INFLUENCE OF AGRICULTURAL SYSTEMS ON HOUSEHOLD FOOD SECURITY IN RARIEDA SUB COUNTY, SIAYA COUNTY, KENYA

BY

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DECLARATION

Declaration by student

I declare that this Thesis is my original work and has not been presented for award of any degree in any other university.

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DEDICATION

I dedicate this project to my adoring husband Mr. Abade, my late mother Rose, my two beautiful daughters Michelle and Meghan, my colleagues especially Christine who have inspired me tirelessly throughout the spiraling journey.

ABSTRACT

The number of people lacking food security globally has continued to rise, despite the numerous global interventions that have been put in place to address it. For instance, approximately 2.3 billion people (25.9%) lack food security, with approximated 828 million being undernourished. In Kenya approximately, 17 million people are food insecure with two million relying on food relief. Therefore, there was need to build local resilience of food systems and intensify local agricultural production to ensure food security. This can be achieved through sustainable agricultural systems like home gardening, mixed cropping and single food crop farming. However, many researches on food systems have focused on rainfall variation and climate change. There is less documentation on the influence of Agricultural Systems on Household Food Security. Despite the measures taken by the County government of Siaya to ensure food security, 80% of households are not food secure as indicated by the Government report. In Rarieda Sub-County 68% of households lack food security as revealed by the 2019 Demographic Survey. Food situation in Rarieda was of great concern. Therefore, the purpose of this study was to examine the influence of agricultural systems on household food security in Rarieda Sub-County.The specific objectives were; to examine the influence of home gardening on household food security in Rarieda Sub County, Siaya County; to determine the influence of mixed cropping on household food security in Rarieda Sub-County, Siaya County and to examine the influence of single food crop farming on household food security in Rarieda Sub-County, Siaya County. The study was anchored on Food Availability Decline Theory and Endowment and Entitlement Theory. The study employed cross-sectional research design with a target population of 25,428 households and a minimum sample size of 384 derived using fisher's formula. The household heads' selection was done through stratified random sampling for questionnaire administration. Purposive sampling was used to get the 6 key informants. Primary data were collected through key informant interview, photography, questionnaires and direct observation, while secondary data were obtained from journals, internet sources and government published reports. Qualitative data was examined through content analysis and quantitative data was analyzed using frequencies, percentages, mean and standard deviation. Chi-square test was conducted to determine the association between agricultural systems and household food security. Results were presented in tables, plates and text. The results indicated that 67.65%, 33%, 59.15%, and 55.55% of the respondents significantly agreed, that horticulture crops, tubers, domestic animals and fish farming were home gardening practices contributing towards household food security (χ^2 - 0.026). Mixed cropping of maize and beans, and perennial crops and seasonal crops were significantly associated with household food security in Rarieda Sub-County, at a 99% significance level (χ^2 - 0.001). Single food crop farming was not a major contributor to household food security in Rarieda sub-County. The χ^2 – value of 0.103 points to the fact that the practice was weakly associated with household food security at 90% significance level. The study concluded that mixed cropping and home gardening systems were strongly associated with household food security while single food crop farming system was weakly associated with household food security. The study recommended that the three agricultural systems should be emphasized to enhance food security.

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LIST OF ABBREVIATIONS AND ACRONYMNS

ASDS	**:**	Agricultural Sector Development Strategy
CIDP	**:**	County Integrated Development Plan
DDS	**:**	Dietary Diversity Score
FAO	**:**	Food and Agriculture Organization
FAD	**:**	Food Availability Decline Theory
FEET	**:**	Food Endowment and Entitlement Theory
GDP	**:**	Gross Domestic Product
GOK	**:**	Government of Kenya
IFAD	**:**	International Fund for Agricultural Development
KNBS	**:**	Kenya National Bureau of Statistics
KPHC	**:**	Kenya Population and Housing Census
MOA	**:**	Ministry of Agriculture
SD	**:**	Standard Deviation
SDG	**:**	Sustainable Development Goal
UN	**:**	United Nations
UNICEF	**:**	United Nations Children Fund
USAID	**:**	United States Agency for International Development
USDA	**:**	United States Department of Agriculture
WFP	**:**	World Food Program
WFS	**:**	World Food Summit
WHO	**:**	World Health Organization

DEFINITION OF KEY OPERATIONAL TERMS

Agricultural System: Is a collection of components that has as its overall purpose as the production of crops, vegetables, fruits, fish and livestock products. In the current study, the Agricultural systems are home gardening, mixed crop farming and Single food crop farming.

Food Accessibility: It is when individuals have adequate income or other resources to purchase or to barter so as to obtain levels of appropriate food needed to maintain consumptions of an adequate diet.

Food Availability: It is when there are sufficient quantities of appropriate necessary types of food from domestic production, commercial imports or donors that are consistently available to the individuals, are within reasonable proximity to them, or are within their reach.

Food Security: This is when all people at all times have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs for active and healthy life.

Food Stability: It is the ability of a population or a household to obtain adequate supply and access to food at all time.

Food Systems: Are networks needed to produce and transform food and ensure it reaches consumers.

Food Utilization: It is the ability of individuals to make good use of the food they access. This can be achieved through diet, clean water, sanitation and health care.

Home Gardening: Home gardening is been defined as portions of cultivated land within the homesteads planted with trees, crops, livestock in reference to household preferences with an aim of providing supplemental food and income.

Mixed Cropping: It is the growing of two or more crops simultaneously without distinct row arrangement. Mixed cropping has been used interchangeably with intercropping and crop diversification in this thesis.

Single Food Crop Farming System: It is the growing of one type of food crop on a piece of land. Single food crop farming system has been used interchangeably with sole or monoculture.

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CHAPTER ONE
INTRODUCTION

1.1 Introduction

This chapter covers the background of the study, statement of the problem, research objectives, research questions, significance, scope and delimitation, theoretical and conceptual framework.

1.2 Background of the Study

The World Food Summit of 1996 defined food security as a situation whereby at all times all people have adequate economic and physical access to enough, nutritious and safe food to meet their needs for a healthy and active life (FAO et al., 2022). Despite the right of every man, woman and child to be free from the effects of food insecurity, these effects still linger in the global society (Herforth et al., 2020 & Vos et al., 2022). Latest Global Report on Food Crisis (GRFC, 2033) revealed that about 2.3 billion people (25.9%) of the world population were food insecure and required urgent food assistance. The proportion of the world's population facing chronic hunger in 2022 was about 9.2% compared with 7.9% in 2019 (Elver, 2023). Some of the major global causes of food insecurity have been said to be: disasters, conflicts, high population growth rate, neglect of agriculture and socio-economic inequalities (Gonzalez, 2014). Despite the global efforts employed in terms of research policy and capital investments to achieve food security, it has remained a dream yet to be fulfilled.

The proportion of the population lacking food security in Africa is much larger compared with other regions as 20% of population were food insecure in 2022 compared with 8.5% in Asia, 6.5% in Latin America and Caribbean, and 7.0% in Oceania (FAO et al., 2023). It is estimated that about 44.4% of the undernourished people in Africa live in Eastern Africa, 26.7% in Western Africa and 6.2% in Northern Africa (Drammer et al., 2019). In Ethiopia, food insecurity is a critical challenge being that it is the most populous country in Africa after Nigeria with about 123 million people in 2022(World Bank, 2023). A study by Sisha (2020) revealed that Ethiopia has a long history of famine and food shortages, mostly due to climate shocks exacerbated by socio-economic and political factors. About 3.7 million people in Ethiopia were aided by World Food Program emergency relief assistance due to reduction in the amount of rainfall in 2019 (Sisha, 2020). Food insecurity and hunger are on the rise in Nigeria (GRFC, 2023). According to United Children Fund (UNICEF, 2023) 25 million Nigerians were food

insecure. This revealed an increase of about 8 million from the 2022 estimates (UNICEF, 2023). Nigeria was ranked 107th out of 113 countries and 25th out of 28 Sub -Saharan Africa (SSA) countries with a Global Food Security Score of 42/100 (Otekunrin et al., 2013). Comprehensive African Agriculture Development Programme (CAADP) under Maputo declaration proposed an increment in the various countries' budgetary allocation for agriculture by 10%. However, only 7 countries in Africa managed to achieve Maputo Declaration by allocating 10% of the revenue to agriculture. Therefore, Africa has remained a home of 282 million people who are food insecure (UNICEF, 2023). Hence, the need for this particular research.

Multiple strategies are required to address the issue of food insecurity. According to Drammer et al. (2019) the choice of feasible approaches hinges on the existing social, political and resources available to design and implement the intervention. Agricultural systems such as home gardening system are widely adopted and practiced by local communities with limited resources to achieve food security (Galhena et al., 2013). It is evident from the reviewed literature that home gardens are a part of the agriculture and food production systems in many developing countries and are widely used as a remedy to alleviate hunger and malnutrition in the face of global food crisis (Wright, 2014). Studies by Galhena (2013) & Boone & Taylor (2016) concluded that home gardening systems had the ability to enhance food security by providing food for household consumption, reducing food expenditure, and diversified food consumption. A study by Akrofi (2012) in Ghana focused on home gardening systems and its contribution to household food security amongst HIV/AIDS households. The results showed that home gardening systems provided households with improved nutrition through the provision of nutritious food making such households food secure. A study by Baiyegunhi & Makwangudze (2013) in South Africa revealed that home gardening provided significant contribution to Dietary Diversity Score to HIV-positive households. For instance, the integration of livestock in home gardening systems reinforced food and nutritional security for the families as eggs, milk and meat from home raised animals provided the main sources of protein. The above studies acknowledged that home gardening systems could aid households to achieve food security. However, some of these studies focused on households living with HIV/AIDS which encounters challenges of poor economic conditions and labor shortage. However, current study focused on all households irrespective of their HIV/AIDS status.

Goshu et al. (2012) carried out a study in Ethiopia and found out that agricultural system like mixed cropping was a positive determinant of household food security. According to Baba & Abdulai (2021) crop production in Africa is majorly based on mixed cropping. A study by Makate (2016) in Zimbabwe found out that mixed cropping had direct effect on food availability since it improved the yields, led to crop cushion effect and crop yield stability. According to Okunlola & Ofuya (2013) grain growing in mixed cropping system enabled households to obtain high yields. This study concluded that mixed cropping system could help to achieve food security because it has the potential to reduce total crop failure chances since failure in one crop does not mean other crops cannot be produced. However, the above studies acknowledged that mixed cropping could achieve food security by focusing only on availability dimensions of food security. The current study focused on all the four dimensions of food security to adequately address food security.

In Kenya, 17 million people lack food security with about 2 million people living on food relief (KNBS, 2018; FAO et al., 2019). Several strategies have been adopted to enhance food security. For instance, when President Uhuru Kenyatta administration came into power, the big four agenda was coined with the aim of wheeling the country towards realizing vision 2030. To achieve this, food security was given precedence (Parliamentary Budget Office, 2018). From the planned and outlined strategies, it was clear that food security could be achieved through collaboration between National government and County governments in eliminating levies for agricultural products across the counties, provision of farm inputs, establishing credit system, expansion of extension services and provision of certified seeds at a subsidized rate (Parliamentary Budget Office, 2018). The timeline for realizing this agenda was in the year 2022. However, the farmers still could not get the farm inputs in time and at the affordable prices. According to Anami (2020) only 1% of The Big 4 Agenda was achieved, however the report was only for Housing, there were no specific records on food security status. Therefore, there was need to carry on with this research to reverse food insecurity situation in the country.

Agricultural systems have the potential to achieve household food security. For instance, Musotsi et al. (2008) conducted a study in Butere on the influence of home gardening system on household food security. The findings of this study revealed that the most important agricultural system remains home gardening. The daily nutritional demands and household needs can be

accessed in the established home gardens. This system importance to household food security and livelihood cannot be underscored. However, the above study focused on crops and livestock aspect of home gardening. It did not focus on fruit trees and fish farming which are also part of home gardening systems. Therefore, a study focusing on horticultural crops, fruit trees, livestock and fish farming aspects of home gardening is likely to yield different results. Therefore, there was need to carry out the current research.

Siaya County records a high poverty level of approximately 47.6% compared to 43.37% at the national levels (MoALF, 2016a). Food insecurity is high and is characterized by scarcity of food, limited meals across majority of the households and limited variety in diets (MoALF, 2016 b). Previous government report further indicated that 80.7% of households in the County lack food security (GOK, 2014). This was attributed to low use of inputs, unreliable and poorly distributed rains, poor crop husbandry, negative attitude by the population towards agriculture and low education level of most farmers that also affected their decision-making (MoALF, 2016a). A report by Siaya County Integrated Development Plan (2022) noted that the County's food production could only last six months every year. However, with unstable food output, the deficit can be as high as 8 months during poor harvest seasons. Other counties in region registered lower Food Insecurity Index. For instance, a study done by Opiyo et al. (2018) revealed that 71% of households in Kisumu County were food insecure. In Homabay County, 50% of the population was food insecure (Kandagor &Nyandoro (2018). In Migori County, a study by Anino et al. (2024) revealed that 34% of the respondents were food insecure. From the reviewed literature it is evident that Siaya County has a higher Food Insecurity Index of 81% compared to Kisumu which was at 71%, Homabay 50% and Migori 34%. Therefore, the current study was timely since large population of the county was food insecure.

In Rarieda Sub-County, 68% of households lack food security (KNBS, 2019). This is higher than other Sub-Counties in the County for instance; Gem Sub-County which had 37% of households lacking food security, Ugunja had 46.6% and Bondo which was at 56% (Otieno, 2014; Obonyo, Otieno & Angawa, 2016 & Oloo, 2021). Therefore, Rarieda Sub-County is contributing much to Siaya County food insecurity compared to other Sub-Counties. Previous studies on food security in the Sub-County focused on other variables such as socio-cultural determinants and poverty (Musyoka, 2021&Otieno, 2014). Not much has been documented on the influence single food

crop farming systems on household food security in Rarieda Sub-County. Thus, creating a gap for the current study that sought to determine the influence of Single food crop farming systems on household food security in Rarieda Sub-County. These agricultural systems such as home gardening, mixed cropping and single food crop farming are influenced by level education of the farmer, income and weather.

1.3 Statement of the Problem

Globally 2.3 billion people lack food security despite the various global intervention that have been put in place to achieve food security. In Kenya approximately, 17 million lack food security with two million relying on food relief. Therefore, there is need to build tenacity of local food systems and intensify local food production to ensure food security and good nutrition for all. Agricultural systems like home gardening, mixed cropping and single food crop farming could be viable and sustainable alternatives in this regard. However, most studies on food systems have focused on the effect of rainfall variation on food security. Moreover, most international studies on food security have concentrated at regional and national levels, neglecting households, which is the basic unit of food production.

According to Siaya County Integrated Development Plan of 2022, 80% of households in Siaya-County lack food security. This is a high compared to Kisumu County which had 71% of households lacking food security, Homabay was at 50% while Migori was at 34%. Therefore, it is evident that Siaya County has higher Food Insecurity Index compared to Migori and Kisumu County. In addition, the 2022 report by the Government of Kenya revealed that Siaya County produced food that can only last six months in a year. However, the output was not stable thus food deficit could go up to eight months in poor seasons. Therefore, there was need for the current research in Siaya County. In Rarieda Sub-County, 68% of the households lack food security as revealed by the latest Demographic survey of Kenya 2019.The Sub-County has a higher food insecurity index compared to other Sub-Counties in the County for example, Gem which was at 37%, Bondo 56% and Ugunja 46.6%. Therefore, Rarieda Sub-County contributes much to food insecurity in Siaya County, thus necessitating the current research that sought to assess the influence of agricultural systems on household food security in Rarieda Sub-County.

1.4 Objective of the Study

The main objective of this study was to assess the influence of agricultural systems on household food security in Rarieda Sub-County, Siaya County, Kenya.

The specific objectives of the study were to:

1. Examine the influence of home gardening system on household food security in Rarieda Sub- County, Siaya County.
2. Determine the influence of mixed cropping system on household food security in Rarieda Sub- County, Siaya County.
3. Examine the influence of single food crop farming system on household food security in Rarieda Sub-County, Siaya County.

1.5 Research hypothesis

i. H_0 Home gardening system does not influence household food security.
   H_1 Home gardening systems influence household food security.

ii. H_0 Mixed cropping system does not influence household food security.
   H_1 Mixed cropping system influence household food security

iii. H_0 Single food crop farming system does not influence household food security
   H_1 Single food crop farming system influence household food security.

1.6 Significance of the Study

The current research on the influence of agricultural systems on household food security focused on Rarieda Sub-County in Siaya-County. This study was to benefit various stakeholders in the agricultural sectors, the County agricultural officers, Sub-County agricultural officers and individual farmers. The results of this study were to create awareness on the influence of agricultural systems on household food security and add to the existing body of knowledge. The study also identified informational gaps on agricultural systems to be adopted to ensure food security. Rural farmers were not only assured of food security, but also empowered with new farming skills hence ensuring sustainability in agriculture and food production. Given that the result of the study is expected to change the attitude of the local farmers and youth towards farming, it would further create employment opportunities as many local members would engage in smallholder farming. To the policy implementers such as the Ministry of Agriculture (MOA), the research findings were significant in solving the persistent food crisis.

1.7 Scope of the Study

This research was done in Rarieda Sub-County because 68% of the households were food insecure (KNBS, 2019). The study area has various economic activities that could be used to enhance food security. However, the study was aligned to agricultural sector because 60% of the households depend on Agriculture for their livelihoods (Siaya County Integrated Development Plan, 2018). The study focused on home gardening, mixed cropping and single food crop farming. This was because the three agricultural systems directly influenced household food security in Rarieda. Even though there are four levels of food security in terms of concept-regional, national, household and individual level-the study was dominated by household levels. This followed the understanding that once improved food security was achieved at household level, then it automatically spread to the regional and national levels. Additionally, this study intends to focus on all the four dimensions of food security to adequately address the issue of food security. This is because each dimension is necessary but alone not sufficient to ensure the achievement of food security (Barret, 2010). Furthermore, the current study adopted Chi-square test to measure the association between agricultural systems and household food security. The current study treated weather, policy issues and income as intervening variables.

1.8 Limitation of the Study

The researcher met non-cooperative respondents during the period of data collection that feared for the confidentiality and use of the information for other purposes. However, this was sorted out by informing them that their identity shall remain anonymous. In addition, the researcher presented the authority letter from the learning institution and the local administration that clearly attested that the information was strictly for academic purpose**.** Some of the study areas were inaccessible due to poor road networks. To solve these, the researcher sought help from village heads who knew the area well. The researcher also created a rapport with the respondents and convinced them that the study was strictly research and the information divulged remained confidential. Lastly, the researcher encountered respondents who could not understand English or Kiswahili. The researcher solved this problem by using the research assistant from the area of study who understood Luo, English and Kiswahili languages to help in translation of the questionnaires.

1.9 Theoretical Framework

This study employed Food Availability Decline Theory and Food Endowment and Entitlement theory.

Food Availability Decline Theory (FAD) was proposed by Amartya Sen in his book Poverty and famine, which was published in 1981.Under this theory, food availability is defined as when all people have sufficient quantities of food available on a consistent basis, with the food availability being determined by the amount of food produced (Sen, 1981). This theory assumes that famine is caused by a sudden reduction of per capita food supply which can be triggered by sudden natural disasters such as floods, pest infestation, wars and epidemics. As a result, food prices go up leading to consumption of less calories and nutrients for the affected households. Therefore, anything that disrupts food production can lead to lack of food security. Therefore, in order to examine the main hindrance for agricultural production, which leads to decline in food availability, stability and utilization FAD theory can be used. However, this theory implies that food security is essentially a matter of expanding food availability. As a solution, it focuses majorly on the food availability of food which is dictated by production rather than the capacity of a household to have access to food. The FAD theory as adapted by the current study addresses availability, stability and utilization tenets of food security at the farm households as it applies to all the specific objectives of the study. However, in an effort to adequately tackle all the four dimensions of food security it necessitated the current research to adapt the Food Endowment and Entitlement Theory as well to address the accessibility tenet of household food security.

The second theory is Food Endowment and Entitlement Theory. This theory was proposed by Amartya Sen in his book Food, Economic and Entitlement which was published in 1984. This approach emerged to consider a wider sense of food security other than production, which is the concern of FAD approach. Sen argued that famine can still occur without a decline in the food production. Therefore, in an attempt to offer the solution to the paradox of why in the presence of abundant food, still a significant number of people lack food security, The FEET theory can be used. Sen divided the approach in two categories: Endowment set and Entitlement set. He argued that in order to provide food a farmer needs a set of resources such as, capital to purchase fertilizers and certified seeds, land, and farmer's skills among others (Sen, 1984). The entitlement set refers to the product obtained from using the resources. To transform these

endowments into production requires knowledge, capital, land, skills and experience. Therefore, in order to satisfy one's entitlement to food, endowments should be put into production or one's income in employment to provide means of access to food. This approach focuses on the individual purchasing power, which gives him or her access to food thereby addressing the access tenet of food security which was not addressed by the FAD theory.

Therefore, this study used the two theories to adequately address household food security challenge in Rarieda Sub-County. In this study the two theories are useful in the following ways: Firstly, they are used to identify and understand variables of the study. Secondly, they form a background upon which to formulate objectives.

For instance, the current study borrowed the tenet of single food crop farming from the FEET theory explaining that one needs financial muscles to access appropriate farm inputs, and the necessary knowledge, skills and experience in a certain food crop to successfully grow and harvest the maximum possible amount of yields from the single food crop. Therefore, this relationship between the study variables and the tenets of the FAD and FEET theory forms a strong basis for the choice of the two theories in the current study. Further, Home gardening and Mixed cropping agricultural systems are variables that fit well under FAD theory because the two systems ensure consistent food production from the family farms, the households harvest food every season, and therefore they are almost assured of food availability most of the times. FAD Theory as adapted by the current study addresses availability, stability and utilization tenets of food security while FEET theory addressed Accessibility tenet thereby, necessitating the current study to adopt the two theories because the two together effectively address household food security.

Conceptual Framework

The conceptual framework of the study given in the Figure 1 shows the interaction of various key study variables and their influence on household food security in the study area. Dependent variable for the study was food security that has four dimensions: availability, accessibility, stability and utilization. The independent variable was an agricultural system which was divided into home gardening system, mixed cropping system and single food cropping farming systems. weather, policy issues and income levels were the intervening variables.

Agricultural System Influencing Household Food Security

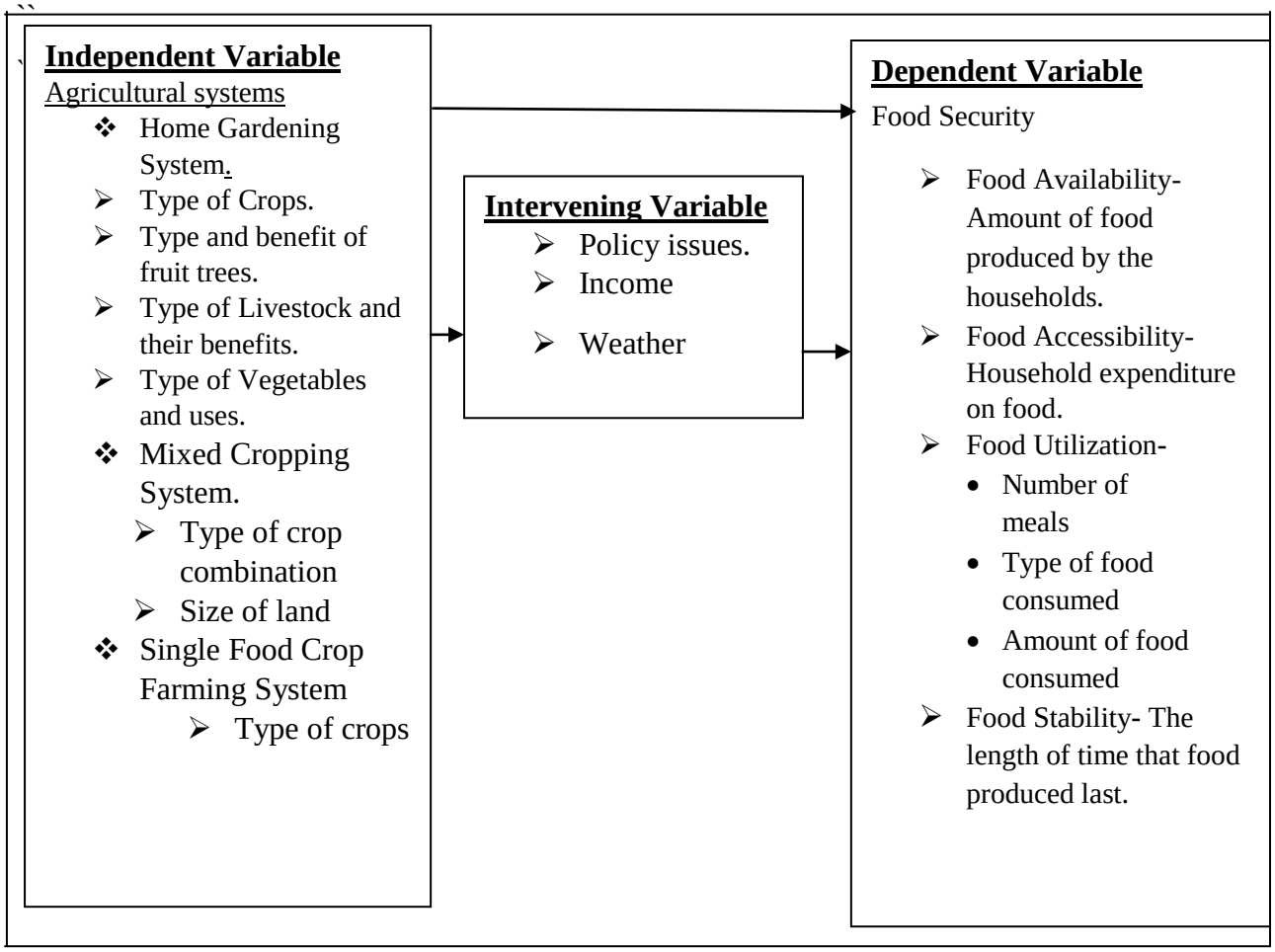

Figure 1: Conceptual Framework on the Influence of Agricultural Systems on Household Food Security.
Source (Researcher, 2021)

The three-study variables were linked as follows: When the household farmer is endowed with resources such as land, income to purchase inputs, knowledge, skills and positive perception to Agriculture. Such household farmer is likely to adopt agricultural systems such as home gardening, mixed cropping and single food cropping and that could translate to food availability, accessibility, utilization and stability as shown in the conceptual framework.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter presents the reviewed literature aligned to the study objectives**.**

2.2 Home Gardening System and Household Food Security

Home gardens are widely applied as an anecdote to eliminate hunger and undernourishment in the wake of worldwide food crisis (Odebode, 2006; Galhena, et al., 2013 & Tumwebaze, 2018). Global studies revealed that home gardens are sources of a variety of fresh farm produce and nutritional supplements that can enhance household food security (Wright, 2014; Saediman et al., 2021). Matson (2017) carried out a study in Sri-Lanka and found out that home gardening enhanced food security throughout the year especially for poor household at a low cost. Taylor and Boone (2016) carried out a study to evaluate the impacts of home gardens on food sovereignty and resistance of farmers to change their food production and consumption patterns to embrace eco-diverse home gardens. The study findings revealed that about 90% of households viewed home gardens as a source of healthy and diversified diets; households were able to save money by not purchasing food supplies from the local vendors thus achieving food accessibility. Despite the diversified diets, the results revealed the necessity to protect the home gardens through fencing to protect them from animal damage. Unreliable rainfall, limited and unconsolidated parcels of land were some of the challenges facing farmers who were practicing home gardening. These studies agreed that home gardening systems enabled households to achieve food security with a number focusing on availability dimensions of food security. However, the current study focused on all the four dimensions of food security to adequately measure food security.

A study by Chakraborty (2018) in India revealed that home gardening improved accessibility of food by increasing access to variety of fresh foods, lowering food expenditure and providing additional income. The income obtained from the sale of surplus produce was used to buy other food items thereby enhancing household food security. Pioneer research in Indonesia conducted at the beginning of 1930s by Ochse and Terra as cited by Galhena et al. (2013) revealed that households obtained 14% of protein and 18% of the caloric intake from home gardens. In Indonesia and Nicaragua home garden system contributed 21.1% and 35% of their total income

respectively (Tynsong & Tiwari, 2010). In South-West Bangladesh and North Eastern Bangladesh, an average of 15.9% and 11.8% of household income is derived from home gardens system respectively (Motiur et al., 2005). Therefore, home garden system played a great role in income generation. The income generated from the sale of home gardening fruits, vegetables and livestock products allowed households to use the proceeds to purchase additional food items as well as saving, education and other services. Therefore, home gardening systems enabled households to achieve accessibility dimensions of food security.

A Study by Galhena et al. (2013) revealed that the most fundamental social benefit of home gardening stems from their direct contributions to household food security by increasing availability, accessibility, and utilization of food products. The above study further revealed that home gardening contributes to nutrition and household food security by providing quick and direct access to different foods that can be harvested, prepared and eaten by family members on daily basis. Nevertheless, the above work by Galhena et al. (2013) revealed that in Sri-lanka households also had medicinal plants under home gardening systems which were used by 80% of the people to treat various ailments. However, the current study did not consider the medicinal plants under home gardening systems.

Africa has more than 278 million people lacking food security (FAO et al., 2021). As a result, most nations in the continent have come up with efforts in terms of research policy and capital investments to achieve food security. However, it has remained a dream yet to be fulfilled as hunger is still on the rise. (Herforth et al., 2020). As a result, additional approaches have been suggested to solve the persistent issue of food insecurity. Home gardening has been documented as a system that plays fundamental part of local food systems, mainly in developing countries through facilitating direct access to a variety of nutritionally rich foods including roots & tubers, leafy vegetables, legumes, fruits and livestock products (Musotsi et al., 2008; Bahta et al., 2018 & Oladele et al., 2020). In the recent challenging situations due to Covid-19 pandemic, home gardening was proposed as a versatile option to address food insecurity (Lal et al., 2020 & Herath, 2021). Covid-19 aggravated food insecurity especially in urban areas due to the disruptions in food supply chain and the emergence of physical and economic barriers that limited access to food (Lal et al. 2020 & Herath, 2021). Therefore, households that practiced

home gardening could access various food stuffs such as vegetables and fruits. They also saved the cost spent on food hence food security.

A study from Niger revealed that fruit trees, crops and livestock produced in home gardening accounted for more 60% of household income (Okigbo, 1990). The money accrued from the sale of home gardening products was used to buy other food items hence food accessibility in the region. Oladele et al (2020) carried out a study in Nigeria using 120 questionnaires. The results of this study revealed that home gardening contributed significantly to household food security and recommended that the system should be integrated into the farming systems. This study further recommended that people should be sensitized to utilize empty plots of land around homesteads for home gardening. A study conducted in Ethiopia revealed that home gardening households obtained average of 195 Euros from sale of home gardening products implying that the system has the ability to achieve food accessibility (Legesse et al. 2016). However, the study by Legesse et al. (2016) included bee keeping and mushroom cultivation under home gardening systems which is not captured by the current study.

The agricultural sector contributes significantly to Kenya food security, employment creations, poverty reduction and income generation (UNEP, 2015). Despite that 17 million people lack food security and about 2 million rely on food relief (FAO et al., 2021; KNBS, 2018). A recent study by Huho & Muriuki (2021) found out that home gardening played a major role in achieving food security among households in Machakos. This study revealed that home gardening produced fresh vegetables and fresh fruits. The farmers sold some of their produce to the nearest markets getting an income which they used to purchase other food items. However, production was low and therefore up scaling was recommended. Further, a study by Boedecker et al. (2019) in Kenya revealed that households who had home gardens enhanced the quality of their diet by consuming vegetables rich in Vitamin A and vitamin C and could access dietary diversity. Chepkirui (2019) study related the quality of women diet directly to the composition of home gardens. She found a positive correlation between garden size and number of crops with nutrient diversity and micronutrient adequacy. Further, this study revealed that home gardens provided a buffer to nutritional deficiencies due to their rich diversity which encourages dietary diversity and nutritional benefits. However, the above study focused on utilization tenet of food security while the current study focused on all the four dimensions of food security.

Hansen et al. (2022) carried out a study in Siaya-County. This study aimed at identifying perceptions and experiences among rural caregivers of children less than five years and local stakeholders working in the fields of agriculture or nutrition with regard to home gardening in Siaya County, the findings of this study revealed that home gardening was beneficial for household nutrition, finances and women empowerment. For instance, home gardening boosted finances through increased home production and thus saving on food purchases. The above study also brought forth the concept of women empowerment through home gardening system which is not the concern of the current study thus necessitating the current research.

2.3 Mixed Cropping Systems and Household Food Security

Previous research findings have revealed that household farmers that practice mixed cropping could achieve food security; because this system enhances soil fertility when intercropped with nitrogen fixers, increases resilience against pest and diseases, increases abiotic tolerance, reduce weed competition, stabilizes yields and all year round and farm income is guaranteed by the practice because it lessens the likelihood of total crop failure because if one crop fail other crops in the field might still produce (Streit et al., 2019 & Hirst, 2020).Globally, studies done in Bangladesh, India and Nepal revealed that mixed cropping increased the farmer's income by 92%,83% and 74% respectively (Raseduzzaman, 2013). Therefore, mixed cropping improved food security status of households as the income was used to purchase other food items. A study done in Cuba revealed that mixed cropping is risk advantageous compared to other systems. For instance, after Hurricane Ike hit Cuba in 2008, one field survey was conducted to estimate the agricultural damage in the provinces of Holguin and Las Tunas, and the findings indicated that losses were only 50% in the field where farmers practiced mixed cropping compare to 90% or 100% in the fields where farmers adopted other systems (Altieri et al., 2012).Likewise, fields that followed mixed cropping showed faster recovery (80-90%within 40 days) (Altieri et al., 2012 & Raseduzzaman, 2013). Therefore, mixed cropping can be an important consideration in the achievement of food stability in the global space.

Cho et al. (2016) studies on assessment of household food security through mixed cropping in Myawar revealed that mixed cropping was positively correlated with household food security. However, this study focused only on annual crops grown by household farmers and not perennial crops. The study by Cho et al. (2016) only focused on utilization tenet of food security and

employed Household Dietary Diversity Score (HDDS) to measure food security. The current study considered both perennial and annual crops, and focused on all the four dimensions of food security to adequately address food security and measured food insecurity using Household Food Security Access Scale (HFIAS)

In Africa crop production is majorly based on mixed cropping of cereals including maize, sorghum and millet with legumes such as beans (Singh & Ajeigbe, 2007). Adedipe *et al*. (2004) conducted a study in the South Western Nigeria and found that 88% of his respondents practiced mixed cropping with a diverse number of crop combinations. Further, this study revealed that farmers in Nigeria earned gross income over 300%, since their mixed cropping was over yielded and reduced expenses behind the fertilizers (Singh & Ajeigbe, 2007). A study by Adjimoti & Kwadzo (2018) in the Collines Region of Benin revealed that that mixed cropping contributed positively and significantly to rural household food security. This study further indicated that farmer-specific and institutional variables like level of education, credit, household size, availability of produce storage facilities and access to extension service also affected household's food security status. In addition, Goshu et al. (2012) carried out a study in Eastern and Central Ethiopia and found out that mixed cropping is a positive determinant of household food security. However, although the above studies agree that mixed cropping systems enabled households to be food secure. They were done in other countries in the continent. Therefore, there was need to carry out the current study in Kenya specifically Rarieda Sub-County that sought to determine the influence of mixed cropping on household food security in Rarieda Sub-County

A study by Baba & Abdulai (2021) on the determinants of mixed cropping and its influence on household food security in northern Ghana revealed significant positive associations between mixed cropping and household food security. However, the above study used Herfindah index to measure mixed cropping which is not employed in the current study. A study by Appiah Twamusi et al (2022) found out that mixed cropping had positive and statistically significant effect on farm household food security status. This finding revealed that mixed cropping had direct impact on food availability and access at the household level. Thus, an increase in the mixed cropping index of a household increases its likelihood of achieving acceptable food consumption and attaining psychometric food security. However, the study by Appiah Twamusi

et al (2022) used the Theory of Diversification which was derived from Utility Maximization Theory while the current study employed FAD and FEET Theory because the FAD theory enabled the current study to tackle utilization, availability and stability dimensions of food security while the FEET theory enabled the current study to tackle accessibility dimension. Therefore, the use of two theories was justified as they enabled the current study to fully address food security.

A study by Fawole & Oladele (2007) argued that mixed cropping improved household food security. Further, this study revealed that households adopted Yam and Maize crop mixture. Mango et al. (2018) in their study among smallholder farming households in central Malawi, found a positively significant relationship between mixed cropping and smallholder farm household food security. The study concluded that mixed cropping is one viable option for establishing resilient agricultural systems that can enhance farm household food security. Obasi et al. (2013) examined the factors affecting agricultural productivity with 99 farmers in Nigeria. The results indicated that mixed cropping systems of combining yam, casava, maize, vegetable and melon were the main crops combinations practiced in the state. Adedipe (2004) conducted a study in Niger and found out that 88% of his respondents practiced mixed cropping with a diverse number of crop combinations. Further, this study revealed that mixed cropping led to 26% rise in total output and 32% rise in profit for cowpea farmers hence food accessibility.

Ayanwuyi et al. (2010) assessed farmer's perception of impact of climate change on food crop production in Ogbomoso Agricultural zone of Oyo State, 360 respondents were used in the study. Approximately, 74.7% of the farmers mentioned planting of different crops as adaptation strategies for the negative impact of climate change. A study by Okunlola & Ofuya (2013) revealed that mixed cropping had better growth and yield parameters. Therefore, mixed cropping system enhanced yields and contributed to household food security. Further, Okunlola & Ofuya (2013) study found out that mixed cropping system-controlled insect pests in addition to enhancing yields. Using 480 respondents, Ajayi (2014) estimated the economics comparative of mixed and sole cassava cropping systems in the six major cassava-producing states. The results indicated that mixed cropping system provided opportunities of all-year-round farm incomes, serving as a better way to achieve food security. Further, he observed that the system lessens the likelihood of total crop failure because even if one crop fails, other crops in the field might still

produce. In Uganda, a study by Buyinza (2018) found out that mixed cropping of maize and beans among Ugandan farmers led to increased productivity by contributing to sustainable domestic food. However, the above studies employed different measurement of food security indicators such as Dietary Diversity Indicator, Coping Strategy Index while the current study adopted Household Food Insecurity Access Scale. Household Food Insecurity Access Scale food was suitable for the current research because it captures all the four dimensions of food security thereby adequately addressing food security.

In Kenya, a study by Kemboi et al. (2016) found out that farmers who practiced mixed cropping generated high revenue and were therefore food secure. Fermont et al. (2010) study revealed that intercropping of cassava as a staple crop is a common practice among the marginal farmers in Eastern Africa. In Kenya and Uganda, around 51% and 30% respectively of cassava acreage were intercropped with legumes mainly barley and also beans, sorghum, groundnut and cotton. By this way the economic return increased by over 70% compared to the sole cassava production (Fermont et al., 2010). A study in Kenya by Matusso et al. (2013) & Kiprono (2012) found out that mixed cropping of maize and soya improved farmers income due to high yields. Herforth (2010) in his study found a positive association between number of crops grown and farm household food security in Kenya. Therefore, mixed cropping system has been fruitfully adopted to improve food production as well as income for small farmers. It promotes diversification of agricultural productions, securing the regularity of returns throughout the season as well as safety net against climatic uncertainties. An all-year-round farm income is guaranteed by the practice because it lessens the likelihood of total crop failure.

In Siaya-County approximately, 80.7% of the households lack food security (SCIDP, 2022). As a result, additional policies should be formulated to achieve food security. In Rarieda Sub-County where the current research was conducted 68% of households were food insecure. However, most of the research work in the Sub-County has focused on other variables and their influence on food security. The relationship between mixed cropping and household food security in Rarieda has not been fully explored. This is so despite the fact that previous studies on mixed cropping and household food security in other areas have shown that the system contributes to food security since it produces more yields hence can lead to food availability, This system also improves soil fertility through biological nitrogen fixation with the use of

legumes, makes the system resilient against environmental perturbations and provides high insurance against crop failure especially in the extreme weather conditions (Frison et al., 2011; Lithourgidis et al., 2011& Streit et al., 2019). However, the above studies were done in other areas other than Rarieda implying that a study done in Rarieda Sub-County is likely to yield different results. Further, the above studies adopted different theories such as Access theory and Malthusian theory as they examined the influence of mixed cropping on household food security.

2.4 Single Food Cropping Systems and Household Food Security

Research has shown that single food crop farming system impact positively on food security through increased productivity and efficiency, specialized productions, and yield maximization (Soomro, 2019). A study done in Bangaladesh by Majumder (2016) found out that rice grown as a single food crop accounted for nearly 70% of calories consumed in the Country. Th study by Majumder (2016) concluded that any effort to improve household food security must find ways to increase availability of rice grown as a single crop system. However, this study focused on availability and utilization tenet of food security providing a gap for the current study that adequately addressed food security by looking at all the dimensions of food security. Another study by Brinkley et al. (2021) focused on the challenges of single food crop systems but did not link it to food security.

In Africa, conventional mono-cropping system is much easier to large scale farmers who uses heavy machineries, synthetic fertilizer and pesticides, but not the small-scale farmers who don't have readily access to the market (Raseduzzadman, 2013). A study by Ojo (2013) in Nigeria studied the profitability of Melon based on sole and mixed cropping enterprise. This study found out that Melon did well when grown on its own than when grown with other crops. Further, the findings from this study revealed that farmers sold the surplus produce and obtained income which they used to purchase other food items hence achieving of food security. However, the above study was a comparative one since it focused on comparing the two cropping systems of mixed cropping and single food cropping system. The current study took a different turn as it looks at the two cropping systems independently and their influence on household food security.

A study done in Nigeria by Ibeawuchi et al. (2017) revealed that legume crops performed well in mono-cropping system. Further, this study revealed that when a farmer cultivates a single crop on a piece of land, only one method of harvesting was adopted, hence boosting profitability for the farmer. A study by (Frison, Cherfas, & Hodgkin, 2011) in South Africa revealed that farmers who grew sweet potato as a single food crop were food secure since sweet potato is highly nutritive and it outranks most carbohydrates food in terms vitamin, mineral and protein content. However, this study focused on sweet potato while the current study focused on legumes, tubers and cereals grown independently on the farm. Another study in Tanzania by Massawe (2016) revealed that the large proportion of households in Mvomero that grew only one crop may be associated with the fact that they lived closer to Dodoma and Morogoro and therefore were more likely to supplement their income with income generated from off farm work (Massawe, 2016). This study further revealed that farmers who practiced single food cropping earned less income. However, this study adopted Expected Utility Theory and Theory of Planned Behavior which focused on ranking the acts according to how choice worthy they are. The current study adopted FAD and FEET because the two theories enabled the current study to tackle all the dimensions of food security.

In Kenya, most households depend on agriculture for their livelihoods. According to Soomro, (2019) single food crop systems increased productivity and efficiency, led to yield maximization and obtained higher revenue. Therefore, this system has the ability to achieve the food security for rural households that depend on Agriculture. A study by Githunguri et al. (2015) revealed that small holder farmers who grow cassava as a sole crop on their farms witnessed increased food production hence improved food security status. This is because of the ability of the cassava to tolerate drought and to grow in a range of agro-ecologies. It is one of the cheapest and most readily available food crops that can be used as a strategy to overcome food insecurity (Feleke et al., 2016). However, this study focused on cassava while the current study focused on food crops such as groundnuts, and beans grown as a sole crop on the farm.

According to Wabwile (2016) household farmers who grow sweet potato as a sole crop on their farm in Bungoma were able to improve their food security status because potato could be grown under short rains since it has shorter growth cycle compared to maize which depends entirely on rainfall. The farmers were able to sell their produce to various restaurants in Bungoma who used

the sweet potatoes to produce French fries. Through the sale of the sweet potatoes, the farmers got income which they used to purchase other food items (Wabwile, 2016). Ayiera (2020) carried out a study in Imenti Sub-County on Banana production and its implication on food security. This study adopted mixed research design and Rationale Choice Theory. The findings of this study revealed that farmers who grew banana as a sole crop on their farms witnessed an increase in food availability hence food security. The farmers could also sell the surplus banana in the nearby markets and obtain an income used for other family obligations. However, the above studies focused on sweet potatoes and banana respectively with Ayiera (2020) study in Imenti adopting Rationale Choice Theory.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the research methodology that was applied by the current study. It presents the research design, study area, study population, the sample size and procedure for sampling, data collection techniques, reliability and validity of data instruments, data analysis techniques, results presentation analysis and ethical considerations that were considered while conducting the current study.

3.2 Research Design

This study was anchored on cross-sectional research design which allowed for one-time data collection, was inexpensive and incorporated both quantitative and qualitative analyses. The study data was collected from farm households. The cross-sectional research design involves the researcher measuring the outcome variable and the exposure variables in the respondents of the study at the same point in time (Mugenda &Mugenda, 2003). Such a design is useful in agricultural production and household food security surveys. It provides information about the amount of food produced from each of the agricultural systems, food available and accessible for consumption by the households all year round. It allows estimation of odd ratios to study association, relationship between the agricultural systems and household food security. The unit of analysis was households while the household's heads were the respondents.

3.3 Study Area

3.3.1. Location

The study was undertaken in Rarieda Sub-County in Siaya-County. The Sub-County has an area of approximately 405 square kilometers, has a population of 152,570 persons representing 25,428 households according to 2019 census report (Republic of Kenya, 2019). It has five wards namely: North Uyoma, East Asembo, West Uyoma, West Asembo, and South Uyoma constitute Rarieda Sub- County. The wards are further sub-divided into 23 Sub-locations (GOK, 2018). The Sub-County boarders Seme Sub-County to the North East, Bondo Sub-County to the North West and Homabay Sub-County to the South. The Sub-County lies between latitude $0^{0}15'$ North to $0^{o}26'$ in the equatorial south and longitude $34^{0}15'$ to $34^{0}29'$ East of the Prime Meridian. Farmers in the Sub-County faces several challenges leading to low food production compared to

neighboring Sub-Counties of Gem where there has been some level of sustainability in food security for their households (Odunga, 2019). For instance, in Gem Sub-County, only 37% of households lack food security, in Ugunja Sub-County 46.6% households is food insecure while in Bondo Sub-County 56% of households lacked food security (Otieno, 2014 & Oloo, 2021). In Rarieda Sub-County, 68% of the households lack food security. The high food insecurity status of Rarieda Sub-County necessitated the current research that sought to assess the influence of agricultural systems on household food security in Rarieda Sub-County. Figure 2 shows the Map of the Study Area.

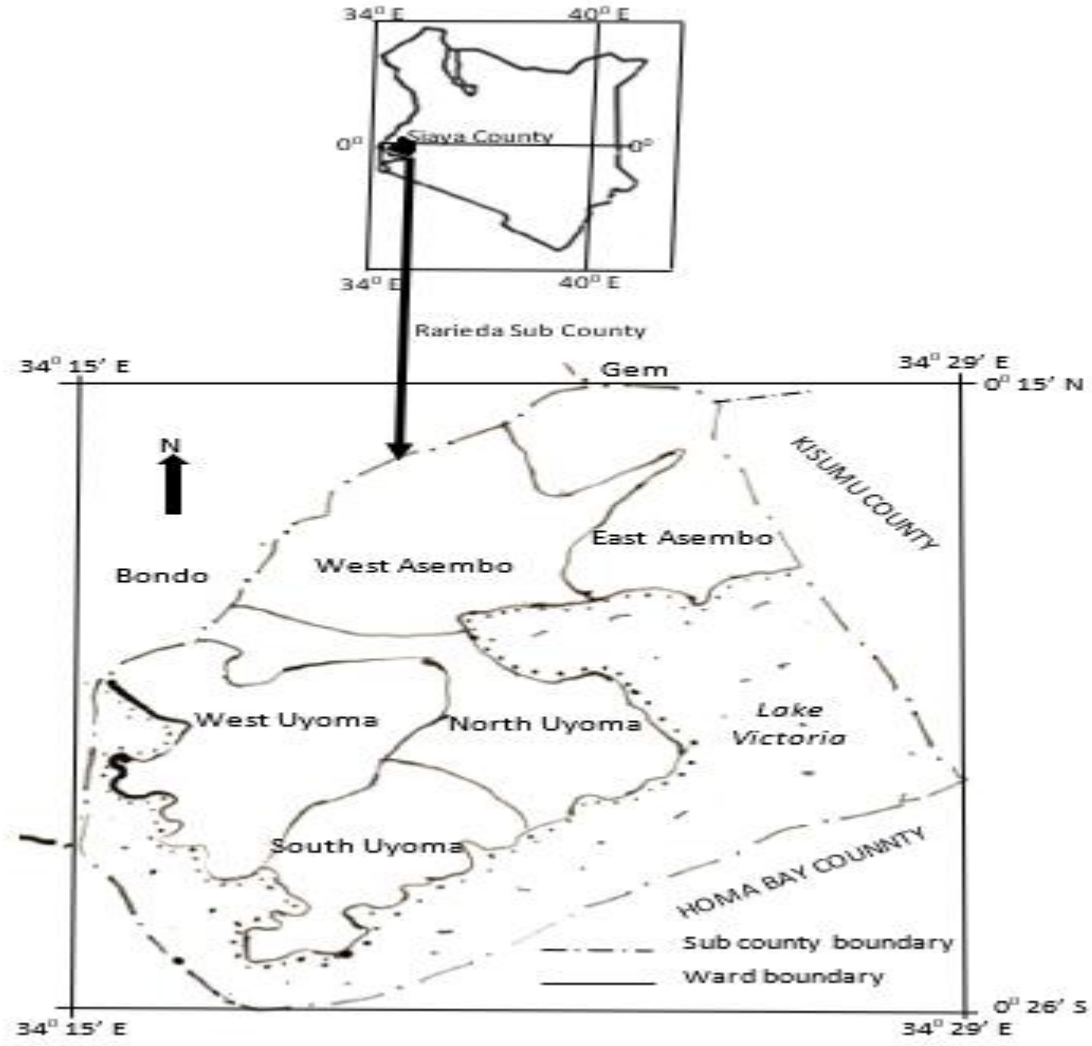

Figure 2: Map of Kenya Showing Wards of Rarieda Sub-County

Source: (Modified from Gok, 2018)

3.3.2 Climate

Rarieda Sub-County experiences equatorial climate throughout the year. However, nearness to Lake Victoria has modified the climate such that it does not display the characteristics of a typical equatorial climate. The Sub-County experiences long rains that start in March to June and short rains that start in August to November. The rainfall ranges between 800-1600mm annually. Temperature ranges from 21° Celsius to about 22.5° Celsius (Siaya County Integrated Development Plan, 2018). However, the area's rainfall is unreliable and this has impacted subsistence agriculture resulting to escalated cases of food insecurity in the Sub-County (Siaya County Integrated Development Plan, 2018)

3.3.3 Land Use

The land activities in the Sub-County consist of residential, gold mining, charcoal burning, brick making and agriculture (Siaya County Integrated Development Plan, 2018). Approximately,60% households practice subsistence production of maize, sorghum and millet, sweet potatoes, beans and small-scale livestock keeping. The average farm size in Sub-County is 1.5ha and soils type's ranges from black cotton soil in Madiany and sandy, loamy, and red volcanic soils in Rarieda Division (Siaya County Integrated Development Plan, 2018). The soils are generally poor due to over cultivation resulting to low productivity hence lack of food security.

3.3.4 Livelihoods

Agricultural production is the leading economic activity in the region. Crops such as maize, cassava, millet, sweet potatoes, sorghum, and cotton are majorly cultivated in the Sub-County (Clinton et al., 2018). The main cash crops grown in the region is groundnuts. Some of fruits grown in the area include pawpaw, mango, watermelon and vegetables such as tomatoes, kales and onions. The major livestock breeds kept in the Sub-County include upgrade and pure dairy cattle, zebu, local goat and sheep (SCIDP, 2022). Almost, 60% of households in the Sub-County entirely depend on agriculture for livelihoods. Despite that, the Sub-County has continued to register high incidences of food insecurity as 68% of the households are still lacking food insecurity. Open lake fishing is also carried out in the Sub-County and it contributes to economic growth and household food security. In the Sub-County, open lake fishing is carried out in Lake Victoria. The major fish species from the fisheries are Nile perch, sardine, Tilapia and the rarely found African Catfish (Siaya County Integrated Development Plan, 2022). However, the

fishermen in the region are affected by the problems of water hyacinth that has reduced their catch and therefore, fishing has not significantly improved the food security situation of households in Rarieda Sub-County**.**

3.3.5 Agricultural Systems

According to Siaya County Integrated Development Plan (2022) household farmers in Rarieda Sub-County engage in various agricultural systems such as mixed cropping. In this system, household farmers cultivate two or more crops simultaneously in the same farm without any distinct row arrangement. Farmers in the Sub-County cultivate crops such as maize, beans and bananas in their farms to ensure continuous production of food and diversified food production. Further, the SCIDP (2022) revealed that home gardening system is a common practice. Households have gardens near their homes where they cultivate horticultural crops, fruit trees such as mangoes, oranges, melons and rear livestock such as cows, goats, sheep, poultry, pigs and donkey which provide transport services. Some households practice fish farming under home gardening system.

This system ensures no total loss to the farmer since the farmer benefits from livestock in times of low crop production and crops when there is reduced livestock production. Surplus animal products like milk and eggs were sold to earn income which was be used to meet other family needs. The fruits from the fruit trees were consumed by the households thus providing the necessary vitamins and nutrients. Therefore, this system has the ability to enhance household food security in the County. Household farmers in Siaya-County also engaged in Single food cropping of either maize, beans and groundnuts etc. The surplus from these crops is sold to earn income which is used to meet other family financial obligations.

3.3.6 Household Food Security Status

Siaya-County is synonymous with high poverty level of 47.56% compared to the national levels which stands at 43.37% (MoALF, 2016b). Published and classified reports indicate that 80.7% of the residents are food insecure, (GOK, 2014). Further, statistics from (KNBS, 2014) revealed that the County has a stunting rate of 24.7% and wastage rate of 0.2% implying that food production failed to match food demand by the growing population in the County. The worsening food insecurity situation is escalated by limited or small farm lands, drought or floods, crop and livestock pest and diseases. This has worked against the main objective of

Siaya-County strategic plan which is to ensure that all the households in all the Sub-Counties are food secure. Additionally, Rarieda Sub-County had 68 % of its household's lacking food security compared to Gem Sub-County which stood at 37%, Ugunja 46.6% and Bondo at 56% (Obonyo, Otieno, & Angawa, 2016; Otieno, 2014 & Oloo, 2021). The high food insecurity index in Rarieda Sub-County necessitated the current research in the area.

3.4 Study Population and Sampling

Study population refers to population relevant to investigator's study and would wish to infer the findings of a study (Kothari, 2015). For this study, the target population is household heads in Rarieda Sub-County. As per the KNBS Statistics (2019) Rarieda Sub-County has a population of 152,570 persons consisting of 72,569 males 79,999 females and 2 intersexes. The household total is 25,428 persons with household average size of 6 persons (KNBS, 2019). An exclusion and inclusion criteria were employed to determine the household heads to be selected for sampling. According to Khan (2015) inclusion criteria are the attributes that the potential subject must possess to be included while exclusion criteria are the attributes that disqualifies the potential subject from inclusion in the study. Therefore, in this study cropping systems and demographic characteristics such as Age and Gender were taken into account. Hence, only household heads either male or female of age 18 and above and were practicing either of the three agricultural systems were considered. Table 1 Shows the Wards in Rarieda Sub-County with the total number of Sub-locations and the Population.

Table 1: Name of Wards, Sub location and Total Population in Rarieda Sub-County

NO	Wards	Sub-locations	Population
1	East Asembo	Omia mwalo, Omia malo, Omia diere, South Ramba, North Ramba	47,497
2	West Asembo	Siger, Nyagoko, Akom, Memba, Mahaya	29,441
3	North Uyoma	Ragengni, Ochienga, East katwenga, West Katwenga, Masala	32,322
4	West Uyoma	Rachar, Kokwiri, Kagwa, Kobengi, Nyabera	22,759
5	South Uyoma	Naya, Ndigwa, Lieta	20,551
Total		**23**	**152,570**

Source: Field Data (2022)

3.4.1 Sampling Procedure and Sampling Size

Hanlon and Larget (2011) define a sample as a statistical sub-set of individuals in a population. In order to come up with the appropriate sample size, the study employed the Fishers et al 1990 formulae since the Sub-County unit population is in excess of 10,000 persons. The formula is represented below

$$n = \frac{z^2 pq}{d^2}$$

With: **n**= as the desired sample size

Z=the standard normal deviation required confidence level i.e., at 95%, while z=1.96

P=the proposition in the estimate target population to possess the desired characteristics described by **q** =**1-p**

d=set level statistic

Therefore, at 0.05 confidence level=1.96, p=0.5.

Thus,

$$(\frac{1.96^2)\times(0.5\times0.5)}{(0.05)^2}=384$$

Therefore, a minimum sample size of 384 respondents was used for the current study. The questionnaires were administered to the 384 household heads selected from the five wards in Rarieda Sub-County.

The sample size per ward used in the study was achieved by dividing the total number of households from each ward by the total households of the whole Sub-County and the multiplied by the total sample size as shown in Table 2

Table 2: Sample size Determination from each Ward in Rarieda Sub-County

No.	Name of ward	Total population	Number of households	Sample Size
1	East Asembo	47,497	$\frac{47497}{6}=7916$	$\frac{7916}{25428}\times384=120$
2	West Asembo	29,441	$\frac{29441}{6}=4906$	$\frac{4906}{25428}\times384=74$
3	North Uyoma	32,322	$\frac{32322}{6}=5387$	$\frac{32322}{25428}\times384=81$
4	West Uyoma	22,759	$\frac{22759}{6}=3793$	$\frac{22759}{25428}\times384=57$
5	South Uyoma	20,551	$\frac{20551}{6}=3425$	$\frac{3425}{25428}\times384=52$
Total	**5 Wards**	**152,570**	**25,428**	**384**

Source: Modified from (KNBS, 2019)

In order to get the individual household heads from the sample size for each ward, stratified random sampling was used. The five wards namely East Asembo, West Asembo, North Uyoma, South Uyoma and West Uyoma were considered as strata. A catalogue of all household names was obtained from the Ward executive officer, to get the sample frame after which the respondents were selected randomly by allocating a number to every subject of the accessible population by using computer. Data was then entered in a computer per ward using the sampling frame for each ward. A sample size of 384 households out of 25,428 was generated randomly. Through the help of Ward administrators, the respondents were then identified for questionnaire administration. Thus, the questionnaires (Appendix B) were administered to the 384 household heads who provided relevant information as per stated in the specific objectives. On the other hand, purposive sampling was applied to get the sample of key informants that included five ward administrators and one Sub-County agricultural officer who gave holistic and representative information on the Sub-County food security status.

3.5 Sources of Data

In this study, both primary and secondary data sources were applied to collect quantitative and qualitative data. Primary data on home gardening mixed cropping, single food crop farming and Household food security was acquired from heads of household and key informants through questionnaire, key informants' interview, observation and photography.

The secondary data on the other hand was acquired from relevant publications, internet sources, journals and government published reports. Further, unpublished dissertations and theses with relevant information were reviewed. The Siaya County Integrated Development plan also formed a major source of secondary data. This data brought insight into the research topics by enabling comparisons of various studies on agricultural systems and household food security. It also established the knowledge gaps and the means through which food security can be achieved.

3.6 Methods of Data Collection

Both primary and secondary data collection methods were used. The primary data collection methods used by the current study were as follows;

3.6.1 Questionnaire

Questionnaires were administered to 384 household heads who were the respondents to collect the quantitative data. It consisted of close ended questions and open-ended questions. This allowed the interviewee to address the closed questions from the presented choices and also give their opinions when addressing open ended questions. The questionnaires helped to generate information on agricultural systems, household demographic characteristics, type of single food crops grown, amount of yield for crops and contribution of livestock, types of fruit trees grown and their uses, types of intercrop combinations, and status of food security in Rarieda among households. The questions were categorized into three sections to ensure that all the specific variables and objectives of the study were covered. This method is appropriate since it has the potential to reach a sizeable number of informants with a short time and it offers security to the respondents (Kothari, 2015)

3.6.2 Key Informant Interviews

Key informant interviewed included five chiefs, and one Sub-County agricultural officer. The five chiefs were picked to represent each ward and the Sub-County Agricultural officer was included because of their deep knowledge and experience on Agriculture and food security. The key informant interviews schedule was restructured to address the three specific objectives of the study. Besides having general questions aligned to the objectives, the interview schedules also had specific questions tied to their area of expertise. This helped in-depth understanding of underlying issues around food security and agricultural systems. The interviews with the administrative chiefs yielded information on the amount of crop and livestock yields per season per year, challenges of home gardening systems, challenges of single food crop farming, benefits of mixed cropping regime, amounts of yields when crops are intercropped, and amounts of yields when sole food crop system is adopted. Interviews with the Sub-County agricultural officer on the other hand yielded information on of food security situation in the Sub-County, advantages of mixed cropping, benefits of home gardening systems together with its shortcomings and challenges of fishing as an alternative economic activity. The information collected helped to corroborate data collected from households using questionnaire.

3.6.3 Observation and Photography

The current study employed observation and photography so as to collect primary data. The researcher observed the types of agricultural systems adopted by the household farmers in the Sub-County, the types of fruit trees grown by residents, the type of livestock kept, the challenges experienced in most home gardens and the type of crops grown (Appendix E). This aided the investigator to understand the lifestyle of the informant and even crosscheck their responses. The researcher also used photographs to enhance the outcome of the research since they represented observable physical household farming activities relevant to the interest of the current study.

3.7 Validity and Reliability of Data

The accuracy of data collection procedure is crucial for the quality research. The information acquired from the various techniques of data were accurate and relevant to research questions or objectives thus making reliability and validity a measure of relevance (Babbie, 2010)

3.7.1Validity of the instruments

Validity in research denotes the degree to which the research instrument measures what they are designed to measure without errors (Kirk & Miller 2007). Both content and face validity were considered. Content validity was ascertained through the review of questionnaires by the supervisors. The data collection tools were ready for use after their approval and ensuring that all content in terms of variable of the study were covered. Face validity was ascertained by use of simple English, and use of basic terms in constructing the questionnaires, in addition, the questionnaires were typed and printed in clear font that could easily be read by all. Subsequently, ensuring content and face validity in the study thus enhanced the accuracy for the indicators and information sought for the variables were properly aligned to them. The questions were further restructured according to the objective of the study for enhanced validity.

3.7.2 Reliability of Data Instruments

According to Babbie (2010), a measuring instrument is considered reliable if it gives compatible results over the years. It was ascertained through pre-testing the tools and the questions to ensure the response given addressed the variables (Kronsnick &Stanley, 2009). To ascertain the reliability of data instruments, the researcher conducted a pilot study at South Ramba Location in East Asembo Ward which was chosen because it had the same geographical and environmental attributes to the study area. Such attributes included soil type, rainfall amounts and similar agro

ecological zones. Reliability was achieved by administering the research instruments to a sample size of 10% (38 respondents). It was redone after three weeks and yielded the same response. A reliability test was also performed and Cronbach's alpha of 0.746 attained. This indicated a strong internal consistency of the items in the questionnaire. Therefore, the questionnaire was reliable to be used in the study.

3.8 Data Analysis and Results Presentation

3.8.1 Data Analysis

Both qualitative and quantitative data were analyzed. Quantitative data from questionnaire and key informant interview were edited, encrypted and entered into a computer for analysis. The data was processed in Microsoft Excel and analysis was done using Statistical Package for Social Science (SPSS version 22). Results were presented in percentages, SD, means, and frequency tables to answer each objective of the study. Chi-square text was conducted to determine the association between agricultural systems and household food security. Qualitative data on the influence of agricultural systems on household food security was analyzed by creating themes and patterns.

Table 3: Quantitative Data Analysis Matrix

Research objectives	Independent Variable	Dependent variable	Data analysis procedure
1.Examine the influence of home gardening system on household food security	Home Gardening System	Food Security	Chi-Square test, Means, Standard Deviation and Percentages.
2.Determine the influence of mixed cropping on household food security	Mixed Cropping System	Food Security	Chi-Square test, Means, Standard Deviation and Percentages.
3.Examine the influence of Single food crop farming on household food security	Single food crop farming system	Food Security	Chi-Square test, Means, Standard Deviation and Percentages
4.Assess the influence of agricultural systems on household food security	Agricultural systems	Food Security	Chi-Square test.

Source: Researcher (2022)

3.8.2 Results Presentation and Discussions

The presentation and discussion of the findings were done in the form of Plates, Tables and Discussions. The findings are anticipated to raise awareness on the influence of agricultural systems on household food security in Rarieda Sub-County.

3.9 Ethical Considerations

Before carrying out the study, research permission was given by the university through approval of proposal by School of Graduates studies, Ethic Review Committee of Maseno University and National commission for science and technology (NACOSTI). Furthermore, approval of ward administrators to undertake the study in their area of jurisdiction was sought. Informed consent is another principle of research, it is a voluntary agreement to participate in research; it was adhered to by the respondents signing the consent forms. Participation on the study was on voluntary basis. Respect for anonymity and confidentiality is another ethical factor which is defined as keeping the identity of the participant from everyone, including the researcher. This was guaranteed through coded identifiers in questionnaires administered without applying real respondent names.

The purpose of the study was clearly stated to clear any ambiguity and misunderstanding from the respondent on information collection and use. The identified participants were duly informed on benefits and shortcomings of the intended research. They were also enlightened on their right to drop out from the study. The researcher made sure the provided information by each respondent was confidential and not passed to unauthorized third parties. The completed questionnaires were kept in lockable drawers to ensure that no one accesses any information already researched until that time the questionnaires would be due for shredding. As a precaution to data protection, computer data bases with a strong password were created. Any other information from other sources that support this study was acknowledged in references. The study also ensured honesty through using the exact data as collected from the field without alteration.

CHAPTER FOUR

RESULTS, PRESENTATION AND DISCUSSION

4.1 Introduction

This chapter presents the data analysis, interpretation and discussion of the findings that are presented in order of specific objectives. The chapter too presents the demographic characteristics of the respondents.

4.2 Demographic Characteristics of the Respondents

This section looked at gender, age, household heads, educational qualifications, household land sizes, level of household monthly incomes and main occupation as the main demographic characteristics of the respondents in the study area. The aspect of gender was important as it revealed the gender roles in food security while age also indicated the age group majorly involved in food production.

The outcome has been highlighted in Table 4.

Table 4: Demographics Characteristics of the Respondents

Characteristics	Frequency	Percent
Respondents' Gender		
Male	187	48.69%
Female	197	51.31%
Total	**384**	**100%**
Respondents' Age (Years)	**Frequency**	**Percent**
18-35	99	25.82%
36-50	118	30.72%
51-65	87	22.55%
66-70	64	16.66%
>70	16	4.25%
Total	**384**	**100%**
Respondents' Education Qualification	**Frequency**	**Percent**
None	0	0.00%
Primary	79	20.59%
Secondary	139	36.27%
Certificate /Diploma	95	24.84%
Degree and above	70	18.30%
Total	**384**	**100%**
Head of the Household	**Frequency**	**Percent**
Male Headed	234	65.25%
Female Headed	150	34.75%
Total	**384**	**100%**
Approximate Household Size	**Frequency**	**Percent**
1	9	2.29%
2-5	146	37.91%
6-8	172	44.77%
Above 8	58	15.03%
Total	**384**	**100%**
Main Occupation	**Frequency**	**Percent**
Formal Employment	48	12.42%
Business	98	25.49%
Farming	181	47.06%
Fishing	51	13.40%
Other (Specify)	6	1.63%
Total	**384**	**100%**
Monthly Income	**Frequency**	**Percent**
0-4,000	108	28.10%
4001-10,000	193	50.33%
Above 10,000	53	21.57%
Total	384	**100%**
Approximate Land Size	**Frequency**	**Percent**
1-3Ha	232	60.46%
4-6Ha	118	30.72%
Above 7Ha	18	4.5%
Others (Specify)	16	4.25%
Total	**384**	**100%**

The results as presented in Table 4 revealed that the current study was balanced with both female and male respondents. The female respondents were at 51% while the male respondents were 49%. This implied that for their livelihood, both female and males were actively involved in activities that produced food for their households. This finding conforms to the findings of Asha (2009) which found out that both men and women were actively participating in activities that aims to provide food for the family.

Approximately, 31% of the respondents were within 36-50 years age bracket (Refer to Table 4) This revealed that agriculture is majorly done by the middle age population The younger population normally migrates from rural to urban areas in search of employment in other sectors of economy different from agriculture which is attributed to uneducated and older generation (Arunga, 2012). Additionally, agriculture is labor intensive, which makes it difficult for the older, lesser energetic population to practice it. The elderly (<70years) were not actively involved in farming because they were less energetic therefore, they opted to stay at home to be taken care of by the energetic respondents (Arunga, 2012). This implied that the right age groups involved in agricultural production were sampled.

On level of education; the study sought to determine how literate the respondents were as that would determine their ability to apply scientific knowledge and skills in agricultural productivity. The results in Table 4 revealed that 20.59% of the household heads had primary education level, 36.27% had secondary education level, 24.84% had certificate and diploma education level while 18.30% had degree and above level of education. According to UNESCO (20I5), basic education is important as can enable one to read and understand the world around him. Educational attainment by the household head could lead to awareness of the possible advantages of modernizing agriculture by means of technological inputs which enables them to read instructions on fertilizer packs and diversification of household incomes which, in turn enhances households' food supply.

On head of households the current study further aimed to establish where decision making and control over agricultural production resources are vested. The result on gender representation for household respondents and household heads was very significant as it brought in the aspect of gender participation which was seen to be very important in terms of food security and resource

management (Adam *et al*., 2019). The findings in Table 4 revealed that majority 65.25% of households were headed by male while female headed households was at 34.75%. According to Arunga (2012) male headed households are expected to be food secure because they have ownership and control of land.

In establishing the household sizes, the study sought to ascertain the burden of feeding the families and this was important as it helped to estimate the household food ration requirement. Majority of the households had 6 to 8 members at 44.77% as shown in Table 4. This implied that the family sizes were big and needed high agricultural productivity to meet their food requirement needs.

On determining the respondents' occupation, the study sought to assess the respondents' major sources of livelihoods. Approximately, 47.06% practiced agriculture. (Refer to Table 4) This implies that most of the households' respondents in Rarieda are subsistence farmers who grow crops such as maize, sorghum, beans, millet and small-scale livestock keeping. This finding conforms to the findings of the report by Siaya County Integrated Development Plan, (2022) which revealed that 60% of households in Rarieda practiced subsistence agriculture.

On determining the income brackets of respondents, the study sought to ascertain the respondents' ability to meet their financial obligations as far as their basic needs are concerned. Results indicated that most of the respondents were low-income earners with Ksh 4001 to 10,000 accounting for over 50% while those above Ksh10,000 were only 21.57%. (Refer to Table 4) This implies that the households had low purchasing power and could barely meet the financial thresh-hold to buy food stuff for their households in case they did not produce enough in their farms. Further, this determined their ability to afford the agricultural inputs for food productivity. These findings corroborate the findings obtained by Mo ALF (2016) that revealed that Siaya-County where Rarieda Sub-County sits records a high poverty level of approximately 47.6% hence persistent food insecurity.

Further, about 60.46% of the respondents had land sizes of 3ha and below as shown in Table 4. This implied that their small land-holdings could not sufficiently support meaningful agricultural productivity leading to scarcity and underproduction of agricultural produce, hence food insecurity. These findings agree with the findings of a study by Obonyo (2016) in Ugunja that

revealed that most rural population depended on small ancestral land for production hence persistent food insecurity.

4.3 Influence of Home Gardening System on Household Food Security.

The first specific objective set out to examine influence of home gardening system on household food security in Rarieda Sub-County, Siaya County. Table 5 displays a summary of the findings from the study area.

Table 5: Descriptive Statistics on Home Gardening and Household Food Security

Home Gardening Statements	Strongly agree 5	Agree 4	Neutral 3	Disagree 2	Strongly disagree 1	Mean	S.D
I do practice home gardening to boost household food security	140(36.60%)	142(36.93%)	24(6.21%)	50(13.07%)	28(7.19%)	3.83	1.254
Horticultural crops are the most preferred crops grown under home gardening	137(35.62%)	123(32.03%)	40(10.46%)	64(16.67%)	20(5.23%)	3.76	1.243
Tubers are common crops grown under home gardening	65(16.99%)	61(16.01%)	38(9.80%)	125(32.68%)	94(24.51%)	2.68	1.433
Fish farming is practiced under home gardening	102(26.47%)	112(29.08%)	43(11.11%)	90(23.53%)	38(9.80%)	3.39	1.353
Domestic animals in home gardening are majorly kept for food and dietary supplements	103(26.80%)	124(32.35%)	46(12.09%)	82(21.24%)	29(7.52%)	3.50	1.291
Domestic animals in home gardening are reared majorly for their by-products like manure, skin and biogas; and services like transport and animal power	34(8.82%)	41(10.78%)	44(11.44%)	103(26.80%)	162(42.16%)	2.17	1.318
Domestic animals in home gardening are reared mainly for sale to provide income	98(23.49%)	119(31.05%)	49(12.75%)	77(19.93%)	41(10.78%)	3.41	1.343
Domestic animals in home gardening are reared for socio-cultural purposes like to pay dowry and maintain high social status in the community	35(9.15%)	51(13.40%)	63(16.34%)	102(26.47%)	133(34.64%)	2.36	1.321
There are fruit orchards in home gardening that provide fruits and income to the households	104(27.12%)	129(33.66%)	41(10.78%)	79(20.59%)	30(7.84%)	3.52	1.296
Composite Mean and Standard Deviation						**3.23**	**1.315**

Results from Table 5 revealed that 36.60% of the respondents were in strong agreement while 36.93% were in agreement that indeed they practiced home gardening to boost their household food security by cultivating horticultural crops, fruit trees, rearing animals and fish farming. This means that 74% households in Rarieda Sub-County practiced home gardening upon realization of the food benefits that accrued from this system hence explaining the high adoption rate. Households that adopted this system could obtain fresh fruits, livestock products, fish, vegetables, cereals and root crops. They consumed the food accrued from this system thus enhancing their household food security. These findings agree with the findings of studies by Bahta (2018) & Musotsi (2008). The two studies revealed that home gardening system was responsible for about 41% and 45% decline in food insecurity respectively. However, the two studies did not focus on fish farming which are also part of home gardening systems.

Approximately, 16.99% of the respondents strongly agreed while 16.01% agreed respectively that tubers such as sweet potatoes, cassava, groundnuts were commonly grown under home gardening system (Refer to Table 5). Households that grew tubers such as sweet potatoes, cassava and groundnuts on their garden could access food all year round thereby ensuring food stability. These findings conform to the findings of a study by Saptana, (2011) which found out that roots and tubers grown under home gardening systems contributed to household food security by 30% in USA. However, the study by Saptana, (2011) was done in America which is highly developed nation thereby, creating a gap for the current study that was done African rural set up which is characterized by high poverty levels and high population growth rate.

Further, results in Table 5 indicate that rearing domestic animals in home-gardening systems was popular. About 26.80% of the respondents strongly agreed while 32.35% agreed respectively that most of the domestic animals in home gardening systems were reared for food such as milk, meat and eggs. The animals reared by households in the Sub-County included cows, goats, sheep, chickens, ducks and pigs. However, this was majorly done on small-scale and with either local or improved livestock breeds through cross-breeding. Plate 1, shows cross-breed cattle in a home gardening systems.

Plate 1: Cross Breed Cattle in Home Gardening System in East Asembo

Source: Field data, 2023

In Plate 1, a worth note is that the cattle is being fed on maize stalks, something that supports the value attached to mixed farming under home gardening. Crops benefit from livestock manure, and some livestock is used in providing farm labor. Livestock, on the other hand, are fed on some crop residues. Again, home gardening ensures no total loss to the farmer since the farmer benefits from livestock in times of low/no crop production and benefits from crops when there is no or reduced livestock production. Surplus animal products such as eggs and milk were sold to obtain income which was used to acquire other food needs of the households (Galhena, 2013) Therefore, rearing of domestic animals in this system improved household food security based on availability, accessibility. These findings agreed with the findings of a study by Hansen, (2022) which found out that domestic animals in the home gardening system enabled households to boost their income through enhanced home production and subsequently saving on food expenditure. Additionally, the livestock products from the systems such as eggs and milk were

consumed by households thereby improving the quality of their diet. However, the study by Hansen (2022) brought forth the aspect of women empowerment through home gardening system while the current study focused only on the food benefits of home gardening.

In addition, an interview with the key informant supported the above facts by revealing that:

> *In this area, households have established home gardens where they plant fruit trees, vegetables, cereals, and rear livestock such as cows, goats, sheep and chicken. This has improved their dietary diversity and has enabled them to obtain food continuously throughout the year. Additionally, this system provides supplemental food which has enabled households to be food secure. Households that do have home gardens lack food security.*
>
> (Administrative chief of North Uyoma)

This sentiment implies that home gardening system had the ability to enhance household food security. Therefore, this agricultural system should be able to reverse the observation made in Table 6 which showed that approximately 69% of the respondents in the Sub-County could not produce enough food from their farms to sustain their food needs.

In addition, analysis on Household Food Security through Likert scale was done and presented in Table 6.

Table 6: Descriptive Statistics on Household Food Security

Household Food Security Statements	Strongly agree 5	Agree 4	Neutral 3	Disagree 2	Strongly disagree 1	Mean	S.D
We produce enough food in my household to last to the next season	49(12.75%)	65(16.99%)	30(7.84%)	142(36.93%)	98(25.49%)	2.55	1.367
The farm produce can sustain the foods needs of my household	44(11.44%)	50(13.07%)	25(6.54%)	141(36.60%)	124(32.35%)	2.35	1.352
We buy most of our household food requirement from the market	102(26.47%)	134(34.97%)	24(6.21%)	74(19.28%)	50(13.07%)	3.42	1.396
We depend on food donation from relatives for our household needs	48(12.42%)	73(18.95%)	26(6.86%)	138(35.95%)	99(25.82%)	2.56	1.376
We can afford to have all the three means a day	79(12.75%)	70(18.30%)	33(8.50%)	110(28.76%)	122(31.70%)	2.52	1.422
Our meals are made of balanced diet and are in enough proportions	34(8.82%)	46(12.09%)	39(10.13%)	127(33.01%)	138(35.95%)	2.25	1.297
We sell our surplus to the market to supplement our income for other household expenditure like school fees	41(10.78%)	75(19.61%)	33(8.50%)	143(37.25%)	92(23.86%)	2.56	1.330
The food we consume is highly nutritious and is available throughout the year	34(8.82%)	45(11.76%)	43(11.11%)	128(33.33%)	134(34.97%)	2.26	1.289
There is enough food supply in the local market and is easily affordable without having to travel far	51(13.40%)	100(26.14%)	33(8.50%)	103(26.80%)	97(25.16%)	2.76	1.421
We sometimes go hungry without food for up to 2 days or even more	93(24.18%)	89(23.20%)	29(7.52%)	99(25.82%)	74(19.28%)	3.07	1.494
Composite Mean and Standard Deviation						**2.63**	**1.374**

The results in Table 6 revealed that respondents at 36.93% disagreed that they produced enough food in their household to last them to the next season while 25.49% strongly disagreed with the above statement. This implies that 61% of the household's produced food that was hardly enough to last them to the next season therefore were food insecure most months of the year. These findings agreed with the findings of a report by Siaya County Integrated Development Plan that revealed that Siaya-County produced food that could only last six months in a year with deficit going up to 8 months in poor climatic seasons (Siaya County Integrated Development Plan, 2018).

Out of the respondents that were interviewed, 36.60% disagreed that their farm produce could sustain food needs of their households while (32.35%) strongly disagreed on the same. On the other hand, 11.44% strongly agreed while 13.07% agreed respectively that their farm produce could sustain food needs of their household (Refer to Table 6). This implies that 68% the households in Rarieda Sub-County did not produce much food crops from their farms to sustain their food needs. Therefore, they either went hungry or had to buy their foods stuffs from the local food markets which also depended on availability of foodstuffs and income (SCIDP, 2022)

About 8.82% of respondents strongly agreed while 12.09% agreed respectively, that their household diets were balanced and were in enough proportions. While on the other hand 35.95% of the respondents strongly disagreed while 33.01% disagreed with the above statement (Refer to Table 6) This implies that majority of households in Rarieda Sub-County could not access balanced diet and depended majorly on sole consumption of maize that do not provide recommended nutrients to households leading to nutritional insecurity

The current study further established that 8.82% of the respondents were in strong agreement while 11.76% agreed respectively that the food they consumed was highly nutritious and available throughout the year. On the other hand, 34.97% of the respondents strongly disagreed while 33.33% disagreed respectively with the statement (Refer to Table 6). This implied that majority of the household respondents at 68% ate less nutritious food which was also not available throughout the year. These households depended on maize and any other accompaniments which were the most popular dietary provisions for the majority of the households. These households further revealed that as long as they had something to hold their stomachs, they were “okay”. This clearly showed that households in Rarieda Sub-County are food insecure. These findings agreed with the findings of a study by Odunga (2016) whose results revealed that 68% of the respondents relied majorly on maize to make *Githeri* (beans and maize cooked as a mixture). However, the above study focused on one dimension of food security which is availability while the current study focused on all the four dimensions of food security so as to adequately address food security.

Further, results in Table 6 revealed that 24.18% of the respondents strongly agreed that they sometimes went hungry without food for up to 2 days or more while 23.20% of the respondents

agreed with the above statement. This pointed towards a situation where by food-aid might be required in Rarieda Sub-County for a significant part of the year by majority of the residents. The findings agreed with the findings of the Ministry of Agriculture and Livestock MO ALF (2016) on Siaya County's poverty level which stood at 47.5%. With the high levels of poverty, households had no financial ability to access other food stuffs from the market and were forced to go without food for two days or so. This clearly showed that the current study was timely since a sizable population of Sub-County is still struggling with food insecurity.

Further, Chi-Square test was run to establish association between home gardening system (Table 5 page 40) and household food security (Table 6 Page 44). The results were presented in Table in 7.

Table 7: Chi-square test Analysis on Association between Home Gardening and Household Food Security

		% influence			
		Horticulture	Tubers	Domestic animals	Fish farming
Home gardening practice	Strongly disagree	5.23	16.01	7.52	9.80
	Disagree	16.67	16.99	21.24	23.53
	Neutral	10.46	9.80	12.09	11.11
	Agree	32.03	32.68	32.35	29.08
	Strongly agree	35.62	24.51	26.80	26.47
	TOTAL	**100**	**100**	**100**	**100**
	df = 12; Pearson's Chi-Square = 0.026; Likelihood Ratio = 0.014				

From Table 7, 67.65%, 33%, 59.15%, and 55.55% of the respondents significantly agreed, that horticulture, tubers, domestic animals and fish farming were home gardening practices contributing towards household food security (χ^2 - 0.026). If embraced, then horticulture, domestic animal, fish farming and tubers will contribute to improved household food security in Rarieda Sub-County. The implication here is that as households intensify home gardening, food security was significantly enhanced. For instance, home gardening system enabled household respondents in Rarieda to meet the first dimension of food security that is availability by enabling instant continuous physical access of food due to close proximity to the kitchen. The womenfolk could always pull, pick, cut or harvest the produce such as vegetables and tubers

from their backyard as appropriate food or even for the markets. The additional income from the surplus sale was used to buy other food items to meet other households' needs. Therefore, home gardening system enabled households to achieve food accessibility hence food security.

Home gardening system also met the other food security dimension of utilization for uptake of nutritious and quality supplements. This system enhanced households' capacity to access fresh, nutritious and variety produce. Therefore, home gardening system made households to have more dietary diversification hence meeting the nutritional needs of households. This finding agreed with the findings of a study by Chepkirui et al. (2019) which revealed that dietary diversity score for households with home gardens increased as they were able to access fresh vegetables, meat, milk, eggs, fish and tubers. Consequently, the findings differed from Depenbusch et al. (2021) who reported statistically insignificant impact of home gardens on household diets in Uganda and Kenya. Home gardening systems also enabled households to obtain food throughout the season since the production occurs almost continuously all year round and their proximity to home ensures access to food at all times. In addition, home gardening systems is variable that fit well under FAD Theory. It ensures consistent food production from the family farms, the households harvest food every season and is assured of food availability most of times.

4.4 Influence of Mixed Cropping System on Household Food Security.

The second specific objective of the study set out to determine the influence of mixed cropping on household food security in Rarieda Sub-County, Siaya County. Table 8 displays a summary of the finding from the study area.

Table 8: Descriptive Statistics on Mixed Cropping and Household Food Security

Mixed Cropping Statements	Strongly agree 5	Agree 4	Neutral 3	Disagree 2	Strongly disagree 1	Mean	S. D
I do practice mixed cropping regime to enhance my household food security	114(29.74%)	151(39.22%)	35(9.15%)	65(16.99%)	19(4.90%)	3.72	1.198
Maize and beans are the most common mixed cropping regime with most households	158(41.18%)	151(39.22%)	24(6.21%)	40(10.46%)	11(2.94%)	4.05	1.076
Mixed cropping regime gives better yields than mono-cropping regime	129(33.66%)	144(37.58%)	25(6.54%)	56(14.71%)	29(7.52%)	3.75	1.269
Mixed cropping regime makes pest and diseases less prevalent	82(21.24%)	174(45.42%)	28(7.19%)	65(16.99%)	35(9.15%)	3.53	1.252
Households rarely experience total crop failure under mixed cropping regime	69(17.79%)	143(37.25%)	34(8.82%)	95(24.84%)	43(11.11%)	3.26	1.312
Mixed cropping cushions farmers from weather related crop failure.	133(34.64%)	149(38.89%)	30(7.84%)	48(12.42%)	24(6.21%)	3.83	1.207
Mixed cropping promotes conservation agriculture and the land can sustain high crop yields over a long period of time	119(31.05%)	144(37.58%)	29(7.52%)	60(15.69%)	31(8.17%)	3.68	1.284
Mixed cropping enhances dietary options available for the households	134(34.97%)	139(36.27%)	31(8.17%)	54(14.05%)	25(6.54%)	3.79	1.242
Mixed cropping regime gives surplus yields that can be sold to acquire other household needs not harvested from the farm	94(24.51%)	128(33.33%)	56(14.71 %)	75(19.61%)	30(7.84%)	3.47	1.268
In mixed cropping regimes perennial crops are grown with seasonal crops and this ensures continuous supply of food to the households	118(30.72%)	114(29.74%)	29(7.52%)	69(17.97%)	54(14.05%)	3.45	1.439
Composite Mean and Standard Deviation						**3.65**	**1.255**

The results as presented in Table 8 revealed that respondents at 29.74% agreed while 39.22% strongly agreed that they practiced mixed cropping regime to enhance their household food security. This means that approximately 68% of the household's respondents in Rarieda Sub-County adopted various mixed food crop combinations to achieve food security. This could be understood that the most of the households had realized the food benefits that accrued from this

system. It is noteworthy that households who adopted mixed cropping system realized better food security than those who had not because the system enabled household farmers to obtain variety of foods which could be harvested at different intervals. Therefore, households had access to food all the times. At times the household farmers could sell their surplus produce in the market to obtain income which they used to meet other household needs. These findings agreed with the findings of the study by Cho et al. (2016) which revealed that mixed cropping was positively correlated with household food security. However, the study by Cho et al. (2016) focused only on annual crops grown by household farmers and not perennial crops. Further, the study by Cho et al. (2016) focused only on utilization tenet of food security and employed Household Dietary Diversity Score (HDDS) to measure food security. The present study bridged all the identified gaps by focusing on all the four dimensions of food security and on both annual and perennial crops.

Approximately, 21.24% of the respondents strongly agreed while 139(45.42%) agreed respectively that mixed cropping regime makes pest and diseases less prevalent and that enhanced crop yields and productivity (Refer to Table 8). About 66% of the households' respondents confirmed that severity of pest and diseases such as gray leaf spot, bean rust greatly declined whenever they adopted mixed cropping system of maize and beans. This system made it difficult for the pest and diseases to spread through the farm; it also decreased the availability of host plants and alteration of pathogen dispersal by micro climate changes. These findings affirmed the findings of a study by Ememwa et al. (2017) which revealed that cassava brown streak disease was managed by mixed cropping.

About 17.79% of the respondents strongly agreed while 37.25% agreed respectively that mixed cropping regime was credited for saving the households from experiencing total crop failure (Refer to Table 8). The household farmer could access food throughout the season because if one crop failed to produce the household farmers could still rely on the other crop. For instance, the household farmer in Rarieda Sub-County who had mixed crops like maize, beans on one farm, bananas, groundnuts on the other farm and potatoes, and cassava the other farm could obtain food consistently because even if maize failed to yield they could still turn to groundnuts, beans, cassava, potatoes and banana which they could consume and sell the surpluses to the local market to get money to buy other foodstuffs such as meat and fish thereby improving the food

security status of households. This finding conforms to the findings of a study by Streit et al. (2019) which found out that mixed cropping lessened the likelihood of total crop failure because if one crop fails the other crop in the field might still produce. However, the study by Streit et al. (2019) was done in Germany thus providing a gap for the current study which was done in Africa specifically Rarieda Sub-County, Kenya. This so because of economic disparity between Germany and Rarieda Sub-County in Kenya.

About 30.72% of the respondents strongly agreed while 29.74% agreed respectively that in mixed cropping regimes, perennial crops such as sweet potatoes, cassava and banana are grown with seasonal crops such as maize and beans and this ensures continuous supply of food to the households thus improving the food security status of households(Refer to Table 8).These findings agree with the finding of a study by Frison et al. (2013); Streit *et al*. (2019) & Lithourgidis et al. (2011) that revealed that mixed cropping provided households with food throughout the season. However, the above studies focused on stability and availability dimension of food security. The current study focused on all the four dimensions of food security so as to adequately address food security (Barret, 2011).

Further, results in Table 8 revealed that approximately 41.18% of household's respondents strongly agreed while 39.22% agreed respectively that maize and beans were the most common mixed cropping regime. This was so because maize and beans combination were presumed to produce more yields compared to other combinations. Plate 2 shows mixed cropping of Beans, Maize and Bananas crops in South Uyoma.

Plate 2: Mixed Cropping of Beans, Maize and Banana Crops in South Uyoma
Source: Field data 2023

In Plate 2, the good performance of intercropping maize, beans and bananas is as a result of the two crops utilizing natural resources more exhaustively. Green bean crop is a legume that helps in fixing biological nitrogen in the ground, transferring it to the maize cereal crop, and in increasing the efficiency of nitrogen use by the maize cereal crop as revealed by the studies of Kerman et al. (2019) & Zeng et al. (2021). Further, there occurs less incidences of pests, diseases and weeds attack when maize and beans are intercropped, an observation that leads to greater crop yields. The study findings agreed with that of Arunga et al. (2012) which found out that most farmers in the Country preferred maize and beans combination. Bouman's (2009) findings also conformed to the current study findings that a bigger percentage of households in Africa value maize and beans. However, the current study findings differed with the findings of a study by Obasi et al. (2013) & Fawole & Oladele, (2007) which listed crops such as yam, cassava, maize, vegetable and melon as the main crop combinations practiced in Nigeria

An interview with the key informant further revealed that:

> *Mixed cropping has enabled household farmers in the Sub-County to grow variety of crops on their farm, thus able to obtain food throughout the season since the systems allows them to grow both the perennial crops such as potatoes, cassava and banana and seasonal crops such as maize and beans. This has helped most households in this area to be somehow food secure. Mixed cropping has also improved soil fertility leading to high food production*
> (Rarieda Sub-County Agricultural Officer)

These sentiments revealed that a farmer who adopted mixed cropping systems of tubers and cereals obtained food on regular basis and was food secure.

Further, Chi-Square test was run to establish association between Mixed cropping (Table 8 Page 48) and household food security (Table 6 page 44). The results were as presented in Table 9.

Table 9: Chi-square Test Analysis on Association between Mixed Cropping Practices and Household Food Security

Mixed cropping practices and household food security			
		Maize and beans	% influence Perennial crops and seasonal crops
Mixed cropping practice	Strongly disagree	2.94	14.05
	Disagree	10.46	17.97
	Neutral	6.21	7.52
	Agree	39.22	29.74
	Strongly agree	41.18	30.72
	TOTAL	**100**	**100**
	df = 4; Pearson's Chi-Square = 0.001; Likelihood Ratio = 0.002		

The results in Table 9 found out that mixed cropping of maize and beans, and perennial crops and seasonal crops were significantly associated with household food security in Rarieda sub-County, at a 99% significance level (χ^2 - 0.001). An overwhelming 80.40% and 60.16% of the respondents agreed, that the planting of maize and beans, and perennial crops and seasonal crops, respectively, on the same piece of land and at the same time were key contributors to household food security in Rarieda sub-County. About 6.21% of the respondents observed neutrality in both cases of mixed cropping. Planting of maize and beans and perennial crops together with seasonal crops enabled households to have continuous food production, households also could access

variety of food items enabling them to be food secure. These findings agreed with the findings of Adjimoti & Kwadzo (2018) that revealed that mixed cropping contributed positively and significantly to rural household food security. However, the study by Adjimoti & Kwadzo (2018) used multi-dimensional food security index while the current study used Household Food Insecurity Access Scale to measure food security. Therefore, mixed cropping systems should be considered in the broader context to achieve food security.

4.5 Influence of Single Food Crop Farming on Household Food Security.

The third specific objective of the study set out to examine the influence of single food crop on household food security in Rarieda Sub-County, Siaya County. Table 10 displays a summary of the finding from the study area.

Table 10: Descriptive Statistics on Single Food Cropping and Household Food Security

Single Cropping Statements	Strongly agree 5	Agree 4	Neutral 3	Disagree 2	Strongly disagree 1	Mean	S. D
I do practice single food cropping regime in my farm	69(17.97%)	83(21.57%)	49(12.75%)	107(27.78%)	76(19.93%)	2.90	1.416
I practice plantation agriculture and this ensures I harvest high yields	60(15.69%)	88(22.88%)	45(11.76%)	127(33.01%)	64(16.67%)	2.88	1.358
Single cropping ensures ecological crop-matching and this leads to better yields	84(21.90%)	125(32.68%)	43(11.11%)	80(20.92%)	51(13.40%)	3.29	1.368
Single cropping regime focuses on household food needs and ensures the staple food is grown	108(28.10%)	119(31.05%)	49(12.75%)	68(17.65%)	40(10.46%)	3.49	1.341
Single cropping regime allows for mechanization and this ensures high productivity for food security	93(24.18%)	94(24.51%)	54(14.05%)	92(23.86%)	51(13.40%)	3.22	1.394
Single cropping regime is more suitable for subsistence farming due to the small-holder land sizes	117(30.39%)	129(33.66%)	41(10.78%)	64(16.67%)	33(8.50%)	3.61	1.302
Single cropping regime sometimes leads to severe famine during total crop failures	151(39.22%)	161(41.83%)	24(6.21%)	28(7.19%)	21(5.56%)	4.02	1.116
It is easy to master the agronomic practices employed on single cropping regime and this enhances crop yields and food security	120(31.37%)	128(33.33%)	30(7.84%)	61(16.01%)	44(11.44%)	3.57	1.373
Crop pests and diseases are more prevalent in single cropping regime and this negatively affects crop yields and food security	162(42.16%)	128(33.33%)	13(3.27%)	44(11.44%)	38(9.80%)	3.87	1.335
Composite Mean and Standard Deviation						**3.49**	**1.314**

Results in Table 10 revealed that about 28.10% of the household's respondents strongly agreed while 95(31.05%) agreed respectively that single cropping regime focused on household food needs and ensured the staple food is grown. For instance, Maize has been grown as a single food crop in Rarieda Sub-County for years and it is known to solve the problem of food security due

to its shorter growth cycle averaging about 90 days depending on the variety and the prevailing ecological conditions. For instance, Katumani maize variety has been embraced by most of the farmers due to its short maturity period and resistant to drought conditions. Therefore, it is serving the farmers very well because it is planted twice a year during both long rains (March - May) and short rains (Oct-Dec) hence more harvest from the farms. This finding agreed with the finding of a study by Kaguongo (2013) that revealed that maize forms one of the staple foods among Kenyan households and was widely planted by farmers across the County. However, the study by Kaguongo (2013) used the Malthusian theory which argued that populations inevitably expand until they outgrow the available food supply, causing the population to be reversed by diseases, famine war or calamity. The current study adopted FAD and FEET Theory so as to effectively address food security.

Out of the total number of respondents interviewed about 30.39% strongly agreed while 103(33.66%) agreed respectively that single cropping regime is more suitable for subsistence farming due to the small farm size (Refer to table 10). Household farmers in the Sub-County grow crops like maize as a sole crop on their farms majorly for family use. Most of the times the production is low due to striga weed menace and erratic and unreliable rainfall. Therefore, the little produce obtained by the household farmer is used for subsistence purpose. These findings confirmed the results in Table 6 which indicated that only 24.51% agreed that their farm produce could sustain the food needs of their households while 68.95% of the respondents revealed that their farm produce could not sustain food needs of their households.

Approximately, 42.16% of the respondents strongly agreed and 102 (33.33%) agreed respectively that crop pests and diseases were more prevalent in single cropping regime that negatively affected crop yield and food security (Refer to Table 10). Maize crops in the fields could be attacked by pest and diseases such as armyworms and Striga weed leading to huge loses. The armyworms reduced the foliage part of the maize crop interfering with photosynthesis process. They also fed on the center part of the maize crop from which new leaves shoot out hence weakening the entire maize crop. The weeds competed with the main crop for space and nutrients. This contributed to smaller harvests characterized by reduced maize cobs and fewer maize grains. Plate 3 shows single maize crop under armyworm attack in South Uyoma Location of Rarieda Sub-County.

Plate 3: Maize Crop under Armyworm Attack in South Uyoma Location

Source: Field data 2023

In Plate 3, maize crop which is the staple food for majority of households in Rarieda is attacked by armyworm. The armyworms reduced the foliage part of the maize crop interfering with photosynthesis process. They also fed on the center part of the maize crop from which new leaves shoot out hence weakening the entire maize crop. Therefore, if not checked can lead to huge losses thus escalating food insecurity in the Sub-County.

Further, the results in Table 10 revealed that 21.57 % of the respondents agreed while 17.975% strongly agreed that they practice single cropping regime, an indication that single cropping system was not a very popular agricultural practice in the study area. Some of the single food crops grown were maize, beans and ground nuts. Plate 4 below shows a single food crop of groundnuts on a farm in West Asembo.

Plate 4: Single Food Crop of Groundnuts on Farm in West Asembo Ward

Source: Field data 2023

From Plate 4, it is evident that, if embraced, single food crop farming can significantly contribute to household food security in the region. The crop is healthy and the soil is of good humus content. This observation where less than half of the population practice single food crop farming could be attributed to small farm sizes since 60% of the household had land sizes of 3ha and below as shown in Table 4. As a result, most respondents failed to adopt this farming system which had the ability to improve household food security. This finding agreed with the findings of a study by Oloo (2021) which revealed that 60% farmers in Ugunja Sub-County did not practice single cropping regime due to the small farm sizes. However, the study by Oloo (2021) focused on factors leading to food insecurity in Ugunja using Access Theory which focused only on accessibility dimensions of food security. The present study looked at the influence of agricultural systems on household food security using the FAD and FEET theory to effectively address the four dimensions of food security.

In addition, an interview with the key informant revealed that:

> *Single food crop farming systems is not very popular in this area due to small parcels of land. However, households that engage in these agricultural systems obtain high yields especially when they grow leguminous crops. Therefore, these systems can enable households that practices it be food secure.*
>
> (Rarieda Agricultural Officer)

Further analysis through Chi-Square test was run to establish association between Single food crop farming systems (Table 10 page 54) and household food security (Table 6 page 44) and the results were presented in Table 11.

Table 11: Chi-square Test Analysis on Association between Single Food Cropping Systems and Household Food Security

		% influence	
		Better yields	Famine
Single food cropping outcome	Strongly disagree	15.40	5.56
	Disagree	20.92	7.19
	Neutral	11.11	6.21
	Agree	32.68	41.83
	Strongly agree	21.90	39.22
	TOTAL	**100**	**100**
	df = 4; Pearson's Chi-Square = 0.103; Likelihood Ratio = 0.563		

From Table 11, the study noticed that single food crop farming was not a major contributor to household food security in Rarieda sub-County. The χ^2 – value of 0.103 points to the fact that the practice was weakly associated with household food security at 90% significance level. As much as 54.58% of the respondents observed that single food crop farming had better farm yields, about 81% of them reported that the practice led to famine in case of total crop failure. Therefore, Single food crop farming did not significantly achieve food security in Rarieda Sub-County. This findings agree with the findings of studies of Obonyo, Otieno & Angawa(2016) that revealed that 60% of household farmers in Ugunja did not practice single food crop farming because of small farm sizes. Therefore, Single food crop farming systems did not significantly contribute to household food security in Rarieda Sub-County.

In order to establish the association between the three agricultural systems together and household food security. Chi -square test analysis was conducted and the results were presented on Table 12.

Table 12 Chi-square test Analysis on Association between Agricultural Systems and Household Food Security in Rarieda Sub-County

		% influence		
		Home gardening	Mixed cropping	Single food crop farming
Household food security	Strongly disagree	3.68	0.91	15.64
	Disagree	11.96	2.74	6.13
	Neutral	23.62	4.27	23.31
	Agree	22.09	35.06	53.99
	Strongly agree	38.65	57.01	3.68
	TOTAL	**100**	**100**	**100**
	Degree of freedom	*4*	*4*	*4*
	Pearson's chi-square	*0.047*	*0.009*	*0.086*
	Likelihood ratio	*0.431*	*0.444*	*0.422*

Results in Table 12 indicate that Mixed cropping (χ^2 - 0.009) and home gardening (χ^2 - 0.047) were significantly associated with household food security in Rarieda sub-County. There existed a weak significant relationship between single food crop farming and household food security (χ^2 - 0.086). This weak relationship between single food crop farming and household food security was as a result of the continually reducing farm sizes with the on-going land subdivisions and fragmentations to meet the population needs. On the other hand, mixed cropping systems enabled the household respondents in Rarieda Sub-County to achieve food security. For instance, in mixed cropping systems, the household farmers grew variety of crops and that improved soil fertility especially when maize was intercropped with beans. Mixed cropping also cushioned farmers from experiencing total crop failure and reduced the prevalence of pest and diseases. Therefore, mixed cropping is significantly contributing to the model in predicting household food security. These findings agree with the findings of studies by Cho et al. (2016); & Adjimoti & Kwadzo (2018) & Baba & Abdulai (2021). However, the study by Cho et al. (2016) focused only on annual crops and not perennial crops. Further, the study by Cho et al. (2016) focused on utilization tenet of food security and employed Household Dietary Diversity Score (HDDS) to

measure food security. The current study focused on both annual and perennial crops and all the four dimensions of food security.

Home gardening systems on the other hand contributed to household food security by enabling households to achieve availability, accessibility, utilization and stability dimensions of food security. Households that had home gardens obtain food such as vegetables, tubers and animal products for consumption or sale thereby meeting the availability and accessibility dimensions of food security. Home gardening households could access variety of food stuffs and in consistent basis. These findings agreed with the findings of studies by Galhena et al. (2013); Musotsi et al. (2008) & Hansen, (2022). However, the study by Galhena et al. (2013) revealed that in Sri-lanka households also had medicinal plants under home a gardening system which was used by 80% of the people to treat various ailments. The current study did not consider the medicinal plants under home gardening systems. The study by Hansen et al. (2022) brought forth the concept of women empowerment through home gardening which was not the concern of the current study while the study by Musotsi et al. (2008) in Butere considered crops, vegetables and livestock aspects of home gardening systems. It failed to look at fruit trees and fish farming which have been included in the current study.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter highlights key findings in summary, conclusions and recommendations focusing on the influence of home gardening on household food security*;* mixed cropping influence on household food security, and single food cropping system influence on household food security.

5.2 Summary of the findings

The first objective of the study aimed to examine the influence of home gardening systems on household food security in Rarieda Sub County. The results indicate that 73.53% of the respondents practiced home gardening to boost household food security. Approximately, 67.65%, 33%, 59.15%, and 55.55% of the respondents significantly agreed, that horticulture, tubers, domestic animals and fish farming were home gardening practices contributing towards household food security (χ^2 - 0.026). Home gardening system enabled farm households in Rarieda Sub-County to achieve all the four dimensions of food security which include access, utilization, availability and stability

The second objective of the study aimed to determine the influence of mixed cropping on household food security in Rarieda Sub-County. Almost 69% of the households practiced mixed cropping to enhance food security with maize and beans being the most common mixed crops, at 80.4%. About 60.46% of the households intercropped perennial crops with seasonal crops. Approximately 67% of the respondents reported that mixed cropping made pest and diseases less prevalent while 55% revealed that mixed cropping saved households from experiencing total crop failure. Therefore, mixed cropping was significantly associated with household food security in Rarieda sub-County, at a 99% significance level (χ^2 - 0.001).

The third objective of the study aimed to establish the influence of single food cropping on household food security in Rarieda Sub County. The current study results indicated that single food crop farming was not a major contributor to household food security in Rarieda sub-County. The χ^2 – value of 0.103 points to the fact that the practice was weakly associated with household food security at 90% significance level. As much as 54.58% of the respondents observed that single food crop farming had better farm yields, about 81% of them reported that

the practice led to famine in case of total crop failure. Therefore, Single food crop farming did not significantly achieve household food security in Rarieda Sub-County.

Among the three agricultural systems, mixed cropping (χ^2 - 0.009) and home gardening (χ^2 - 0.047) were significantly associated with household food security in Rarieda sub-County. While single food crop farming indicated a weak significant relationship with household food security (χ^2 - 0.086). This weak relationship between single food crop farming and household food security was as a result of the continually reducing farm sizes with the on-going land subdivisions and fragmentations to meet the population needs.

5.3 Conclusion

Home gardening systems enhanced household food security in Rarieda Sub-County. Therefore, alternative hypothesis which stated that home gardening influenced household food security was confirmed to be true while null hypothesis was rejected.

Mixed cropping systems improved household food security in Rarieda Sub-County due to its ability to improve soil fertility and reduce prevalence of pest and diseases. Therefore, the alternative hypothesis was confirmed to be true while null hypothesis was rejected.

Single food crop farming systems was not a major contributor to household food security in Rarieda sub-County because most households had small farm size. Therefore, null hypothesis which stated that single food crop farming systems does not influence household food security was accepted while alternative hypothesis was rejected.

The results from the Chi-square test for the three agricultural systems analyzed together against their collective influence on household food security found out that mixed cropping and home gardening were significantly associated with household food security in Rarieda Sub-County while single food crop farming systems was weakly associated with household food security in Rarieda Sub-County.

5.4 Recommendations

For policy and practices the here-in highlighted recommendations were made to be implemented by government agencies and other mandate related stakeholders;

i. Home gardening should be promoted such that in the households' backyards are food production systems that should be utilized to enhance food security.

ii. Mixed cropping should be emphasized in order to ensure that households do not suffer from severe impacts of climate change and environmental conditions that can lead to total crop failures thus negatively influencing food security.

iii. Single cropping regimes for crops that do well when planted without intercropping and with proven ecological matching should be encouraged but regularly rotated to control crop pest and diseases.

5.5 Areas suggested for Further Research

The study hereby suggests that factors that influence food security in Rarieda Sub-County other than the agricultural systems be studied.

The study also suggests that environmental factors besides socio-economic factors that influence food security be studied and recommendations made on how to surmount them to improve on the food security in Rarieda Sub County.

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APPENDICES

Appendix A: Participants consent form

Eunice Achieng Anyona

MASENO UNIVERSITY

Dear Respondent.

RE: PARTICIPANTS CONSENT FORM

You are requested to participate in a research study on the influence of agricultural systems on household food security in Rarieda Sub-County of Siaya-County Kenya. The objectives of the study are to examine the influence of home gardening systems on household food security, determine the influence of mixed cropping on household food security and establish the influence of single food crop farming on household food security. All your responses and information provided will be treated with confidentiality and your identity remain anonymous. You are free to seek clarification by asking questions before agreeing to be part of the study. In addition, you are free to withdraw from the study at any time without fear of being victimized.

I have been briefed on what the study is about. I am assured that the information I will give is confidential and I therefore agree to participate in the above study.

_____ _____

Signature Date

Appendix B: Questionnaires

TITLE: INFLUENCE OF AGRICULTURAL SYSTEMS ON HOUSEHOLD FOOD SECURITY IN RARIEDA SUB-COUNTY

WARD……..LOCATION……SUBLOCATION

My name is Eunice Achieng Anyona, a finalist student pursuing Master of Arts in Geography at Maseno University. I am conducting a research study focusing on "Influence of Agricultural systems on household food security in Rarieda Sub-County, Siaya County, Kenya". You have been selected to participate in the study. Your participation is entirely voluntary and the questionnaire is completely anonymous. Please be assured that the information is sought for research purposes and your responses will be treated with absolute confidence. No individual respondents will be named and thus your identity will not be published or released to anyone. Kindly answer all the questions by marking as guided.

Thank you very much for participating in this study.

SECTION A: (Socio-Demographic Characteristic of the Respondents)

Personal details

(a) Gender: Male Female (Tick where applicable)

(b) Your Age in years 18-35 36-50 51-65 66-70 > 71years

c) What is your level of education? (Tick where applicable)

None primary Secondary Certificate and diploma

Degree and above

(d) Who is the head of this household?

Male headed Female Headed

(e)What is the size of your household? (Tick where applicable)

(i) 1 (ii) 2-5 (iii) 6-8 (iv) 8 and above

(f)What is your main occupation? (Tick where applicable)

(i)Formal Employment (ii) Casual laborer (iii) Business (iv) Farming
(v) Fishing

(g) What is your monthly income (KSH)? (Tick where applicable)

0- 4000 (ii) 4001-10000 (iii) above10000

(h)Approximate size of land

1-3ha 4-6ha Above 7ha Others specify

SECTION B: Examine the Influence of Home Gardening Systems on Household Food Security.

The section requires you to rate the statements depending on your agreement levels at the intersection of statement/weight. 5 means the highest level of agreement while 1means the least in descending order

Item	Home Gardening Statements	Strongly agree 5	Agree 4	Neutral 3	Disagree 2	Strongly disagree 1
B1	I do practice home gardening to boost household food security					
B2	Vegetables and other horticultural crops are the most preferred crops grown under home gardening					
B3	Tubers are common crops grown under home gardening					
B4	Grains and cereal crops are major crops grown under home gardening					
B5	Fish farming and aquaculture is practiced under home gardening					
B6	Domestic animals in home gardening are majorly kept for food and dietary supplements					
B7	Domestic animals in home gardening are reared majorly for their by-products like manure, skin and biogas; and services like transport and animal power					
B8	Domestic animals in home gardening are reared mainly for sale to provide income					
B9	Domestic animals in home gardening are reared for socio-cultural purposes like to pay dowry and maintain high social status in the community					
B10	There are fruit orchards in home gardening that provide fruits and income to the households					

Which crops do you grow in your home garden and what is the harvest in bags

Crops	Harvest in bags

2.Do you sell the produce from your home garden? YES/NO (Tick where applicable)

a) If YES, how much do you earn from the sale of:

a) Crop produce …….

b) Tree products …….

c) Livestock produce ……..

b) If NO why?.....

3. How do you spend the money obtained from the sale of the crops, livestock and tree products? (Tick where applicable)

a) Buy other food products.

b) Pay school fees.

c) Pay medical bills.

d) Other uses…….

……

4. Do you use any animal products on crop production? YES/NO (Tick where applicable) (a) If YES, which ones?

(i)……..

(b) If NO, why…….

5. How often do you use the above stated products on crop land?

(a) More often (b) Often (c) Less often

6. What is the influence of the use of the above stated animal products on crop production?

(i)……..

7. Do you use any crop products on animal production? YES/NO (Tick where applicable) If yes which ones?

i)……

ii)……

If NO, why?.....

8.How often do you use the above stated crop products on animal production?

(i) More ☐ often (ii) Often (iii) Less often

9.What is the influence of the above stated crop products on animal production?

……

……

10.Do you practice fish farming under home gardening? YES/NO

11. Does fish farming under home gardening systems improve your household food security? YES/NO

If YES give reasons……

If NO give reasons……

12. Why do you engage in home gardening? (Tick where applicable)

(i) To produce food for the family

(ii) To generate additional income

(iii) As a means of employment

(iv) Others, specify …….

……

13. What are some of the factors that affect productivity of your home garden?

(i) Shortage of land

(ii)Poor soils

iii)Lack of finances

iv)Unavailability of information and advisory support

v) Damage by livestock

14.In your opinion, has home gardening improved your food security status? YES/NO (Tick where applicable)

If YES, Give reasons……

…….

If NO, Give reasons …….

……..

SECTION C: Determine the Influence of Mixed Cropping on Household Food Security.

The section requires you to rate the statements depending on your agreement levels at the intersection of statement/weight. 5 means the highest level of agreement while 1mean the least in descending order

Item	Mixed Cropping Statements	Strongly agree 5	Agree 4	Neutral 3	Disagree 2	Strongly disagree 1
C1	I do practice mixed cropping regime to enhance my household food security					
C2	Maize and beans is the most common mixed crop regime with most households					
C3	Mixed cropping regime gives better yields than mono-cropping regime					
C4	Mixed cropping regime makes pest and diseases less prevalent					
C5	Households rarely experience total crop failure under mixed cropping regime					
C6	Crop diversification cushions farmers from weather related crop failure under mixed cropping regime					
C7	Mixed cropping promotes conservation agriculture and the land can sustain high crop yields over a long period of time					
C8	Mixed cropping enhances dietary options available for the households					
C9	Mixed cropping regime gives surplus yields that can be sold to acquire other household needs not harvested from the farm					
C10	In mixed cropping regimes perennial crops are grown with seasonal crops and this ensures continuous supply of food to the households					

15.Does the yield harvested last you to the next harvest? YES\NO (Tick where applicable)

(a) If NO:

i.How many months does it last?.....

ii.Where do you get food after your produce is finished?

a. ……

b. ……

c. ……

(b) (i) If YES, do you produce any surplus for sale? YES\NO (Tick where applicable)

(ii)If YES, what do you use the money accrued from the sale for?

a) Buy other food products
b) Pay school fees
c) Pay medical bills
d) Other uses (specify) ……

……

16.In your opinion has mixed cropping improved your household food security status? YES/NO? (Tick where applicable)

If YES, Give reasons……

…..……..

If NO, Give reasons…….

……

SECTION D: Establish the Influence of Single Food Crop Farming and Household Food Security.

The section requires you to rate the statements depending on your agreement levels at the intersection of statement/weight. 5 means the highest level of agreement while 1mean the least in descending order

Item	Single Cropping Statements	Strongly agree 5	Agree 4	Neutral 3	Disagree 2	Strongly disagree 1
D1	I do practice single cropping regime is my farm					
D2	I practice plantation agriculture and this ensures I harvest high yields					
D3	Single cropping ensures ecological crop-matching and this leads to better yields					
D4	Single cropping regime focuses on household food needs and ensures the staple food is grown					
D5	Single cropping regime allows for mechanization and this ensures high productivity for food security					
D6	Single cropping regime is more suitable for subsistence farming due to the small-holder land sizes					
D7	Maize is predominantly grown in the single cropping regimes and the staple food for most households in Rarieda					
D8	Single cropping regime sometimes leads to severe famine during total crop failures					
D9	It is easy to master the agronomic practices employed on single cropping regime and this enhances crop yields and food security					
D10	Crop pests and diseases are more prevalent in single cropping regime and this negatively affects crop yields and food security					

17.Do you practice single food crop farming. YES/NO (Tick where applicable)

a) If YES, which single food crop do you grow? How much is the harvest (in bags)

.....

……

b) If NO, Why?.....

18.Does Single Food Crop farming influence food security in Rarieda Sub-County. YES/NO (Tick where applicable)

(a)If YES, State how…….

……

(b) If NO, give reasons…….

…….

SECTION E: HOUSEHOLD FOOD SECURITY

The section requires you to rate the statements depending on your agreement levels at the intersection of statement/weight. 5 means the highest level of agreement while 1mean the least in descending order

Item	Household Food Security	Strongly agree 5	Agree 4	Neutral 3	Disagree 2	Strongly disagree 1
E1	We produce enough in my household to last to the next season					
E2	The farm produce can sustain the foods needs of my household					
E3	We buy most of our household food requirement from the market					
E4	We depend on food donation from relatives for our household needs					
E5	We can afford to have all the three means a day					
E6	Our meals are made of balance diet and in enough proportions					
E7	We sell our surplus to the market to supplement our income for other household expenditure like school fees					
E8	The food we consume is highly nutritious and is available throughout the year					
E9	There is enough food supply in the local market and is easily affordable without having to travel far					
E10	We sometimes go hungry without food up to 2 days or even more					

19. How many meals do you take in a day?

……

20. What is the main food taken in this household mostly?

……

21. What is the source of the food in this household?

……

23. What was maize yield last season? .....

This season? .....

23. How do you evaluate your household food security status? i. Food secure ii. Food insecure

Appendix C: Key Informant Interview Guide

Tittle: INFLUENCE OF AGRICULTURAL SYSTEMS ON HOUSEHOLD FOOD SECURITY IN RARIEDA SUB COUNTY, SIAYA COUNTY, KENYA

WARD**……**LOCATION**……**SUB LOCATION

DATE**……** GENDER OF RESPONDENT**……..**

MAIN OCCUPATION**……**

1.What is the approximate bags of maize, beans and millet that a household farmer harvests every season.

……..

……..

2.(a) What are the reasons for low crop produce in this area?

……..

……

……

(b)Why do most farmers in this region sell there produce at lower price during harvesting seasons?

……

……

3(a) Has home gardening systems improved household food security?

……

……

3(b) What are the challenges facing home gardening systems?

(i)……..

(ii)……

(iii)……..

(c) What are the challenges experienced by those practicing fish farming under home home gardening system.

(i)…….

(ii)……

(iii)…….

4(a). List the advantages of mixed cropping systems

(i)……

(ii)……

(iii)……

iv)……...

b). In your opinion, has mixed cropping improve household food security?

……

……..

5.What are the limitations of single food crop farming?

i)……

ii)……

iii) ……

iv)……

6.What do people do when there is shortage of food?

i)……

ii)……

Appendix D: 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 lack of resources?

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

3. Did you or any member of your household 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 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 you 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 (3) 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 E: Observation Checklist

TITLE: IFLUENCE OF AGRICULTURAL SYSTEMS ON HOUSEHOLD FOOD SECURITY IN RARIEDA SUB-COUNTY.

Ward……...Location…… Sub-location……...

Date……...Gender of the respondents……main occupation…….

1. Challenges of home gardening systems

2. The types of fruit trees planted by respondents

3. Types of livestock kept by respondents in Rarieda Sub-County.

4. The various types of agricultural systems in Rarieda Sub-County

5.The size of farm for respondents in the Sub-County

Appendix F: MUERC

MASENO UNIVERSITY SCIENTIFIC AND ETHICS REVIEW COMMITTEE

Tel: +254 057 351 622 Ext: 3050
Fax: +254 057 351 221
Private Bag – 40105, Maseno, Kenya
Email: muerc-secretariate@maseno.ac.ke

REF: MSU/DRPI/MUSERC/01146/22 **Date**: 9th November, 2022

TO: Eunice Achieng Anyona
MA/ NS/ 00071/018
Department of Geography and Natural Management
School of Arts and Social Sciences, Maseno University
P. O. Box, Private Bag, Maseno, Kenya

Dear Madam,

RE: Influence of Agricultural Systems on Household Food Security in Rarieda Sub County, Siaya County, Kenya

This is to inform you that **Maseno University Scientific and Ethics Review Committee (MUSERC)** has reviewed and approved your above research proposal. Your application approval number is MUSERC/01146/22.The approval period is 9th November, 2022 – 8th November, 2023.

This approval is subject to compliance with the following requirements;

i. Only approved documents including (informed consents, study instruments, MTA) will be used.
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by Maseno University Scientific and Ethics Review Committee (MUSERC).
iii. Death and life threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to Maseno University Scientific and Ethics Review Committee (MUSERC) within 24 hours of notification.
iv. Any changes, anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to Maseno University Scientific and Ethics Review Committee (MUSERC) within 24 hours.
v. Clearance for export of biological specimens must be obtained from relevant institutions.
vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.
vii. Submission of an executive summary report within 90 days upon completion of the study to Maseno University Scientific and Ethics Review Committee (MUSERC).

Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) https://oris.nacosti.go.ke and also obtain other clearances needed.

Yours sincerely

09 NOV 2022

Prof. Philip O. Owuor, PhD, FAAS, FKNAS
Chairman, MUSERC

MASENO UNIVERSITY IS ISO 9001 CERTIFIED

Appe

Appendix G: Research Permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **301708**

Date of Issue: **12/April/2023**

RESEARCH LICENSE

This is to Certify that Ms.. EUNICE ACHIENG ANYONA of Maseno University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Siaya on the topic: INFLUENCE OF AGRICULTURAL SYSTEMS ON HOUSEHOLD FOOD SECURITY IN RARIEDA SUB COUNTY, SIAYA COUNTY, KENYA. for the period ending : 12/April/2024.

License No: **NACOSTI/P/23/25123**

301708

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

See overleaf for conditions

THE SCIENCE, TECHNOLOGY AND INNOVATION ACT, 2013 (Rev. 2014)
Legal Notice No. 108: The Science, Technology and Innovation (Research Licensing) Regulations, 2014

The National Commission for Science, Technology and Innovation, hereafter referred to as the Commission, was the established under the Science, Technology and Innovation Act 2013 (Revised 2014) herein after referred to as the Act. The objective of the Commission shall be to regulate and assure quality in the science, technology and innovation sector and advise the Government in matters related thereto.

CONDITIONS OF THE RESEARCH LICENSE

1. The License is granted subject to provisions of the Constitution of Kenya, the Science, Technology and Innovation Act, and other relevant laws, policies and regulations. Accordingly, the licensee shall adhere to such procedures, standards, code of ethics and guidelines as may be prescribed by regulations made under the Act, or prescribed by provisions of International treaties of which Kenya is a signatory to
2. The research and its related activities as well as outcomes shall be beneficial to the country and shall not in any way;
    i. Endanger national security
    ii. Adversely affect the lives of Kenyans
    iii. Be in contravention of Kenya's international obligations including Biological Weapons Convention (BWC), Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO), Chemical, Biological, Radiological and Nuclear (CBRN).
    iv. Result in exploitation of intellectual property rights of communities in Kenya
    v. Adversely affect the environment
    vi. Adversely affect the rights of communities
    vii. Endanger public safety and national cohesion
    viii. Plagiarize someone else's work
3. The License is valid for the proposed research, location and specified period.
4. The license any rights thereunder are non-transferable
5. The Commission reserves the right to cancel the research at any time during the research period if in the opinion of the Commission the research is not implemented in conformity with the provisions of the Act or any other written law.
6. The Licensee shall inform the relevant County Director of Education, County Commissioner and County Governor before commencement of the research.
7. Excavation, filming, movement, and collection of specimens are subject to further necessary clearance from relevant Government Agencies.
8. The License does not give authority to transfer research materials.
9. The Commission may monitor and evaluate the licensed research project for the purpose of assessing and evaluating compliance with the conditions of the License.
10. The Licensee shall submit one hard copy, and upload a soft copy of their final report (thesis) onto a platform designated by the Commission within one year of completion of the research.
11. The Commission reserves the right to modify the conditions of the License including cancellation without prior notice.
12. Research, findings and information regarding research systems shall be stored or disseminated, utilized or applied in such a manner as may be prescribed by the Commission from time to time.
13. The Licensee shall disclose to the Commission, the relevant Institutional Scientific and Ethical Review Committee, and the relevant national agencies any inventions and discoveries that are of National strategic importance.
14. The Commission shall have powers to acquire from any person the right in, or to, any scientific innovation, invention or patent of strategic importance to the country.
15. Relevant Institutional Scientific and Ethical Review Committee shall monitor and evaluate the research periodically, and make a report of its findings to the Commission for necessary action.

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