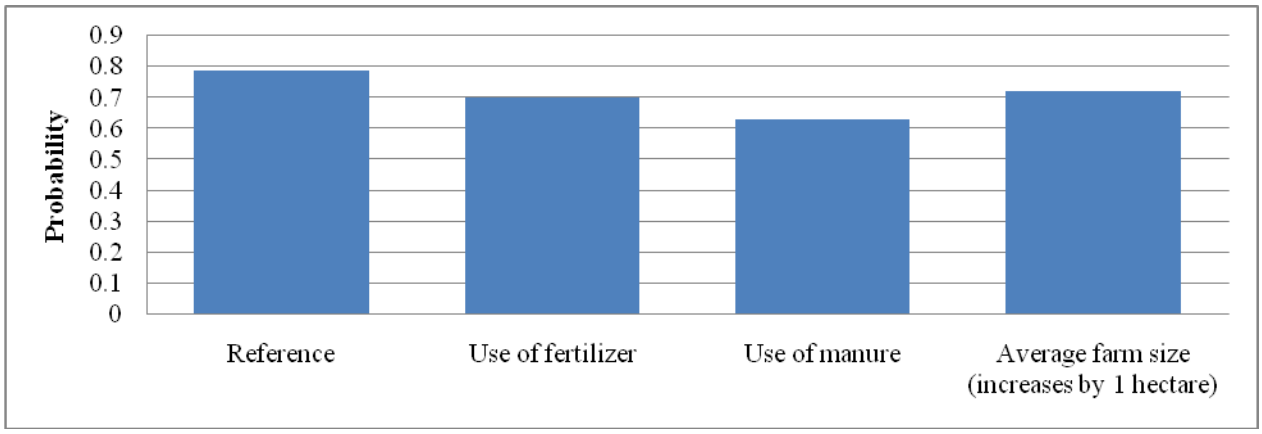


Figure 5.5: Single bar graph of Probability of household food security by farming practices
Source: Field data, 2015

Results in Figure 5.5.show that the probability of a household being food insecure when inorganic fertilizer is used drops by 0.09 compared to the reference value while this probability drops by 0.16 when organic manure is used compared to the reference. In addition, a one unit

(ha) increase in farm size decreases the probability of a household being food insecure by a factor of 0.07 compared to the reference value. The reference represents a situation when a household does not use inorganic fertilizer, does not use manure and has an average farm size of 0.99 hectares. It is worthy to note that the results from this analysis show that the use of inorganic fertilizer, use of organic manure and size of farm are major determinants of food security in the study area. The study establishes that the probability of a household being food insecure decreases with the use of inorganic fertilizer; use of organic manure and an increase in farm size.

These results agree with Faridi and Wadood (2010) and Feleke, *et al*. (2005) that crop farming practices influence household food security. Further, Bogale and Shimelis (2009) noted that the positive influence of crop farming on food production requires intensive agriculture based on modern and sustainable practices because land owned by households are decreasing due to increase in human population (Omotesho, *et al*. (2010) and consequent overuse of agricultural land (Faridi and Wodood, 2010)

In summary of crop farming practices and food security, the most common source of seeds was the open air markets (49%), followed by the households' own production (46%). Cooperatives and extension services and input (agrovets) shops provided seeds to 2% and 3%, respectively. The low percentage of households accessing seeds from input shops could be attributed to the fact that seeds could be more expensive from these sources and that cooperatives are few and extension may not be reaching farmers for awareness and incentives. This resulted in households planting uncertified seeds. Further, seeds bought from the local markets or sought from the households' own yields may not be of the best quality to improve crop yields. The sourcing hence wrong choice of seeds resulted in low crop production hence reduced food security.

Whereas the study area experienced low and unreliable rainfall, farmers greatly depended on rain-fed agriculture, with irrigation being adopted by 8.9% of households. This low adoption of irrigation could have resulted in low crop yields experienced hence reduced household food security. Results further show that 39.1% of the respondents constructed anti-erosion hedges. Probably, the low level of adoption could be due to lack of awareness of the importance of anti-erosion hedges in improving soil conservation and crop yields. The current study however, has established that adoption of anti-erosion hedges had little influence on production of sorghum. This poses a challenge to households in the study area, that indigenous crops are still very important in food crop production regardless of adopting anti-erosion hedges.

There was a strong correlation between food security and use of manure, fertilizer and irrigation as their P-values were 0.000, 0.011 and 0.032, respectively. This suggests that the use of manure is better than use of fertilizer for improving soil fertility and productivity, but they are both very important because they both had significant positive influence on the likelihood of a household being food secure. The findings reinforce the calling for farmers not to rely exclusively on chemical fertilizers because manure has better potential of improving soil fertility and most importantly while sustainably preserving the soil minerals. Further, it is evident that even though irrigation was not adopted by many farmers, it has a great potential to improve food security.

CHAPTER SIX: LIVESTOCK FARMING PRACTICES AND FOOD SECURITY

6.1 Introduction

Livestock production is practiced by almost all (over 90%) of households in the semi-arid Nyakach, hence a major economic and social activity towards attainment of food security. Livestock play a key role in contributing to household food security both directly and indirectly through enabling direct access to animal products such as milk, meat and eggs; providing cash income especially during times of food shortage; providing employment to the farmers and farm workers; provision of draught power and increased grain yields as a result of improved productivity from use of manure and traction (Table 6.1).

Table 6.1: Role of livestock on food security

	Direct role	Indirect role
Positive	• Source of food (energy, protein and nutrients). • Source of income. • Source of employment. • Improved social status of the farmer. • Store of wealth and a buffer against crop failure. • Broadened resource base (recycling household wastes and utilization of marginal lands and crop residues).	• Source of energy (draft power, manure for fuel and biogas). • Source of manure or soil conditioner. • Means of weed control. • Increasing animal production saves foreign exchange. • Provide investment and savings. • Provide leather, bones and other by-products for building, clothing and tools. • Social and cultural prestige to the farmer.
Negative	• Competition with humans for arable land. • Higher resource use compared to crops. • Increased risk of certain diseases due to high consumption of livestock products. • Human health threats from zoonotic diseases, food safety and incorrect use of antibiotics.	• High environmental impact like soil erosion due to overgrazing. • Intensification may displace small-scale farmers from the market. • Livestock may displace the consumption of balanced, healthy plant-based foods.

Source: Field data, 2015

Livestock ownership relates positively to household food security. Livestock provide foods that are rich in energy, proteins, vitamins and minerals.

The consumption of these foods particularly by the rural poor, can therefore substantially contribute to dietary diversity and improved food security. Sale of live animals and livestock products also provide households with cash that is spent on purchasing food hence food accessibility is enhanced. The use of livestock for traction and provision of manure on farm enhances crop production therefore leading to improved food availability, access and utilization (Figure 6.1).

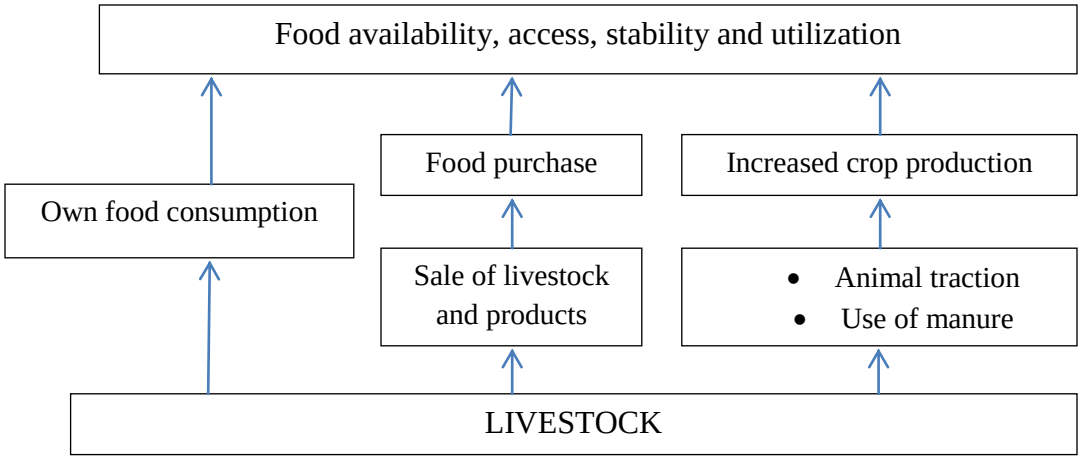


Figure 6.1: Association between Livestock and food security
Source: Field data, 2015

Figure 6.1 is an illustration of the association between livestock and household food security. Livestock ownership plays a vital role in enabling households to benefit from a more diverse diet, and contribute to own production and consumption of milk, meat and eggs. Further, crop production is enhanced by livestock production through provision of manure by livestock that improve soil fertility. These benefits have implications on household productivity, income levels and ultimately household food security.

6.2 Livestock Types, Ownership, Numbers and Market prices

In general livestock provide an important source of farm income to the people of semi-arid areas. Milk and meat provide food and source of income generation. Since rainfall is insufficient, unreliable and irregular, yields from livestock farming is more reliable than crop farming. Cattle, sheep, goats, poultry and donkey constitute the animal wealth in the study area. Table 6.2 shows data on the types, household ownership, numbers and market prices of various livestock.

Table 6.2: Households by Livestock types, Ownership, Numbers and Market prices

Type of livestock	Households owning livestock (%)	Mean owned	Total population	Average price of male (Ksh)	Average price of female (Ksh)
Cattle	62.3	41.7	15,760	20,000	18,000
Sheep	55.7	32.6	24,800	3,500	3,200
Goat	43.7	82.1	19,245	2,800	2,500
Donkey	5.7	1.8	958	1,600	14,000
Poultry	68.2	79.5	17,600	800	600
Pig	3.0	1.4	196	4,000	3,800

Source: Field data, 2015

Results in Table 6.2 show that 62.3% of households in the semi-arid Nyakach own cattle, while 43.75 own goats, which are referred to in various literatures as “poor household animal”. Further 55.7% of households own sheep while 3.0% and 5.7% own pigs and donkeys respectively. Further, 68.2% of the farmers owned poultry, showing that poultry is the most popular livestock among the households, followed by cattle, sheep then goats. Popularity of poultry could be explained by the fact that chicken is the easiest and cheapest to keep, especially the local breeds kept on free-range system. Cattle and sheep were preferred because as grazers they survive well under grass vegetation of semi-arid Nyakach. Goats are browsers and palatable shrubs are rare thus curtailing grazing of goats in the study area.

These results conform to the findings by FAO (2015a) and Paul and Shahidur (2013) that sale of livestock in sub Saharan Africa contributed 78% of household income while Jabbar (1995) noted that in semi-arid areas of Nigeria, 41% of 5,460 sales of small ruminants were done by owners of the livestock.

6.3 Livestock Housing and Veterinary Services

Housing and access to veterinary services determine livestock productivity, which then translates to food security status of a household. Table 6.3 shows data on livestock housing and access to veterinary services.

Table 6.3: Livestock Housing, Access to Veterinary Services and Sale by households

Practice	Yes households (%)		No households (%)	
Livestock housing	47	(12.3)	337	(87.7)
Veterinary services	17	(4.3)	367	(95.7)
Sale of livestock at the market	316	(82.3)	68	(17.7)

Source: Field data, 2015

Results in Table 6.3 show that 12.3 % of the households housed their livestock in fenced enclosures, sheds and houses. The remaining 87.7% percent of the households tethered their livestock in the open without any form of enclosure or housing. This may partly explain the low productivity of livestock in the study area. Elzaki *et al*. (2011) found out that livestock that are housed produced more milk and meat than the non-housed livestock. Animals were grazed on open grazing fields both during dry and rainy seasons. Grazing was done by family members commonly the mother or the father during times when schools were in session and the children when schools closed besides a few households that employed farm workers.

All households that kept cattle, goat, sheep and donkey indicated that their livestock were attacked by ticks that spread East Coast Fever, anaplasimosi, basesiosi and heartwater and tsetsefly that spread tripanosomiasis diseases. However, results on Table 6.3 show that 4.3% of the households seek veterinary services for their livestock. Farmers cited high fees charged by the veterinary officers as the main challenge to seeking these services. The remaining 95.7% of the households relied on either livestock treatment from the black market that was cheaper or local herbs, which are believed to be the cheapest option because it has been used by generations and it works for them. Results on Table 6.3 further established that 17.7% and 82.3% of the households sold their animals within homesteads and at local primary and secondary markets, respectively for subsistence especially to purchase food. Livestock sold within homesteads averagely fetched 15% lower prices than those sold at the market places. The markets for livestock in the region are Katito and Ahero. This study concurs with the findings of Elzaki *et al*. (2011) that revealed positive relationships between livestock ownership and food security.

6.4 Food Supply and Consumption among Livestock Farmers

Food security among livestock farmers in the semi-arid Nyakach was measured by household food supply and consumption (Table 6.4 and Table 6.5). These variables are used because they are good indicators of household variation in income, the relative purchasing power and access to other resources.

Table 6.4: Livestock ownership on stability of household food supply

Livestock species	Months per year that households owning livestock had adequate food supply	Months per year that households not owning livestock had adequate food supply	t-value
Cattle	9.2	7.3	-3.602*
Goats and sheep	8.9	7.4	-1.639***
Exotic chicken	9.7	7.4	-1.677***
Local chicken	9.7	7.4	-1.621

*1%, **5%, ***10% Significance level

Source: Field data, 2015

Results in Table 6.4 show that ownership of livestock increases the probability of households having more food supply. Households that own livestock have more adequate food supply as shown by the increase in the number of months that such households had adequate food. Households that own cattle, goat, sheep, exotic chicken and local had adequate food supply for 9.2, 8.9; 9.7 and 9.7 months per year respectively. However, households that do not own these livestock had adequate food supply for 7.3; 7.4; 7.4 and 7.4 months per year, respectively. Notably, ownership of livestock increased the probability of households having more adequate food supply for about 2 months. This suggests that households owning livestock could spend income from livestock sales on food purchases, bringing about the difference in the number of months for households' adequate food supply. Studies by Quisumbing *et al*. (1996), Shackleton, *et al*. (2001), Bogale and Shimelis (2009) and FAO (2013; 2015c) agree that increasing ownership of livestock has positive influence on food supply.

Further, results in Table 6.5 shows the trend of consumption of particular animal source foods per week, in households that own livestock and in households that do not own livestock.

Table 6.5: Livestock ownership and household consumption habits

Livestock type	Household owning livestock			Household not owning livestock		
	Number of times consumed per week			Number of times consumed per week		
	Meat	Milk	Egg	Meat	Milk	Egg
Cattle	2.7	6.5	-	1.9	2.9	-
Goat/sheep	3.4	4	-	2.1	0	-
Exotic chicken	2	-	4.1	0	-	1.1
Local chicken	1.2	-	2.2	1.0	-	1.2

Source: Field data, 2015

The results in Table 6.5 indicate that the frequency of animal source foods' consumption in households that owned livestock was considerably higher than in households that did not own livestock. There are significant differences in meat consumption between households that owned and those that did not own cattle and exotic chickens. Cattle milk consumption was 6.5 times per week in households that owned cattle, whereas it was 2.9 times in households that did not own cattle. Households that owned exotic chicken consumed meat 2 times and eggs twice 4.1 times per week, while households that did not own exotic chicken did not consume chicken meat but consumed eggs 1.1 times per week. These results can be explained that food consumption was stable in households that owned livestock which could translate to long-term household food security. However, owning of local chicken did not determine the consumption of meat and eggs between households that owned and those that did not. This could be explained that local chicken could have been kept for sale.

Further, the results in Table 6.5 show that livestock types and ownership patterns play significant roles in determining household food consumption habits. These results can be understood that income gains from exotic chicken sales enabled households to purchase a greater diversity of food and enjoy a more varied diet than households keeping traditional chicken. Also, households owning exotic chickens consumed significantly more eggs from

their own production than those that do not own exotic chickens, which have to buy eggs. However, there are no significant differences in meat and egg consumption in households that owned local chicken and those that did not. This scenario is most likely due to the local chicken's lower productivity. It is evident from the results in Table 6.5 that livestock ownership relates positively with meat, milk and eggs consumption. Further, the results explain that food availability (supply) and utilization (consumption) are stable and sustainable in households that owned small livestock, translating to long-term household food security.

These findings confirm the findings of studies conducted in Ethiopia by Fartahun, *et al*. (2007) which revealed that in all types of animal-production systems, livestock had a specific role of household food provision. FAO (2005) also concurred that commercialization of the livestock sector can create a pathway out of poverty for smallholder livestock keepers. Further, the results agree with Jabbar (1995) who observed that in southern Nigeria, 41% of 5460 sales of small ruminants in four village markets over a period of 14 months were done by owners of the livestock. Jabbar (*ibid*) also confirms that 75 % of income from the sales of livestock was spent on food and clothing. Further, these findings suggest that animal production systems should be improved as an intervention to improve household food security. For many households in rural communities, the sale of livestock provides the only outlet to the cash economy. Even in times of food abundance, livestock sales enable households to diversify their diets. Paul and Shahidur, (2013) conducted a study in semi-arid Mali, which established that livestock contributed 78% of cash income from smallholder mixed crop and livestock farming.

In pastoral areas of East Africa, sale of livestock and milk is the main source of income used to buy grain for household consumption (Gill, 2002). However, a study conducted in Ethiopia by Gryseels (1988) found that meat consumption from own slaughter was infrequent except in

cases of sick and or unproductive animals or for ceremonial reasons. He noted that while animal source foods contributed considerably to household diets particularly in livestock owning households, there was an exception with regards to meat consumption. The frequency of meat consumption was highest in households with no cattle, goats and exotic chicken, compared with households who owned these livestock. Adebayo (2012) shows evidence to suggest that when the cost of producing livestock products domestically is lower than its production in the commercial sector, households are more likely to opt for the sale of these products, rather than use them for domestic consumption.

Results of a study conducted in Nigeria by Agwu (2004) shows that at the household level, poor producer families are less inclined to consume poultry products and more likely to sell them, especially when the household is in need of cash. At farm level, the importance of livestock as the source of income vary across different ecological zones and production systems, which in turn determines the species raised and the products and services generated (Swanepoel, *et al*., 2010). Trends in livestock food supply in developing countries show that livestock are important contributors to total food production (FAO, 2012). Moreover, their contribution increases at a higher rate than that of cereals (FAO, 2015a)). Recent increases in livestock products appear to be even more spectacular than those achieved for cereals from the green revolution (Swanepoel, *et al*., 2010).

Therefore, the current study has established that ownership of cattle, sheep, goat and chicken related positively with meat, milk and eggs consumptions thus increasing household food security.

6.5 Livestock Products as Source of Income

Results in Table 6.6 show the income from sale of livestock products.

Table 6.6: Income from sales of livestock products

Product	Quantity	Annual Revenue (Million Ksh)
Milk	2.5 million litres	125
Beef	701 metric tons	195.8
Goat meat	58.5 metric tons	175.5
Mutton	24.5 metric tons	7.35
Poultry meat	318.2 metric tons	23.86
Pork	8.4 metric tons	2.1
Eggs	2.4 million eggs	28.8
Total		558.41

Source: Sub-County Agricultural Office, 2015

Results in Table 6.6 indicate that milk was the most regular source of income, followed by eggs, beef, goat meat, mutton and pork, respectively. On average, dairy farming contributed Ksh.125 million (US$1.32 million) to the economy of the study area annually. Households recorded 63.93% increase in total income from milk sales between the years 2011 and 2014. This increase was attributed to increased animal population, especially the exotic varieties and increase in production area. The dairy sector was however affected by decline in forage availability, high cost of commercial supplements and high cost of dairy animals which had negative impact on the total number of dairy cattle hence milk production. However, milk deficit was mitigated by supply from neighboring counties mainly Nandi and Kericho. The semi-arid Nyakach is milk deficit hence all milk produced easily and readily found market. Further, there was no co-operative society handling milk. Organized milk outlets were milk bars in the local shopping centres like Rae, Katito and Pap-Onditi, whose milk supply was mainly imports.

FAO (2012) attests to the fact that milk sale is a source of regular income to households and recommends that dairy development programs should be encouraged among households in the

rural areas as this would enhance sustainable household food security. Delgado, *et al*., (2010) agree that India's Dairy Development Program "Operation Food" has created cooperatives that pay daily for the milk delivered by households, thereby providing regular income to thousands of poor farmers in India. Also, FAO/United Nations Development Programme (UNDP) Dairy Project in Burkina Faso assisted 100 families in increasing their monthly income by about US$80, which is equivalent to an extra labour unit per family (FAO, 2012).

Further, the results illustrate that 701 metric tons of beef, 58.5 metric tons of goat meat and 24.5 metric tons of mutton was produced in the year 2015. The production of beef cattle was characterized by traditional systems that mainly rely on indigenous breeds whose overall productivity is low. Although productivity remained low the farmers developed exceptional adaptive traits to utilize the poor roughage and tolerate endo-parasites and ecto-parasites. Beef cattle served the households as a source of investment and income to solving some astringent family financial and customary issues such as payment of school fee and other levies, providing family healthcare, purchasing food, clothing and payment of dowry. Further, Poultry farming contributed 318.2 metric tons of meat and 2.4 million eggs per year, which are valued at a total of Ksh.52.66 million (US$554,316), despite its population being kept in check through off-takes and mortalities. The pig industry although still very subsistence, contributed Ksh.2.1 million (US$ 22,105) in a year.

The total revenue from the livestock sub-sector in the study area is Ksh.558.41 million (US$ 5.873 million). This is 32% of the total annual revenue of Nyakach Sub-County. This is about 5% higher than at the national level where revenue from livestock food products represents 27% of the total agricultural output (KCDP, 2013). These results can be interpreted that livestock provide increased economic stability to the households by both small and large livestock acting

as a cash buffer and as capital reserve. Since the households managed mixed-farming systems, livestock reduced the risks associated with crop production. Livestock also represent liquid assets that could be realized at any time, adding further stability to the production system. In addition, there are various other products and services provided by livestock that are not accounted for in these statistics, but which considerably increase the total value of livestock.

These results are in agreement with Pimbert, *et al*., 2006 and Omotesho, *et al*., 2010 that animal products are an important source of income for many smallholder farming households in developing countries, an income that these households use for purchasing food, non-food items as well as agricultural inputs such as seed, fertilizers and pesticides. In Kenya, the livestock subsector has achieved the greatest growth in production over the last three decades, and it is expected that it will continue to grow faster than all other agricultural subsectors in the next 20 years (GoK, 2012b). The total value of milk and meat represents 3.5 times the value of wheat and rice and 2.8 times the value of fish (GoK, 2008c). The importance of livestock as a source of household income is also illustrated by the example of the Grameen Bank in Bangladesh, which assists only the poorest segment of the population and provides about 50% of its loans for the purchase of livestock, mainly large ruminants for milk production and draught power (Adugna and Wagayehu, 2012). This further shows that livestock help alleviate seasonal food variability through sale of its products. Omotesho, *et al*. (2010) noted that income from livestock was spent on purchasing food and agricultural inputs such as seed and fertilizers while Elzaki, *et al*. (2001) further agrees that cash is generated regularly from direct sales of livestock products like milk, eggs and manure and occasionally from the sale of live animals, meat and skins and from fees for draught power or transport services.

6.6 Correlation Matrix for Livestock Production and Household Food Security

Further, the study conducted Correlation Matrix to establish the association between milk production, Livestock sales and household food availability, access and utilization. The results are summarized in Table 6.7.

Table 6.7: Rank Correlation Matrix for Milk Production, Livestock Sales and Food Security variables (availability, access and utilization)

Item	CMP	SMP	GMP	LAS	FV	FA	FU
1.Cattle Milk Production Pearson Correlation Significance	1 -	0.322** 0.026	0.060 0.665	0.180* 0.130	0.002 0.983	0.036 0.707	0.198* 0.049
2.Sheep Milk Production Pearson Correlation Significance	0.322* 0.026	1 -	0.585** 0.000	0.381** 0.002	-0.034 0.755	-0.195* 0.067	0.298** 0.007
3.Goat Milk Production Pearson Correlation Significance	0.060 0.665	0.585** 0.000	1 -	0.393** 0.001	0.353** 0.000	0.327** 0.000	0.501** 0.000
4.Live Animal Sale Pearson Correlation Significance	0.180 0.130	0.381** 0.002	0.393** 0.001	1 -	0.266** 0.001	- 0.377** 0.000	0.643** 0.000
5.Food Availability Pearson Correlation Significance	0.002** 0.983	-0.034 0.755	0.353** 0.000	0.266** 0.001	1 -	- 0.347** 0.000	0.335** 0.000
6.Food Access Pearson Correlation Significance	0.036** 0.707	-0.195 0.067	-0.327** 0.000	-0.377** 0.000	-0.347** 0.000	1 -	-0.327** 0.000
7.Food Utilization Pearson Correlation Significance	0.198** 0.049	0.298** 0.007	0.501** 0.000	0.643** 0.000	0.335** 0.000	- 0.327** 0.000	1 -

** Correlation is significant at 0.01 level (2-tailed). * Correlation is significant at 0.05 level (2-tailed).
Key: CMP=Cattle milk production; SMP=Sheep milk production; GMP=Goat milk production; LAS=Live animal sale; FV=Food availability; FA=Food access; FU=Food utilization

Cattle milk production relates positively with food availability (0.002), food access (0.036) and food utilization (0.198). The positive values indicate that an increase in independent variable is associated with an increase on the dependent variable and vice versa. From the results in Table 6.7, cattle milk production is positively associated with food availability, food access and food utilization hence an increase in cattle milk production results in household food security. Milk produced from sheep relates positively with food utilization (0.298) but negatively with both

food availability (-0.034) and access (-0.195). This could be attributed to the fact that most households did not milk sheep. The milk produced from goats relate positively with food availability (0.353), food access (0.327) and food utilization (0.501). Sales of live animals relates positively with food availability (0.266), positively with food utilization (0.643), but negatively with food access (-0.377). However, milk production and sale of live animals did not have any significant associations at 0.05, which was the standard alpha value set for this study.

Results in Table 6.7 further reveal that households producing milk from cattle, sheep and goats were generally food secure. This could be explained by the fact that these households consumed the milk. Further, households with surplus produce sold the milk for income, which would then be spent on purchasing other food stuffs. Other households opted to sell all the milk produce and spent the proceeds on food related items. However, while it would seem that households with livestock would sell livestock to supplement their diets, live animal sale related negatively with food access (-0.377). This implies that some livestock sales were not used for bulk food purchases that would reduce the number of months households did not have enough food. The results show that livestock relates positively to household food security.

The findings by Elzaki (2005) noted that livestock contributed about 36% of the total household income in the irrigated areas of Gezira in Sudan. Further, the findings of Elzaki *et al*. (2011) revealed positive relationships between livestock ownership and food security in the Rural White Nile State of Sudan. However, the current study established that milk production and live animal sales have both negative and positive influence on household food availability, access and utilization in semi-arid areas of Nyakach.

In summary, results of Objective 3 show that poultry is the most popular livestock type among households (68.2%) followed by cattle (62.3%), sheep (55.7%), goats (43.7%) donkeys (5.7%) and pigs (3.0%). Popularity of poultry among households could be explained by the fact that chicken is the easiest and cheapest to keep, especially the local breeds kept on free-range system. Cattle and sheep were preferred because as grazers they survive well under grass vegetation of semi-arid Nyakach. Goats are browsers and palatable shrubs are rare in the study area thus curtailing grazing of goats. In addition, the study sought to establish the influence of the number and type of livestock ownership on stability of household food supply. Results show that households that owned cattle, goats and sheep, exotic chicken and local chicken had adequate food supply for 9.2, 8.9; 9.7 and 9.7 months per year respectively while households that did not own these livestock had adequate food supply for 7.3; 7.4; 7.4 and 7.4 months per year, respectively. Notably, ownership of livestock increased the probability of households having more adequate food supply for about 2 months. This suggests that households owning livestock could spend income from livestock sales on food purchases, bringing about the difference in the number of months for households' adequate food supply.

The study therefore established that livestock type and ownership determined household food consumption habits. Results indicate that households owning cattle consumed milk 6.5 times per week while households that did not, consumed milk 2.9 times per week. Households owning exotic chicken consumed eggs 4.1 times per week while those that did not consumed eggs 1.1 times per week. These results can be explained that food consumption is stable in households that owned livestock which could translate to long-term household food security.

Further, the study conducted Correlation Matrix to establish the association between milk production, Livestock sales and household food availability, access and utilization. Results indicate that milk produced from cattle related positively with food availability (0.002), food access (0.036) and food utilization (0.198). The positive values indicate that an increase in cattle milk production resulted in an increase in food availability, access and utilization hence food security. Milk produced from sheep related positively with food utilization (0.298) but negatively with both food availability (-0.034) and access (-0.195).This could be attributed to the fact that most households did not milk sheep. Sales of live animals related positively with food availability (0.266) and utilization (0.643), but negatively with food access (-0.377). This could imply that income from livestock sales may not have been spent on bulk food purchases. The current study therefore established that milk production and live animal sales have both negative and positive influence on household food availability, access and utilization in semi-arid areas of Nyakach.

CHAPTER SEVEN: SUMMARY, CONCLUSION AND RECOMMENDATIONS

7.1 Introduction

The study aimed at establishing if household socio-demographic and economic characteristics and agricultural practices influenced household food security with specific reference to semi-arid Agro-Ecological Zones of Nyakach Sub-County in Kisumu County, Kenya. The study specifically sought to: establish the influence of socio-demographic and economic characteristics of households on food security; determine the influence of crop farming practices on food security; and examine the influence of livestock farming practices on food security. The findings and interpretations of data were presented and discussed in the previous chapters. This chapter summarizes the findings, draws conclusions and makes recommendations based on the findings.

7.2 Summary of the Findings

Binary logistic estimation revealed that gender, age; family size; level of education; number of livestock; input use; credit use and off farm employment, the value of own food production and consumption and dependency ratio were significant in explaining the likelihood of a household being food secure (Table 4.1). About 80% of the respondents had 4 to 7 dependants. The average household size was 6.8. More than half (65%) of the households experienced some degree of food insecurity, with 12%; 9% and 44% reporting household, individual and child food insecurity, respectively (Table 4.2). The comparison of food secure and insecure households indicated that the latter had lower household income and income per capita (and more living below poverty line income), larger household size and higher number of children and school-going children. Further, the food secure and insecure households differed significantly on most household characteristics. About 22.6% and 59.5% of the food secure households and the food insecure households, respectively, lived below the international poverty line of USD1 per day

with slightly more than half (51.7%) being poor households and 7.8% categorized as hard-core poor households (USD 0.33 per day). About 44.0% of the food insecure households reported decrease in household income from one year to another; half (50.0%) of the food insecure households reported lesser household income in the year that the study was conducted than in the previous year; 67.2% reported fluctuation in monthly income and a further 50.9% intimated that their household income for the month during which the study was conducted was lesser than the previous month's income.

These food secure and food insecure households reported 38.1% and 45.2% yearly (long term) income instability, respectively. However, the monthly (short-term) household income instability between the two categories differed significantly as the households reported 44.0% and 58.3% respectively (Table 4.3). For both types of households, major expenditures were on foods, utilities, child education, loans and transport. The food insecure households spent 97.7% of their total incomes compared to food secure households that spent 83.9% of their total incomes (Table 4.4). Further, the food secure households spent 52% of the total income on food; 7% on utilities; 7.9% on child education; 8.9% on loan repayment and 8.3% on transport costs, while the food insecure households spent 60% of their total incomes on food; 7.9% on utilities; 12.5% on child education; 9.1% on loan repayment and 8.2% on transport. Female and male respondents produced 76% and 24% of food respectively. Men owned 81% of family assets in terms of land and movables. Practices such as leasing and renting out family land (23%); selling livestock to purchase food items during famines (41%) and selling family land to buy food and other household utilities (16%) were decisions made by male respondents. As the age of the household head increased, the likelihood of being food insecure decreased by 0.858. Results on Table 4.1 show that other factors held constant, the odds ratio in favor of food insecurity increases by a

factor of 6.041 as household size increased by one person, indicating that increase in family size resulted in increased household food demand hence decreased access to food.

Total Livestock holding was positively and significantly related to the probability of being food secure (Table 4.1) if other factors were kept constant, the odds ratio in favor of being food secure increased by a factor of 10.101 as a farmer used more units of inputs. Participating in credit use by the respondents according to data on Table 4.4 contributed in increasing the probability of being food secure by a factor of 0.181. From Table 4.1, it was evident that household heads who engaged in such employment were more likely to be food secure since off-farm employment negatively correlated with the probability of being food insecure (-3.827) hence such employment reduced household food poverty. From Table 4.1 the study established that the value of foods from the household's own food production and consumption had a negative relation (-0.004) with the probability of being food insecure at less than 0.01 significance level. A unit change in dependency ration increased the chance of households to be food insecure by a factor of 0.029, keeping other factors constant. Farmers' low level of education resulted in low agricultural production due to them not having technical know-how and expertise in farming.

The second objective yielded the following results: The crop farming practices analyzed here include the use of improved seeds, chemical products (fertilizer, herbicides and pesticide), organic soil improvements and other soil management practices. Farm practices commonly used included bush burning, mulching, weeding and fertilizer-use. A total of 46 percent of the respondents got their seeds from their own stocks of the previous harvest. Cooperatives constituted a source of seeds for 3 percent of the respondents. The market supplied seeds for 86 percent while extension services provided seeds for 4 percent of the respondents, respectively (Table 5.1). Pesticide was the most important chemical product reported to be used by a larger

proportion of the respondents, at 4%, while chemical fertilizer followed with a proportion of 19 percent of the respondents and finally herbicide was used by a proportion of 2% of the respondents. As indicated on table 5.4, 92 % of respondents affirmed the use of landfill practices, followed by composting with a proportion of 71% of the respondents. Mulching and manure was also used by the respondents in the study area at 76 percent and 62 percent most farmers fed the residues to livestock. Mean production was higher for manure users compared to non-users. This shows that when the farmers use manure on their farms then food availability increases at household level (Table 5.6). There is no statistically significant difference in mean production of maize, beans and sorghum between adopters and non-adopters of irrigation (Table 5.9). There was a statistically significant difference in mean production of rice, maize, and beans between adopters and non-adopters of anti-erosion hedges (Table 5.10).

Multiple Regression analyses show a significant positive effect of fertilizer and manure use on the likelihood of being food secure at the 0.05 significance level. The log of the odds of being food insecure decreases by a factor of 0.484 when households use fertilizer compared to those that do not use fertilizer, all factors held constant. Similar situation is observed in the case of manure application where the log of the odds of being food insecure decreases by a factor of 0.788 when households use manure compared to households not using manure, all factors held constant. This means that households that use manure are less likely to be food insecure than households that do not utilize manure, all factors held constant. The results show also that households with a smaller farm size are more likely to be food insecure compared to households with larger farm size (Table 5.12). Figure 5.1 shows that the probability of being food insecure when fertilizer is used drops by 0.09 compared to the reference value while this probability drops by 0.16 when organic manure is used compared to the reference.

The third objective's findings were as follows: 62.3% of households in the semi-arid Nyakach owned cattle, while 43.75% owned goats. Further 55.7% of households owned sheep while 3.0% and 5.7% kept pigs and donkeys respectively. Further, 68.2% of the households owned poultry. The total livestock population of the study area was 78,559 heads. 5.7 % of the households owned cross breeds of dairy cattle while 64.3 % of the households owned the indigenous breeds of all types of livestock. About 4.3% of the households sought veterinary services. The remaining 95.7% of household heads cited high fees than usual when they contacted the veterinary officers. A further 8.3% of the households got livestock medication from the black market because the cost of such medication was affordable. The remaining 87.4 % relied on local herbs for livestock treatment. 29% of households sold part of the milk yield to supplement income from crop production and off-farm sources of food and income. Sales of Livestock helped to alleviate seasonal food variability (Tables 6.4 and Table 6.5). The milk produced from goats and live animals sale related negatively with food access (-0.327 and -0.377, respectively) and positively with food availability (0.353 and 0.266, respectively) (Table 6.7).

Livestock production contributed positively to food security. The livestock sub-sector contributed 32% of revenue in semi-arid Nyakach. Almost 97% of the respondents who used organic manure reported more than 52% increase while the remaining 3% reported between 10%-51% increase in crop yield per unit area of land. The number of months of adequate food supply increased for households that owned livestock (Table 6.4). The frequency of meat, milk and eggs consumption in households that owned livestock was considerably higher than in households that did not own livestock (Table 6.5).

7.3 Conclusions

There is no problem of underdevelopment that can be more serious than food insecurity that has an important implication for long term economic growth of low income countries. Kenya has been plagued with food insecurity for decades. The problem is worsening especially in the semi-arid environments, despite massive resources invested each year into humanitarian aid and food security programs. Food insecurity in the long run may cause irreparable damage to livelihoods of the poor, thereby reducing self-sufficiency.

The general objective of the study was to determine the influence of agricultural practices on food security, through specifically investigating the influence of demographic and socio-economic characteristics of households, crop farming practices and livestock farming on household food security in semi-arid agro-ecological zones of Nyakach Sub-County. Household food security was measured from food availability, accessibility, stability and utilization at household and individual member of the family's levels. The study found out that food accessibility, stability and utilization take their roots in food availability as the major variable of food security. However, food availability is not assured if appropriate farming practices are not upheld in order to increase food production and supply. Moreover, given the high population pressure, increasing agricultural productivity of the available land is needed in order to provide food for every household.

Socio-demographic and economic household characteristics that are significant determinants of food security in semi-arid agro-ecological zones of Nyakach Sub-County are age of the household head, gender of the household head, family size, household total livestock unit, input use, accessibility to credit facilities, off-farm employment, household consumption of own-produced food, dependency ratio and level of education of the household head.

Crop farming practices investigated by the study are found to be significant determinants of household food security in semi-arid agro-ecological zones of Nyakach Sub-County, both individually and collectively. These practices are: choice of seeds and crop varieties; soil organic matter improvement practices such as use of inorganic fertilizer, organic fertilizer, mulching and composting; water conservation practices such as irrigation; agro-forestry practices and soil conservation practices.

Further, livestock farming is a significant determinant of household food security in semi-arid agro-ecological zones of Nyakach Sub-County. This is confirmed by the findings that live animals and livestock products are a source of food and income. Further, Livestock type, ownership, housing and veterinary services influenced household food availability, accessibility and utilization.

Social, demographic and economic household characteristics and agricultural practices identified and discussed in this study present challenges and opportunities for agricultural production hence household food security. The current study educates the smallholder farmers on the importance of upholding appropriate farming practices for improved food security. Further, understanding the causes and level of household food security in semi-arid environments would help policy makers to design and implement more effective policies and programs for the smallholders and thereby help to pave way to improve their food security. In this respect, this study provides a base and point of departure for similar studies in the future.

7.4 Recommendations

Based on the findings and conclusion drawn above, the study makes the following recommendations. Firstly, it was established that most socio-demographic and economic

characteristics of households had significant positive influence on food security, yet this has not been given priority by food producers and providers in Kenya. The study recommends that capacity building should be encouraged among the farmers through Farmer Field Schools (FFS) programs. These could enhance the farmers' ability in decision-making to assist in selecting enterprises that best suit their optimal production potential. It is important to develop and disseminate the knowledge base on sustainable agricultural practices through participatory research, grass-root organizations and farmer field schools that support and build upon the strength of farmers' knowledge and experience. Timely delivery of inputs and long term credit service facilitation is mandatory to improve technology use by smallholders and then improve productivity to enhance their food security level. Improving productivity through input delivery would enhance the value of own consumption at household level. Further, households in the study area have very limited alternative sources of income. Hence, for these households to enhance their food security, they must have diversified access to off-farm income alternatives such as petty trade and wage access through establishing industries.

The fact that family size and dependency ratio influenced household food security was alluded to by the findings of the study. The study hence recommends that attention has to be given to limit the increasing population in the study area. This can be achieved by creating sufficient awareness on the positive relationship between small household size and food security. Level of education of the household head is also a socio-economic characteristic that significantly influences food security. The study recommends that the government of Kenya develops education curricula that will reflect local situations and productive sectors, particularly agriculture, being the backbone of food security in the country. All levels of education from primary to university should have such curricula. At the same time, the value of education attained from outside of Kenya needs to be

re-addressed. Kenya should develop ways of retaining local and attracting non-local scientists, especially from other developing countries. By the same pay, scientists must themselves be made aware of our country's and local region's needs. Training and all the means to enhance the productivity of land should be specifically aimed at the primary producers, especially the resource-poor farmers and women among them. As much as possible, training should be carried out in situ with the producers themselves.

The study established also that women play a crucial role in attainment of household food security. The study recommends, therefore, that Land reforms should recognize women's crucial role in food production and provision. Women should be given direct rights in land, especially where they are heads of households. They should be given as many educational opportunities as men. There should be more female extension workers to ensure that female farmers will have access to extension work; and women should participate in field visits. Women should have access to credit in their own right and there should be non-discriminatory access to inputs. Women's organizations should be promoted in decision-making regarding agricultural programs. Targeting direct distribution of free food and food- for -work to needy families during the harshest time of food shortage is an inevitable task. However, the food insecure households should be discouraged from overdependence on food aid.

Secondly, the study noted that household food security is significantly dependent on crop farming, though amount of produce from annual crops preferred by small-scale farmers in the semi-arid Nyakach is decreasing. This has no doubt led to decreased food security. The study recommends that Government of Kenya, through its relevant agencies, improves yields and the share of nutrient-rich roots and tubers in the diet of its growing population. Roots and tubers contribute only about l3% of the calories in the average Kenya's diet, which is a smaller portion

than other staples. Root and tuber crops such as groundnut, arrow root, sweet potato and cassava are "insurance crops" that yield highly under semi-arid conditions hence should be adopted by the farmers so as to increase household food security.

Thirdly, the study also established that household food security is significantly dependent on livestock type, ownership and amount of livestock products production, though the sub-sector was poorly developed in semi-arid Nyakach. The study therefore recommends that provision of extension and veterinary services should be strengthened, through the collaborative arrangements involving the government, private sector and beneficiary communities. Further, the identified Pastoral Thematic Groups should be supported in accordance to the priorities specified by the Economic Recovery Strategy for Wealth and Employment Creation (2003-2007) aimed at re-invigorating the livestock sector in Kenya. In this aspect, livestock development packages must be introduced and promoted by all stakeholders.

Lastly, the study recommends that the idea of "food sovereignty" should be adopted by the government of Kenya, and therefore the resource-poor farmers in the country. Food sovereignty is the right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems. It puts those who produce, distribute and consume food at the heart of food systems and policies rather than the demands of markets and corporations. It defends the interests and inclusion of the next generation. It offers a strategy to resist and dismantle the current corporate trade and food regime, and directions for food, farming, pastoral and fisheries systems determined by local producers. The essential characteristics of the food sovereignty concept are that: villages, counties, countries have control of their food production and supply; food availability in

sufficient quantities and quality; food that is culturally appropriate; production systems that are environmentally sustainable.

7.5 Suggestions for further Research

The main finding of this research is that demographic and socio-economic characteristics of households determine household food security. In addition, there are various crop and livestock farming practices that influence household food security status either positively or negatively, a fact that the farmers are not aware of and the government does very little to address. In the light of the findings of this research there are suggestions for further research to complement this study.

1. A cultural-context research would be conducted to help understand the various risk factors and coping strategies in relation to household income and food sufficiency, for instance urban and rural household differences; inter-ethnic differences; female-headed versus male-headed households and household food insecurity. Knowledge on such information would facilitate efforts to address household food security effectively and efficiently based on varied socio-demographic and economic household characteristics.
2. The crops explored by this study were staples. It would be interesting to establish the relationship between cash crops and household food security.
3. The current study examined the influence of livestock farming practices on household food security in semi-arid environments. A similar study would be conducted to assess the relationship between livestock farming and individual food security in arid areas.

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APPENDICES

APPENDIX I
QUESTIONNAIRE FOR HOUSEHOLD HEAD

Your name (Optional)……

A: HOUSEHOLD DEMOGRAPHIC AND SOCIO-ECONOMIC CHARACTERISTICS

Your Gender: Male / Female (Tick where applicable)

Your Age: .....

What is your marital status? (Tick where applicable)

(1) Single (2) Married (3)Widowed, separated, divorced

Level of formal education: (Tick where applicable)

(1)None (2)Primary (3)Secondary (4)Tertiary

Size of Household: (Tick where applicable)

(1) 1 (2) 2- 4 (3) 5- 7 (4) 8 and above

The number of school-going children(tick where applicable)

(1) 1 (2) 2-4 (3) 5-7

What is your employment status (Tick where applicable)

(1) Unemployed (2) Self-employed (3) Employed

What is your monthly income (Ksh.)? (Tick where applicable)

(1) <1,425 (2) 1,425 ~2,755 (3) >2,755

What percentage of this income do you spend on the following;

(1) Food (2) utilities (3) children education (4) Loan (5) others

How many acres of land do you own? .....

What proportion do you use for the following activities for?

(a) Crop farming …… (b) Animal farming ……(c) Other uses? .....

1. Do you use any agricultural inputs? YES/NO
2. If YES, which ones? .....
3. If NO, why? .....
4. List the crop and animal farming practices that you engage in

a) ……...

b) ……...

c) ……...

d) ……...

5. What is the source of your labor? (a)Family (b) Hired (c)Both family and hired

6. Is this labor sufficient? YES/ NO (Tick where applicable)

If NO, Why are you not hiring more labor?

……..

7. How do you cope during food shortage?

(a) ……
…….

(b) ……
…….

(c) ……
…….

(d) ……
…….

(e) ……
…….

B: CROP FARMING PRACTICES

8. Of the total land under crop production, what proportion do you put under;

(a) Food crops ……..

(b) Cash crops ……..

9. Which food crops do you grow? How much is the harvest (in bags) for each crop?

a) ……

b) ……

c) ……

d) ……

10. Which cash crops do you grow? How much is the harvest (in bags) for each crop?

a) …….

b) …….

C) …….

d) ……..

11. Does the yield harvested last you to the next harvest? YES/ NO
12. If NO, how many months does it last? .....,,..
13. If NO, where do you get food after your produce is finished?

(a) …….

(b)……..

(c) …….

(d) ……..

14. What measures have you taken in order to cushion yourself from food shortage?

……
……
……
……
……
……

15. If YES, do you produce any surplus for sale? YES/ NO (Tick where applicable)
16. What do you use the money accrued from the sales for?

.....
.....

C. LIVESTOCK FARMING PRACTICES

17. Which animals do you keep?

a) ……

b) ……

c) ……

d) ……

18. Do you experience animal deaths and underproduction? YES/NO (Tick where applicable)
19. If YES, due to?

a) ……..

b)……

c)……

d)……

e) ……..

f) ……..

20. IF NO,

Why?.....
.....
.....

21. Do you produce only for subsistence? YES/NO

22. If NO, how do you get food after the harvest is finished?

……
……
.....
.....

23. Do you produce livestock for commercial purposes? YES/NO

24. If YES, what do you spend the cash from animal sales on?

……

25. Are you aware of any policies addressing sustainable agricultural land-use practices? YES/NO

26. If YES,

a) How did you come to know about it?

(a)Extension officer (b)NGO (C)Media campaigns

b) What does the policy stipulate?

……

27. Have you adopted that (those) policy (ies)? YES/ NO

28. If NO, Why?

.....
.....

If YES,

i) How would you rate your practice of it?

(a) Poor (b) Fair (c) Good (d) Excellent

ii) How has this impacted on your food security status?

(a) Poorly (b) Fairly (c) Good (d) Excellent

29. Apart from farming, what are your other sources of income?

(a) …….
(b) …….
(c) ……

30. Would you rate yourself and your household as food-secure? YES/NO

31. If YES, what recommendations, in regard to agricultural practices and agricultural policies would you give as appropriate interventions to solving the problem of food insecurity in this area?

……
……
……

31. If NO, give reasons why you think so.

a) ……

b) ……

c)……

d)…….

Thank you so much for your participation.

APPENDIX IIA

INTERVIEW SCHEDULE FOR KEY INFORMANTS

1. What is the population growth rate of Nyakach Sub-County? ……..

2. In which months of the year does the area normally experience flooding? drought?

……..

b) How does this relate to the seasons of cultivation, cropping, weeding, harvesting?

……
……

3. What is the frequency of flooding and drought?
…….

4. What are the effects of flooding and drought on the area's food security status?

a) ……

b) ……

c) ……

d) ……

5. What are the measures taken by stakeholders like the local farmers, NGOs, the government in enhancing food security?

a) Farmers

b) CBOs

c) NGOs

d) Government

e) Others

7. (a) What are the various agricultural land use practices in the area?
……
……
……

(b) To what extent do they influence food security?

……
……
……

8. (a)Which are the crops grown and animals kept in this area

Crops:……
……
……

Livestock:……
……
……

b) What are the off-farm and non-farm economic activities carried out here?
……
……

9. Do farmers use inputs? YES/ NO

a) If YES, what percentage uses inputs …….

And what is the impact of this on food availability and access to food?

b) If No, why?
……
……
……
…….

10. What percentage of land is under

a) Private ownership? .....

b) Communal ownership .....

c) Trust land .....,.....

11. What is the approximate food crop, cash crop and livestock production on,

a) Private land .....,.....

b) Communal land .....

12. What are the soil fertility improvement practices in the area?

a)……

b)……

c)……

d)……

13. What acreage is under:-

a) Annual food crops? .....

b) Perennial food crops?.....

c) Annual cash crops? .....

d) Perennial cash crops? .....

e) Open grazing? .....

14. What is the average acreage per farmer? .....

15. What is the average production per acre?
……

16. How do the local farmers respond to reverse low agricultural production?

a)……

b)……

C)……

d) ……

17. What are the coping strategies by the farmers (cushioning measures) in case of food crisis?

a) ……...

b)……

c) ……...

d) ……..

18. What are the likely short term, mid-term and long term agricultural practices to alleviate food insecurity in the area?

a) Short-term
……
……
……
……..

b) Medium-term
……
……
……
……..

c) Long-term
……
……
……..

APPENDIX IIB

Interview schedule for the Non-Governmental Organization Official

1. Name of the organization:

2. Which year did you start your activities in Nyakach? .....

3. What was the food-poverty level at the time you started your activities?

……..

4. Which agricultural land-use practices are you engaged in?

a)……

b)……

c) ……

d) ……

5. Which sub-locations do you operate in? .....

6. How many farm households have adopted your practices?

……

7. What is the seasonal trend in yields per unit area?

……

8. Has household food security status improved for the time that you have been here?

YES/ NO

9. If YES, Explain how.

……
……
……

Thank you so much for your participation

APPENDIX III

GUIDE QUESTIONS FOR FOCUS GROUP DISCUSSION

1. What are the common agricultural practices in this area?

(a) .....(b) .....

(c) ……..(d) ……..

2. What is the average family size of the locals? .....

3. Do the households produce enough food to last them to the next season? YES/ NO

4. If NO, why?

……
……

5. Are there non-traditional systems that the farmers would adopt to ensure availability of more food? YES/ NO

6. If YES, which ones?
……
……

7. Do you engage in any measures to improve availability and accessibility to food? YES/ NO.

8. If YES, what activities?
……
…….....

9. Is any CBO, NGO or the Government helping you to increase production and productivity of your farm? YES/NO.

10. If YES, which organization(s) help you? ……

How?
……
……

11. Do you categorize yourself as food-poor?

(1) Strongly agree (2) Agree (3) moderately agree (4) Disagree

12. Which interventions do you suggest as appropriate to solving the problem of food insecurity in this area?

(a) ..... (b) .....

(c) ..... (d) .....

APPENDIX IV

THE HOUSEHOLD FOOD INSECURITY ACCESS SCALE (HFIAS)

QUESTIONS ON HOUSEHOLD FOOD SECURITY STATUS

(Tick where applicable)

1. Did you worry that your household would not have enough food?

(0)Never (1)Rarely (2)Sometimes (3)Often

2. Were you or any household member not able to eat the kinds of food you preferred because of a lack of resources?

(0)Never (1)Rarely (2)Sometimes (3)Often

3. Did you ar any member eat just a few kinds of food day after day?

(0)Never (1)Rarely (2)Sometimes (3)Often

4. Did you or any household member eat food that you would have preferred not to eat because of a lack of resources to obtain other types of food?

(0)Never (1)Rarely (2)Sometimes (3)Often

5. Did you or any household member eat a smaller meal than felt you needed because there was not enough food?

(0)Never (1)Rarely (2)Sometimes (3)Often

6. Did you or any household member eat fewer meals in a day because there was not enough food?

(0)Never (1)Rarely (2)Sometimes (3)Often

7. Was there ever no food at all in your household and there were no resources to get more?

(0)Never (1)Rarely (2)Sometimes (3)Often

8. Did you or any household member go to sleep hungry because there was not enough food?

(0)Never (1)Rarely (2)Sometimes (3)Often

9. Did you or any household member go a whole day without eating anything because there was not enough food?

(0)Never (1)Rarely (2)Sometimes (3)Often

APPENDIX V

RADIMER/CORNELL HUNGER AND FOOD INSECURITY QUESTIONNAIRE

1) I worried whether my food would run out before I got money to buy more. YES/NO
2) The food that I bought just didn't last and I didn't have money to get more. YES/NO
3) I couldn't afford to eat balanced meals. YES/NO
4) I relied on only a few kinds of low-cost food to feed the children because I was running out of money to buy food. YES/NO
5) I couldn't feed my children a balanced meal because I couldn't afford that. YES/NO
6) My children were not eating enough because I just couldn't afford enough food. YES/NO
7) In the last 12 months, since last (name of current month), did you ever cut the size of your meals or skip meals because there wasn't enough money for food? YES/NO
8) How often did this happen - almost every month, some months, but not every month, or in only 1 or 2 months? YES/NO
9) In the last 12 months, did you ever eat less than you felt you should because there wasn't enough money to buy food? YES/NO
10) In the last 12 months, were you very hungry but didn't eat because you couldn't afford enough food? YES/NO
11) In the last 12 months, did you lose weight because you didn't have enough money for food? YES/NO
    (If affirmative response to any one of the questions above, continue, otherwise skip to end).

12) In the last 12 months did you ever not eat for a whole day because there wasn't enough money for food? YES/NO (*If affirmative response to question 12)*
13) How often did this happen?

    (a) almost every month (b)some months but not every month or (c)in only 1 or 2 months?(*If there are children under 18 years old in the household, ask the next questions, otherwise skip to end.*)

14) The next questions are about children living in the household who are under 18 years old. In the last 12 months, since (current month) of last year, did you ever cut the size of your child's meals because there wasn't enough money for food? YES/NO

15) In the last 12 months did (child's name) ever skip meals because there wasn't enough money for food? YES/NO(*If affirmative response to questions 14 and 15)*
16) How often did this happen – (a) almost every month, (b) some months but not every month, or (c) in only 1 or 2 months?
17) In the last 12 months, was your child ever hungry but you just couldn't afford more food? YES/NO
18) In the last 12 months, did your child ever not eat for a whole day because there wasn't enough money for food? YES/NO

Thank you so much for your participation.