ECONOMIC DETERMINANTS INFLUENCING PARTICIPATION IN FOOD CROP DIVERSIFICATION AMONGST SMALLHOLDER SUGARCANE FARMERS IN MUMIAS EAST SUB-COUNTY, KAKAMEGA COUNTY, KENYA

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DECLARATION AND APPROVAL

Declaration

This thesis is my original work and has not been presented for the conferment of a degree or award of a diploma in this or any institution: -

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DEDICATION

This thesis is dedicated to my parents for their constant encouragement and unceasing support during the entire period of my studies. I also dedicate this thesis to my siblings for their moral, financial and social support. May Almighty God abundantly reward all of you.

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This research thesis would not have been accomplished without the support and contributions of others. Firstly, I wish to sincerely thank the Almighty God for offering me life and profound grace. Secondly, my humble appreciation goes to my supervisors, Dr Elijah Ng'eno and Dr Naomi Rioba for their tireless support, encouragement and guidance through the conception and development of this research thesis. Finally, to all who in one way or the other, contributed significantly to the success of this study, may the Almighty God abundantly reward your efforts.

ABSTRACT

Crop diversification is a predominantly important coping mechanism for agriculture's income, production and marketing risks. It is a key strategy for mitigating food insecurity among small-scale farmers in Kenya. It enables them to spread production and income risk, reducing livelihood vulnerability to weather or market shocks. Crop diversification among sugarcane farmers has been on the rise over time due to risks associated with sugarcane production and marketing and declining sugarcane productivity. Consequently, this has led to impaired sugarcane farmer households' goals of improving food, income and nutrition security. Therefore, the general objective of this study was to analyse economic determinants affecting participation in food crop diversification amongst smallholder sugarcane farmers in Mumias East, Kakamega County, Kenya. The specific objectives of the study were to determine the socio-economic factors, and factors influencing smallholder sugarcane farmers' participation and to estimate the income differentials in diversified cropping systems. The study was guided by Random Utility Maximization (RUM) theory and descriptive and cross-sectional research designs were adopted. Multistage sampling whereby purposive, stratified and systematic random sampling techniques were employed in the study to select 154 farmers from a target population of 11,885 smallholder sugarcane farmer households. A questionnaire was used to collect data on Socio-economic factors and other factors influencing participation and income differentials. The data was analysed using multivariate regression, farm gross margin and logistic regression models with the help of STATA version 16 software. The analysed data was presented in the form of tables. Descriptive results revealed that the mean age and farming experience of the farmers were 55.72 and 22.76 years respectively and owned on average 4.33 hectares of land. Multivariate linear regression results indicated that age, household income level, education level, land size and household size were all statistically significant and had an influence on food crop diversification among smallholder sugarcane farmers. Binary logistic regression results indicated that a unit increase in age, level of education, land size, membership to a farmer group and market price positively influenced farmer participation in diversified cropping systems by 117%, 81.7%, 745.5%, 228.2% and 117.3% respectively. Gross margin results revealed a significantly higher value of revenues for diversified cropping systems of farming of KShs. 42,959.73 as compared to non-diversified of KShs. 35,634.69. Sugarcane production generated the maximum GM of Kshs. 61,371.47 per acre per season whereas maize, potatoes, cabbages, sorghum, beans and millet crop enterprises produced returns of Kshs. 57,609.82, KShs. 37,413.16, KShs. 33,856.20, KShs. 21,371.18, Kshs. 19,741.60 and Kshs. 16,246.33 per acre respectively. Therefore, from the results of this study, relevant stakeholders, county and national governments should come up with an agricultural policy that supports the shift from non-diversification to crop diversification through the development of guaranteed access and subsidies to farm inputs resources that will help boost farm production among smallholder sugarcane farmer

households. Likewise, more farmers need to be trained on food crop diversification through the strengthening of the extension services. This will help to solve the issues of food insecurity and also help farmers realize high profit margins from their farm output.

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ABBREVIATIONS AND ACRONYMS

AGRA	Alliance for a Green Revolution in Africa
ASALs	Arid and Semi-Arid Lands
ASDS	Agricultural Sector Development Strategy
AWSC	African Women Studies Centre
CAADP	Comprehensive Africa Agriculture Development Programme
CC	Climate Change
CDI	Crop Diversification Index
CEO	Chief Executive Officer
CIDP	County Integrated Development plan
COMESA	Common Market for East and South Africa
CSA	Climate Smart Agriculture
FAO	Food and Agriculture Organization
FAW	Fall Armyworm
GDP	Gross Domestic Product
GM	Gross Margin
GoK	Government of Kenya
HVCs	High Value Crops
IFAD	International Fund for Agricultural Development
KALRO	Kenya Agriculture and Livestock Research Organization
KARI	Kenya Agricultural Research Organization
KSh.	Kenya Shillings

KSB	Kenya Sugar Belt
MAFF	Ministry of Agriculture, Forestry and Fisheries
MDG	Millennium Development Goals
MLR	Multivariate Linear Regression
MoA	Ministry of Agriculture
MSC	Mumias Sugar Company
NACOSTI	National Commission for Science Technology and Innovation
NPV	Net Present Value
RUM	Random Utility Maximization Theory
SAPs	Sustainable Agricultural Practices
SDGs	Sustainable Development Goals
STATA	Statistical Analysis
SSA	Sub Saharan Africa
TR	Total Revenue
TVC	Total Variable Cost
UN	United Nations
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Emergency Fund
UN-OSAA	The United Nations Office of the Special Adviser on Africa
VIF	Variance Inflating Factor
WFP	World Food Programme
WHO	World Health Organization

OPERATIONAL DEFINITION OF TERMS

Diversification: It is the process of shifting from less profitable crops like sugarcane to other profitable crops. In this study. It was an important coping mechanism for income, production and marketing risks among sugarcane farmers in the study area.

Food security: It is the situation in which all people at all times have physical and economic access to sufficient, safe and nutritious food enabling them to meet their dietary needs and food preferences for an active and healthy life.

Household: It is a knowledgeable person in the household who will be interviewed to provide the necessary information.

Smallholder farmers: They are the farmers who grow sugarcane on an area of between 0.2 and 5 hectares under these crops.

Extension: It is passing new knowledge to farmers through farmer education.

Socio-economic factors: It is the farmer household's social factors such as age, marital status, income, and beliefs that affect the production and food crop diversification by smallholder sugarcane farmers in the study area.

Economic Factors: In this study, economic factors refer to factors that affect the discretionary income and purchasing power of households and eventually affect food crop diversification by smallholder sugarcane farmers in the study area. Such factors include production and marketing factors. Others include labour costs, equipment costs, limited supplies, and cost of

administration in food crop diversification.

Economic Effects: It is the effect of economic factors on crop diversification on the living standards of smallholder sugarcane farmers.

Diversified cropping system: It is the practice of producing a variety of crops on one farm, as distinguished from specializing in a single commodity.

Gross Margin: It is the amount of total sales revenue that the farmer retains after incurring the direct costs associated with producing a crop.

Return on labour and capital: It is an investment such as sugarcane farming to give return to what has been invested in it in terms of human labour and capital.

CHAPTER ONE

INTRODUCTION

1.1 Overview

This chapter provides the background information, statement of the problem, general and specific objectives of the study, hypothesis, justification, significance, scope, limitations and assumptions of the study.

1.2 Background Information

All over the world, enough food is produced to attain the food security of a nation (Islam, 2005). However, the number of people who are malnourished globally has been on the rise from 840 million to 925 million in 2010, with approximately 98% living in third-world countries (Food and Agriculture Organization, FAO, 2015). Over time, the world has been grappling with hunger and poverty. Whenever hunger and poverty arise; agricultural sector performance is viewed as a strategy for food security, economic growth and poverty reduction (FAO, 2015). In this regard, many countries in the world have strategized to eradicate poverty and hunger through agriculture as documented in many global policy statements on hunger and poverty eradication for example; the Green Revolution which was introduced in the 1960s to deal with issues of malnutrition in the developing world (Sebby, 2010). This was a response technologically to a worldwide food scarcity which was a threat in the time after the Second World War. According to Fitzgerald & Parai (1996) (cited in Sebby, 2010), the Green Revolution improved farming practices in many parts of the tropical and sub-tropical regions where the

primary food crops were rice, wheat and sugarcane. The technology employed the use of improved high-yielding varieties of seeds as well as chemical fertilizers. The Green Revolution has been credited with increasing yields in many places where it was embraced though resulting in unequal benefits across regions and groups (Sebby, 2010).

The United Nations (UN) Millennium declaration of the year 2000 found out that one eighty-nine (189) nations guaranteed to relief people of numerous deprivations, acknowledging each persons right to dignity, freedom, equality as well as basic standards of living; freedom from hunger and Violence (FAO, 2015). This declaration devoted nations to a new universal partnership to decline extreme poverty and establish a series of eight time-bound targets that have been branded as Millennium Development Goals (MDGs), with a deadline of 2015 (United Nation Development Plan (UNDP), 2015a). The first of the eight MDGs was to eliminate extreme poverty and hunger.

Furthermore, the Sustainable Development Goals (SDGs), otherwise known as Global goals were developed in 2015. SDGs are a universal plea to action for poverty eradication, planet protection and safeguarding peace and prosperity for all people who enjoy building on the achievements of MDGs (UNDP, 2015b). It is however recognized that the greatest global challenge and an essential requirement for sustainable development is to eradicate poverty in all its forms and dimensions including extreme poverty, (UN, 2015). Despite of the progress in the fight against hunger, an unacceptably huge number of people

are still food insecure (FAO, 2015). It is alarming that the number of undernourished people in 2016 increased to 815 million from 2015's 777 million (WHO, 2017).

In Africa, 20.4 percent of the continent's population which is approximately 257 million people are undernourished, up from 19.7 in 2016 which is approximately 241 million people. In sub-Saharan Africa, there were 237 million undernourished in 2017, up from 222 million in 2016 (FAO, 2018). The worsening situation in Africa is due to difficult global in economic conditions and, in many countries, conflict and climate-related disasters, sometimes in combination. Economic growth slowed in 2016 due to weak commodity prices, in particular for oil and minerals. Food insecurity has worsened in countries affected by conflict, often exacerbated by drought or floods, and in Southern and Eastern Africa, many countries have been adversely affected by prolonged drought. Notably, several countries have achieved sustained progress in reducing food insecurity in the face of challenging circumstances.

In recognizing that agriculture is key to her development towards global goals of ending hunger and poverty, and reducing food insecurity in the face of challenging circumstances, Africa developed a comprehensive policy framework for the transformation of the sector; Agenda 2063. Agenda 2063 is a strategic framework for the socio-economic transformation of the continent over the next 50 years. It builds on and seeks to accelerate the implementation of past and existing continental initiatives for growth and

sustainable development (African Union Commission, 2015). Reforms in the sector are advocated for in the framework, important ones being a growth of 6% annually in Agricultural GDP and at least 10% allocation from the public expenditure to the agriculture sector. Africa acknowledges that enhanced performance of the agricultural sector is strategic to economic development and poverty reduction by directly contributing to job creation, increasing opportunities for women and youth, and enhancing food and nutrition security and resilience (UN-OSAA 2015). In addition, he acknowledged agriculture as a significant driver of economic growth whose power is also accredited by economists and political leaders since it is the sector that has enormous potential for the reduction of poverty and inequality (NEPAD, 2003).

Crop diversification is increasing across the world in favour of more competitive and high-value crops. It has enabled farmers to spread production and income risk; and therefore, reduced livelihood vulnerability to weather or market shocks (FAO, 2018; Mango et al., 2018). Nguyen (2014) defines crop diversification as the strategy of shifting from less profitable crops, changing variety and cropping systems, and increasing exports and competitiveness in both domestic and international markets. Clements et al., (2011) and Feliciano (2019) relate crop diversification to the replacement of low-value commodities by high-value commodities, usually fruits and vegetables for the export market.

Farmers in Africa have long adapted to climatic and other risks by diversifying their farming activities (Ebi et al., 2011), which may increase their ability to cope with change. This can happen by spreading the risk among different crop

and livestock types (Antwi-Agyei, Stringer, & Dougill, 2014), income diversification (Block and Webb, 2001) or by increasing the range of agricultural products for markets or subsistence (McCord, Cox, Schmitt-Harsh, & Evans, 2015). Selling their own products is also very important for overall food security outcomes for farmers in sub-Saharan Africa. Eighty-three percent of farm households in sub-Saharan Africa sell part of their crop produce, sometimes even before they produce enough to be self-sufficient (Frelat et al., 2016). Also, many African farmers own livestock as insurance during periods of drought (Kazianga & Udry, 2006). One way of measuring agricultural diversity is to assess the crop and farming diversity, that is, the number of crops grown and the number of overall farming activities including livestock husbandry (Frelat et al., 2016).

In East Africa, many communities depend largely on agricultural products for their livelihoods (Altieri, 1999). The majority of farmers here are smallholders owning less than 5 acres (2 hectares) of land (which is likely to be further reduced due to current land fragmentation and unregulated urban centre expansion) and practising “low-resource” agriculture (Altieri, Funes-Monzote, & Petersen, 2012). These farmers are more vulnerable to the overall effects of climate change since they have limited resources to invest in expensive coping strategies (Lin, 2011). Crop diversification is seen as one of the most ecologically feasible, cost-effective, and rational ways of reducing uncertainties in agriculture, especially among small-scale farmers. This strategy is based on cultivating more than one variety of crops belonging to

the same or different species in a given area. Crop diversification brings about higher spatial and temporal biodiversity on the farm and increases resilience, for example, the ability of an agroecosystem to return to its original productive state after being perturbed (Holling, 1973).

The East Africa region has been ravaged by perennial food insecurity. The governments in the region, the donor community, regional economic blocks and the Farmer Organizations (FOs) have been putting a lot of effort and resources into addressing this issue. One of the main objectives of the East Africa Community (EAC) as set out in the treaty is the achievement of food security and rational agricultural production (EAC food policy, 2005). To meet the global food human needs by 2050, the world's agricultural system must simultaneously produce far more food for a growing population and provide economic opportunities for the rural poor who depend on agriculture for their livelihoods (Roberto, et al 2013). The only way to solve the above is through food crop diversification.

The government of Kenya has emphasized on crop diversification and value addition in agriculture. Key areas of policy concern and strategy highlighted in Kenya Vision 2030 include catalysing enhanced agricultural productivity, food security and income growth through crop diversification. In line with government policy, Kakamega County has developed a strategic plan on promoting diversification of crop and livestock enterprise (County Integrated

Development Plan 2017-2022, (2018). Agriculture is one of the key sectors targeted to bring out development in the county as documented in the County Integrated Development Plan 2017-2022 (2018). Poverty and food insecurity, however, remain a foremost challenge in the County (Kakamega County CIDP, 2018). Agriculture can alleviate poverty by enhancing food security, creating employment and generating income for the County's population. According to Waswa, et al., (2012), results of their findings from Lurambi, Koyonzo and Chemelil areas in western Kenya show that on average, farmers retained only 31, 32 and 34% respectively of the gross income from contract sugarcane farming. Although net income was influenced differently by conventional input costs, yield appears to be a key determinant of gross income across the sites. Net income was significantly depressed by company-driven deductions for which farmers had no control. Such skewed sharing of income, where the sugar companies retain at least 60% of the gross income raises sustainability concerns that need to be addressed through a participatory approach involving all key stakeholders (Waswa, et al., (2012).

The smallholder sugarcane farmers in the study area continue to suffer largely owing to production and marketing risks associated with sugarcane production. Declining sugarcane production has impaired smallholder sugarcane farmer's goals of improving food, income and nutrition security, especially in the study area. Cropping system diversification is one of the potential strategies for sustaining agricultural productivity and coping with

marketing risks. It is also a transitional step from subsistence to commercial agriculture (Rehima et al., 2013). It reduces uncertainties in agricultural productivity and income among smallholder farmers, production stability and marketing (Makate et al., 2016). Empirical findings reveal that those engaged in diversified cropping systems are more likely to experience increased agricultural productivity (FAO, 2018), yield stability, nutrition diversity and food security (Mango et al., 2018). Mehta (2005) and Behera et al., (2007) observed that crop diversification leads to comparatively high net return from crops, optimization of resource use and high land utilization efficiency. Li et al., (2009) observed that farmers with diversified cropping realized increased yields between 33.2% and 84.7% in Yunnan province of China.

Mumias East Sub-County is a major sugarcane-producing sub-county in Kakamega County, Kenya. It produces sugarcane of the total 192, 532 metric tons in the country (CIDP, 2018). In 2015, Mumias East Sub-County produced 632,000 metric tons of sugarcane (Ministry of Agriculture Livestock and Fishery (MoALF, 2020). However, the smallholder sugarcane farmers continue to suffer largely owing to production and marketing risks. Although sugarcane production is the most important in terms of economic contribution and livelihood generation, its productivity in the sub-county has largely declined from 632,000 in 2015 to 193,532 metric tons in 2020 (MoALF, 2020). These problems lead to the perennial sugarcane decline in the sub-country and consequently, farmers are forced to diversify into other more profitable

cropping systems. As the sub-country struggles with persistent sugarcane problems of poor returns, unpredictable prices, and post-harvest losses, among other issues, farmers are moving away from the production of this crop and diversifying into other agricultural ventures.

1.3 The Problem Statement

In Mumias East Sub-County, about 11,885 farmers practice sugarcane farming whereby 191.2 thousand hectares of land is put into sugarcane farming than the rest of crops. Sugarcane farming in the Sub-County is dominated by smallholders who account for about 75 per cent. The Sub-County hoped that sugarcane farming would raise farmers' incomes and somehow help reduce poverty, but the farmers are still among the poorest and are also food insecure in Kenya. Although sugarcane production is the most important in terms of economic contribution and livelihood generation, its productivity in the sub-county has largely declined from 632,000 in 2015 to 193,532 metric tons in 2020. Declining sugarcane productivity has impaired the household goals of improving food, income and nutrition security, especially in the study area. Such impediments call for immediate measures by MoALF to ameliorate the situation through diversification of the cropping system as a strategy for sustaining agricultural productivity and coping with marketing risks among smallholder sugarcane farmers in the study area. Food crop diversification in the study area is gaining ground because of these sugarcane problems. Smallholder sugarcane farmers in the study area have to diversify from sugarcane farming to other crops to alleviate household incomes and food

insecurity. It is based on this study attempted to fill this research gap by analysing economic determinants that affect participation in food crop diversification among smallholder sugarcane farmers in Mumias East Sub-County, Kakamega County, Kenya.

1.4 General Objective

The general objective of this study was to investigate the economic determinants influencing participation in food crop diversification among smallholder sugarcane farmers in Mumias East Sub-County, Kenya.

1.5 Specific Objectives

This study was guided by the following specific objectives:

(i) To determine the socioeconomic factors influencing food crop diversification among smallholder sugarcane farmers in Mumias East Sub-County, Kenya;

(ii) To examine the factors influencing farmer participation in diversified cropping system among smallholder sugarcane farmers in Mumias East Sub-County, Kenya;

(iii) To determine income differentials of diversified cropping system among smallholder sugarcane farmers in Mumias East Sub-County, Kenya

1.6 Hypotheses

This study tested the following hypotheses:

H_{01}: Socioeconomic factors have no significant effect on food crop diversification among smallholder sugarcane farmers in Mumias East Sub-County, Kenya.

H_{02}: There are no statistically significant factors influencing farmer participation in crop diversification among smallholder sugarcane farmers in the Mumias East Sub-County, Kenya.

H_{03}: Income differentials have no significant effect on crop diversification among smallholder sugarcane farmers in the Mumias East Sub-County, Kenya.

1.7 Justification of the Study

This study investigated economic determinants influencing participation in food crop diversification among smallholder sugarcane farmers in Mumias East Sub-County, Kakamega County, Kenya. The continued decline of sugarcane production in Mumias East Sub-County led to a reduction in household income and food security. Thus this problem would be solved when farmers diversify to other crops that are of high value that would result in an increase in household income and thus food security in general. The current study also helped in bridging the information gaps in the area of study.

Despite the effect of crop diversification on the sugarcane crop, there is no documented study on economic determinants influencing participation in food crop diversification. This, however, is a very crucial matter that needed attention. This study will provide knowledge that will contribute to the intervention of strategies on poverty alleviation in the sub-county and other regions hence benefiting the smallholder farmers. The government of Kenya has emphasized crop diversification and value addition in agriculture. Key areas of policy concern and strategy are highlighted in Kenya Vision 2030

which includes catalysing enhanced agricultural productivity, food security and income growth through crop diversification.

1.8 Significance of the Study

The findings of the study provided information that bridged the present knowledge gap in the area of study. Findings from this study are useful in decision-making and planning purposes by the Department of Agriculture, other relevant departments and stakeholder organizations in the county. In addition, information that already generated by this study could help in resource mobilization and allocation by the relevant actors that are involved either directly or indirectly in food security matters. Research institutions like KALRO and universities among others, may also get valuable information from the findings. This study also provide information upon which the existing agricultural policies could be reviewed. Finally, the national and the county governments may also benefit from these findings hence helping in implementation of policies and strategies for the improvement of food security.

The study is useful in informing both county and national governments and other stakeholders in the sub-sector on potential policy interventions for food crop diversification in the sugarcane sector in the area and similar settings. This study is also important in informing the public and private extension service providers, the agri-based learning institutions and in evaluating their strengths and weaknesses to bring change as well as corrective strategies to improve food crop diversification. Finally, this study is important in enriching the available literature on sugarcane farming and helps identify opportunities for further research concerning smallholder sugarcane performance.

1.9 Scope of the Study

This study focused mainly on Mumias East Sub-County, Kakamega County in an attempt to analyse the economic determinants affecting participation in food crop diversification among smallholder sugarcane farmers. This study focused on the smallholder sugarcane farmers in Mumias East Sub-County and the period of data collection was between 1st and 31st August 2021. The statistical inferences from the sample size that was taken were representatives of the whole of Mumias East Sub-County. The data types used in the study included both primary and secondary data collected directly from the small-scale sugarcane farmer household heads and through a literature review respectively. Further, the study used multivariate regression, farm gross margin and logistic regression models for data analysis.

1.10 Limitations of the Study

The study was not free from limitations. Best & Khan (2008) defined

limitations as factors that the researcher has no control over and may place shortcomings on the findings of the study and their applicability in different situations. Firstly, using a purposive sampling technique to select the study area would limit the generalization of results. The study's results may be generalized to the entire country with caution. Secondly, some respondents who were reluctant to give the true information freely and wanted to provide information that they thought was pleasing to the researcher were enlighted and informed that that the research was purely objective and not subjective. Thirdly, the study might have encountered the problem of unreliable information from the respondents since it relied purely on their memory. Finally, the language might have been another barrier to some respondents since the questionnaire was written in English. However, the researcher self-administered and translated the questions into their local language so that they could understand and respond.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presents an overview of the existing literature in the field of crop diversification among smallholder farmers. It contains a review of related literature, theoretical framework, conceptual framework and knowledge gap.

2.2 Review of Related Literature

This section focuses on crop diversification aspects related to the objectives of the study. These include a review of the extent of crop diversification, and determinants influencing food crop diversification.

2.2.1 Review of the Role of Agriculture in the Economy

Agriculture plays and will continue to play a critical role in the economy and wellbeing of Kenya; in terms of providing food to and ensuring food security for the populations of most African countries (GoK, 2012). The growth in Gross Domestic Product (GDP) and agricultural productivity increase provides favourable conditions that make poverty reduction possible. Sustained poverty reduction in the long run will help in releasing a workforce that can then be engaged in other productive sectors of the economy, such as industrial production. The challenge is to bring about a long-term, sustainable increase in agricultural productivity (Food and Agriculture Organization of the United States (FAO, 2009).

A report by the World Bank (2019) indicates that Kenya's agriculture forms the basis of which the economy thrives, directly contributing 21.9 per cent of the GDP annually, with at least 56 per cent of the total labour force employed in agriculture in 2017. Approximately 25 per cent of the labour force is employed indirectly through agricultural relationships and interactions with other sectors of the economy. The sector contributes approximately 65% of total exports and provide employment to over 70% of Kenya’s rural population in informal employment. It supports industrialization by supplying raw materials for industries. It is important to note that for any country to industrialize it must grow its agricultural sector (GoK, 2012).

The agricultural sector also allows various off-farm activities to thrive. Such activities include the transportation of agricultural produce and research activities that seek to come up with improved technologies that can be used in agriculture. Kenya Agricultural and Livestock Research Organization (KALRO) is an example of such an institution that does research in Kenya. Agriculture makes sure that the food is constantly supplied thus ensuring that there is sufficient food for Kenya's populace. A well-fed workforce has enough energy to supply labour to other sectors of the economy (Yakubu et al., 2015). The sector also saves funds that the country would have used in the importation of food from other countries. Consequently, the balance of payment will be improved. The country will have surplus money which can be invested in other sectors of the economy such as safety nets, roads and health.

The sector has an important contribution to reducing rural-urban migration. By creating employment in rural areas, the rural population does not have an incentive to move to urban areas and this aids in solving the income inequality problem in the country as well as balanced use of social amenities (Mabior, 2014)

It is estimated that at least 65% of farmers account for Kenya's marketed volumes. The land sizes range from 0.2 to 3 hectares in size. In these farms, the use of improved innovations such as the use of improved inputs and mechanization is generally low. Medium-scale farms which range from three to forty-nine hectares in size often make use of improved innovations, apply for credit for use in making various farm developments, and can do marketing of their produce. Large-scale farms are farms that are over 50 hectares in size. Growing cash crops like tea, coffee, maize and wheat as well as keeping livestock which include dairy and beef are common in these farms (GoK, 2012).

2.2.2 Review of the Role of Sugarcane Farming in Kenya

According to the Kenya Sugar Board, the sugar sub-sector generates an estimated Kshs. 12 billion annually, providing about 500,000 jobs and supporting the livelihoods of about 6 million people, directly or indirectly. This translates to about 15% of the country's GDP with a major impact on the economies of Western Kenya, Nyanza regions and Rift Valley (KSB, 2009). Total sugar production grew from 436,238 tonnes in 1980 to 523,652 tonnes

in 2010, while sugar consumption increased from 300,000 tonnes in 1980 to 743,000 tonnes in 2010. Kenya's sugar deficit of about 200,000 tonnes is mainly filled through imports of raw sugar from the Common Market for Eastern and Southern Africa (COMESA) region (Monroy et al., 2012). This deficit is mainly brought about by sugar mills operating inefficiently and below capacity.

Sugarcane is one of the most important crops in the world because of its strategic position and immense uses in the daily life of any nation as well as for its industrial uses. Sugarcane contributes about 75% of the total world sugar requirements while the remaining 25% comes from sugar beet (Onwema and Sinha, 2003). Due to the greater importance of sugar, there is a need to expand sugarcane production. The average worldwide yield of sugarcane crop is estimated at 70 tons per hectare with Peru recording a higher average of 133 tons per hectare, Guatemala 104 tons per hectare, Colombia 101 tons per hectare, Philippines 94 tons per hectare and Australia 81 tons per hectare. The main determinants of cane production in these countries as identified include favourable cane prices, favourable weather conditions, increased acreage under cane, the use of irrigation, increased investments in sugarcane production and application of inorganic fertilizers (FAO Stat. 2014).

The sugar sector is the third most important contributor to Gross Domestic Product (GDP) after tea and coffee (KSB, 2008). The sugar industry is a major

contributor to the agricultural sector and supports of livelihood of 6 million people directly and indirectly or at least 25% of the Kenyan population. The subsector accounts for about 15% of the agricultural GDP; it is a dominant employer and source of livelihood for most households (KSB, 2008). The small -scale sugarcane farmers employ the entire value chain and hence decline in cane output will result into high unemployment levels. Area under cane is approximately 123,622 hectares out of which 111,189 hectares are in the hands of small-scale farmers and the balance of 12,433 hectares constitutes nucleus estate. In 2008, the industry employed about 500,000 people directly or indirectly in the sugarcane business chain from production to consumption (Bracing for COMESA: Kenyan Sugar industry bulletin, 2008). These statistics explain the reason for the focus on small scale farmers in Nyando Sugar Belt, Kenya.

In addition, the sugar industry saves Kenya over USD 250 million in foreign exchange annually and contributes significant tax revenue to the exchequer. In the Sugar Belt, the sugar industry contributes to infrastructure development through road construction and maintenance, construction of bridges and towards provision of various social amenities. The industry also contributes towards environmental and energy conservation thereby attracting donor support through grants (Kenya Sugar Board strategic plan, 2008-2012). Due to the importance of the sugar industry, the Kenya government continues to provide subsidized fertilizers to the farmers to enhance cane output. Cane farming has of late been threatened due to the imminent end of Common

Market for Eastern and Southern Africa (COMESA) safeguards expected in February 2019, wherein the sugar industry will be expected to operate under a liberalized trade regime. In such environment, the industry will have to enhance its competitiveness along the entire value chain and reduce production costs by 39% to be in line with other COMESA sugar-producing countries (KSB, 2008).

The reduction in average cost of production can be realized through
increase in output/yield. This research therefore examines the socioeconomic determinants of sugarcane production to reduce production bottlenecks leading to an increase in cane output. During the year 2012/2013, sugarcane production in Kenya stood at 600,179 metric tons which represents 54% of the factory capacity against an annual demand of 841,957 metric tons and production potential of about 1 million metric tons at 89% factory capacity. The deficit was compensated mainly through importation from sugar-surplus countries such as Egypt, Thailand, South Africa, Saudi Arabia, Sudan, Zambia and Madagascar (KSB, 2008). The focus of this research is to ascertain the possibility of shift in sugarcane production from import oriented to export oriented through enhancement in cane output by examining the socio-economic determinants of cane output.

2.2.3 Extent of Crop Diversification

Diversification of crops can be defined as the reallocation of resources,

especially cultivated land at the access of farmers to accommodate a wide range of cropping patterns (Mandal & Bezbaruah, 2013). The concept of crop diversification at different levels expresses diverse connotations to different people (Mwangagi, 2021). Ellis, (2011) in Ojo *et al.,* (2014), define diversification as the process whereby rural households develop a variety of activities and assets to existence geared towards improving their living standards. Emrys & Ngau, (1991), in the same study, identified two types of diversification namely; farm diversification (crop diversification) and farm income diversification (diversification of activities). Farm diversification comprises of variation of agricultural portfolios within the farm while diversification of activities involves varying the income generating portfolios within and outside the farm. Crop diversification involves the production of different varieties of crops of related or different species in an area rotationally and or by intercropping (Makate, Wang', Makate & Mango, 2016). Diversification refers both to the number of economic activities an economic unit is involved in and the distribution of those activities in the total economic unit of activity (Kimenju & Tschirley, 2011). In this study, diversification will be based on the micro-level (household) which is the individual smallholder sugarcane farmer household that practices diversification to heighten food security and increase income sources.

Crop diversification through rotations and intercropping is one of such climate -smart techniques identified. Although diversification of crop production is not

a completely new practice, Climate Change's impact on agriculture has given it popularity. Adopting the technology could significantly bring down risks linked to agricultural production by improving productivity, income, food and nutritional security among smallholder farmers (Makate et al, 2016). According to Joshi, (2005) in Makate et al, (2016), crop diversification is among the most ecologically viable, efficient and practical strategies for minimizing uncertainties in agriculture, particularly with small-scale farmers. Crop diversification also boosts farm spatial and biodiversity thus enhancing resilience (Makate et al*,* 2016). Lin, (2011) indicates that soil fertility is improved through crop diversification. It also aids in pest and disease control, facilitates yield stability, and improves nutritional diversity as well as health improvement. Crop diversification is also a dominant substitute for chemical use in soil fertility conservation and control of pests.

Diversified cropping systems generally, are more ergonomically stable and resilient due to decreased weed and insect, reduced requirement of nitrogen fertilizers (when leguminous crops are incorporated), reduced erosion due to cover crops use, and increased productivity (Lin, 2011; Makate et al*,* 2016). Moreover, Makate et al, (2016) indicate that crop-diversified systems provide a conducive environment for beneficial insects hence reducing the number of pests by making the host crops less conspicuous for attack by pests. Crop diversification also contributes to local biodiversity more so when indigenous crop varieties are grown. Lin, (2011) also indicates that proper management of

soils helps maximise the use of water by plants thereby improving overall crop yields. Crop diversification therefore contributes in one way or another to all the three principles of CSA through improvement of productivity, livelihood and resilience of agricultural systems including reduced carbon dioxide emission. This study considered crop diversification on the selected food crops among the smallholder sugarcane farmers, namely maize, sorghum, finger millet, cabbage, passion fruit, Irish potatoes, sweet potatoes and beans.

2.2.4 Determinants of Crop Diversification

Determinants of people's decision to adoption of new technologies or practices like diversification have been studied by different scholars over time. The classic theory of diffusion of innovations considers the impact of social norms and values, individual characteristics, traits of the concerned technology as well as other external factors such as infrastructure and the policy environment. Ellis, (2000) also indicates that the decision to adopt an innovation is determined by a risk minimizing strategy as they are quite vulnerable to a risk arising out of natural and anthropogenic uncertainties. Due to such uncertainties, farmers in developing countries are vulnerable to various risks that the severity leads to the eventual loss of assets and income.

Many scholars have carried out studies on crop diversification in many places such as India, China, Pakistan and many African countries like Nigeria, Malawi, Zambia, Ethiopia, Zimbabwe and Kenya among others. Most of these studies

identified the role of socioeconomic, demographic and institutional factors in crop diversification. For example, Kumar, Kumar & Sharma, (2012), sought to establish the position of crop diversification and identify its determinants in Eastern India. The kind of determinants they evaluated were age and education of the household leader, agriculture as the main occupation, household size, credit access, farm assets, and operated area, use of technology components, infrastructure and caste. Three-stage and stratified sampling were used in this study where 2885 farmers were studied. They used the Herfindahl Index to establish the extent to which farmers have diversified their crop production while the Tobit regression model was applied in identifying elements of diversification towards vegetable cultivation in the study area. They established that the crop sector in the eastern region was moderately diversified. The study also showed that education, the size of the household, the value of productive assets and the primary household head's occupation had a very significant influence on diversification. Age and gender however did not have a substantial influence on farmers' decision to diversify in favour of vegetables. While seeking to identify factors which guide household decisions to the diversification of crop production in Ukhonul District, Manipur, Aheibam, Singh, Feroze & Singh, (2017) adopted Heckman's two-stage model to evaluate the determinants of household diversification and its intensity. The results showed that the education of the head of the household had a positive association with the level of crop diversification which is similar to Kumar et al, (2012), Mithiya, Mandal & Datta, (2018) and

Shabzah et al, (2017). Other factors with positive influence are access to fertilizer, access to plough, availability of irrigation, exposure to farming information regularly, distance to the nearest market and experience of the farmer.

Mithiya et al., (2018), while seeking to establish trends of crop production and identify factors of their diversification by smallholders in West Bengal, used secondary data from different districts. Using the Simpson Index (SI) which was also used by Aheibam, (2017), the results showed that every district in the Western region of Bengal and the whole state demonstrated higher crop diversification levels during the new millennium in relation to the nineties. The factors analysed include the level of literacy, the urban population percentage of the district, comparative earnings from high-value crops compared to cereals, regional market density, smallholders' percentage and area under high-yielding food grain varieties. Education, land size, distance from the market as well as income from other sources had a significant influence. In addition, Huang', Jiang', Wang' & Hou, (2014) also investigated how crop diversification is used as a coping mechanism against extreme weather occurrences in China. They used multiple-stage sampling to obtain 3330 smallholder farmers. It was established that age had an undesirable effect on diversification where aged farmers did not implement crop diversification compared to young farmers. Young farmers had less experience hence more likely to adopt crop diversification as a means to avoid production risks. Young people were also more willing to try new things. This

is in line with Aheibam et al, (2017), Dube, Numbwa & Guveya, (2016) and Ojo et al, (2014). Huang' however noted that farmers with lower education levels are more vulnerable and are likely to use crop diversification to mitigate the threats of extreme weather events. In addition, Huang' found out that farmers with larger farming fields are more willing to diversify their crop types. A household with more access to land was expected to grow more crops since more arable land is available, better enabling them to plant more crops.

While seeking to identify determinants of crop diversification in the mixed cropping zone of Punjab in Pakistan, Shahbaz, Boz & Ul Haz, (2017) used multiple-stage sampling to select 100 growers for the study. They applied the Herfindahl index to calculate the farmer's level of diversification which has been used by many other scholars such as Kumar et al, (2012), Ojo et al, (2014) and Kanyua, Ithinji, Maluvi & Gido, (2013). The expected elements of crop diversification were analysed using the Tobit model which was also used by Kumar et al, (2012), Ojo et al, (2014) and Kanyua et al, (2013). It was established that the level of education and farm size positively and significantly influence how farmers vary crop production. A more educated farmer would understand the market condition better thus resolving the impact of the uncertain events appropriately. Similarly, ownership of farm machinery enhanced the levels of diversification in crop cultivation. The study nevertheless indicates an undesirable relationship between age and diversification in crop production. This is possible because younger farmers

can innovate, take risks and are physically strong in farming activities, unlike old people. The study also revealed that self-owned operated farms were less diversified in crop production compared to other tenures like rented or shareholder.

Sichoongwe et al., (2014), also carried out a study to identify the determinants and establish the extent of crop diversification in smallholder farming in the Southern Province of Zambia. They analysed the gender, age, and education level of the head of the household including the size of the household, land holding size, number of fields or land plots, hired labour, tillage time, plough tillage, fertilizer quantity and distance from the market for 1,555 farmers. They established that crop diversification in smallholder farming was relatively low. In their study, the size of land holding, quantity of fertilizer, distance to the commodity market, time of tillage including tillage were established to significantly impact crop diversification.

A study was also undertaken by Dude, et al, (2016) to identify factors influencing smallholder crop diversification among 479 smallholder farming households in the Zambian provinces of Manicaland and Masvingo. They used the Herfindahl Index to assess diversification level and the Tobit regression model to evaluate factors associated with it. This study revealed that male-headed households were marginally more diversified in comparison to households headed by female farmers. Tobit regression model also revealed

that education, number of livestock units, access to irrigation, membership of a farmers' group, access to markets, farming experience, farms of flat terrain, farmer-to-farmer extension, agro-ecological zone and household income were the weightiest factors in crop diversification.

Ojo et al, (2013) in addition examined the factors that influence the diversification of small-scale food crop farming in North Central Nigeria. Multiple-stage sampling was used to obtain a sample of 300 respondents. Using Herfindahl Index, their study revealed that North Central Nigerian smallholders were less diversified. The study also showed that experience, extension contacts, as well as land size, positively influenced diversification. Age and income from other sources however had no influence. In another study investigating the profitability of food crop diversity and its determinants in the south-eastern part of Nigeria, Rahman and Chima, (2015) used the Multivariate Tobit approach. Their analysis revealed that farm size is the foremost determinant of diversity compared to profitability. Other factors that vary in their influence include; proximity to the market and extension office, extension contact, training, agricultural credit and subsistence. The study covered a total of 450 households.

A significant positive association between crop diversification and farm income was found by Makate et al., (2016) in Zimbabwe, by Bravo-Ureta et al., (2006) in El Salvador and Honduras, and by Perz (2004) in the Brazilian

Amazon. Bravo-Ureta et al., (2006) estimated a 21% average increase in farm income of the entire sample in the analysis, whereas Perz (2004) found a very strong positive relationship between diversification and income. Makate et al., (2016) observed that increased production from diversified cropping systems (crop rotations, intercropping) resulted in higher income for farmers.

Mesfin et al, (2011) studied the pattern and trend of crop diversification identifying its determinants among 167 small-scale farming households in the Eastern region of Ethiopia. The tobit regression model was used to analyse covariates of crop diversification and its intensity. Among the determinants under scrutiny were; farm size, age of the household head, household size, distance to the market, number of extension contacts, farm machinery (tractor and water pump), off/non-farm income, number of farm plots, access to market information, irrigation intensity and sex of the household. They used a modified Entropy Index to measure crop diversification. Mesfin (2011) established that farmers with a greater number of plots are more likely to diversify by growing different crops on each plot of land which is similar to the findings of Mussema et al, (2015) and Ogutu and Obare, (2015). It was also established that with access to market information, irrigation and machinery, farmers were likely to diversify. The findings however established that there was a negative relationship between extension contacts and diversification since extension was advocating for productivity and profitability which favoured specialization at a micro level and overlooked the role of

diversification in risk minimization.

In another study seeking to identify determinants of diversification of crop production in the Oromia region, Ethiopia, Mussema et al, (2015) used Margalef's Index (MI) to analyse determinants of crop diversification. The results suggested that asset ownership, soil quality, agricultural extension and level of infrastructure development are significant drivers of crop diversification. Three-stage sampling model was used to arrive at 382 households. The results revealed that land size and number of plots affected crop diversification decisions positively and significantly. In the same way, Extension services, market information and access to all-weather roads had positive and significant impacts. Their findings on access to the market were in line with those of Kumar et al, (2012), Aheibam et al, (2017), Mithiya et al, (2018), Sichoongwe et al, (2014), Dube et al, (2016) and Kanyua et al, (2013).

Furthermore, Kanyua et al, (2013), investigated factors influencing diversification and the intensification of horticultural production among smallholder tea farmers in Gatanga District, Kenya. They analysed participation in diversified cash crop farming, occupation, age and education level of the household head, tools, credit, distance from the market, and contract among others. Heckman's two-step model was used to establish the determinants and it was found that farm size and value of farm tools are the most significant in crop diversification. Heckman two-stage model was also used by Aheibam et al, (2017). The study also established that the amount of

land owned by a farmer has a very significant effect on the degree of diversification; with an increase in the farm size leading to a rise in the crop diversification index. From their study, it was established that the amount of free land owned by the farmer had a very significant effect on diversification to horticulture production. Other farmers with big lands however had little crop diversity since more land had been allocated to tea. Gender was a very significant factor in diversification into horticulture by tea farmers; male-headed households were more diversified than female-headed households. This was similar to the findings of Dube et al, (2016) that male-headed households were more diversified. The experience of the household head had a significant effect on the degree of diversification possibly due to the learning curve effects.

Finally, Ogutu and Obare, (2015) compared crop choice and adoption of sustainable agricultural intensification practices in Eastern and Western Kenya among 532 randomly sampled smallholder households. They used the stochastic production function model which established that gender played an important role in the adoption of sustainable agricultural intensification (SAI) innovation and cropping choices. Female decision-makers were seen to practice more intercropping in their plots. Land size and number of plots also had a positive influence. Education however did not have any influence on SAI practice and crop choice while income from other sources had a negative influence.

None of the above studies however focused on diversification within the food crops sub-sector among smallholder farmers in Mumias East Sub-county. This study thus backs the knowledge gap concerning this aspect of diversification by the smallholder households.

2.2.5 Effects of Crop Diversification

Herforth (2010) examined the relationship between farm diversity and dietary diversity among households in central Kenya and northern Tanzania. In both Kenya and Tanzania, the number of crops grown by a household was positively associated with the dietary variety of the household (i.e., the number of unique foods in the diet) and in Tanzania, crop diversity was associated with the diversity of food groups in household and individual child diets. In both countries, crop diversity was also positively associated with the diversity of home-produced fruits and vegetables consumed. In the rural highlands of Ecuador, on-farm species diversity and family-level dietary diversity were also positively correlated (Oyarzun, Mary, Sherwood, 2013). Parra Families with low agro-biodiverse farms in this setting consumed more off-farm food items. In western Mali, the number of crops cultivated by a household was positively associated with adult nutrient adequacy (Torheim, 2004).

Jones et al., (2014) found that the production diversity of farms in Malawi was consistently and positively associated with the diversity of household diets.

Farm diversity demonstrated a consistent positive association with household dietary diversity independent of differences in household wealth and social standing. This relationship was significantly greater in wealthier house-holds as well as in households headed by women. Farm diversity was especially strongly associated with the consumption of legumes, vegetables and fruits. Although there is no single approach to measuring household food security status, an accurate measurement indicator is necessary to target resources toward those most in need or at risk of sliding into hunger. Accurate measurement of household food security is also essential for effective research and well-targeted policies and programs. According to Carletto et al., (2013), a wide range of indicators are used for food security analysis and the best way is to define clearly the intended scope.

Pretty, Morison, and Hine (2003) found out that 89 out of 208 agricultural diversification projects, such as home garden intensification with vegetables or tree crops, inclusion of vegetable son rice bunds, introduction of fish ponds in paddy fields, or dairy cows and trees on farms, implemented in 52 developing countries contributed to an increase of food production in a per hectare basis. For the successful projects, the impact of crop diversification on food production was very high, contributing, on average, to a 93% increase in food production per hectare. By assuming a direct relation between food production and food security, the authors also assumed a strong positive impact of the 89 diversification projects on food security.

Makate et al., (2016) also discovered a significant positive impact of crop diversification on cereal crop productivity, on food security, and the nutrition indicators (Food Consumption Score and Household Dietary Diversity Score) in Zimbabwe. In Nicaragua, Bacon et al., (2014) confirmed the importance of mixing corn and beans, which Mesoamerican farmers have managed in their production systems for thousands of years, but found out that simply adding more crops or animals had no significant impacts on seasonal hunger and that an integrated agro-ecology-based approach was needed. In Guatemala, evidence from an “ex-post” classification of crop diversification patterns and food security in a household survey indicated that crop diversification patterns varied extensively within and between regions, and those small farmers who diversified from maize to potatoes were more likely to suffer negative food insecurity and malnutrition than those who diversified from maize into wheat and vegetables (Immink & Alarcon, 1991).

2.3 Review of Relevant Empirical Studies

2.3.1 Review of Farm Gross Margin Model for Crop Productivity

The farm gross margin model is a simple method of comparing the performance of enterprises that have similar requirements for capital and labour. It provides information with an additional planning tool to help evaluate options between different farm activities. Gross margin is the difference between total revenue and variable cost as specified in Equation 2.1.

$$GM_i = TR_i - TVC_i \quad \text{..... (2.1)}$$

GM_i is the gross margin per year,

TR is the total revenue (gross output) per year and,

TVC is the total variable cost all in Kenya shillings (KSh).

The gross margin of smallholder sugarcane farmers participating in a diversified cropping system in Mumias East Sub-County will be compared to non-participants to determine the more profitable system in the short run. The use of Gross Margin analysis depends on some assumptions; in this case, all prices used will be those prevailing during the production season for each of the crops grown by the farmer. The process of analysing a farm business has been traditionally divided into two parts; the general analysis based primarily upon financial accounts and other appropriate records and a more detailed analysis of the individual enterprises on the farm in the form of budgetary analysis where gross margins for each enterprise are calculated (MAFF, 1980). In recent years, with the increasing economic pressure on agriculture, there has been a greater use of cost accounting techniques which result in net margin or profit per enterprise.

By using the above formula for calculating GM, Olasunkanmi et al., (2015) in the study to determine enterprise combination in the livestock sector in Southwestern, Nigeria found that all the profitability indicators in livestock enterprise are profitable in the study area. The various profitability analyses conducted across the combinations showed that it is more profitable to combine two different livestock to maximize profit. In terms of gross margin and net farm income, poultry/piggery production recorded the highest value in

each category, followed by poultry/fishery and the least is recorded by sole poultry enterprise. Christopher (2008) did a study on comparative analysis of enterprise combination using costs and returns in cassava-based food crop farming systems in Delta State, Nigeria. The study found that all of the techniques can be useful in helping to assess the economic efficiency of individual enterprises within an organic farming business. The current study adopted the budgetary analysis model used by Olasunkanmi et al., (2015) to determine the GM for maize, coffee and sugarcane and the results obtained were used to determine the optimal combination of the three crops.

2.3.2 Review of Logistic Regression Model

Logistic regression is a dichotomous analysis method (Conteh et al., 2015) that is commonly used in adoption studies (Pattanayak et al., 2003). Logistic regression as a classification tool has been widely used in various fields such as economics, medical science (epidemiology and health), psychology, classical ergonomics etc. To cite a few relevant references, Johnson et al. (1996) described the relationships between weather and outbreaks of potato late blight in the semi-arid environment of south-central Washington with linear discriminant and logistic regression analyses and forecasted late blight outbreaks. Vergara and Page (2002) classified lumbar discomfort/absence of discomfort by relating back posture and mobility in sitting posture using both discriminant analysis and logistic regression. Gent *et al.,* (2003) used logistic regression for classifying the geographical regions of origin of Xanthomonas

strains. Mila *et al.* (2004) used logistic regression to estimate the probability of soybean Sclerotinia stem rot prevalence in the north-central region of the United States using tillage practice, soil texture and weather variables (monthly air temperature and monthly precipitation from April to August) as inputs.

Pitipunya (1995) used the Logit model and found out that education, trade experience, and level of information influence farmers' cropping patterns in Thailand. In Central Queensland of Australia, Windle and Rolfe (2005) used a multinomial Logit model to analyze determinants of agricultural diversification. The model revealed that age, education level, number of children, off-farm income, farm size, start-up cost, net income, other crops grown and risk time influence agricultural diversification. Using Heckman's Two-stage model, Rehima et al., (2013) found that age, gender, education and trade experience, extension services and transaction costs influence farmer participation in Southern Nations, Nationalities, and Peoples' Region (SNNPR), in Ethiopia. A study by Valera et al., (1989) also revealed four determinants influencing crop diversification. They include dry season rainfall, availability of irrigation water, limited irrigation management and inappropriate on-farm irrigation and drainage facilities. In Zambia, Sichoongwe et al. (2014) employed a double-hurdle model to analyze the determinants of crop diversification. The study revealed that the size of landholding, fertilizer quantity, distance to market, and tillage using a plough significantly influence farmers' probabilities to

practice crop diversification. Besides, the extent of crop diversification is significantly influenced by the fertilizer quantity and distance to the market.

2.4 Theoretical Framework.

A literature review indicates the existence of one economic theory to model farm household behaviour. Each approach assumes that households have an objective function to maximize with a set of constraints. First is the profit maximization theory, which has been criticized that it does not consider the aspects of consumption in the household decision processes. Second is the Utility maximization theory which incorporates both the production and consumption goals. In consideration of these two models, other economists have developed the risk aversion theory which indicates that the objective function of a household is to secure and avoid risks (Mendola, 2007). Utility maximizing theory is most commonly used when household consumption and production decisions are interdependent like in rural areas (Lin, 2011). In this study, therefore, sugarcane farmers are expected to diversify food crops not only for food security but also to increase income hence livelihood improvement in general.

2.4.1 Random Utility Maximization Theory

This study used random utility maximization (RUM) theory. The farm household seeks to maximize utility subject to its limited resources and with a trade-off in its goal of minimizing risk. It does this by treating off-farm

investment just like any other on-farm investment; it will only invest if the present value of the benefits of the investment exceeds the present value of the associated costs of the investment (Mishra and Morehart, 2001). Given that the farmer is usually capital-constrained, the farmer will choose the investment with the highest net present value (NPV). The NPV of the off-farm investment is as shown in Equation 2.2.

$$NPV = \int_{t=0}^{T} e^{-rt}(R_t - C_t)dt, \quad \text{..... (2.2)}$$

where T is time,

r the discount rate,

R_t the expected net returns of the investment and,

C_t represents the expected costs of the investment.

Economic research into risk attitudes is based on a set of axioms proposed by Von Neumann and Morgenstern (1947) and later developed by others. The axioms are used to demonstrate that an individual's risk attitude can be inferred if the preference ordering and distributional properties of the risky prospect are known.

The smallholder sugarcane farmer is assumed to maximize its utility function subject to farm production and cash flow constraints. An implicit assumption is that the smallholder sugarcane farmer household behaviour is primarily the result of purposeful, rational decisions designed to provide the greatest possible level of satisfaction for household members, given the available resources. It is known that farmers' decision to supply one market or another

is categorized as a function of a set of incentives and capacity variables that allow the fulfilment of technological requirements. The farmers or producers behave like neoclassical firms who control the transformation of inputs into valuable outputs to maximize profits (Varian, 2000). The decision on whether or not to adopt a new technology is considered under the general framework of utility or profit maximization (Norris, 1987; Pryanishnikov, 2003). Rural households may be producers and consumers of both marketed and non-marketed commodities and they may or may not participate in a labour market. The household is assumed to maximize its utility function subject to a production function and time and income constraints.

It is assumed that economic agents, including smallholder subsistence farmers, use certain diversified cropping systems only when the perceived utility or net benefit from using such a method is significantly greater than is the case without it. Again, smallholder sugarcane farmers are assumed to be rational and they want to derive the highest utility from the choices they make; either to participate in crop diversification independently or not. They make their choices with respect to random utility theory, which states that a decision maker is guided by unobservable, observable and random characteristics when making a decision. Although utility is not directly observed, the actions of economic agents are observed through the choices they make. This study formulated participation in diversified food cropping system choice decision as a two-alternative choice (participation in diversified food cropping system =

1 and not participating (growing sugarcane crop) = 0).

Let a decision maker choose from a set of mutually exclusive alternatives, j = 1, 2…, J. The decision maker obtains a certain level of utility U_{ij} from each alternative. The discrete choice model is based on the principle that the decision maker chooses the outcome that maximizes the utility. The producer makes a marginal benefit marginal cost calculation based on the utility achieved by diversifying to a particular food crop or another. His/her utility is not observed, but some attributes of the alternatives as faced by the decision maker are observed. Hence, the utility is decomposed into deterministic (V_{ij}) and random (ε_{ij}) parts as shown in Equation 2.3.

$$U_{ij} = V_{ij} + \varepsilon_{ij}; \forall_{ij} \in N \quad \text{.....} \quad (2.3)$$

Since ε_{ij} is not observed, the decision makers' choice cannot be predicted exactly. Instead, the probability of any particular outcome is derived. The utilities (or the difference between benefit and cost) cannot be observed directly, but the choice made by the producer reveals which one provides the greater utility (Greene 2003). A producer selects market channel j=1 if;

$$U_{ik} > U_{ij} \forall_j \neq k \quad \text{.....} \quad (2.4)$$

where U_{ik} denotes a random utility associated with a particular crop enterprise j=k, and, V_{ij} is an index function denoting the producer's average utility associated with this alternative. The second term, ε_{ij}, denotes a random error which is specific to a producer's utility preference (McFadden, 2000). Now, suppose that Y_i and Y_j represent a household's utility for two diversified food

crop enterprises, which are denoted by U_i and U_j, respectively. In the linear random utility model, the diversified food crop enterprise choice is modelled as in equation 2.5.

$$U_{ij} = \beta_j X_{ij} + \varepsilon_{ij} \quad \text{..... (2.5)}$$

Where U_{ij} is a vector of participation in diversified food crop enterprise choices (j = 1 diversified food crop enterprises; and 0 not to diversified crop enterprise i.e. to continue growing sugarcane crop) of i^{th} smallholder sugarcane farmer, β_j is a vector of participation in diversified food crop enterprise. ε_{ij} is the error term assumed to have a distribution with mean 0 and variance 1 and identically distributed (Greene, 2003). X_{ij} is the vector of explanatory variables that determines and or influences the perceived desirability of the participation in the diversification of food crop enterprise. Therefore, for the case of participation in diversified food crop enterprise choice, if a smallholder sugarcane farmer decides to use option *j* crop, it follows that the perceived utility or benefit from option *j* crop is greater than the utility from other options (say *k*) depicted as shown in Equation 2.6.

$$U_{ij}(\beta_j^1 X_i + \varepsilon_j) > U_{ik}(\beta_k^1 X_i + \varepsilon_k), \quad k \neq j \quad \text{.....(2.6)}$$

The probability that a smallholder sugarcane farmer will choose crop enterprise *j* among the set of diversified food crop enterprise choices instead of the *k* sugarcane crop could then be defined as shown in Equations 2.7, 2.8 and 2.9.

$$P(Y = 1 \mid X) = P(U_{ij} > U_{iK}) \quad \text{..... (2.7)}$$

Therefore,

$P(\beta_j^1 X_i + \varepsilon_j - \beta_k^1 X_i - \varepsilon_k > 0 \mid X)$ ……. (2.8)

Hence $P(\beta_j^1 X_i - \beta_k^1 X_i + \varepsilon_j - \varepsilon_k > 0 \mid X)$

$P(X^* X_i + \varepsilon^* > 0 \mid X = F(\beta^* X_i)$ …….. (2.9)

Where; *P* is a probability function, U_{ij}, U_{ik}, and X_i are as defined above, $\varepsilon^* = \varepsilon_j - \varepsilon_k$ is a random disturbance term, $\beta_j^* = (\beta_j^1 - \beta_k^1)$ is a vector of unknown parameters that can be interpreted as a net influence of the vector of independent variables influencing the participation in diversified food crop enterprise choices, and $F(B^* X_i)$ is a cumulative distribution function of the error terms (ε^*) evaluated at $B^* X_i$. The exact distribution of *F* depends on the distribution of the random disturbance term, ε^*. Depending on the assumed distribution that the random disturbance term follows, several qualitative choice models can be estimated (Greene, 2003).

2.5 Conceptual Framework

The conceptual framework in Figure 2.1 shows a schematic representation of the perceived correlation on how the independent variables affect the dependent variable in the study. It sought to analyse economic determinants affecting participation in food crop diversification among smallholder sugarcane farmers in Mumias East Sub-County, Kakamega County, Kenya. This study will focus on diversification of food crops, which in this case are sorghum, finger millet, Irish potatoes, sweet potatoes and beans by the smallholder sugarcane farmers as the dependent variable (Y_i). The decision of the sugarcane farmers to diversify or not to diversify their food crop

production is influenced by the three categories of determinants the outcome of which will be to enhance increase income and food security. Nine of the socio-economic factors will be analysed. These include the household head's gender, age, education level, experience in farming, household size, land size and membership in a farmers' group.

Participation in food crop diversification system factors include age, gender, level of education, labour available, household size, land size, cropping systems, crop types, farm size and credit facilities, distance to market, market price, cost of market information, extension contacts and credit access, membership to a farmers' group. The income differential factors included prices, production cost, wages and profits.

Independent variables Dependent variable

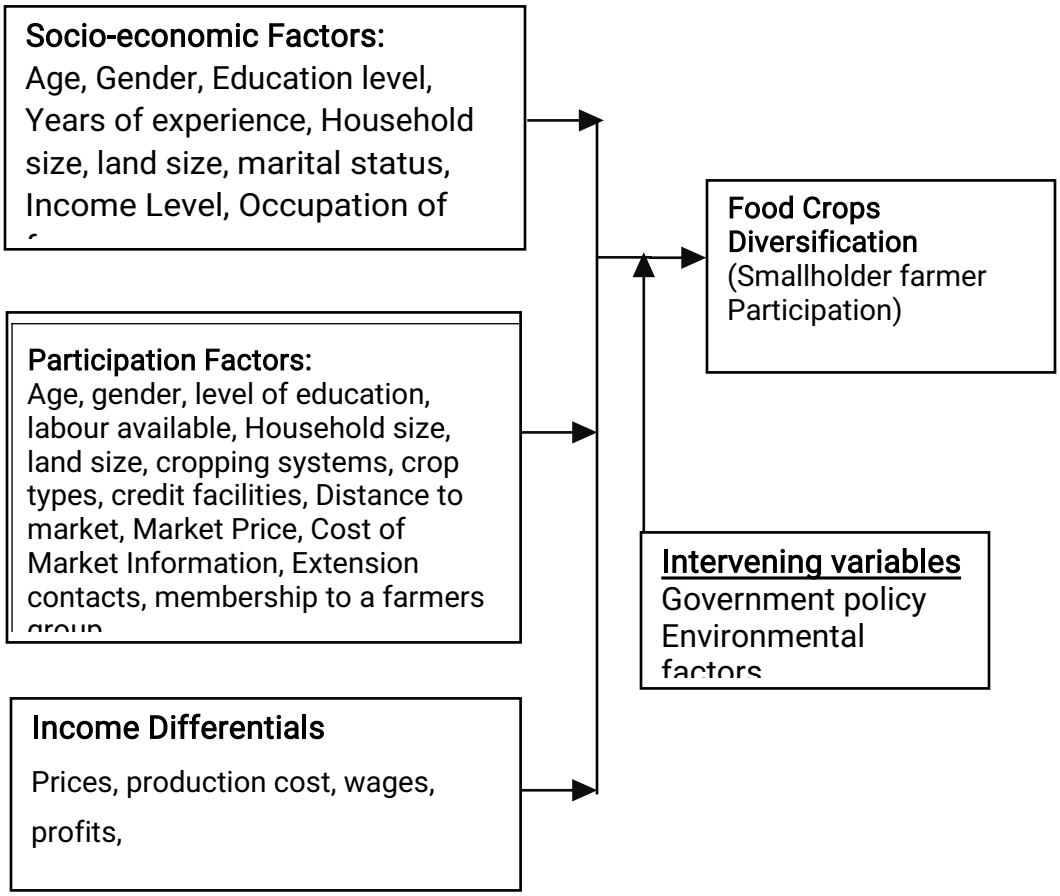

Figure 2.1: Conceptual Framework

Source: Author's own conceptualization

2.6 Identification of Knowledge Gap

There are a number of studies; particularly by Mugendi Njeru (2013) and Kiprono (2012) on diversification across Kenya. However, these studies focused much on-farm and off-farm diversification and on impacts of crop diversification on food security. Among the recommendations from the aforementioned studies shows a need for more studies that focus on food crop diversification in Kenya with respect to status of food crop diversification,

income differentials as well factors influencing it. Therefore, this current study will seek to determine the economic factors affecting smallholder sugarcane farmer participation in food crop diversification in Mumias East, Kakamega County, Kenya. The results from the study informs policymakers on the importance of crop diversification in agricultural productivity for improved livelihoods.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter presents the research design, the study area, the research design, the target population, the sample size, the sampling procedure, data types and sources and data collection instruments, validity and reliability of instruments, data collection procedure, data analysis, diagnostic tests, ethical considerations, definition, measurement of variables and expected signs.

3.2 Research Design

This study adopted descriptive and cross-sectional survey designs. These were used to target smallholder sugarcane farmers to analyse economic determinants affecting participation in food crop diversification in Mumias East Sub-County. The designs are more appropriate because they can give provisions for the comparison of research findings. Furthermore, they are exploratory and allow the researcher to collect, sum up, evaluate, analyse, present and interpret the data more simply and understandably (Kothari, 2008).

3.3 Study Area

3.3.1 Location, Position and Size

The study was done in Mumias East Sub-County, Kakamega County, Kenya as shown in Figure 3.1. The Sub-County is one of the eight Sub-Counties of Kakamega County. Mumias East Sub-County covers an area of 149.2 km² with

a human population of 116,851 (KNBS, 2019). It is situated on the western side of Kakamega County and it borders Navakholo Sub County to the Eastern part, Butere to the Southern part, Lurambi to the Southeastern part and Matanga to the Northern part. The Sub-County is further subdivided into Lusheya-Lubinu, Malaha-Isongo-Makunga, and East Wanga wards. It is situated at a latitude and longitude between 0° N to 20° N and 29°E to 34°E respectively. The altitude ranges between 1240 and 2000 meters above sea level and is characterized by distinct ecological zones of upper medium and lower medium with an annual mean temperature of 23.5^{o} C (CIDP, 2018).

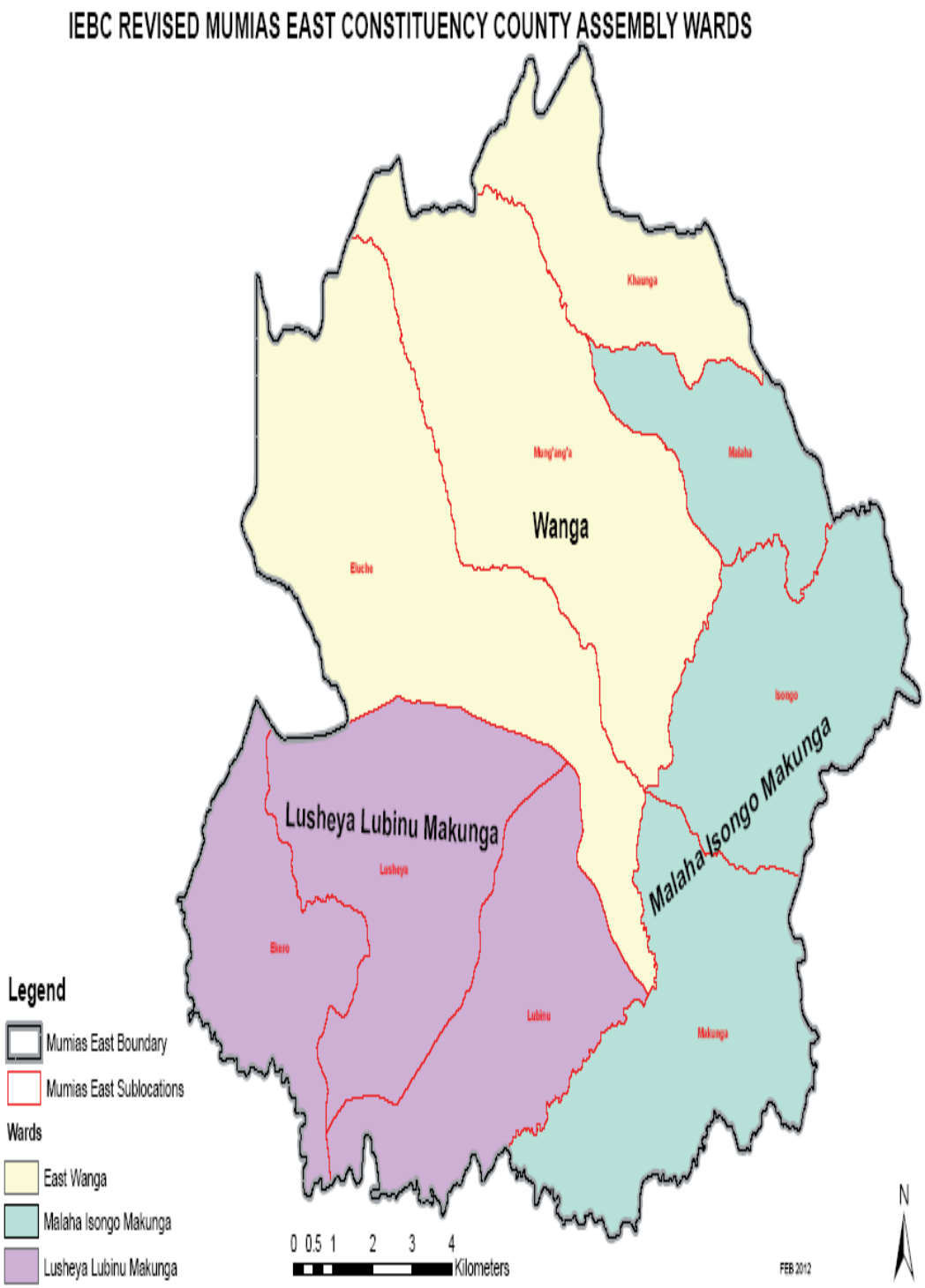
IEBC REVISED MUMIAS EAST CONSTITUENCY COUNTY ASSEMBLY WARDS
Khaunga
Mung'ang'a
Malaha
Wanga
Eluche
Isongo
Lusheya Lubinu Makunga
Malaha Isongo Makunga
Lusheya
Ekero
Lubinu
Makunga
Legend
Mumias East Boundary
Mumias East Sublocations
Wards
East Wanga
Malaha Isongo Makunga
Lusheya Lubinu Makunga
0 0.5 1 2 3 4
Kilometers
FEB 2012
N

Figure 3.1: Map of Mumias East Sub-County

Source: Interim Electoral and Boundaries Commision, (2017)

3.3.2 Physiographic and Natural Conditions

There are two main ecological zones in the sub-county namely; the Upper Medium (UM) and the Lower Medium (LM). The Upper Medium covers the central and northern parts of the sub-county which is Wanga ward. The second ecological zone, the Lower Medium (LM), covers a major portion of the southern part of the sub-county is Lusheya-Lubinu and Malaha-Isongo-Makunga.

The annual rainfall–in Mumias East Sub-County ranges from 1,280.1 mm to 2,214.1 mm per year. The rainfall pattern is evenly distributed all year round with March and July receiving heavy rains while December and February receive light rains (CIDP, 2018). The temperatures range from 18^0C to 29^0C. January, February and March are the hottest months with other months having relatively similar temperatures except for July and August which have relatively cold spells (CIDP, 2018). The sub-county has an average humidity of 67 percent. Since the early 1960s, both minimum (night) and maximum (day) temperatures have been on a warming trend throughout Kenya (CIDP, 2018).

3.3.3 Economic Activities

The County consists of mostly small-scale farmers. Farmers in the study area practice both livestock and livestock production. There is a need for more

effort to promote the production of high-value crops like horticulture to maximize outputs. Most of the farmers in the sub-county are small scale farmers with farm/land sizes that range between 1-5 acres. There are few peasants though i.e. farms less than 1 acre. There are countable number of medium-scale farms with farm/land sizes of between 5-50 acres and large-scale farms that own more than 50-100 acres which are very few in the sub-county (CIDP, 2018). The main crops produced in the study area are maize, beans, sweet potatoes, cassava, bananas, sorghum, finger millet, local vegetables, sugarcane and horticulture. Maize production is supported by farm input subsidies and agricultural mechanization programmes. The farmers in the study area mainly grow sugarcane as a commercial crop.

3.4 Target Population

According to Brenda (2009), the target population for a survey is the entire set of units for which the survey data are to be used to make inferences. Thus, the target population defines those units for which the findings of the survey are meant to generalize. According to the IEBC (2017) register, Mumias East Sub-County has three wards namely; Lusheya-Lubinu, Malaha-Isongo-Makunga and Wanga as shown in Table 3.1. The Sub-County has a total population of 11,885 sugarcane farmers (KNBS, 2019).

Table 3.1:

Population of Small-Scale Sugarcane Farmers per Ward

S. No.	Ward	Target Population

1	Lusheya-Lubinu	3,751
2	Malaha-Isongo-Makunga	5,678
3	Wanga	2656
	Total	**11,885**

3.5 Sample Size and Sampling Procedure

According to Intell, (2012), a sample is a part of an entire population that possesses attitudes, opinions, habits, or characteristics that you wish to study. The appropriate sample size is influenced by your purpose in conducting the research.

3.5.1 Sample Size

The sample size determination for the study was based on the formula provided by Nassiuma (2000) as shown in Equation 3.1.

$$n = \frac{NC^2}{C^2 + (N-1)e^2} \quad \text{..... (3.1)}$$

Where, n = sample size, N = population, C = coefficient of variation, e = error term.

Nassiuma (2000) asserts that in most surveys, for a population of more than 10,000, a standard error of 2% ≤ e ≤ 5% and a coefficient of variation in the range of 21% ≤ C ≤ 30% are usually acceptable. This study, therefore, will use a coefficient variation of 25% and a standard error of 2% to lower the variability and minimize error in the sample. Therefore, fitting the values to equation 3.1 gives the sample size of 154 as shown below.

$$n = \frac{11{,}885 * 0.25^{2}}{0.25^{2} + (11{,}885 - 1)0.02^{2}} = 154$$

Therefore, from the above calculations, a total of 154 small scale sugarcane farmer households formed the required sample size and was used for data analysis in this study.

3.5.2 Sampling Procedure

Sampling, according to Orotho and Kombo (2002), is the process of selecting the required individuals for the study whereby some individuals are selected from a population such that the selected group has elements representative of the characteristics found in the entire population. Therefore, this study employed a multistage sampling procedure whereby purposive, stratified and simple random sampling techniques were used. In the first stage, purposive sampling was used to select the study area since the study area led in terms of sugarcane production in Kakamega County. Thereafter, a stratified random sampling procedure was used to obtain the sample of small-scale sugarcane farmers in the whole Sub County. The area under study has three administrative wards, which formed the three strata for this study. In each of the wards, a proportionate size sampling procedure was used to pick respondents for the study. Thereafter, a list of smallholder sugarcane farmer households from each ward was obtained from the sub-county Agricultural Office. The names of the farmers in the lists were first serially numbered and then randomly ordered and picked using a systematic random sampling

technique. This technique gave each farmer an equal opportunity of being selected and therefore, this increased the chances of obtaining an appropriate and representative sample size. This was advantageous in the sense that the sample frame was already available in the form of a list (Kothari, 2004). The sample size distribution is shown in Table 3.2.

Table 3.2:

Sample Size Distribution per Ward

S. No.	Ward	Target population	%	Proportionate Size Sample
1	Lusheya-Lubinu	3,751	31.6 %	49
2	Malaha-Isongo-Makunga	5,678	47.8 %	74
3	Wanga	2456	20.6 %	31
	Total	**11,885**	**100**	**154**

3.6 Data Types and Sources

This study used both primary and secondary data sources. Primary data was collected directly from the small-scale sugarcane farmer household heads through personal interviews. The small-scale sugarcane farmers were asked questions as guided by the questionnaire (Appendix II). The primary sources of information that were gathered included the socio-economic characteristics such as age, gender, education level, years of experience, household size, land size, marital status, income level and occupation of farmer.

Gross Margins (GM) for maize, sugarcane, millet, sorghum and Irish

potatoes and crop productivity (costs and returns) for maize, sugarcane, millet, sorghum and Irish potatoes were also collected. The data types include the average annual returns over the past five years and the Total Variable Cost *(TVC)*. *TVC* include ploughing, seeds, fertilizers, planting, weeding, harvesting, transportation, and agrochemicals while the crop productivity (costs and returns) data types for sugarcane are the average annual returns over the past five years and its *TVC.* Sugarcane *TVC* that was collected includes ploughing, cuttings, planting, weeding, harvesting, fertilizers, transport, and trash alignment. For cabbages, the TVC is ploughing, seeds, fertilizers, planting, weeding, harvesting, transportation, and agrochemicals.

Market-related factor variable data collected include distance to the nearest market, availability of markets, market price, cost of market information, and cropping system. Institutional factor variable data collected include extension contacts, credit access and a member to a group.

Secondary data was collected through a literature review. A review of various reports such as from Ministry of Agriculture, Livestock and Fisheries annual reports, published theses and economic journals, economic surveys, statistical abstracts, conference reviews, books, magazines, national and county development and strategic plans, National Bureau of Statistics publications, desktop literature, and the internet sources.

3.7 Data Collection Instruments

In this study, primary data was collected directly from the respondents using a questionnaire as shown in Appendix II. Mugenda and Mugenda (2003) defined a questionnaire as a list of questions that are prepared by a researcher to fit a certain inquiry. A questionnaire was developed and used to collect data from small scale sugarcane farmer households in Mumias East Sub-County. Data that was used in the study was collected from samples of small-scale sugarcane farmer households. The structured questionnaire was administered to the respondents through face-to-face interviews by the researcher with the help of trained enumerators. The items in the questionnaire were derived from the three specific objectives of the study.

3.7.1 Validity of the Research Instrument

Kimberlin et al, (2008), describe validity as the extent to which a research tool measures what it is expected to measure. It is the degree to which the outcomes of a test are acceptable. To ensure that the results obtained from this study meet all the credentials of scientific research, the instruments were presented to two experts from the Department of Agriculture Economics and Biosystems, University of Kabianga. The two experts have extensive experience in teaching and supervising postgraduate students. They were able to ascertain the validity by the clarity of wording and whether the respondents were able to interpret all questions similarly. Their comments were incorporated into the instrument.

3.7.2 Reliability of Research Instruments

Kothari, (2008), refers to reliability as the degree to which scores obtained with an instrument are consistent. The instrument should return the same measurements when it is used at different times. According to Mugenda, (2003), a pilot scope of between 1% and 10% is considered suitable. Therefore, for this study, the reliability of the instrument was determined by pre-testing the instrument with a sample of 15 respondents in Mumias West Sub-County who have similar characteristics as the study sample but they never took part in the study. Cronbach's alpha coefficient was used to calculate the reliability coefficient of data from the pilot study, mathematically expressed as shown in Equation 3.2. A coefficient of 0.7 and above is considered acceptable.

$$\alpha = \frac{N\bar{c}}{\bar{v} + (n-1)\bar{c}} \quad \text{.......} \quad (3.2)$$

Where α is the Cronbach's Alpha coefficient, $\bar{c}$ is the average inter-item covariance among the items, $\bar{v}$ is the average variance and N is equal to the number of items/observations.

After calculating the Cronbach's Alpha coefficient for this study, the reliability coefficient results are as shown in Appendix 3. The sample test results generated a coefficient of 0.79, which is an acceptable reliability coefficient of data from the pilot study and therefore, the data collection instrument was deemed reliable for the study.

3.8 Data Collection Procedure

The researcher obtained permission to undertake the research from the National Commission for Science Technology and Innovation (NACOSTI) through an introductory letter from the Directorate of Postgraduate Studies, University of Kabianga. The County Commissioner and County Director for Agriculture were briefed on the reasons for the study. Finally, the researcher proceeded to make appointments with the household heads through the Ward Agricultural Extension Officers. The researcher interviewed the heads or the authorized representative of the household at the scheduled appointment time. In the case where both the household head and the authorized representative were absent, another appointment was scheduled.

3.9 Data Analysis and Presentation

Upon receipt of the filled semi-structured questionnaire initial screening of data began by sorting, coding and cleaning. Incomplete data sources were discarded. The questionnaires were then numbered and coded using a coding frame ready for entry and analysis. For the determination and description of elements of independent variables on the dependent variable, descriptive and inferential statistics were used and results were presented in the form of means, standard deviations, and frequencies. Editing, organizing and analysis of data collected were done with the aid of STATA software. Distribution tables and frequencies were used to present the analysed data.

3.9.1 Estimates of Socioeconomic Factors on Food Crop Diversification

To assess the effects of socio-economic factors on food crop diversification

among small-scale sugarcane farmers in Mumias East Sub-County, Kenya, a multivariate linear regression model, which describes the relationship between the dependent variable and the independent variables, was used. This model presumes the existence of a linear relationship between the dependent variable, independent variables, and latent variables. It can be modelled as shown in Equation 3.3 and as adopted from Brown (2009).

$$Y = b_0 + b_1 x_1 + b_2 x_2 + b_3 x_3 + b_4 x_4 + b_5 x_5 + b_6 x_6 + b_7 x_7 + b_8 x_8 + b_9 x_9 + e \text{ ..... (3.3)}$$

Where Y = food crop diversification,

X_1 = Age,

X_2 = Gender

X_3 = Marital status,

X_4 = Education level,

X_5 = Years of experience,

X_6 = Household size,

X_7 = Land size,

X_8 = Income level,

X_9 = Occupation of farmer,

b_0 to b_9 are the regression coefficients and e is the error term that is normally distributed with a mean of zero and constant variance of sigma squared, $e \sim N(0, \sigma^2)$.

3.9.2 Estimates of Factors Influencing Participation in a Diversified Cropping System

The study further employed the Logistic Regression Model. The Binary logistical regression model was used to determine the factors influencing participation in a diversified cropping system. It is preferred to a linear probabilities model because it has more density mass than the Probit model. Additionally, the Logit model is consistent with parameter estimation with the assumption that the error term has a logistic distribution. In this study, the dependent variable was the participation of the smallholder sugarcane farmers in a diversified cropping system where "p_i" = 1 if there is participation (diversifying farmers) and 0 otherwise (non-diversifying farmers), as shown in Equations 3.4 and 3.5.

$$P_i(Y_{it} = 1) = \frac{\exp(\beta_i Z_{it})}{1 + \exp(\beta_i Z_{it})} \quad \text{..... (3.4)}$$

$$P_i(Y_{it} = 0) = 1 - P_{ii}(Y_{it} - 1) = \frac{1}{1 + \exp(\beta_i Z_{it})} \quad \text{..... (3.5)}$$

Where $P_i\ (Y_i = 1)$ is the probability of a smallholder sugarcane farmer participating in a diversified cropping system (dependent variable) and "Z_{it}" are independent variables influencing participation in a diversified cropping system.

The specified empirical model that was used to determine the factors influencing participation in a diversified cropping system is the Binary logit model. The dependent variable was the participation of smallholder sugarcane

farmers in a diversified crop system of farming (the Dummy variable takes values of 0 for farmers growing less than 2 crops and 1 for farmers growing more than 3 crops) while the number of independent explanatory variables is as specified in Equation 3.6.

$$P_i(Y_i) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + \beta_7 x_7 + \beta_8 x_8 + \beta_9 x_9 + \beta_{10} x_{10} + \beta_{11} x_{11} + \beta_{12} x_{12} + \beta_{13} x_{13} + \beta_{14} x_{14} + e \quad \text{.....(3.6)}$$

Where $P_i\ (Y_i = 1)$ is the probability of a smallholder sugarcane farmer participating in a diversified cropping system of farming.

X_1 = Age

X_2 = level of education

X_3 = labour available

X_4 = Household size

X_5 = land size,

X_6 = cropping systems

X_7 = Distance to market

X_8 = Cost of Market Information

X_9 = Extension contacts

X_{10} = Membership to a farmer's group

X_{11} = Gender

X_{12} = Crop type

X_{13} = Credit access

X_{14} = Market price

βo is a constant, while β_1 *to* β_{14} are parameters for independent variables; the

age of the farmer, gender, level of education, gender, labour available, cropping systems, crop types, farm size and credit facilities, and ε represents the error term.

3.9.3 Estimates of Extend and Income Differentials of the Diversified Cropping System

To estimate the extent and income differentials of diversified cropping systems among smallholder sugarcane farmers in Mumias East Sub-County, Kenya, the farm gross margin model was used. Gross margins analysis for different types of crops was done. The farm gross margin model is a simple method of comparing the performance of enterprises that have similar requirements for capital and labour. It provides information with an additional planning tool to help evaluate options between different farm activities. Gross margin is the difference between total revenue and variable cost as specified in Equation 3.7.

$$GM_i = TR_i - TVC_i \quad \text{..... (3.7)}$$

GM_i is the gross margin per year, TR_i is the total revenue (gross output) per year and TVC_t is the total variable costs all in Kenya shillings (KSh).

The TR_i for each crop was calculated by multiplying the average price of the diversified crop with the average output per hectare as shown in Equation 3.8 and as adopted from Lin et al., (1974).

$$TR_i = P*Y \quad \text{..... (3.8)}$$

Where TR_i is the Total Revenue per year (KSh), P is the average annual price of the diversified crop over the past five years and Y is the average annual yield per hectare over the past five years. Profit returns for each crop was then calculated by multiplying the average price of each crop with the average output per hectare for that particular crop in order to obtain the individual crop gross returns as shown in equation 3.5. The Total Variable Costs (TVC) analysis for the diversified cropping was calculated independently.

The Gross Margin of smallholder sugarcane farmers participating in a diversified cropping system in Mumias East Sub-County was compared to non -participants to determine the more profitable system in the short run. The use of Gross Margin analysis depends on some assumptions. In this case, all prices used were those prevailing during the production season for each of the crops grown by the farmer. Return to capital and labour was also used to determine various aspects of profitability generated from each type of crop grown by farmers after finding the gross margins for the different types of crops. Returns to labour were calculated by dividing the gross margin by the labour costs per acre for each type of crop farming while return to capital was calculated by dividing the gross margin by the total variable cost (TVC) per acre.

3.10 Diagnostics Tests

Diagnostic tests were also conducted from the regression results of STATA

output. STATA has some routines for detecting multicollinearity which allow for correction before the analysis is done. Diagnostic test results provide information on how these raw data may be modelled. When a model is estimated, diagnostic tests on model residuals yield information about model adequacy (Mahmood, 2018). In this study, a multicollinearity test was performed to check for the correctness of the estimates of the variables using the Variance Inflating Factor (VIF) as shown in Equation 3.9. It is the most widely used measure with independent variables. The formula is as shown below as adopted from Marquardt, (1984).

$$VIF = \frac{1}{1 - R^2} \quad \text{..... (3.9)}$$

Where R^2 is the R^2-value obtained by regressing the j^{th} predictor on the remaining predictors.

The Variance Inflating Factor of 1 indicates that there is no correlation between the independent variable and any others. VIFs between 1 and 5 suggest that there is a moderate correlation, but it is not severe enough to warrant corrective measures. VIFs greater than 5 represent critical levels of multicollinearity where the coefficients are poorly estimated, and the *p*-values are questionable.

3.11 Definition, Measurement of Variables and Expected Signs

Table 3.3 presents definition, measurement and expected signs of variables that were used in the study.

Table 3.3:

Description and Measurement of Variables

Variables	Description	Units	Expected sign
Dependent variable			
Food crop diversification	Dummy	1=Yes, 0=No	+/-
Independent variables			
Socio-Economic Factors			
Age	Continuous	Years	+/-
Gender	Categorical	1=male, 0=female	+
Income level	Continuous	KSh	+
Education level	Ordinal	1=Primary 2=Secondary , 3=College 4=University 5=post-graduate	+
Years of experience	Continuous	Years	+
Family size	Continuous	Continuous	+
Extension contacts	Continuous	Hours	+
Credit access	Continuous	Shillings	+/-
Distance related factors	Continuous	Kilometres	+
Availability of market	Continuous	Continuous	+/-
Market price	Continuous	Shillings	+
Cost of market information	Continuous	Shillings	+/-
Cropping systems	Continuous	Continuous	+
Access to credit	Dummy	1=Yes, 2=No	+
Extension contacts	Continuous	Hours	+
Member of a group	Dummy	1=Yes, 2=No	+

3.12 Ethical Considerations

High professional and ethical conduct was maintained to ensure that the respondent's privacy and confidentiality was safeguarded during the study period. The need to carry out the study was communicated to the farmers through a copy of the permit from NACOSTI. Every effort was put in place to ascertain that no plagiarism occurred during the research study and that the intellectual property right is upheld. The thesis document was also scanned for plagiarism using the recommended antiplagiarism software. All the people who were involved in this research were handled with the utmost human dignity and respect.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents the results and discussions of the major findings of this study. It comprises the introduction, response rate, results on effects of socio-economic factors, participation factors, extend and income differential factors affecting smallholder sugarcane farming respectively.

4.2 Response rate

Out of the 154 questionnaires administered to smallholder sugarcane farmers, 152 were duly completed, representing a response rate of 98.7%. Evaluation of response rate plays a critical role in research based on the study by Mugenda and Mugenda (2003) which established that 50% response rate is adequate, 60% is good, and a rate of 70% above is excellent. Concerning the statement, the response rate for this study was considered excellent for analysis.

4.3 Descriptive Statistics Results

The study evaluated the demographic and socioeconomic characteristics of the respondents such as gender, education level, access to credit, membership to a farmers' group, age, family size, income level, years of experience, land size, labour available, distance to the market, cost of market information, as shown in Table 4.1 of results. Gender, education level, access to credit and membership to a farmers' group were presented in terms of percentages while results on age, family size, income level, years of

experience, land size, labour available, distance to the market and cost of market information were continuous variables and therefore presented in terms of means and standard deviations.

Table 4.1:

Demographic and Socio-economic Characteristics of the Respondents

Variables	Characteristics	Count	Valid Percentage (%)
Gender	Male	89	58.6
	Female	63	41.4
	Total	**152**	**100**
Education level	Primary	51	33.6
	Secondary	15	9.9
	Tertiary/College	53	34.8
	University	33	21.7
	Total	**152**	**100.0**
Access to credit	Yes	106	69.7
	No	46	30.3
	Total	**152**	**100**
Membership to a framers' group	Yes	124	81.6
	No	28	18.4
	Total	**152**	**100**

Results in Table 4.1 on gender show that male smallholder sugarcane farmers were 58.6% while female farmers were 41.4%. The results illustrate the variation in the gender distribution among the respondents because the number of males who participated in the study was more than that of females. The current study finding is contrary to the findings by Muyukani and Muthama (2019), done in Kiminini Sub-County of Trans-Nzoia County, who reported that 83% of household heads were male-headed. This has also been

supported by the findings by Chinai (2011), and Ayela et al., (2019) who posited that male-led households in rural agricultural areas are common, especially in Sub-Saharan Africa, because men are regarded as the custodians of property and thus alienating women in heading the households. Sserumaga *et al.,* (2013), in their study in Uganda, reported contrary findings where more than 43% of women were found to be household heads compared to 36% of male-headed and 21% of households headed by children. They also argued that the household head is a contentious issue because of changes in shared roles in modern communities.

On average, 34.8% of the farmers in the table of results had attained college/tertiary education, 33.6% were primary school leavers, 21.7% had attained university education, and 9.9% had completed secondary school education. Majority of the respondents had attained a college/tertiary school level of education. Additionally, a significant proportion of farmers were university graduates. These results imply that most of the farmers were well-educated. Furthermore, it is widely assumed that higher education improves one's ability to absorb and apply essential agricultural information. According to Kalungu & Filho (2016), highly educated farmers are more likely than others to embrace important agricultural information and technologies. The level of education plays an important role in maize production among the members of the household and in particular that of the household head (Kirimi et al., 2013). Formal education provides a route for the acquisition of useful knowledge on

maize production due to the ability to read and comprehend information on agricultural activities. Education also provides an avenue for employment opportunities as a source of income used to purchase food for the household. Mukudi (2003), did a study in sub-Saharan Africa and his results revealed that education plays an integral role in enabling individuals to access public information, especially concerning health, nutrition, and hygiene. He also argues that people with a minimum level of education are more likely than people with no education to obtain information about how to adopt a balanced diet, avoid illnesses, and maintain good hygiene, all of which improve food security. On the other hand, educated people can seek employment elsewhere and the income earned can be used for purchasing maize during food shortages. The current study result is also in convergence with the research finding by Haile, Alemu and Kudhlande (2005), which was conducted in Ethiopia on educational attainment by the household head. The finding revealed that educational attainment by the household head could lead to awareness of the possible advantages of modernizing agriculture using technological inputs. The current study results on education levels are higher than those reported by Omoro (2013), in Nyando District, Nyanza Province, where 83% of the respondents had not gone beyond primary school levels with only 6% having gone past secondary school level. The current high level of education is associated with improved agronomy (Omondi, 2019); adoption of current technologies (Kibet *et al.,* 2011), and high yields (Momanyi et al., (2019).

The findings in Table 4.1 show that the vast majority of the farmers had access to credit facilities which constituted 69.7% of the sample. This could be an indication that many farmers have information on the importance and availability of credit facilities to finance their farming activities. Credit constraints affect farm productivity through their adverse effects on small scale's farm output and investment Karlan et al., (2014). As most small-scale farmers tend to be poor, self–financing of necessary agricultural inputs is not easy; thus, there remains a lag between inputs and the expected agricultural output. Credit can help farmers purchase the inputs required to ensure increased agricultural output. In addition, it helps to smoothen consumption and can affect poverty levels. Therefore; ease of access to agricultural credit in the study area has the potential to increase optimal crop combination plans. The findings of the current study agree with the finding by Feder et al., (2014) who noted that access to credit may affect farm productivity because farmers facing binding capital constraints would end up using lower levels of inputs in their production activities compared to those not constrained. The findings of the current study also compare favourably with the findings by Guikenger (2008) who suggested that credit constraints have a negative impact on the productivity of constrained farmers in Peru. The study suggests that Peruvian farmers do not have other financing alternatives such as an informal sector, capable of fully meeting the liquidity need for constrained farmers in the formal sector.

Further, results show that a vast majority of the farmers (81.6%) were

members of farmers' groups. This implies that most of the farmers have realized the importance of forming groups to increase their bargaining power when it comes to borrowing loans and obtaining other services such as agricultural extension services. Idiong (2007) in his study on the smallholder swamp rice among producers in Nigeria observed that farmers who are members of a producer organization can benefit, not only from the shared knowledge among themselves concerning modern farming methods but also from economies of scale in accessing input markets as a group. Mwaura (2014) in his study in Uganda found that group members had significantly higher maize and banana yields (p<0.01) compared to non-group members. Wanjala et al., (2015) in a study in Western Kenya reported similar positive and significant results on dairy farmers belonging to the farmer's group. Therefore, this current study finding is in convergence with the previous findings by Idiong (2007), Wanjala et al., (2015), and Mwaura (2014).

Table 4.2 of results show that the average monthly household income is Kshs. 20,438.36 with the lowest household income being Kshs 5,000 while the highest household income is Kshs 50,000. This means that the majority of the sugarcane farmers in the study area were middle-income earners and were living above the poverty level. These farmers can easily purchase the necessary inputs needed during sugarcane production. However, the current study findings are in contrast with the findings by Wanjala et al., (2015), who reported that in Western Kenya, the majority of dairy farmers belong to low-income groups and earn an average of Ksh 678,000 annually.

Table 4.2 of the results shows that the mean age of smallholder sugarcane farmers in the study area was 40.46 years, with the youngest being 23 years and the oldest being 70 years old. These outcomes imply that the majority of the farmers are aged above 40 years, and that relatively few youths are engaged in agriculture since most of them seek employment in other sectors of the economy. Farmers within this age bracket are said to be less energetic and unproductive. Fambon, (2011), states that when advanced age comes by, the production of an individual decreases, especially if the individual has a small amount of savings at his disposal to compensate for the loss of production and income. This finding is almost similar to that of Kanana et al., (2019), in their study in Imenti North, Meru County who reported that the majority of farmers were between 40-50 years.

Table 4.2:

Socio-economic Characteristics (Continuous variables) of the Respondents

Variables	Observations (N)	Minimum	Maximum	Mean	Standard Deviation
Household income	152	5,000	50,000	20,438.36	314.25
Age	152	23.00	70.00	40.46	10.07
Years of experience	152	2.00	33.00	22.76	10.18

Land size in acres	152	0 .50	5.00	3.66	1.55
Household size	152	1.00	11.00	5.21	5.40
Workers on the farm	152	0.00	8.00	1.59	2.52
Distance to the market	152	3.00	43.00	8.33	1.28

From Table 4.2 of results, the average household size of a family was 5 people with the smallest family size comprising of 3 members and the largest being made up of 13 members. Osondu et al., (2015), reported that 55.0% of the farmer co-operators in Imo State had a dependency ratio of between 5 to 8 persons, while 24.0% and 21.0% of them had 1 to 4 and 9 to 12 people respectively. The economic performance of the household with the lower number of dependents is greater than that of the households with higher dependents. This is because nuclear family production is greater than in extended family households (Muzari et al., 2012). A similar result was also put forward by Korir *et al.,* (2015), in their study in Eldoret Municipality Kenya where they found that households with a slightly higher number of dependents (10-15) were highly likely to engage in urban agriculture for both home consumption and income.

Table 4.2 of the results further shows the average years of experience of the smallholder sugarcane farmer household head. From the results, the average number of years of experience in farming was 22.76 years. The years of experience ranged from 2 to 33 years. These outcomes showed that the majority of the farmers had a long period of farming hence wider knowledge about farming activities. Previous studies have shown that farming experience goes hand in hand with age and this translates to motivation to adopt new agricultural technologies. Therefore, more experienced farmers are more motivated in farming and hence have physical and economic support to fully engage in more beneficial and rewarding agricultural activities. This current finding compares favourably with the studies done by Wanjala et al., (2015) who found that farmers with many accumulated years of experience in a particular field have a higher stock of skills and hence can apply the skills more effectively resulting in increased and sustainable production. A study by Elisha (2018) on the assessment of rural farmers' perceptions and adaptation strategies to climate change in Nigeria revealed that the farmers who had lived in the study area for over 20 years were aware of climate change and had adopted climate change adaptation strategies. Farmers had a better standard of living than those who had fewer years of experience in farming in the area and this underscored the importance of experience in farming in improving crop production and productivity.

Results on land size in hectares show that the smallholder sugarcane farmer

households owned on average 3.66 hectares with the farmer household with the smallest land size of 0.5 hectares while farmer households with large land size owned 5 hectares. From the farmers' land sizes, the results depict that the majority of smallholder sugar cane farmers were small-scale farmers. Thus, this increases the tendency of practising diversified farming by the sugarcane farmer households. These findings compare favourably with the studies done by Kumba, Wegulo & Otieno (2015a), and Van der Veen and Tagel, (2011) in their study in Kisii County, who reported that a large percentage of households who owned less than one acre (97.6%) were involved mainly in maize production while those with higher acreage were engaged in both maize and cash crop production which increased their chances of being food secure. Similarly, FAO (2006), conducted a study in northern Ethiopia and found out that with increased land under cultivation, the farmer can produce more maize for sufficient consumption and also diversify. The current finding is similar to the findings by Muui et al., (2020), who carried out a study in Western Kenya and found out that most of the farmers had farm sizes ranging between 0.5-5 acres. Similarly, Jayne et al., (2001), also found that the majority of the farmers in Uasin Gishu County had 5 acres of land, which is almost in convergence with the current study finding.

Results further reveal that the average labour available (measured in terms of a number of farm workers) was approximately 2 workers per farm. The number of workers ranged from 0 to 8 workers. This is an indication that most

farms had a mean of less than 2 farm workers. It is also possible that most farmers used family members to work on the farms. A similar finding was put forward by Ogundele and Okoruwa (2006) who found that farmers had less than 3 workers in a rice farm production in Nigeria. Contrary results were also put forward by Luzinda et al., (2019) in a study in Uganda where they reported that 5 labourers provided labour in improved coffee technologies.

The average distance covered by the smallholder sugarcane farmer households to the nearest market as shown in Table 4.2 of results was 8.33 kilometres. The distance to the nearest market ranged from 3 to 43 kilometres. This result implies that most of the farmers were near to the nearest market as they travelled for less than 8 kilometres. This finding is in concurrence with the findings by Kamara (2004) who studied the impact of market access on agricultural productivity in Machakos District. The results indicated that aggregate physical productivity decreases with an increase in distance to the market and aggregate physical productivity increases with improvement in market access. Ochieng et al., (2016) noted that where input and output markets are weak, and access to insurance is limited, small-scale farmers use crop diversification as a mechanism to manage risk. However, revenue does not necessarily rise as crop production systems become more diversified. They noted that the larger the number of crops may be a disincentive to invest in improved seed varieties and fertilizers.

4.4 Diagnostic Test Results

A multicollinearity test was performed to check for the correctness of the estimates of the variables using the Variance Inflating Factor (VIF) as shown in Table 4.3. VIFs between 1 and 5 suggest that there is a moderate correlation. Results in Table 4.2 show that all the VIFs are between 1 and 5. Thus the model was deemed appropriate for the variables.

Table 4.3:

Diagnostic Tests

Model	Collinearity Statistics	
	Tolerance	VIF
Gender	0.751	1.331
Age	0.921	1.086
Family size	0.605	1.652
Education level	0.592	1.690
Income level	0.176	4.959
Years of	0.212	4.726
experience	0.553	3.291
Membership to	0.634	1.783
a framers' group	0.314	3.995
Access to credit	0.917	1.216
Land size	0.221	4.214
Labour available	0.338	2.765
Distance to the market		

4.5 Econometric Analysis Results

To answer the three specific objectives of this study, econometric models were used to empirically analyse each objective separately. Multivariate linear regression model and binary logistic regression models were used to determine the factors influencing participation in a diversified cropping system. The results are presented in the sections that follow.

4.5.1 Estimates of Socioeconomic Factors on Food Crops Diversification

The first objective of the study sought to determine the socio-economic factors influencing food crops diversification among smallholder sugarcane farmers in Mumias East Sub-County, Kenya. As shown in the Table 4.4 of results, the value of *R*-Square indicates the goodness of fit of the linear regression. *R*-square is at 0.709 which means that 70.9% of the total variation in the dependent variable (food crop diversification) is attributed to the socio-economic factors and variables and the remaining 29.1 lies within the error term in the regression model for this study. According to Wooldridge (1991), adjusted *R*-squared ranges from 0 to 1, and a coefficient of determination of 0.7 to 1 is acceptable.

Table 4.4:

Model Summary Results

R	(R^2)	Adjusted *R* Square	Std. Error of the Estimate
0.842[a]	0.709	0.692	0.219

	Sum of Squares	Df	Mean Square	*F*	*P*-value (Sig.)
Regression	16.11	5	3.22	63.89	0.000[b]
Residual	7.36	146	0.05		
Total	23.47	151			

The overall significance of the regression model (ANOVA) was generated which yielded the results as shown in Table 4.3. The findings indicated that the *p*-value is less than the level of significance, i.e., P<0.05. Thus, the sample data provide sufficient evidence to conclude that the regression model fits the data which shows that the independent variables in the model improve the model fit. The *F*-value (63.885) is calculated from the data and was compared to the *F* critical value, $F_{\alpha=0.05}$ (5, 146) = 2.276. The calculated *F* value is larger than the critical *F* value (63.885>2.276). In this regard, the null hypothesis (H_{01}) was rejected. Hence conclude that socio-economic factors have a significant effect on food crop diversification among smallholder sugarcane farmers in Mumias East Sub-County.

The regression results are shown in Table 4.5 of results. The result of the multivariate linear regression analysis showed that household income level, education level, land size and household size were all statistically significant at a 1% level and influenced crop diversification positively except age of the household which was also statistically significant at 1% but influenced crop diversification negatively.

From Table 4.5 of the results, the age of the smallholder sugarcane farmer household head was significant at a 1% level with a negative coefficient (-0.150). The negative sign of the coefficient shows that as the age of the household head increases by one year, a decrease/reduction is probable in crop diversification among smallholder sugarcane farmers by 15% when other factors are kept constant. This implies that as the age of the farmer increases, crop diversification reduces. This is because an older farmer is considered less energetic to supply labour to the farm. The results differ from that of Wiredu et al., (2010), who showed that in rice cultivation in Ghana, age had a positive effect on yield meaning experience in rice cultivation implied accumulated knowledge in rice production. The study is almost similar to the findings in the study done by Von Braun, Hazell, Hoddinot and Babu (2003), on achieving long-term food security in southern Africa, which found that in terms of labour supply, the age of the household head has a negative effect on the amount of maize crop production in the sense that young people in the family households are labour providers on the farm activities and are expected to

cultivate large tracts of land as compared to the older people. These findings are also consistent with the outcomes by Makate et al. (2016), who discovered that crop diversification has shown a positive relationship with the farm household's annual income.

Table 4.5:

Estimates of Effects of Socio-economic Factors on Food Crop Diversification

Variables	Unstandardized β	Std. Error	Standardized B	*T*	Sig. (*P*-value)
(Constant)	-0.625	0.164		-3.820	0.001*
Age	-0.150	0.048	-0.188	-3.116	0.002*
Gender	0.091	0.008	-0.013	11.517	0.773
Income level	0.064	0.016	0.346	4.047	0.001*
Education level	1.877	0.486	0.231	3.860	0.000*
Years of experience	-0.14	0.002	0.031	-6.374	0.432
Household size	0.053	0.009	0.402	5.072	0.001*
Marital status	-0.596	0.962	-0.036	-0.620	0.537
Land size in acres	0.237	0.080	0.588	4.872	0.000*
Occupation	-4.094	5.3760	0.580	6.443	0.446

Legend
Number of observations = 152
LR Chi^2 (9) = 148.9
R^2 = 0.709
Prob >Chi^2 = 148.9
Log likelihood = 0.00
* = significant at 1% level

Results also revealed that education level was statistically significant at a 1% level with a positive coefficient of 1.877. This implies that with an increase in

the educational level of the smallholder sugarcane farmer household head, food crop diversification also increases by 187.7%. The current study results on education level are convergent to those of Ekou (2015) who did a study on the effects of education level on farm production in the Ivory Coast and found out that education level was significant at 1% level with a coefficient of 0.1630. Nyemeck et al., (2004) in Cameroun found that literacy level has an important effect on technical efficiency in the single-crop system of maize, but it has no impact on groundnut production and in the associated production of groundnut. These results show that a farmer, whose literacy number exceeds or is equal to four years, is technically more effective. These findings are similar to those of Weir (1999) who found out that in Ethiopia, literacy level has a positive effect on cereals but it is only noticeable after a minimum of four years of training. However, the current study results differ from the findings by Obierio, (2013) who found out that there is a negative correlation of -0.075 between education and maize yield in Siaya County, meaning education is negatively correlated with farm yield.

Crop diversification and household family size results were also found to have a positive and significant relationship. Household family size of the smallholder sugarcane farmer household head was statistically significant at a 1% level with a positive coefficient of 0.053. With an increase in family size of the smallholder sugarcane farmer household head, food crop diversification also increases by 5.3%. This implies that with numerous agricultural husbandry practices, including land preparation, sowing of seeds, planting

crops, and harvesting; homes with a large family size will tend to grow a bigger range of crops. The findings of the current study are comparable to study findings by Babatunde et al., (2007) in Nigeria who reported that in farming activities, households with larger labour supplies are better positioned to increase the production of their land. This is also consistent with the findings of Muyanga et al., (2008), who noted that relatively larger households tend to be labour suppliers. Increasing labour use in maize production by a single worker increases the mean household income by Kshs 3.517 per day, holding other factors constant.

Further, from the Table 4.5 of results, land size was also statistically significant at a 1% significance level with a positive coefficient of 0.237. The result of land size implies that an increase in land size by one acre leads to a 23.7% increase in food crop diversification among smallholder sugarcane farmer households. This means that smallholder sugarcane farmers who had large fields/farms were seen as more likely to diversify crops in their farms. This could be attributed to the fact that households with large farm sizes may want to maximize the production from their farms as they may have to combine various crops. Similar results on farm size were realized by Chiona (2011) in his study on the technical and allocative efficiency of smallholder farmers in Zambia, where she reported a positive relationship between farm size and efficiency. Increasing the size of the field by one hectare increased the level of technical efficiency by 3 percent and allocative efficiency by one

percent. Idumah et al., (2013) in a study in Edo State, Nigeria found that farm size was significantly positive to yam production in the area. The results of the efficiency estimation, however, indicated that farm size (1.55) was underutilized. Further, Dom et al., (2003), in a study in Nigeria, found that farm size had a positive impact on the output of flutted pumpkin and was significant at a one percent level and the elasticity of production with respect to farm size was 0.71. Therefore, the current study findings are in convergence with that of Chiona (2011), Dom *et al.,* (2003) and Idumah et al., (2013).

4.5.2 Estimates of Factors Influencing Farmer Participation in Diversified Cropping System

The second objective of the study was to examine the factors influencing farmer participation in diversified cropping system among smallholder sugarcane farmers in Mumias East Sub-County, Kenya. In this study the dependent variable was the participation of the smallholder sugarcane farmers in a diversified cropping system where "*pi*" = 1 if there is participation (diversifying farmers) and 0 otherwise (non-diversifying farmers)

Table 4.6 of results shows McFadden's psudo-R^2. From the likelihood calculation, the log likelihood is zero and pseudo- R^2 is 0.623. This implies that 62.3% of the variability in the output of sugarcane production in the study area is accounted for by the specified independent variables. The remaining 37.7% is due to other factors beyond the scope of this study.

Table 4.6:

Model Summary Results

Step	-2 Log likelihood	Pseudo R^2
1	0.000[a]	0.623

The estimated parameter coefficients in the binary logistic regression model are summarized in Table 4.7 of the results. The table of results shows that diagnostic tests age, cost of market information, land size, and market price were the variables which significantly positively influenced cropping systems, credit access and distance to the market were negatively significant farmer participation in crop diversification system.

Results in Table 4.7 show that the age of the smallholder sugarcane farmer household head is statistically significant at a 5% level and with a positive coefficient of 1.170. The result means that a one-year increase in the age of the household head leads to a 117% increase in the probability of the farmer's participation in the crop diversification system. It is most probable that, as the farmers become old, they tend to acquire knowledge and skills in diversified cropping systems. The current study concurs with the findings by Achoja et al., (2020) on the agricultural labour force in Nigeria who observed that the age of the labour force had a significant effect on financial performance. Agricultural productivity was declining with the aging labour force and the study thus recommended upgrading of rural youth capacity to improve agribusiness performance in rural Nigeria. The current study also concurs with the findings

from a study by Medhi (2013) that determined the head of household characteristics and family economic status among Kerman households in Iran. The study revealed that there was a linear relationship between age and income (r = 0.110, p = 0.030). The positive correlation coefficient indicates that an increase in age leads to an increase in income of the farming households. A linear relationship was found to exist between age, and income (r = 0.110, p = 0.030), age and ownership of physical asset (r = 0.300, p = 0.0001). The positive correlation coefficient of 0.110 indicates that an increase in age results to increases in income. The current study further agrees with the findings of the study by Kelly (2001) on effects of age on ownership of physical assets. The study revealed that there is a significant relationship between age and ownership of physical asset indicating that as the age increases, the asset will increase.

Table 4.7:

Logistic Model Outcomes on the Factors Influencing Farmer Participation in Diversified Cropping System

Variable	Coefficient (β)	S. E	Wald	Df	Sig. (p<|z|)	Exp(β)
Constant	5.769	3.675	0.00	1	0.113	320.2174
Age	1.170	0.527	0.00	1	0.029**	3.221993
Gender	1.457	0.180	0.00	1	0.132	0.387653
Level of education	0.817	0.485	0.00	1	0.090	2.263699
Labour available	0.000	0.000	0.00	1	0.393	1.00
Household size	7.023	1984.5	0.00	1	0.997	1122.148
Land size	7.455	0.088	0.00	1	0.006*	1.060775

Cropping systems	-1.229	0.532	0.00	1	0.021**	0.292585
Distance to market	-1.246	0.780	0.00	1	0.112	0.287653
Cost of Market Information	2.082	0.895	0.00	1	0.320	8.020494
Credit access	-2.987	0.963	0.00	1	0.002*	0.050439
Membership in farmers' group	2.282	1.159	0.00	1	0.022**	0.223440
Market price	1.173	1.339	0.00	1	0.000*	1.173543
Crop types	3.082	1.895	0.00	1	0.320	8.020494
Extension Contacts	8.391	10616.962	0.00	1	0.999	4407.223

Legend
Number of observations = 152
LR Chi^2 (9) = 148.9
Pseudo R^2 = 0.623
Prob >Chi^2 = 148.9
Log likelihood = 0.00
***** and ****** are Significant levels at a 1% and 5%, respectively.

Results on Table 4.7 shows that land size was statistically significant at a 1% significance level with a positive coefficient of 7.455. The result on land size implies that a one-hectare increase in land size leads to a 745.5% increase in the probability of participation in crop diversification systems by the smallholder sugarcane farmer households. This result conforms to the expected sign of the study. This means that farmers with big hectarages of land size would increase their likelihood of participating in crop diversification plans, and hence spread the risks associated with agricultural production. The findings of the current study concur with the finding by Chenchen et al., (2019)

which showed that land size greatly affects agricultural productivity, efficiency and rural income. A study by Wanjun & Shigeyuki (2019) in their study to determine the long-run relationship between farm size and agricultural productivity found that the relationship between farm size and agricultural productivity is statistically significant and positive in the long-run. The study showed that farm size has a substantial influence on agricultural sustainability from the aspect of economy, environment and society. It further argued that small farmers can ensure food production through intensive farming with new technology but at higher transaction costs. Agricultural sustainability can be improved based on a better understanding of the role of farm size especially for developing countries where small farms are still dominant. The study is in convergence with the current study on the basis that land size significantly affects agricultural production and consequently farm incomes.

Results in Table 4.7 further show that the cropping system coefficient was statistically significant ($p < 0.05$) at a 5% level and with a negative influence on smallholder sugarcane farmers' involvement in diversified cropping systems. This result implies that as the former increases the cropping systems, the participation of the smallholder sugarcane farmers in a diversified cropping system declines by 122.9%. The current result is convergent with those of Al-Rumikhani, (2002) who did a study on the effectiveness of cropping systems in Saudi Arabia where cropping systems of cereals and alfalfa crops managed with centre pivot systems showed an improvement in soil hydrological properties and subsequent yield improvement. Another long-term study in

Syria conducted by Jones and Singh (2000) showed an increase in crop yield of a barley-legume system compared to continuous barley. A study done in Egypt showed the ability of the cropping system to decrease the nematode population in the soil (Ahlam et al., 2015). Therefore, based on the result of this study, and those conducted across different parts of the world, it has been demonstrated that rotating crops every other year has various economic and environmental benefits.

Results also show that access to credit was statistically significant at a 1% level. However, the variable has a negative coefficient of 2.987, a negative effect on the participation of the smallholder sugarcane farmers in a diversified cropping system. This result means that a decreased change in access to credit services from financial institutions by smallholder sugarcane farmers decreases the likelihood of farmers' participation in a diversified cropping system by 298.7%. A good number of the farmers in the study area are likely to be using credit advanced to them for purposes other than crop production. The results concur with a previous study by Njuguna and Nyairo (2010) who established that access to credit was found to be negative and significant. This current finding is convergent with the finding of Ayo (2010) who argued that the facilitation of access to credit can elevate the amount of productive investment. According to Abass et al., (2017) in their study in Uganda, credits tend to reduce financial difficulties the farmers may face especially during the beginning of a production process by up to 70%. A similar finding was also put forward by Luzinda et al., (2018) who found that access

to credit (p = 0.000) significantly affects the adoption of improved technologies in coffee production in Uganda. The analysis further showed that a 3% increase in access to credit, increases the adoption of improved Robusta coffee technologies by 1%-fold. Arowolo et al., (2020) in a study to determine honey marketing efficiency in Nigeria found that access to credit was a major determinant in determining honey efficiency and was positively significant at a 10% significance level. Therefore, this current study finding is in convergence with the previous study findings by Ayo (2010), Abass, et al., (2017), Luzinda et al., (2018) and Arowolo et al., (2020).

From the results, a farmer's membership in a group is statistically significant at a 5 % level with a positive coefficient of 2.282. This result suggests that a smallholder sugarcane farmer household head who belongs to more than one farmer's groups can leads to 282.2 percent increase in participation in a diversified cropping system by the smallholder sugarcane farmers this is because when the farmer is in several groups and there are several advantages associated with it. Farmer's groups facilitate access to secure markets for their products and encourage income and other agricultural activities. Idiong (2007) in his study on the smallholder swamp rice among producers in Nigeria observed that farmers who are members of a producer organization can benefit, not only from the shared knowledge among themselves concerning modern farming methods but also from economies of scale in accessing input markets as a group. Mwaura (2014) in his study in Uganda found that group members had significantly higher maize and banana

yields (p<0.01) compared to non-group members. Wanjala et al., (2015) in a study in Western Kenya reported similar positive and significant results on dairy farmers belonging to the farmer's group. Therefore, this current study finding is in convergence with the previous findings by Idiong (2007), Wanjala et al., (2015), and Mwaura (2014).

Further, results in Table 4.7 show that the variable market price of sugarcane is significant at a 1% level with a positive coefficient of 1.173. This result implies that an increase in the market price of sugarcane by a shilling per kilogram leads to a 117.3 percent increase in smallholder sugarcane farmers' participation in a diversified cropping system. Increasing the market price of sugarcane will prompt the sugarcane farmer in the study area to participate in a diversified cropping system thereby improving their profit levels. The households in the study area believe that more farmers would engage in certain crop production if the prices were good. Okuthe, Ngesa, and Ochola (2013) in their study in South Western Kenya found that fair prices attract farmers to diversify. Muyukani et al, (2019) in a study in Trans Nzoia County, Kenya reported a negative correlation with maize (r = -0.520, p< 0.01) and argued that low maize prices were likely to induce farmers to diversify their agricultural production and increase sorghum production. Martey et al., (2012) reported a positive and significant result and that an additional increase in the price of maize leads to a 0.2% increase in the amount of maize and cassava sold in Ghana. This current study finding is in convergence with that of Okuthe, Ngesa, and Ochola (2013) and Martey et al., (2012) and in divergence with the

findings of Mukuyani et al., (2019).

4.5.3 Estimates of Extend and Income Differentials of Diversified Cropping System

The third objective of the study was to determine the extent and income differentials of diversified cropping system among smallholder sugarcane farmers in Mumias East Sub-County, Kenya using the Farm Gross Margin Model and by comparing the performance of enterprises that have similar requirements for capital and labour. Gross Margins Analysis for different types of crops was done and the results are shown in Table 4.8.

The results in Table 4.8 show that a vast majority of the smallholder sugarcane farmers cultivate maize (27.6%). Other farmers grow beans (18.4%), potatoes (15.1%), sorghum (13.2%), cabbages (11.8%) and millet (11.2%), while 2.6% of the sampled smallholder sugarcane farmers grow passion fruits. According to a study on economics for farm management decisions by Beck & Demirguc (2013), farmers are looking for ways to make a profit. They may look at prices of products and their costs of production and marketing, and then calculate costs and profit. Other factors relate to the selection of farm enterprises. It concerns whether to specialize in a single enterprise or whether to diversify the farm. Farmers need to decide on concentrating on only one or two enterprises or a number of enterprises. They term this as an economic principle of “comparative advantage.” This concept elucidates how farmers select those enterprises where profits are likely to be the highest. For the

current study, small-scale farmers select crop enterprises that have the highest gross margins, which, according to this study finding are maize and sugarcane in the order of priority.

Table 4.8:

Types of Crops Grown by Smallholder Sugarcane Farmers

Types of crops	Count	Percentage (%)
Maize	42	27.6
Beans	28	18.4
Potatoes	23	15.1
Cabbage	18	11.8
Millet	17	11.2
Sorghum	20	13.2
Passion fruit	4	2.6
Total	**152**	**100**

The smallholder sugarcane farmers who grow one or two types of crops were categorized as non-participants in crop diversification. On the other hand, farmers who grow more than three types of crops were considered to take part in crop diversification as shown Table 4.10. The findings show that nearly 51.7% and 69.1% of the farmers taking part in diversified and non-diversified crop farming, hold less than 5 acres of land. Further, results revealed that 48.3% and 30.9% of the farmers who practiced diversified and non-diversified farming respectively, own between 5 and 9 acres of land. These findings could imply that farmers with comparatively large pieces of land tend to partake in

crop diversification as compared to those with small land sizes. These results contradict a previous study carried out by Basantaray and Nancharaiah (2017) who found that crop diversification is vastly profound in farmers with relatively small sizes of land.

Approximately 25% of smallholder sugarcane farmers practising crop diversification accessed credit facilities, whereas the vast majority (71%) of non-diversifying farmers gained access to credit facilities. This is because the majority of the farmers practise non-diversified crop farming. The results showed that most of the non-diversifying farmers practised mono-cropping system (78.8%), whereas 21.2% of the farmers practised intercropping. This could be attributed to the fact that most of the farmers do not practice diversified crop farming. On the other hand, a considerable percentage of diversifying farmers (24.2%), practised intercropping system.

Table 4.9:

Characteristics of Diversified Crop Farming and Non-Diversified Crop Farming

	Diversified Crop Farming			Non-Diversified Crop Farming		
Farm size	Variables	Count	(%)	Variables	Count	(%)
	Below 5 acres	15	51.7	Below 5 acres	85	69.1
	Between 5-9	14	48.3	Between 5-9	38	30.9
	Above 9 acres	0	0	Above 9 acres	0	0
	Total	29	100	**Total**	123	100
Access to credit	Yes	5	25.0	Yes	71	82.6
	No	15	75.0	No	15	17.4

	Total	20	100	**Total**	86	100
Cropping system	Crop rotation	5	17.2	Crop rotation	0	0
	Mixed cropping	4	13.8	Mixed cropping	0	0
	Mono cropping	13	44.8	Mono cropping	41	78.8
	Intercropping	7	24.2	Intercropping	11	21.2
	Total	29	100	**Total**	52	100

This study additionally sought to compare gross margins between different crops grown by the small-holder sugarcane farmers in Mumias East Sub-County. Gross margin (GM) analysis results for the different types of crops grown by the small-holder sugarcane farmers are shown in Table 4.10 of results. From the table of results, sugarcane production generated the maximum GM of Kshs. 115,594.91 per acre per season whereas maize, potatoes, cabbages, sorghum, beans and millet crop enterprises produced returns of Kshs. 57,609.82, KShs. 37,413.16, KShs. 33,856.20, KShs. 21,371.18, Kshs. 19,741.60 and Kshs. 16,246.33 per acre respectively. Therefore, sugarcane farming produced the highest returns of KShs. 115,594.91 per acre. Millet generated the lowest gross margin of KShs. 16,246.33 per acre. This study results are almost convergent to the study by the Kenya Agriculture and Livestock Research Organization (KALRO, 2016) to determine the viability of sugarcane farming as a business in Bungoma County revealed that the average cost of production was KSh 109,237 and the gross margin was KSh 143,825 per hectare. The finding is almost similar to that of the current study and the small variation between the two can be attributed to the difference in input costs used and the price per Kg of cherry paid during the time of the

study. The current study finding also concurs with the findings from a study by Andrew & Philip (2014) on sugarcane production in the Kigoma Region, Tanzania which revealed that sugarcane productivity was 6,350 kg per hectare and that improving coffee productivity was key to improving household incomes in the study area as farmer did not have control over coffee prices.

Table 4.10

Gross Margins Analysis for Different Types of Crops

Variables	Maize	Beans	Potatoes	Cabbage	Millet	Sorghum	Sugarcane
Gross Output							
Av. Yield/bag (90kg)	21.83	6.48	36.93	15	4.2	6.975	41.34
Av. Price/bag (90kg)	4,228.63	4,570.33	1,589.85	3,366.67	5,580.30	4,933.51	2,796.20
Total Gross Output	92,310.99	29,615.74	58,713.16	50,500.05	23,437.26	34,411.23	115,594.91
Variable Cost/ Acre							
Av. Cost of seeds	1,500	627.14	6,500	458.40	547.08	1,394.57	12,532.33
Av. Cost of fertilizers	4,500.25	1,595.00	4,200	1,058.09	865.00	1,087.13	5,626.67
Av. Cost of labour	25,900.67	6,500.00	7,500	14,207.06	4,500.67	9,022.87	33,499.44
Cost of agrochemicals	2,800.25	1,152	3,100	920.30	1,278.18	1,535.48	2,565.00
Total Variable Cost	34,701.17	9,874.14	21,300	16,643.85	7,190.93	13,040.05	54223.44
Gross Margins	**57,609.82**	**19,741.60**	**37,413.16**	**33,856.20**	**16,246.33**	**21,371.18**	**61,371.47**

To determine various aspects of profitability generated from each type of crop grown by small-holder sugarcane farmers, return to capital and return to labour were also calculated as shown in Table 4.11 of results. From the results, millet produced the highest

return to capital of 2.26 as compared to other types of crops grown by farmers whereas cabbage, beans, potatoes, maize sorghum and sugarcane gave a return on capital of 2.03, 1.99, 1.76, 1.66, 1.64 and 1.13, correspondingly. Sugarcane produced comparatively the lowest return on capital (1.13) though it generated the highest GM (KShs. 61, 317.47). Higher returns on capital in millet, cabbage, beans, and potato crops is attributed to their lower TVCs as compared to that of sugarcane. This study compares favourably to that of Nsubuga (2013) who did a comparison of the net returns of maize and sugarcane in Uganda. From the findings of the study, the net returns a small-scale farmer in the study area obtains an average net return of 13,360,354 and 526,960 Uganda shillings per hectare of maize and sugar cane respectively for five years. Comparing the net returns of maize and sugar cane, the results indicated that sugarcane is a profitable business compared to maize. However, the study differs from the current study as maize production is more profitable than sugarcane production.

Return to labour results yielded 4.99, 3.61, 3.04, 2.38, 2.37, 2.22 and 1.83 for potatoes, millet, beans, cabbage, sorghum maize and sugarcane respectively. From the findings, it can be observed that sugarcane was ranked the lowest in terms of return to labour due to the highest cost of labour. This is because sugarcane entails a lot of farm activities and takes a longer period to be harvested.

Table 4.11

Returns on Capital and Labour

Crops	Aver.GM (Ksh/Acre)	Labour cost (Ksh/Acre)	TVC (Ksh/Acre)	Return to capital (GM/TVC)	Return to labour (GM/L) Cost)
Maize	57,609.82	25,900.67	34,701.17	1.66	2.22
Beans	19,741.60	6,500.00	9,874.14	1.99	3.04
Potatoes	37,413.16	7,500	21,300.00	1.76	4.99
Cabbage	33,856.20	14,207.06	16,643.85	2.03	2.38
Millet	16,246.33	4,500.67	7,190.93	2.26	3.61
Sorghum	21,371.18	9,022.87	13,040.05	1.64	2.37
Sugarcane	61,371.47	33,499.44	54,223.44	1.13	1.83

Table 4.12 of the results presents the GM comparison for diversifying and non-diversifying farmers. The results show that farmers who grow more than three crops enjoyed maximum returns. A combination of maize, potatoes and cabbage crops yielded a total gross margin of KShs. 42,959.73. The same category of farmers growing two types of crops yielded a total gross margin of 35,634.68 per acre. The results are almost convergent to that of Kibet (2011) that show, there was a significant difference between passion fruit crops and maize, wheat, beans, millet, potatoes and dairy farming in terms of gross margin levels.

Table 4.12:

Average Gross Margin Comparison for Diversifying and Non-Diversifying Sugarcane Farmers

Producers	Average Gross Margin (KShs)
Diversifying > 2 crops.	42,959.73
Non-diversifying = 1	35,634.68

To test the hypothesis that Income differentials have no significant effect on crop diversification among smallholder sugarcane farmers in the Mumias East Sub-County, Kenya, the data was further subjected to a chi-square test. The results were presented as shown in Table 4.14 of results.

The results in Table 4.13 show statistical significance (χ^2 = 0.573, df=2, p = 0.004) since the alpha value was set at 0.05. We therefore reject the null hypothesis (H_0) which states that income differentials have no significant effect on crop diversification among smallholder sugarcane farmers in the Mumias East Sub-County.

Table 4.13

Overall Significance of Income Differentials

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	0.573	2	0.004**
Likelihood Ratio	9.538	50	0.020
Linear-by-Linear Association	9.811	52	0.020
N of Valid Cases	52		

****** Significant at 0.05 alpha level

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The chapter provides a summary of the findings based on research objectives and hypotheses, conclusion, recommendations and suggestions for further study.

5.2 Summary

The study aimed to analyse the Socio-economic determinants influencing the participation of smallholder sugarcane farmers in food crop diversification in Mumias East Sub-county. The research collected data from 152 respondents, achieving a high response rate of 98.7%. The demographic information of the respondents was examined, including gender, marital status, family size, education level, main source of income, years of experience, farm size, hectares under maize, and participation in crop diversification. The study found that 58.6% of the respondents were male, while 41.4% were female with a mean age of 55.72 years. Among the respondents, 76.3% were married, 11.8% were single, 9.9% were widowed, and 2.0% were divorced. The average household size of a family was 5 with approximately 5 family members, with the smallest family size comprising of 3 members and the largest being made up of 13 members. Results further show the average years of experience of the smallholder sugarcane farmer household head. From the results, the average number of years of experience in farming was 22.76 years. The years of experience ranged from 2 to 33 years. Results on land size in hectares

show that the smallholder sugarcane farmer households owned on average 3.66 hectares with the farmer household with the smallest land size of 0.5 hectares while farmer households with large land size owned 5 hectares.

On average, 34.8% of the farmers in the study area had attained college/tertiary education, 33.6% were primary school leavers, 21.7% had attained university education, and 9.9% had completed secondary school education. The findings further show that 71.7% of the farmers had access to credit facilities. Further, results show that 82.7% of the farmers were members of farmers' groups.

Results further reveal that the average labour available (measured in terms of number of farm workers) was approximately 2 workers per farm. The number of workers ranged from 0 to 8 workers. The average distance covered by the smallholder sugarcane farmer households to the nearest market was 8.33 kilometres. The distance to the nearest market ranged from 3 to 43 kilometres.

The first objective of the study sought to determine the socio-economic factors influencing food crop diversification among smallholder sugarcane farmers in Mumias East Sub-County, Kenya. Multivariate linear regression was used for data analysis and the results indicated that age, household income level, education level and family size influenced crop diversification. A one-year increase in the age of the household head was found to reduce food crop diversification by 15% when other factors are kept constant. Results also revealed that education level was statistically significant at a 5% level with a positive coefficient of 1.877. Household income level, land size and household

size were all statistically significant at a 1% level with positive coefficients of 0.064, 0.237 and 0.053. They all had a positive influence on crop diversification among smallholder sugarcane farmers.

The second objective of the study was to examine the factors influencing farmer participation in a diversified cropping system among smallholder sugarcane farmers in Mumias East Sub-County. Binary logistic regression was used for data analysis and the results indicated that age, level of education, cropping systems, cost of market information, land size and credit access were the variables which significantly influenced farmer participation in crop diversification. The results show that land size was statistically significant at a 1% significance level with a positive coefficient of 7.455 on farmer participation in crop diversification. Further, results showed that the cropping system coefficient was statistically significant ($p < 0.05$) at a 5% level and with a negative influence on smallholder sugarcane farmers' involvement in diversified cropping systems. Results also show that access to credit was statistically significant at a 1% level. However, the variable had a negative coefficient of 2.987, a negative effect on the participation of the smallholder sugarcane farmers in a diversified cropping system. The results finally indicated that a farmer's membership in a group is statistically significant at a 5 % level with a positive coefficient of 2.282.

The third objective of the study was to determine income differentials of

diversified cropping systems among smallholder sugarcane farmers in Mumias East Sub-County, Kenya using the farm gross margin model. From the results, 27.6% of smallholder sugarcane farmers cultivate maize, beans (18.4%), potatoes (15.1%), sorghum (13.2%), cabbages (11.8%) and millet (11.2%), while 2.6% of the sampled smallholder sugarcane farmers grow passion fruits. Further from the table of results, sugarcane production generated the maximum GM of Kshs. 61,371.47 per acre per season whereas maize, potatoes, cabbages, sorghum, beans and millet crop enterprises produced returns of Kshs. 57,609.82, KShs. 37,413.16, KShs. 33,856.20, KShs. 21,371.18, Kshs. 19,741.60 and Kshs. 16,246.33 per acre respectively. Therefore, maize farming produced the highest returns of KShs. 57,609.82 per acre. Millet generated the lowest gross margin of KShs. 16,246.33 per acre. Further, gross margin results revealed a significantly higher value of revenues for diversified cropping systems of farming of KShs. 42,959.73 as compared to non-diversified of KShs. 35,634.69.

5.3 Conclusions

The first objective of the study sought to determine the socio-economic factors influencing food crop diversification among smallholder sugarcane farmers in Mumias East Sub-County, Kenya. Multivariate linear regression was used for data analysis and the results indicated that age, household income level, education level and family size influenced crop diversification. This implies that the variables had a significant effect on crop diversification.

Therefore, in conclusion, the estimated results of this study rejected the first null hypothesis that household socio-economic factors have no significant effect on food crop diversification among smallholder sugarcane farmers in Mumias East Sub-County, Kenya.

The second objective of the study was to examine the factors influencing farmer participation in a diversified cropping system among smallholder sugarcane farmers in Mumias East Sub-County. Binary logistic regression was used for data analysis and the results indicated that Age, level of education, cropping systems, cost of market information, land size and credit access were the variables which significantly influenced farmer participation in crop diversification. This implies that the variables had a significant effect on food crop diversification. Therefore, in conclusion, the estimated results of this study rejected the second null hypothesis that farmer participation have no significant effect on food crop diversification among smallholder sugarcane farmers in Mumias East Sub-County, Kenya.

The third objective of the study was to determine income differentials of diversified cropping systems among smallholder sugarcane farmers in Mumias East Sub-County, Kenya using the farm gross margin model. The results of gross margin analysis show statistical significance ($\chi 2 = 0.273$, df=3, $p = 0.004$) since the alpha value was set at 0.05. This implies that the variables had a significant effect on crop diversification. Therefore, in conclusion, the estimated results of this study rejected the third null hypothesis that income differentials have no significant effect on food crop diversification among

smallholder sugarcane farmers in Mumias East Sub-County, Kenya.

5.4 Recommendations

The fact that the agricultural sector in Kenya contributes a lot to economic development is proof enough for those involved in the field to come up with appropriate measures for improvement. Since the smallholder sugarcane farmers in Mumias East Sub-County are engaged in agriculture as their main source of livelihood, the emphasis on increased income should be confined to the sector. Therefore, from the empirical results of this study, the following are the proposed policy recommendations: firstly, relevant stakeholders, county and national governments should come up with an agricultural policy that supports the shift from non-diversification to crop diversification through the development of guaranteed access and subsidies to farm inputs resources that will help boost farm production among smallholder sugarcane farmer households. Secondly, more sugarcane farmers need to be trained on food crop diversification through strengthening of the extension services. This will help to solve the issues of food insecurity and also help farmers to realize high profit margins from their farm output. Finally, policymakers should come up with policy directives that encourage the intensification of farm production that would eventually increase agricultural production and incomes among smallholder farmer households.

5.5 Suggestions for Further Research

The study utilized descriptive and cross-sectional data set that was based on

a single production-crop. In future research, the use of panel models should be considered where panel data permits. Also, future study that explores other functional forms and compares the findings with those of this study would inform the growth of literature in the field of agricultural and development economics.

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APPENDICES

Appendix 1: Questionnaire

Introduction

I am Madaphine N. Malala undertaking a master degree course on Agricultural Economics at University of Kabianga. This questionnaire is for collecting data for a research project entitled "**Economic Determinants Influencing Participation in Food Crop Diversification Amongst Smallholder Sugarcane Farmers in Mumias East Sub-County, Kakamega County, Kenya"**. All the information that will be collected will be treated with confidentiality and will be for academic used only. Kindly give your time to answer all questions as accurately as possible.

SerialNo: _____

Date of data collection: ……Location (ward) …….

Sub-County: ……village: ……

Section A: Demographic/Socio-economic Characteristics

Put a tick [ ] or appropriate response(s)

1. Gender (1) Male [ ] (2) Female [ ]
2. Marital status. 1= Single ( ) 2=Married ( )
   3= Divorced ( ) 4=Widowed ( )
3. What is your family size/ number of persons in the family?.....
4. Education level. 1 = None ( ) 2 = Primary level ( )

3 = Secondary level ( ) 4 = Tertiary level ( )

5 = College [ ] 6 = University [ ]

5. What is your main source of family income?

   1. Farming [ ] 2. Employment [ ]

   3. Business [ ] 4. Remittances [ ]

6. For how long have you been doing farming (experience)? .....Years

SECTION B: Resource Availability

7. What is your total farm size in hectares?.....Ha.

a) What is the area in hectares under the following crops in your farm?

Maize……

b) Coffee……..

c) Sugarcane…….

d) Others……..

8. How many workers are available in your farm?.....

9. Do you participate in crop diversification (diversifying farmers) or not (non-diversifying farmers)?

   Yes [ ]

   No [ ]

10. If yes, which enterprises do you practice?

a. ……

b. ……

c. ……

d. ……

11. What benefits do you get from your crop combination in your farm?

1. To increase crop productivity
2. To use land, labour and capital more efficiently
3. To reduce risks and uncertainties
4. To increase farm incomes
5. To ensure food security

Extent of Diversified Cropping System

12. What are the Types of crops grown by smallholder farmers?

List all the crops grown by the farmers

Type of crops	Count	Percentage

Information on the following should also be captured

13. Characteristics of diversified crop farming and non-diversified crop farming

	Diversified crop farming			**Non-diversified crop farming**		
	Variable	Count	Percentage	Variable	Count	Percentage
Farm size	Below 5 acres			Below 5 acres		
	Between5-9			Between5-9		
	Above9 acres			Above9 acres		
	Total			**Total**		
Access to	Yes			Yes		
	No			No		

credit	Total			Total		
Cropping system	Crop rotation			Crop rotation		
	Mixed cropping			Mixed cropping		
	Mono cropping			Mono cropping		
	Inter cropping			Inter cropping		
	Total			Total		

14.. Have you received any training on crop diversification?

1=Yes ( ) 2= No ( )

15. If yes, how many times attended training in the year?

……

……

……

……

16. Who offered the trainings?

1=Government extension officers ( ) 2=Private extension officers ( )

3=NGO extension officers ( ) 4=other specify…….

17. Which topics were you trained on?

……

……

……

……

18. Have you applied the skills received during the training on crop diversification

and food security?

1= Fully ( ) 2=None ( ) 3=Partly ( )

Market Related Factors

19. Name of the nearest sugarcane market ……

20. Distance to the nearest market in Kms …….

21. Total transport cost to the market (KES)…….

22. How much Sugarcane did you harvest last season.....Kgs

23. Where did you sell your produce?.....

24. . Are the prices of the produce Good?

YES [ ]

NO [ ]

25. If your answer is No, what would be your minimum price per kg of sugarcane?

Ksh

26. Are there middlemen in the sugarcane business

YES [ ]

NO [ ]

Institutional Factors

1. What is the average distance you travel to get inputs/outputs in the market.....Km
2. Do you have access to agricultural extension services provider in your area?

Yes [ ]

No [ ]

3. If yes, have you ever gotten his or her services? Yes [ ] No [ ]

4. How many times have you been visited by the extension service provider in the last one year?

   ……

   ……

   ……

   ……

5. Have you received any advice from the extension service providers on maize production for the last one year?

   Yes [ ]

   No [ ]

6. Did you find the advices from extension service provider useful on maize production?

   Yes [ ]

   No [ ]

7. If yes, rate advices provided by the extension service providers on maize production.

   1. Very adequate [ ]
   2. Adequate [ ]
   3. Not sure [ ]
   4. Inadequate [ ]
   5. Strongly inadequate [ ]

8. Have you received any advice from the extension service providers on sugarcane production for the last one year?

Yes [ ]

No [ ]

9. Did you find the advices from extension service provider useful on sugarcane production?

Yes [ ]

No [ ]

10. If yes, rate advices provided by the extension service providers on sugarcane production.

1. Very adequate [ ]
2. Adequate [ ]
3. Not sure [ ]
4. Inadequate [ ]
5. Strongly inadequate [ ]

11. Have you received any advice from the extension service providers on coffee production for the last one year?

Yes [ ]

No [ ]

12. Did you find the advices from extension service provider useful on coffee production? Yes [ ]

No [ ]

13. If yes, rate advices provided by the extension service providers on coffee production.

1. Very adequate [ ]

2. Adequate [ ]

3. Not sure [ ]

4. Inadequate [ ]

5. Strongly inadequate [ ]

14. Do you have access to credit for farming?

Yes [ ]

No [ ]

15. If yes, specify institution….

16. Have you gotten any credit for farm development for last one year?

Yes [ ]

No [ ]

17. If yes, what was the source of credit?

1. Shylock [ ]
2. Micro finance institution [ ]
3. Cooperative society [ ]
4. Commercial bank [ ]

18. How did you acquire the loans?

1. Individual basis [ ]
2. Group basis [ ]

19. Did you give as collateral in order to acquire the loan?

1. Title deed [ ]
2. Logbook [ ]
3. Cattle [ ]

4. Household sugarcane [ ]
5. Proceeds from tea [ ]
6. Proceeds from maize [ ]
7. Proceeds from coffee [ ]

20. Low access to credit facilities to maize farmers influence maize production. D o you agree with this statement?

1. Strong agree [ ]
2. Agree [ ]
3. Not sure [ ]
4. Disagree [ ]
5. Strongly disagree [ ]

21. There are micro finance institutions within my area offering banking facilities.

1. Strong agree [ ]
2. Agree [ ]
3. Not sure [ ]
4. Disagree [ ]
5. Strongly disagree [ ]

22. Are you a member of any group? Yes [ ] No [ ]. If yes, specify……..

23. Is the group engaging in maize production activities?

Yes [ ]

No [ ]

24. Are you satisfied of being a member of the group?

Yes [ ]

No [ ]

25. What benefits have you derived from being a member of the group?

1. Timely sales of milk. [ ]
2. Access to loans. [ ]
3. Joint performance of tasks in the farm[ ]
4. Others. Specify…….

26. What is the distance to the nearest farm inputs market from your farm?

……

……

……

……

27. Was the source of capital used in the production of your sugarcane a credit/loan?

YES [ ] NO [ ]

28. Did you have an extension contact before starting sugarcane production? (Tick)

YES [----] NO [----]

29. If yes, what information did you obtained that influenced your sugarcane production

……

30. Do you belong to a farm group or farmers SACCO? YES [ ] NO [ ]

31. Are there any government policies or regulations that affect your production?

YES [ ] NO [ ]

Income Differentials of Diversified Cropping System

Variables	Maize	Beans	Potato	Cabbage	Millet	Sorghum
Gross Output						
Average Yield/bag (90 Kgs)						
Av. Price/bag (90kg)						
Total Gross Output						
Variable Cost/ Acre						
Av. Cost of seeds						
Av. Cost of fertilizers						
Av. Cost of labour						
Cost of agrochemicals						
Total Variable Cost						
Gross Margins						

Thank You for your cooperation

Appendix 2: Letter of Transmittal

Madaphine Malala,

P.O Box 2192-30100,

ELDORET

Dear Sir/Madam,

REF: REQUEST FOR PARTICIPATION IN RESEARCH STUDY

I am Madaphine Malala a student of the University of Kabianga pursuing a Master's degree in Agricultural Economics and resource management; I am conducting a study on the **Determinants Influencing Participation in Food Crop Diversification Amongst Smallholder Sugarcane Farmers in Mumias East Sub-County, Kakamega County, Kenya**. This information collected from you will be kept confidential and used purely for this academic work. Thanks for your cooperation.

Yours faithfully,

Madaphine Malala

AGR/PGEC/006/19

0708609467

Appendix 3: Questionnaire Reliability Statistics Results

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No. of Items
0.787	0.790	15

Appendix 4: NACOSTI Permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **729292**

Date of Issue: **23/August/2022**

RESEARCH LICENSE

This is to Certify that Miss.. MALALA NAMISO MADAPHINE of University of Kabianga, has been licensed to conduct research in Kakamega on the topic: ECONOMIC DETERMINANTS INFLUENCING PARTICIPATION IN FOOD CROP DIVERSIFICATION AMONGST SMALLHOLDER SUGARCANE FARMERS IN MUMIAS EAST SUB-COUNTY, KAKAMEGA COUNTY, KENYA for the period ending : 23/August/2023.

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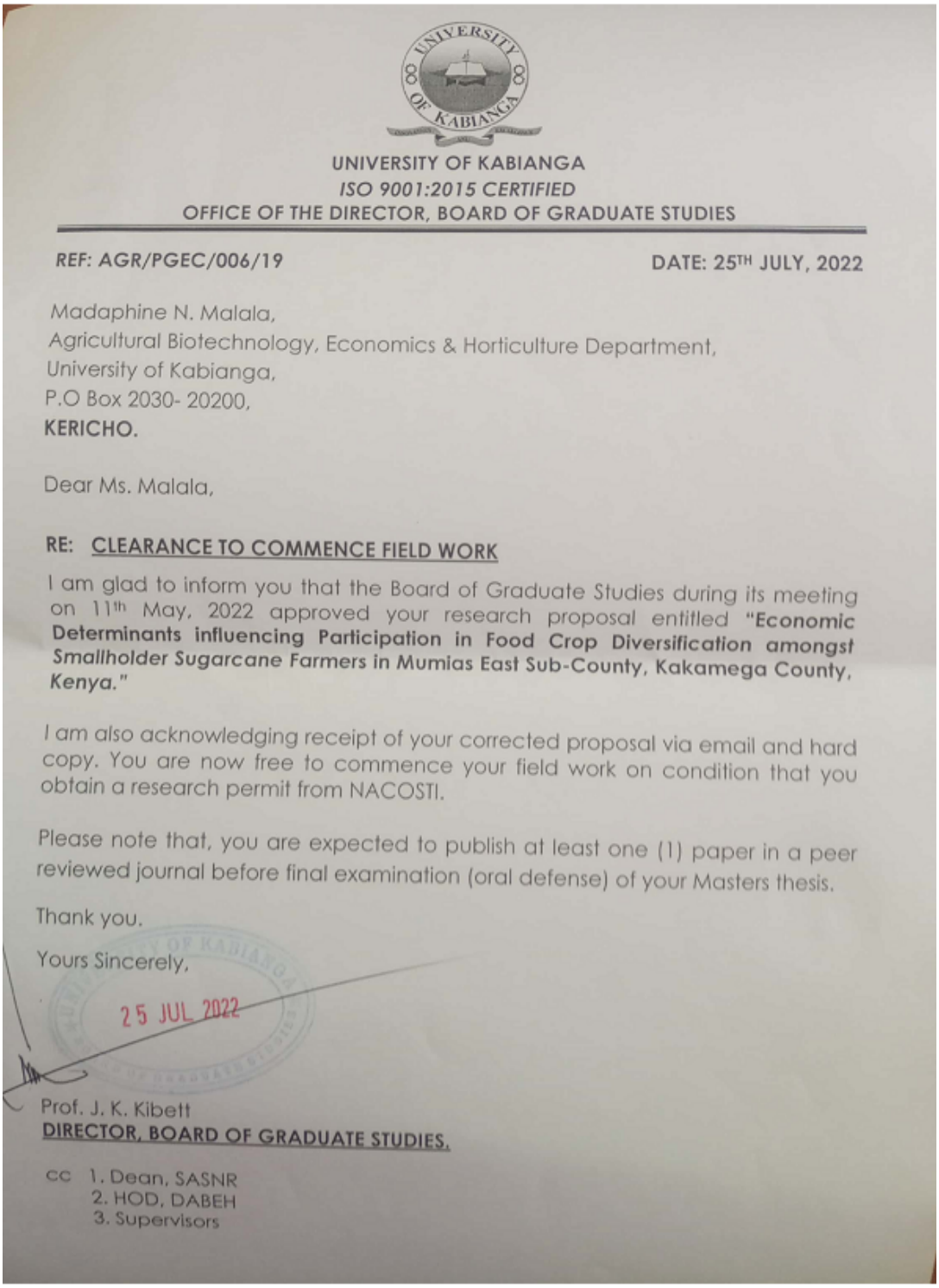
Appendix 5: Clearance Letter



UNIVERSITY OF KABIANGA
ISO 9001:2015 CERTIFIED
OFFICE OF THE DIRECTOR, BOARD OF GRADUATE STUDIES

REF: AGR/PGEC/006/19 DATE: 25TH JULY, 2022

Madaphine N. Malala,
Agricultural Biotechnology, Economics & Horticulture Department,
University of Kabianga,
P.O Box 2030- 20200,
KERICHO.

Dear Ms. Malala,

RE: CLEARANCE TO COMMENCE FIELD WORK

I am glad to inform you that the Board of Graduate Studies during its meeting on 11th May, 2022 approved your research proposal entitled **"Economic Determinants influencing Participation in Food Crop Diversification amongst Smallholder Sugarcane Farmers in Mumias East Sub-County, Kakamega County, Kenya."**

I am also acknowledging receipt of your corrected proposal via email and hard copy. You are now free to commence your field work on condition that you obtain a research permit from NACOSTI.

Please note that, you are expected to publish at least one (1) paper in a peer reviewed journal before final examination (oral defense) of your Masters thesis.

Thank you.

Yours Sincerely,

25 JUL 2022

Prof. J. K. Kibett
DIRECTOR, BOARD OF GRADUATE STUDIES.

cc 1. Dean, SASNR
2. HOD, DABEH
3. Supervisors