EFFECT OF SUBSIDY PROGRAM ON FERTILIZER USAGE AND MAIZE-GRAIN PRODUCTIVITY AMONG SMALL-SCALE FARMERS IN KAKAMEGA COUNTY, KENYA

BY

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DECLARATION

I hereby certify that this thesis has not been previously submitted for the award of a degree in Maseno University or any other University. The work contained herein has been carried out by myself and all sources and information have been specifically acknowledged by means of reference.

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DEDICATION

This thesis is a dedication to my loving mum Judy, dad the late Dr. Abraham Mulupi, sisters, and supervisors for constant inspiration and endless support. May the Lord bless and fulfill their expectations without limit.

ABSTRACT

The continuous use of land over some time has undermined the availability of soil nutrients globally. The decline in soil fertility is among the main challenges facing crop productivity, especially in Africa. To counter the soil nutrients issue, farmers are required to intensify the application of fertilizers. However, inorganic fertilizer application rates in Sub-Sahara Africa remain low compared to other developing regions. A number of government-led interventions and strategies have been introduced to raise fertilizer usage. One policy instrument so far implemented is the fertilizer subsidy program for small-scale farmers. Despite, the criticisms on targeting and voucher allocation procedures, fertilizer subsidies continue to be implemented by national and county governments in Kenya. However, there has not been much achievement in the overall crop yields, especially for maize where productivity is declining despite the continued subsidies for fertilizer as reported in the Kakamega County Integrated Development Plan. This study sought to estimate the proportions of subsidized fertilizer utilized, determine the socio-economic factors affecting the proportions of subsidized fertilizer utilized in the overall inorganic fertilizer usage, and determine the effect of the subsidized fertilizer program on maize-grain productivity among small-scale maize farmers in Kakamega County. The study adopted rational choice theory and theory of production using a Cobb-Douglas function to estimate maize-grain yields attained by farmers. This study was done in Malava and Mumias East Sub-counties on a study population of 44,098 farmers targeting 80% of farmers practicing maize farming; representing the sub-counties with the highest and least number of farmers in Kakamega County. The study employed a cross-sectional survey design using semi-structured questionnaires to obtain data from 300 farmers, selected using a multi-stage sampling technique. Descriptive statistics were used to estimate proportions of subsidized fertilizer utilization, a Tobit regression model to determine the social-economic factors influencing proportions of subsidized fertilizer utilized, and a two-stage probit and Tobit approach controlling for program selection bias to determine the effect of the fertilizer subsidy program on maize-grain productivity. Results revealed that the average proportion of subsidized fertilizer utilized was 59.48% among subsidy program participants. Moreover, the findings showed higher average fertilizer usage of 85.6 kg/ha among the program participants compared to 74.9 kg/ha for non-participants. The proportion of subsidized fertilizer usage by farmers was significantly influenced by the farm size under maize, household size, quantities of seeds planted, age and education level of the household head, distance to the input market, and amount of credit borrowed. Tobit model results showed that subsidy program participation led to an increase in maize-grain productivity by 32.3%, after controlling for actual fertilizer quantities, seed quality, and household socio-economic characteristics. The average maize productivity was 2.216t/ha with Malava having a significantly higher average of 2.265t/ha compared to Mumias East at 2.11t/ha. Farmers who benefited from the subsidy program had average productivity of 2.46t/ha significantly higher than non-participants who had an average of 1.97t/ha. However, despite this positive effect, the fertilizer subsidy program in Kakamega County has not been able to increase maize yields to the potential production levels (5.5 t/ha), since the average fertilizer usage is still low as compared to what is recommended for the county for it to make an impact on productivity. The study recommends the subsidy program as a good strategy to attain the recommended application rates of 200 (NPK) and 150 (CAN) kg/ha as the participants have higher fertilizer application rates. Moreover, policymakers need to consider the socio-economic factors of small-scale farmers when formulating policies on allocation, as they are the main target for the program to attain optimal fertilizer application, and increased maize productivity.

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LIST OF ABBREVIATIONS

AfDB:	African Development Bank
ASDSP:	Agricultural Sector Development Strategy Programme
CAN:	Calcium Ammonium Nitrate
CIAT:	International Centre for Tropical Agriculture
CIMMYT:	International Maize and Wheat Improvement Centre
DAP:	Di-Ammonium Phosphate
FAO:	Food and Agricultural Organization
IMR:	Inverse Mills Ratio
KAPP:	Kenya Agricultural Productivity Program
KCIDP:	Kakamega County Integrated Development Plan
KMDP:	Kenya Maize Development Program
KSHC:	Kenya Soil Health Consortium
MDG:	Millennium Development Goals
MoALF:	Ministry of Agriculture, Livestock, and Fisheries
NAAIAP:	National Accelerated Agricultural Input Access Program
NCPB:	National Cereals and Produce Board
NEPAD:	New Partnership for African Development
NGO:	Non-Governmental Organization
NPK:	Nitrogen, phosphorus and potassium
T/Ha:	Tons per hectares
USA:	United States of America

OPERATIONAL DEFINITION OF TERMS

Dependent variable: The factor being measured is maize productivity in the study.

Dummy variable: A binary variable taking exclusively two mutually values of 0, and 1, when absence 0 and presence 1. In this study, 0 is not participating, and 1 is participating in the program.

Household: A group of people with the same dwelling unit, answerable to one household head.

Independent variable: Socio-economic factors, in this study, are the social, institutional, and farm-related factors affecting maize grain productivity. Variable are the factors being measured.

Model: A theoretical construct representing the economic process by a set of variables and a set of logical relationships designed to yield a hypothesis about economic behavior that can be tested.

Nominal variable: Factors that have categories that can take a particular attribute being measured.

Probit model: A type of regression model analyzed when the dependent variable can only take two values. In this study, the dependent variable for participation is binary.

Productivity: A measure of production efficiency. In this study is the output of maize grain in t/ha

Scale variable: Factors having numeric values. In the study, factors such as age or schooling years.

Social-economic factors: The social, farm, and institutional factors affecting maize farming.

Small-scale farmer: A farmer owning less than 2.5 ha of land, characterized by the rural set-up, in this study, are farmers producing for subsistence purposes and using simple technology

Subsidy program: This is a situation where the government makes part of the payment to lower the cost of agricultural inputs for vulnerable farming households. Basically, the difference between the prices paid to the fertilizer manufactures and the price received from the farmers.

Tobit: Model that estimates a linear relationship between variables when there is either left or right censoring of a dependent variable. In this study, the relationship between socio-economic factors and maize productivity.

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CHAPTER ONE

INTRODUCTION

1.1 Background

The agricultural sector continues to be a cornerstone and pillar for most economies in developing nations and provides livelihoods to millions of people (Geffersa, 2019). The sector is crucial to poverty reduction and socioeconomic transformation globally (Pretty et al., 2011; Akuku et al., 2019). Sustainable long-term development in both developed and developing nations around the world is projected to be reliant on agriculture as a vital sector (Selejio, 2017). Higher farm productivity would reduce both absolute as well as relative poverty among rural households (De Janvry & Sadoulet, 2009; Mellor, 2019). Globally, over 67 percent of the people generate income from the sector, with the sector contributing 39.4% of the Gross Domestic Product (GDP) while exports of agricultural products account for 43% of global total exports (FAO, 2002; Kahanna & Solanki, 2014). In addition, 65% of the African state's employment is sectorial and over 75% of its domestic trade is either directly or indirectly related to agriculture (World Bank., 2016).

Like many other developing nations, Kenya is primarily an agricultural-based country and the sector contributes about 26 percent to the GDP directly and 25 percent indirectly (UNEP, 2015). More so, the sector does not only serve as a primary source of livelihood for the poorest households in the country but also the economic driver (Akuku et al., 2019). This sector employs more than 40 percent of the population in the country comprising over 70 percent of the rural people and generates income for over 80 percent of the Kenyan population (Barmao & Tarus, 2019). Agriculture further promotes exports by over 65% and exceeds all the other economic sectors by contributing to about 75% of raw materials in the industries (World Bank, 2018). Resource-poor small-scale subsistence producers owning land up to 1.3 hectares largely dominate the sector, which further contributes about 78 percent of the total agricultural production (FAO, 2016).

Specifically, maize yield is estimated at 880 million metric tons globally. The United States of America, China, and Brazil are the leading producers accounting for over 60% of the world output (Alexandratos, 2012). Despite the production, 13.6% of the global population of which the majority are in developing countries are still food insecure (FAO, 2014).

In Kenya, maize is one of the essential crops in the country, with 2.2 million hectares or about 40 percent of Kenya's harvested crop area covered by this crop. The crop contributes approximately 12.65% of agricultural GDP and 2.4% of the total GDP (DTMA, 2015; FAOSTAT, 2021). Furthermore, 103 kg of the crop is approximated for consumption per person annually. This is higher than most other countries in Eastern Africa (DTMA, 2015). Regardless of its status in the country on food security and economic development (Ochola & Fengying, 2015), maize productivity has generally stagnated in recent years (DTMA, 2015; Jena et al., 2021). Production and productivity rates are way lower than regional and global averages (Naseem et al., 2018). This has led to persistent maize shortages with annual maize output often falling below the country's consumption (Kirimi et al., 2011; Barmao & Tarus, 2019).

Soil fertility depletion and scarce use of modern technologies are part of the main factors contributing to low yields in crops (Hijbeek et al., 2021; Ejigu et al., 2021). Furthermore, much of the soil fertility depletion has been attributed to increasing human activities and climate change (Diiro & Ker, 2009; Brevik, 2013; Mutea et al., 2020). In addition, poor agronomic practices, limited crop research, inadequate institutional support (Kogo et al., 2020), inadequate use of inorganic fertilizer, leakages from the subsidy programs, and market failure in the agricultural input system (Druilhe & Barreiro-hurlé, 2012), exacerbated by new challenges such as variability in weather and patterns of pest and disease (Akuku et al., 2019), are the other reasons for reduction of soil fertility and low crop productivity in Kenya.

Maize is the primary source of food, largely produced by over 81 percent of the households in Kakamega County (KNBS, 2019). The plant is cultivated on a small to medium scale for subsistence purposes throughout the county. However, commercial production is practiced on a medium scale in the north-eastern part (KCIDP, 2018). Despite an increasing population in the county, productivity has not shown any significant increase. Generally, crop harvests are low; with an average maize production below 0.9 tons per hectare (Diwani et al., 2013; Koomson et al., 2020). The almost stagnant quantities of product output shown (Table 1) are associated with acreage expansion and not productivity which reduced by approximately 10% from 2013 to 2017 just in 5 years according to the most recent documented information (KCIDP, 2018).

Table 1: Maize productivity trends in Kakamega County.

Year	Area (Ha)	Number of bags (90kg)	Yields (Kg ha^{-1})
2013	68,375	1,994,344	2,620
2014	70,938	2,038,790	2,570
2015	79,407	2,212,340	2,510
2016	83,235	2,103,450	2,280
2017	83,235	2,100,000	2,270

Source: Departments reports; Kakamega County Integrated Development Plan 2013-2017.

According to the report compiled by Kenya Soil Health Consortium in collaboration with other partners, in the period 1925 to 2015, soil fertility has deteriorated and poor soil health is prevalent in the Western region of Kenya and is associated with low crop yields. Macharia et al. (2009) also reported low grain yields for farmers in North Western province being caused by declining soil fertility and susceptibility to pests and disease. Similarly, Mbakaya et al. (2011) and Mulinya et al. (2015) reported that soil fertility depletion on smallholder farms is a major natural cause of reduced food productivity in Kakamega North District.

To sustainably increase crop productivity, it is necessary to apply optimal quantities of fertilizer (Anago et al., 2020; Debnath & Babu, 2020). However, commercial farm inputs are expensive for most farmers to access (Selejio, 2017; Barasa, 2019). With an average poverty index of 51% in Kakamega County, it implies that the affordability of fertilizer is a major concern for many farming households (AfDB, 2016). This has lowered the fertilizer application rates exposing farming households to land degradation and food insecurity (Paul et al., 2015).

Several programs have been implemented by NGOs in the region to assist in improving maize productivity. For instance, the Kenya Maize Development Program was funded by USAID. The program began in 2002 and ended in 2010 having accomplished its mandate. The program focused on mid to high potential maize producing areas of the western region. It was able to double maize yield from 0.78 t/ha to over 1.5 t/h (Smale et al., 2012). Like many other economies, in addressing the sustainability of maize sufficiency, formulated strategies to attain optimal output. For instance, the Chinese and USA governments supported maize production by subsidizing farm inputs and offering grants to various agricultural programs promoting maize production (FAO, 2014).

Similarly, to address the issue of input access, the Government of Kenya through the NAAIAP program has been implementing farm input subsidies since 2007. The first phase of the NAAIAP subsidy program was known as *Kilimo* plus which lasted for two years, providing mainly less resource endowed farmers with fully subsidized farm inputs. The aim of *Kilimo* plus was to uplift these farmers so that after two years they can make part payments of the inputs offered through the program (NAAIAP, 2014; Belt et al., 2015). Program participants were supposed to pay Ksh. 1800 which was lower than the market price of Ksh.3100 per 50 kg bag from private agro-dealers. This translates to a 41% subsidy on the price, which is lower than the input subsidy in Malawi where fertilizer was subsidized for up to two-thirds of market cost (Gebeyehu, 2019; Carter & Njagi, 2019). Malawi spends 70 percent of the Ministry of Agriculture's budget subsidizing fertilizer and seeds. In Zambia since 2004, an average of 40 percent of the government's agricultural sector budget has been devoted to farm-inputs subsidies annually (Mason & Ricker-Gilbert, 2012). This initiative was a response to the Abuja Declaration on fertilizer for African resolutions. In the declaration, African heads of state resolved to increase fertilizer usage to at least 50 kg/ha by the year 2015 from eight kg/ha at the time (NEPAD, 2006).

Despite the initiatives, a substantial improvement in yields is yet to be realized even after widening the targeted area under the fertilizer subsidy to the whole country (Druilhe & Barreiro-Hurlé, 2012; Jena et al., 2021). There is an existing yield gap between what is possible with the existing technologies and what farmers currently achieve. Studies had been done on factors influencing subsidized fertilizer access and use intensity on smallholder farmers in Trans Nzoia County (Barasa et al., 2019), the influence of the type of farm input subsidies on maize production in Trans Nzoia (Wafula et al., 2018) and effect of the NAAIA subsidy program on fertilizer usage and food production (Mavuthu, 2017). However, such studies have inadequately evaluated the proportion of subsidized fertilizer usage and factors influencing the usage of these proportions of subsidized fertilizer. In addition, maize productivity has generally continued to stagnate in recent years in Kakamega County and one of the causes, as reported is the depletion of soil fertility levels despite the program being operational. Therefore, the study also sought to determine the effect of the subsidized fertilizer program on maize productivity.

1.2 Statement of the problem

Maize productivity has been on a decline in Kakamega County, this is caused by low soil fertility due to continuous land cultivation. To sustainably increase productivity, the application of optimal fertilizer quantities is a necessity. However, commercial farm inputs are expensive for most farmers, and therefore lowered fertilizer application rates expose farming households to land degradation and food insecurity. The County Government of Kakamega, therefore, introduced a partially paid fertilizer program that aimed at achieving increased fertilizer application rates of at least 75kg/ha by easing affordability. Despite this initiative, maize productivity has remained low in the county. What farmers currently achieve in terms of grain yield is lower than what is possible regardless of the government's efforts to reverse the situation. There is a lack of consensus on the sustainability of the subsidy program in the attainment of optimal maize productivity. This study, therefore, sought to determine the effect of subsidy program on fertilizer usage and maize-grain productivity among small-scale farmers in Kakamega County.

1.3 Objectives of the study

1.3.1 General objective

To determine the effect of subsidy program on fertilizer usage and maize-grain productivity among small-scale farmers in Kakamega County, Kenya.

1.3.2 Specific objectives

I. To estimate the proportion of subsidized fertilizer in the overall quantity of inorganic fertilizer utilization, among small-scale maize farmers in Kakamega County.

II. To determine social-economic factors influencing the proportion of subsidized fertilizer in the overall quantity of inorganic fertilizer utilization, among small-scale maize farmers in Kakamega County.

III. To determine the effect of the subsidized fertilizer program on maize-grain productivity, among small-scale maize farmers in Kakamega County.

1.4 Research questions

I. What proportion of subsidized fertilizer, in the overall quantity of inorganic fertilizer, is utilized among small-scale maize farmers in Kakamega County?

II. What social-economic factors influence the proportion of subsidized fertilizer in the overall quantity of inorganic fertilizer utilization, among small-scale maize farmers in Kakamega County?

III. What is the effect of the subsidized fertilizer program on maize-grain productivity among small-scale maize farmers in Kakamega County?

1.5 Justification of the study

Despite the great potential to improve the country's economy in terms of food supply, low maize output has been persistent in Kakamega County. Low fertilizer usage has reengineered the hitches of declining soil fertility leading to inadequate crop yields (Ngome et al., 2013; Munialo et al., 2020). Maize crop, produced by over 80 percent of the households is a source of livelihood and a necessity for most people (FAO, 2016). To achieve food sustainability for the growing population, the government through policymakers has been concerned about how to raise productivity for the majority of small-scale farmers producing over 75 percent of the agricultural products (FAO, 2016; Lokuruka, 2020). This has created the need for smart policies that improve soil fertility and increase fertilizer application rates in agriculture as a solution (Kordas et al., 2016; Kehinde, 2017; Anago et al., 2020). The County Government of Kakamega initiated a farm inputs subsidy program to ease affordability for resource-poor farmers (Njoroge et al., 2018). The key policy goal of the subsidy program is aligned with vision 2030, the big-four government agendas, the objective of the Strategy for Revitalizing Agriculture, and the goals set in the MDGs of reducing poverty, attaining food reliance, and transforming agriculture from subsistence to commercial.

Regardless the program is in operation, there has been scanty knowledge on how beneficiaries of the program are selected, how quantities of fertilizer are allocated based on the farmers' household socioeconomic characteristics, and how the program has affected fertilizer usage and maize productivity. In addition, scanty information is available on the leakages from the subsidy program. The program's benefits and costs have continuously aroused debates among stakeholders on sustainability in the long term (Makau et al., 2016). The program performance was to be reviewed to strategies on how to further improve on execution and as a guide on future formulation and implementation of social programs in refining soil nutrients and raising agricultural productivity to attain food security, hence the need for the study.

1.6 Scope and limitations of the study

1.6.1 Scope of the study

This study was conducted in Malava and Mumias East Sub-counties of Kakamega County among randomly selected small-scale farmers who benefited from subsidized fertilizer and non-beneficiary in the year 2020. A list of program participants was acquired from the office of the Department of Agriculture. The study addressed the problems of low maize productivity caused by declining soil fertility. It addressed three objectives which are determining proportions of subsidized fertilizer utilization, socio-economic factors affecting these proportions of usage and finally determining the program's effect on maize productivity. Data was collected from 300 small-scale farmers using semi-structured survey questionnaires.

1.6.2 Limitations and measures to minimize.

Despite the county being dominated by small-scale farmers, the study was limited to a sample. For language barrier cases, the researcher read and translated interview questions into the most understandable language. Moreover, since small-scale farmers do not keep records, respondents were allowed to consult household members in case there was missing detail to increase data reliability. The widely spreading disease of Covid 19 scared some farmers from interacting freely with the researcher who was a stranger. This was resolved by observing all the Ministry of Health set guidelines of keeping social distance and proper wearing of a mask. In addition, a new mask was provided to the respondent by the researcher to put on before the interview. Also, the soil-related, climatic factors, and intercropping issues were not considered.

1.7 Assumption of the study

The investigator assumed that the respondents provided authentic and accurate answers to questions provided and recalled most of the basic and crucial information being investigated. In addition, it was anticipated that since the study population has similarities in social and farming activities, the participating farmers properly represented the entire population.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter provides an overview of the previous studies that have been conducted on the concept of subsidy programs and the effect on maize productivity. It has reviewed the literature on global, African, and Kenyan maize productivity, favorable agronomic factors for maize production, the effect of subsidy programs on fertilizer usage, socio-economic factors affecting the program participation, and maize productivity. In addition, a summary of the literature and the gaps are provided. Lastly, the theoretical and the conceptual framework are discussed in this section.

Global maize overview

After wheat and rice, maize is the third-largest crop grown contributing to about 24% of the total cereals produced globally (Imran et al., 2015; Rehman et al., 2016). About 1.2 billion people depend on maize directly as a major food (Barmao & Tarus, 2019). It has been largely classified into white and yellow maize Meyer et al. (2006) and Suri & Tanumihardjo (2016) and the two categories are produced under similar climatic conditions (Ranum et al., 2014). Most maize varieties mature in about 100-130 days, however, this varies with climatic conditions (Fisher et al., 2015).

Maize is a raw material for a wide range of industrial activities ranging from manufacturing services of explosives, plastics, and glue to food processing and traded in huge quantities as an animal feed crop (Kirimi et al., 2011; Greaves & Wang, 2017). Maize stover is used as wood fuel and in biomass fuel production for the transportation sector (Wang et al., 2015). Over 85% of maize produced is consumed as food; it can be boiled, roasted, consumed as popcorns, or processed into flour before the preparation of ugali, and porridge among other local meals (Kirimi, 2012).

Table 2: World maize production

North America	38.8%	Africa	6.9%
Asia	28.5%	Central America	3.4%
South America	11.2%	Oceania	0.07%
Europe	11.1%		

Source: (Kimani et al., 2017; Barmao & Tarus, 2019)

Maize production in African

Despite a 60% expansion in the area under maize production for the period between 2007 and 2017, across Africa, crop productivity continues to deteriorate (Barmao & Tarus, 2019; Mohammed, 2021). These low average yields are attributed to extreme poverty, land degradation, and climate change (Benson et al., 2015; Raimi et al., 2017). The rate of fertilizer application in African countries is low compared to other developing regions. Africa only accounts for 3 percent of the world's fertilizer usage with an average application rate of 7kg/ha which is low compared to the recommended rates to increase crop yields (Druilhe & Barreiro-Hurlé., 2012; Azumah & Zakaria, 2019).

Table 3: African top maize producers

Country	Thousands of tons	Production (kg /h)
South Africa	14900	4500
Nigeria	11500	1800
Ethiopia	8600	3400
Tanzania	6300	1600
Egypt	6400	7700
Malawi	3900	2300
Kenya	4000	1700

Source: (DTMA, 2015)

The rate at which the population is growing has overwhelmed agricultural productivity and this has put pressure on food security which has become a crucial challenge in African countries (Scheiterle et al., 2019). In Kenya particularly, a high number of people are food insecure and highly dependent on food aid. During the period 2016 to 2018, over 30% of the population was undernourished (Boulanger et al., 2020). The maize crop is extensively grown in Trans Nzoia, Nakuru, Bungoma, Uasin Gishu, Nandi, and Elgeyo Marakwet Counties (Kimani et al., 2017). However, it is practiced in the whole country on a small to medium scale. It is cultivated alongside other crops. Higher output can be realized by the use of certified seeds, however, some farmers practice production with their farm varieties (Schroeder et al., 2013).

Table 4: Trends in maize production in Kenya

Data (*tons,000's*)	Change, %	Year
4,000	5.26 %	2020
3,800	-5.33 %	2019
4,014	8.84 %	2018
3,688	10.45 %	2017
3,339	-12.71 %	2016
3,825	8.88 %	2015
3,513	-2.23 %	2014
3,593	-4.19 %	2013
3,750	11.05 %	2012
3,377	-2.54 %	2011
3,465	42.05 %	2010

Source: (Birch, 2018; FAOSTAT, 2021)

Mixed and inter-cropping are the highly farming systems practiced in Kakamega County. Farm labor is mostly offered by the household members, however, a few farmers depend on experienced hired labor. Farm inputs are acquired from the nearby agro-dealers at a market price. In addition, the county government provides inputs at a subsidized price for vulnerable households. Despite, most farmers planting improved maize varieties, a few still prefer their farm seeds. Maize processing is done by business personnel all over the county. Post harvested losses and early harvesting are testified to contribute significantly to low output (KCIDP, 2018).

2.2 Site description and conditions necessary for maize production

Knowledge of the agrological zone is key in agricultural practices, especially maize farming. It is a requirement that forms the basis of the choice of the inputs for the farmer by understanding the soil characteristics despite the plant being adaptive in different types of soils. Maize production requires all nutrients for effective growth at every stage. These nutrients can be supplied by fertile, good aerated, and well-textured soil (Eticha, 2020). At this level of soil fertility, fewer external inputs are necessary. However, because of the continuous cultivation of land for a long time, the soil fertility structure and composition change. Normally, maize grows well in a soil pH of between 5.5 and 7.3 with a pH of 6.0-6.5 being optimal. At this range, nitrogen helps in the establishment of healthy leaves, phosphorus is a requirement for root formation, potassium for fruiting while secondary nutrients such as calcium and magnesium are critical for crop physiological functions (Sindhupalchok, 2016).

In Mumias East according to NAAIAP (2014), the soil pH range from 4.6 to 6.46 while in Malava ranges from 4.18 to 6.09 which is strongly acid to slightly acid in both sub-counties. The soil organic matter content range from 0.9% to 2.03% in Mumias East compared to 0.79% to 3.29% in Malava. Both nitrogen, phosphorus, and potassium are limited nutrients in Mumias East while nitrogen and phosphorus are limited in Malava. Non-acidic fertilizers such as Triple Super Phosphate, Single Super Phosphate, NPK, CAN, and Mavuno are therefore recommended in both sub-counties. For Mumias East application of 8 t/ha of manure, 125 kg/ha CAN, and 250 kg/ha NPK: 17:17:17 for planting are recommended. For Malava, application of 6 t/ha of manure, 200 kg/ha CAN, and 200 kg/ha NPK: 23:23:0 for planting are recommended (NAAIAP, 2014).

The crop can be grown in warm weather with different rainfall ranges. For instance, 1200mm-2500mm, at times also in the region receiving rainfall of up to 400mm (One Acre Fund, 2015; Macleod et al., 2021). There should be sufficient moisture in the soil throughout the planting season and temperatures of between 18 to 23°C. However, a temperature of 20°C is the best for germination, and 21-27 °C is considered the better growth of the plants (Sindhupalchok, 2016).

Management practices are also key for good maize productivity. A few weeks before planting, the land should be prepared through tillage, and organic manure applied before sowing. Maize seeds should be treated with fungicide for controlling dumping-off. During planting, proper spacing, and planting intensity should be ensured. A spacing of 75cm by 25 cm has been recommended in most regions. Weeding should be done after 25-30 days of planting and at the knee height stage and this should be done regularly to reduce the unwanted materials. Thinning should also be done before weeding to control competition for nutrients, water, and sunlight (Eticha, 2020).

2.3 Fertilizer usage in Kenya

Aligning with MDGs in Kenya, the extermination of poverty and hunger will be a result of sufficient food access by vulnerable households and this could be achieved through production-enhancing technology and inputs (McMichael & Schneider, 2011). The government controlled the prices of these inputs through importation policy reforms and the subsidy program. This greatly enhanced farmers' fertilizer access by raising the number of inputs retailers significantly (Freeman & Omiti, 2003; Jayne et al., 2003).

Effect of subsidy program policies on fertilizer usage.

Cash voucher on input subsidies has not prospered to reach the poorest farmers and producers due to poor selection and management systems failures (MAFAP, 2013; Pernechele et al., 2018). By the year 1993, small-holder farmers accessed fertilizer through cooperatives and private sectors after the government had suspended free fertilizer distribution, abolished import quota, and legalized private trade in the early 1990s (Ariga & Jayne, 2009).

The increase of non-governmental dealers in agricultural inputs retailing was a result of removing market and public investments restrictions which raised competition in distribution (Olwande et al., 2015). This led to reduced inputs prices. The presence of retailers all over the country has increased inputs entrance at local levels (Ogada et al., 2015). In 2007, the NAAIAP subsidy program was introduced by the government to provide over 2.5 million smallholder farmers with farm inputs to promote food security through increased input usage and sustainably high agricultural productivity (Ogada et al., 2015). These reforms led to increased use of fertilizer from 45,220 tons in 1990-1994 to 77,285 tons from 2003-2007 (FAO, 2018). Before the implementation of the services, fertilizer was a monopoly business by the Kenyan government (Bunde et al., 2019). The policy implementation increased to about 80% of smallholder farmers who access fertilizer in western Kenya; this has been through increased fertilizer supply through importation, wholesalers' and retailers level and enabling farmers' access through private sectors and co-operatives in the early 1990s (Omamo & Mose, 2001).

According to Ariga & Jayne (2008), the subsidy program increased the amount of fertilizer application in western highlands to up to 163 kg/ha. Similarly, as reported by Banful et al. (2010), based on Nigerian state subsidy rates in 2008, higher fertilizer consumption was conveyed in the states that had generous subsidy allocation. Moreover, Chirwa (2010) and Aiyabei (2018) reported that farmers who received subsidy inputs were able to use more quantities of fertilizer. Similarly, Ricker-Gilbert (2011) found an extra kilogram of subsidy fertilizer used crowding out the purchase of commercial fertilizer by 0.22 kg. In agreement, Takeshima et al. (2012), mentioned that farmers combining commercial and government fertilizer apply more fertilizer by 60 kg per ha.

The reports by Druilhe & Hurle (2012) and Anago et al. (2020) revealed the availability of proof suggesting that subsidy programs are effective in intensifying the usage of inputs in agriculture. Similarly, Jongare & Michael (2015) and Zinnbauer et al. (2018) reported that subsidy programs improved the fertilizer use intensity in Ghana and Zambia respectively. In the report by Makau et al. (2016), increasing quantities of subsidized fertilizer use by one kilogram correspondingly crowded out the market fertilizer by 0.20 kg in North Rift. According to Birch (2018), inputs subsidy programs tend to crowd out market fertilizer. Hemming et al. (2018), mentioned a decrease in purchasing commercial fertilizer by 0.05% resulting from a 1% increased utilization of subsidized fertilizer.

2.4 Empirical studies on the effects of subsidy program on maize productivity

According to Dorward et al. (2008) when evaluating the adoption of FISP in the years 2012/13, based on the simulation findings, authors reported an increment in fertilizer usage, maize output, and improvement in household food security in Malawi as a result of the program. A full package adoption had a probability of increasing output by the lowest 500kg. Equally, a 50 kg bag of subsidized fertilizer had a possibility of increasing maize output between 200kg to 400kg. In addition, a cost-benefit ratio of 0.76 to 1.36 verified that the program yield favorable economic returns. Alene et al. (2008), informed that the complete removal of explicit subsidies on smallholder farms reduced hybrid maize seeds and fertilizer usage quantities in the Eastern and Southern regions of Nigeria. Also, population growth outpaced grain production leading to food insecurity and poor living standards. Similarly, Xu et al. (2009) and Kelly et al. (2011), mentioned a quick improvement in agricultural production which had been formerly reluctant as a result of the introduction of subsidies.

Similarly, Denning et al. (2009) and Gawamadzi & Kosura (2011) while investigating the impact of fertilizer subsidy program adoption on the marketing of maize in Malawi using a two-wave incorporated Household Panel Survey (IHPS) data, the authors determined the average partial effects by analyzing linear and non-linear models through a method of correlating random effects. In their report, though the magnitude of the effects was moderately low, subsidized fertilizer increased farmers' market participation because of increasing production quantities, agro-dealer numbers, quantities sold as well as intensified maize commercialization. Substantially, Chirwa (2010) on evaluating agricultural input subsidy programs using a quasi-experimental design in econometrics controlling for selection biases by creating control groups, reported subsidy programs contributing positively to food production.

According to the study by Dorward & Chirwa (2011), on the Malawi Agricultural Input Subsidy Program (MAISP), authors reported a substantial increase in maize production that contributed to increased food availability, and reduced rural poverty as well as amplified real wages. In the study, further approximation of the subsidy program economic returns was done and reported to have been pleasing using a cost-benefit analysis. Moreover, Ricker-Gilbert et al. (2011) reported an intensification in the production of maize by a range of about 1.82 kg to 3.16 kg if utilized up to the third year in a row being affected by consuming a surplus kilogram of subsidized fertilizer. According to Druilhe & Barreiro-hurlé (2012), fertilizer subsidies were supposed to be the most effective instrument to increase fertilizer usage and raise crop productivity. However, the authors reported that the subsidy program's success highly depends on the policy implementation. He further recommends that in situations where the output is low due to poor inputs accessibility, a solution can be found in the fertilizer subsidies program. The author justified further by giving an example of the Sasakawa Global Initiative which consistently led to increasing production in Ethiopia during and after the program, in Rwanda where maize output rose from 3.8% to 7.9% after the subsidy program, and in Mali where production of cotton enormously increased.

Harmoniously, a report from Ricker-Gilbert et al. (2013), in their findings in research on how maize productivity is affected by fertilizer subsidy in Zambia, an additional one kilogram of the fertilizer increased output by 1.88kg among farmers. Congruently, Chibwana et al. (2013), reported that farm input subsidy programs have a significant relationship with fertilizer use intensity and crop yields. The authors further mentioned that using subsidized fertilizer and using both subsidized fertilizer and hybrid seeds increases maize output for small-scale farmers by 249 kg and 447 kg per ha respectively. They recommended the program as a mechanism to drive poor households towards food self-sufficiency.

Additionally, in the report by Welime (2014), in a research that was done in Kenya on the effects of price subsidy on fertilizer use intensity using panel data and a simple regression model, the author mentioned the usage of the subsidized programs significantly increased yields. Supporting, Ragasa et al. (2013) and Wiredu et al. (2015) who conducted a study on fertilizer subsidy effects on land production in Ghana, authors reported subsidized fertilizer having increased rice production by 29 kg/ha. According to Ochola & Fengying (2015), using cross-sectional data and multinomial logistic analysis, reported subsidized fertilizer has played a vital role in achieving food security among rural households. Consistently, it was suggested by Abdulaleem et al. (2017) who analyzed the cost and return on maize production that to make maize farming lucrative, the government of Nigeria should subsidize all the inputs. In the reports of Theriault et al. (2018) and Bunde et al. (2019) and using a survey design, they mentioned an affirmative relationship between maize productivity and input subsidies while researching on effects of government incentives on maize production in Nandi North, Kenya.

Furthermore, Magut et al. (2019) in a study on evaluating government subsidies on the productivity of maize among farmers in Uasin Gishu, Kenya, the author mentioned an increasing relationship between production and fertilizer subsidy program participation. In addition, Allotey (2019) who assessed the impact of subsidy program participation in Ghana using a propensity score matching reported that farmers who participated in the subsidy program had a higher revenue. He further recommended the expansion of the program as it has the potential to increase productivity. Tallying, Smale et al. (2020) studied the effect of the fertilizer subsidy program on fertilizer usage, farmstead harvest, and crop commercialization in Mali, employing a regression model, they conveyed a positive effect on the crops targeted. However, on millet and sorghum, though the effect was affirmative, it was weak and insignificant. They further reported the inconsequential effect of subsidized fertilizer on yields when the application is less than 65 kg and 87 kg/ha for rice and maize respectively (Smale et al., 2020). According to Baquedano et al. (2010); Kipng'eno (2012) and (Alhassan et al., 2020), the chance presented by the subsidy program is key in African countries to improve food production for resource-poor and attain food security.

However, on contrary, Crawford et al. (2006) reported that subsidies are not desirable in the world of perfectly competitive markets as they result in economic ineffectiveness and high welfare losses. Similarly, Morris et al. (2007) acknowledged the vital role of subsidies in agricultural productivity and the use of improved inputs, however, they reported that it has resulted in inefficiencies, selection biases, dislodgment of commercial sales, and high costs to the government and taxpayer compared to the benefits. They further recommended the removal of the program once a farmer has acquired sufficient skills and invested more in research development and farmers' training.

In addition, Minot & Benson (2010) and Dorward & Chirwa (2011) reported that under any market condition, especially, when output prices are low, the profitability of subsidies is never certain. The author further mentioned that the subsidy program is beneficial only where the technical efficiency especially the quality is considered, timing, and appropriate use. According to Filipski & Taylor (2012), social funds transfer is superior compared to input subsidies. In addition, products price support is more essential to producers as well. As reported by Druilhe & Barreiro-Hurlé (2012), the usage of agricultural inputs can be amplified by subsidies only when the farmer receives is facing market failure for the inputs. The authors acknowledge that though many studies have been done on the subsidy inputs, the contribution to national food security strategies is highly controversial. Subsidies have clear success in farm productivity and input usage, however, they have failed to provide a sustainable solution to rural development and food uncertainty in developing nations.

Similarly, as reported by Kahsay et al. (2015), only complementary actions such as research and development can increase the returns on the input subsidy program. The authors attributed the failure of the program to heavy government expenditure crowding out supplement necessary actions that can lead to increased productivity. Similarly, a report by Ragasa & Chapoto (2017) suggested a more holistic approach to encourage fertilizer application and productivity to be adopted by the government of Ghana rather than subsidies which have left maize production low and unbeneficial for over two decades. According to Leal-Filho et al. (2019) and Monke et al. (2019), who evaluated the effectiveness of different policies on Kenyan agricultural targets and Sustainable Development Goals, they reported that subsidy programs had no impact on agricultural productivity, poverty, and under-nourishment and recommended that increase in productivity could only be achieved through mutual strategies including agriculturalists training and agricultural research and development.

Similarly, the adoption of a subsidy program negatively affected rice productivity in Ghana (Azumah & Zakaria, 2019). Kinuthia (2020) exposes the weakness of the program by revealing an initial increase in maize and rice production in only a few regions in Tanzania, however, it failed in the long run. This implies that the program has raised productivity in different parts globally. However, acute consideration of the quality, delivery time, and yields prices are essential to realizing the larger objective of food reliance and rural livelihood enhancement.

2.5 Empirical literature on socio-economic factors hypothesized to influence the likelihood of participation and usage intensity of subsidized fertilizer

To instantly meet the increased demand for food for the rapidly increasing population, increasing crop productivity among resource-poor farmers is usually essential. This initiative is driven by adopting new technology (Karkie & Bauer, 2004). Participation in technology is usually a psychological process that an individual goes through (Mashaliya et al., 2020**).** Technology participation decision is grounded on a prudently evaluated number of technological, economic, and social factors and administered by multifaceted aspects such as financial access, site, institutional support, and material supply (Hall & Khan, 2017; Vecchio et al., 2020; Bai & Sarkis, 2020).

According to Jaisridhar et al. (2013), education and improved farming practices had a significantly positive association in research assessing factors influencing the adoption of better dairy farming knowledge in Malawi. According to Sigei et al. (2014), farmers who school highly are intelligent to digest information and process faster to adopt new changes in the farming system. As reported by Karkie & Bauer (2004), highly schooled decreased risk-avoiding components and increased fertilizer adoption rate. However, on the contrary, as reported by Mwangi & Kariuki (2015), genetically modified crops adoption was inversely affected by the schooling years in a formal learning institution. According to Etwire et al. (2013), schooling was anticipated to have an influence on the potential to source and interpret agricultural projects information. However, the findings reported were contrary as more educated farmers were found not solely depending on farming but have allocated resources and time to other occupations, therefore, time-constrained to participate in government-initiated agricultural projects. He further recommended that an extra year in school reduces the likelihood of participating in government-initiated projects by 2%.

According to Thirtle et al. (2003) and Karkie & Bauer (2004), age was negatively influencing the probability of technology adoption and innovation in farming. Older farmers were more skeptical of innovations and resistant to changes and mostly they become late adopters of technology or laggards. In contrast, as reported by Alexander & Van Mellor (2005), age intensified the adoption of genetically modified varieties of maize, as the young people gained experience, the more they adopted but declined with the farmers close to retirement. Similarly, according to Felistus (2009) and Martey et al. (2013), young agriculturalists are expected to respond to new farming changes faster than the elderly who may be rigid to changing the production system. As revealed by Etwire et al. (2013) and Mwaura et al. (2021), the authors reported that young farmers have a higher likelihood of participating in agricultural government-initiated projects as they are more pioneering, risk-takers, and always motivated to try new perceptions. Highly experienced aged farmers might be resource endowed, hence they do not see a need of participating in government-sponsored initiatives. Similarly, Imran et al. (2015) testified that the more aging women become, the less they participated in agricultural projects in western Kenya. In addition, they explained that this was caused by physical weakness.

Jayne et al. (2010), reported that in Malawi large-scale agricultural subsidies have yielded more substantial benefits to farmers and the government than small-scale ones. Similarly, Uaiene (2011) mentioned that farmers possessing bigger farms have a higher probability of participating in fertilizer subsidy programs as they can afford to assign part of their land for technology experiments. Similarly, according to Akudugu et al. (2012) and Jongare & Michael (2015), farmers with large farms use more subsidized fertilizer and have higher inputs demand. Owning larger farms is linked to the ability to adopt new technologies and possession of the capability to withstand risks in case of failure (Abeykoon et al., 2015). However, according to Mwangi & Kariuki (2015), smaller sizes of land provide incentives for input-intensive innovations and labor-intensive technologies which increases the likelihood of subsidy program participation increasing the quantities of subsidized fertilizer utilized. This is in agreement with Otitoju & Ochimana (2016), who reported that owning a small piece of land promoted subsidized fertilizer participation in Nigeria. In addition, Makau et al. (2016) indicated that households with larger lands have resources to purchase commercial fertilizers and thus need fewer subsidies. Mutanyagwa et al. (2018) who evaluated factors influencing farmers' choice of improved technology, found land to have an impact on the number of kg of hybrid maize seeds utilized. Farmers owning land of fewer than two hectares participated more in the subsidy program in Ghana as it was only targeting small-scale farmers (Alhassan et al., 2020).

Reports by Felistus (2009) and Sapkota et al. (2017) indicated that female-headed households adopt new changes in technology more often including the use of subsidized fertilizer. These authors attributed this to the fact that females make major decisions and provide most farm labor as men tend to engage in off-farm more rewarding activities. Paul et al. (2015) reported that gender has an impact on resources access and service offered in favor of females as the main decision-maker. On contrary, FAO (2011) reported low fertilizer use by female-headed households due to low asset ownership. The low percentage of men participating in agricultural activities was attributed to the culture of the society which detects them as superior to engage in more rewarding economic activities which have immediate monetary returns (Ong'Ayo & Ndiso, 2020).

Dorward (2009) and Obi-Egbedi & Bankole (2017) reported that when farmers are allowed to borrow loans by effecting financial services, subsidies become more useful. In addition, the authors mentioned that subsidies reduce the prices of inputs increasing access to poor farmers. In developing nations, agricultural credit is a necessity for sustainable production as it enables farmers to adopt improved inputs (Chumo, 2013; Sanusi, 2018). According to Simiyu (2014), credit accessibility is low among most farmers. Many farmers not receiving support from financial institutions have potentially lowered their usage. Similarly, According to Jongare & Michael (2015), more subsidized fertilizer use was reported among farmers receiving credit in Nigeria. However, Oladejo et al. (2011), in their study, did not report any significant relationship between subsidy program participation and credit service access among women in Nigeria.

Mignouna et al. (2011) and Mwaura et al. (2021) associated larger household size with more labor availability, which has a higher probability to reduce labor limitations and increase the likelihood of adopting new technologies.

According to Otitoju & Ochimana (2016), owning a small piece of land promoted subsidized fertilizer participation in Nigeria. Farmers owning land of fewer than two hectares participated more in the subsidy program in Ghana as it was only targeting small-scale farmers (Alhassan et al., 2020).

NCPB is a government agent given a mandate to determine prices and sell government subsidies. A report by Martey et al. (2013) showed a positive relation between fertilizer access and distance. However, in contradiction, long-distance to either NCPB deports or the market for inputs would decrease the likelihood of subsidized fertilizer access associated with higher transportation costs Makau et al. (2016).

According to Azumah & Zakaria (2019), farmers who participated in off-farm business had a higher probability of participating in fertilizer subsidy programs in Ghana. The authors attributed this to extra income generated being used to purchase inputs. In addition, Otitoju & Ochimana (2016) reported that group membership increased the likelihood of farmers participating in the subsidy program and increase the intensity of fertilizer application. They related this to the fact that information about subsidies could be accessed by group members. Moreover, production associations could facilitate the application and payment of the subsidized fertilizer for the members. Wealthy households are expected to access more inputs through subsidy programs. The higher the value of the agricultural assets, the higher the participation in the subsidy program.

2.6 Empirical literature on factors hypothesized to determine maize productivity

According to Abeykoon et al. (2015); Dutta et al. (2020) and Mohammed (2021), farmers owning large pieces of land have a high likelihood of producing more agricultural output. These authors associated the ability to access, acquire and use modern technology and farm inputs among large-scale farmers. Similarly, a report by Azumah & Zakaria (2019) showed that despite farmers who had less than 2 hectares of land benefiting from the input subsidies, large-scale farmers had higher crop productivity. This resulted from their higher usage of fertilizer bought from the small-scale farmers who had received subsidized farm inputs.

According to the report by Justin (2015), female farmers are constrained in acquiring hired labor reflecting low production. Male-headed households have more information and are wealthier and possess assets to be used as collateral to acquire credit (Wongnaa & Awunyo, 2018). In contrast, Adam et al. (2020) reported that females are likely to adopt technology faster. Authors attributed this to the fact that women do most of the farm work therefore likely to have higher productivity, however they participate less in the marketing value chain.

According to Maina (2010), risk attitude is measured by age of the farmer. A report by Sapkota & Joshi (2021) showed that earlier studies indicated that elderly farmers produce highly as they are experienced in input use. Also, Otitoju & Ochimana (2016) and Alhassan et al. (2020) reported similar results on maize productivity in Nigeria and Ghana. In agreement, Belete (2020) reported that an increase in age reduces technical inefficiency in the production of maize in the Guji Zone. On contrary, according to Sibiko (2012), who studied factors determining common bean productivity, technical efficiency was negatively influenced by age in Uganda. The researcher attributed the results to older beans farmers being reluctant to technology adoption. Similarly, young farmers are always ready to take part in innovations and technologies increasing production Kisaka-Lwayo & Obi (2014). Samboko (2011) and Guo et al. (2015) reported elderly farmers being less productive. The authors claimed that the additional knowledge of older farmers cannot be able to reimburse aging influences; therefore, an increase in age is not conducive to agricultural productivity.

According to the reports by Sigei et al. (2014) and Thanh et al. (2015), higher agricultural productivity is likely to be realized by educated farmers. This was credited to accessing financial services and having relevant production knowledge through modern technology adoption. In agreement, Danso-Abbeam et al. (2018) and Njura et al. (2020), reported that high crop production is likely to take place in farms where the extension officers offer education services to farmers.

According to Makau et al. (2016), the larger the household size, the higher the food demand, therefore, the need for high productivity. The author attributed this to labor availability which acts as an inspiration to raise productivity. In addition, Mignouna et al. (2011) and Mwaura et al. (2021) associated larger household size with more labor availability, which has a higher probability to reduce labor limitations and increase crop productivity. However, on contrary, Diallo & Toah (2019) reported that food insecurity increased as households expanded. He further recommended family planning as a way of attaining food security in Mali.

According to Farhad et al. (2015), the application of more than 50 kg/ha of fertilizer increased maize productivity in Uganda to 2 t/ha from the average of 1.1 t/ha previously attained. A report by Ragasa & Chapoto (2017), shows a high intensity of nitrogen needed for faster plant growth while sulfur is required to increase organic matter in the soil necessary for optimal crop production. Rational fertilizer application facilitates improvement in soil nutrients and promotes sustainable harvests (Beeby et al., 2020; Liu et al., 2020; Alhassan et al., 2020). Sustainable crop productivity depends on the continuous regeneration of nutrients when supply becomes limited for plant growth (Yousaf et al., 2017; Cen et al., 2020). However, on contrary, a report by (Guo et al., 2010) stated that acidification of soils by the use of inorganic fertilizer can alter the biochemistry of the ecosystem adversely affecting crop productivity. In addition, Chandini et al. (2019), mentioned that despite the chemical fertilizer increasing plant growth and vigor and meeting global food security, the plants do not develop good nutritional characteristics by maturing properly. In addition, toxic chemicals produced by plants will accumulate in human bodies.

As per the reports of Ogada & Nyangena (2014) and Ragasa & Chapoto (2017), the decision to use certified seeds in maize productivity combined with fertilizer addressed low productivity among the small-scale farmers in Kenya and Ghana respectively. According to Alhassan et al. (2020), certified seed use significantly increased the output of maize. The author associated this with high germination percentage for the seeds as compared to the own farm seeds. Any strategy to elevate the use of certified seeds directly improves productivity. The significance of seeds in the determination of productivity has also been underscored by Mutundi et al. (2019). The study showed certified seeds had a high plant establishment, resistance to disease, lodging, and high yields.

There is a 23% likelihood of not participating in input use by households located 10 km away from the market which affects input access and could lower maize productivity (Ariga & Jayne, 2011). According to Mwaura (2014)**,** group membership motivated the production of beans, maize, and sweet potatoes negatively in Uganda. The author attributed this to the associations providing members with certified and high-quality inputs for farming. According to Martey et al. (2014) and Otitoju & Ochimana (2016), the social participation of framers in associations increased fertilizer utilization and crop productivity. Similarly, Abdul-Rahaman & Abdulai (2018), reported that technical performance in crop production was elevated using farmers' organization participation in Ghana. Similarly, Olagunju et al. (2021) report efficiency in the use of resources and high farm productivity among farmers who belong to cooperative societies. However, Mohammed (2021) reports an inverse relationship between farmers' group participation and maize productivity.

Structural changes such as the emergency of large-scale livestock farming have intensified the production of animal products (Serebrennikov et al., 2020). Manure is one of the most desirable organic fertilizers. It is a source of major and essential soil nutrients as well as soil organic matter that improves soil moisture retention. This increases productivity enormously (Miner et al., 2020). On contrary, most farmers have shifted from the application of manure due to intensive input requirements and low crop output (Parr et al., 2014).

According to Kibaara et al. (2009), evaluating determinants of fertilizer usage growth in Kenya, the author reported that the use of credit targeted by low-income farmers significantly improved maize productivity, fertilizer use intensity, and reduced poverty among rural poor. Similarly, Chumo (2013) reported that accessing credit increased quantities of maize production among poor rural farmers. In agreement, Diiro et al. (2018) studied empowering the female gender in seeking improvement in agriculture production in Kenya, the author suggested credit access influences maize output positively. Relatively, Sibiko & Qaim (2017) observed that insurance cover had a likelihood of elevating fertilizer use intensity by 50%, and the production of maize significantly. Similarly, Haider et al. (2018) report that innovative financial technologies such as mobile service credit have offered cost-effective and secure financial transactions to support and guide rural development and improve agricultural performance. Also, a study by Vink & Kirsten (2019), recommends credit and financial support as part of the factors that would facilitate agricultural productiveness and commercialization.

2.7 Theoretical framework

In the production process, the conversion of resources which are inputs into goods which is the output takes place. In the process of conversion, the form, quantity, and quality of goods produced is of concern. A theory of production, which is part of the microeconomic theory, is therefore of emphasis in the process. The theory focuses on the factors of production that would give sufficient production quantities both in the inputs and outputs. In the theory, inputs determine the quantity of output in the production process and such an input-output relationship is the production function. This function is the technical relationship between inputs and outputs, that is, the relationship between the rate of resources used and the rate of production per unit time/area, and it is a model used to formalize this relationship (Zellner, 2013). For a commodity to be produced, a combination of all factors of production such as land, capital, labor, and entrepreneurship is required. The production is therefore considered to depend on several factors X_i where $i=1, 2, 3...n$ and when Y represents the output, the production function can be written as $Y= f\,(X_i)$

This theory is considered relevant to this study as the factors affecting maize productivity can be considered as factors of production that would influence the output of maize-grain harvested. The production function of a farmer will be determined by the resources available.

A Cobb-Douglas production function was adopted in the data analysis to represent the relationship between the maize yield and the socio-economic factors affecting productivity in Kakamega County. This function was suggested by Paul Douglas and Charles W. Cobb when formulating an equation to describe the relationship among the time series of manufacturing output, labor input, and capital input that had been assembled for the period 1889-1922 in 1928 (Okorie, 2017). The function predicts the production using the combination of production factors. The basic form for production using two factors labor and capital is specified as

$$Y = AL^{\alpha}K^{\beta} \qquad \text{Equation 1}$$

Y- Is total output, A is the total factor productivity, labor contribution is represented by L, capital input denoted by K, output elasticity of capital is signified by β, and labor by α, that is, β is the percentage increase in Y for a 1 percent increase in capital-K holding labor-L constant, and α is the percentage increase in Y as a result of a 1 percent increase in labor-L holding capital-K constant. The sum of β and α is one; β+α=1. The impact of the variant in inputs on outputs is measured by the total factor of productivity. This effect is frequently a result of efficiency advancement. Output elasticity is caused by a change in the workforce or visible capital. A scenario where an intensification in output is more than a corresponding one in inputs is an increasing return to scale. When a decrease is realized, it is known as a decreasing return to scale.

The rational choice theory was popularized by Gary Becker in 1976. It states that when an individual is faced with several courses of action, have perfect discriminatory power and can rank alternatives in a well-defined manner, and usually do what they believe is likely to have the best outcome. They act in a way of balancing costs against benefits to arrive at action that maximizes personal advantage (Ogu, 2013). In economics, it is assumed that people are motivated by money and the possibility of making a profit, and this has allowed economists to construct predictive models of human behavior. This has attracted scientists' attention and they believe that if they could follow the method of economics they could achieve similar success.

In agriculture, for instance, agricultural economists have impressed the idea that all actions are fundamentally rational and farmers do the cost-benefit analysis of any action in farming before deciding on inputs to use. They would always want the best for self-interest as they are faced with a range of alternatives to choose from. Preference for an input depends on the utility derived relative to its alternative satisfaction (Makau et al., 2016). The utility (productivity) derived from a given choice of fertilizer is determined by a linear combination of household socioeconomic characteristics. In this study, for farmers to choose whether to use commercial or subsidized fertilizer, the productivity derived, that will maximize the utility for the household will determine.

2.8 Summary of literature review

Fertilizer is a key ingredient in maize productivity when utilized in the right quantities can increase output. The application rate in Sub-Sahara is low. This is attributed to poor distribution channels, higher prices lowering affordability, inadequate capital, inadequate knowledge about fertilizer, and low technology adoption (Morris et al., 2007; Dorward, 2009). The subsidy program aims to ease affordability to raise usage and enhance soil fertility to improve productivity for poor households (Ochola & Fengying, 2015). The success of subsidy programs in agricultural productivity depends on administration efficiency, timeliness, technical efficiency, and a good beneficiary selection system. Arguments against subsidy programs that it leads to dependency and can be used to manipulate people's decisions politically have been raised (Druilhe & Barreiro-hurlé, 2012).

Gaps in the literature

Despite the government efforts to improve maize-grain productivity through the subsidy program, maize production remains low in the region. Many studies have been done on the effect of subsidy programs on crop productivity. However, regardless of the existing literature reporting controversial findings in different parts on the effect of the program on maize productivity, the highly targeted crop by the program, a gap in what is produced and what is required is evident in the region. Therefore, this study focused on determining if the fertilizer subsidy program has any effect on maize productivity in Kakamega County. In addition, studies have mentioned that in the developing regions, even though the program is functional, the targeted small-scale farmers do not access the program or benefit from the inputs. However, such studies have not shown limitations in terms of the socio-economic organization for small-scale farmers not benefiting despite being the program's target group. On realizing information on factors determining farmers' participation in the program is scanty, especially at the county level, this prompted an investigation on how household's socioeconomic characteristics influence fertilizer subsidy program participation and the proportions of subsidized fertilizer application among farmers in Kakamega County.

2.9 The conceptual framework

In the study, the quantity of maize-grain productivity is affected by the proportions of subsidized fertilizer usage and the socio-economic factors, that is, the institutional factors such as the subsidy program participation, credit received and group membership, farm-related factors such as farm size, fertilizer quantities and quality and quantity of seeds, and the farmers' social characteristics such as schooling, age, and occupation which also affect proportion of subsidized fertilizer usage.

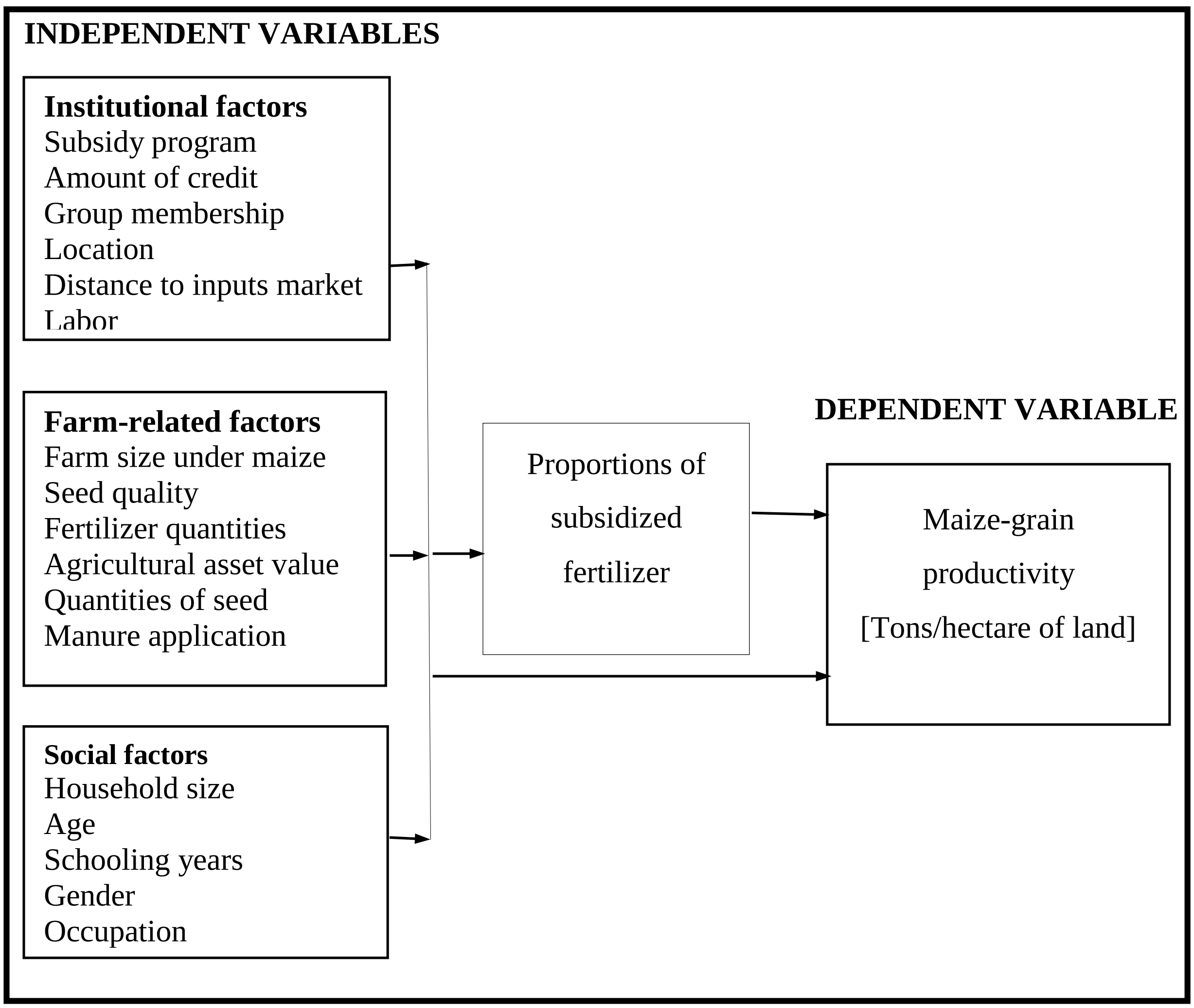

Figure 1: Conceptual framework.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Study Area

The study was conducted in Malava 0.4420°N, 34.8541°E, and Mumias East 0.3351°N, 34.4864°E Sub-counties of Kakamega County in Kenya. The county is divided into two ecological regions with strong east to west divide in temperatures. Malava is located in the upper region alongside Lurambi, Navakholo, Shinyalu, Ikolomani, Likuyani, and Lugari Sub-counties with a mean annual temperature ranging from 21°C to 23°C. However, Mumias East is located in the lower region alongside Mumias West, Butere, and Matungu with an annual temperature below 21°C most of the time. Generally, the county has cool and wet climatic conditions with average annual rainfall in most parts ranging between 1250mm and 1750mm which allows the production of beans, maize, cassava, sweet potatoes, finger millet, sorghum, and groundnuts for subsistence (CIAT, 2018). However, in the north-eastern externality, the average rainfall is low. The main cash crop produced is sugarcane and tea in some parts on a small to medium scale. Cash crops occupy comparatively a higher acreage as compared to food crops. Poverty index is 51%, 22.2% of the households' rear sheep, 11.2% goats, 1.7% pigs, 92% poultry and 0.7% keeps donkeys (KCIDP, 2018). The mean land ownership is 1.4 ha. Agriculture is predominantly rain-fed.

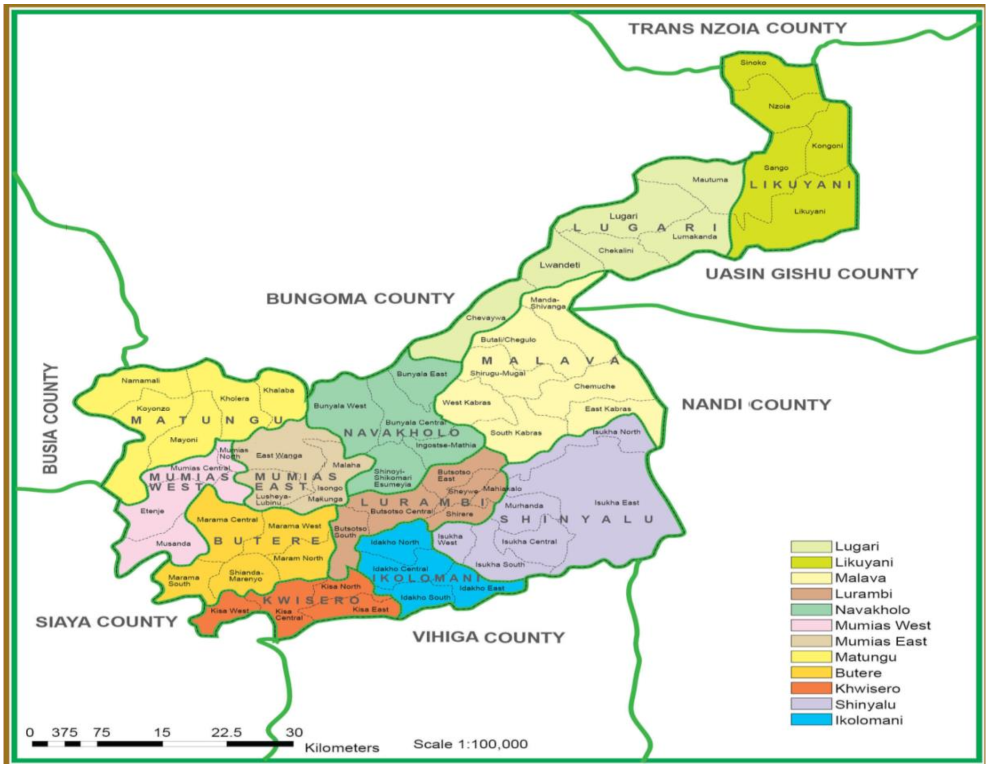

Figure 2: The map showing Sub-counties in Kakamega County, (KCIDP, 2018).

3.2 Research design

Small-scale maize farmers in Kakamega formed the study group where the household was the basic sampling unit. The study adopted a cross-sectional survey design. This design was preferred due to its potential to support the collection of data from a relatively larger group of people (Kothari, 2004). An investigation of the relations between farmers' household socioeconomic characteristics and maize production was done. In addition, the design is effective since it enables the investigator to report on the qualitative and numeric descriptions of samples in a large population (Adam & Kamuzora, 2008).

3.3 Total population

The county had 398,709 households where approximately 60% or 239,225 practiced farming by the year 2019 (KNBS, 2019). The study population was 44, 098 farmers (29,555 in Malava and

14,543 farmers in Mumias East) where the study targeted a proportion of 80 percent of the farmers who specifically practice maize farming in the two sub-counties.

3.4 Sample size determination

The formula adopted by Anderson et al. (2008) was implemented in sample size determination at a 95% confidence interval since the target population was a large number and the exact number of maize farmers was unknown with an estimate of (80 percent of the farmers).

$$n = \frac{z^2 \ p. \ q}{d^2} \qquad \text{Equation 2}$$

Denoted by n is the lowest essential sample, z is 1.96 at a 95% confidence interval, d represents the acceptable error limit taken as 0.05, q signifies the weight variance calculated as 1-p. Records show that 80% of all farmers in the county engage in maize production thus p will be 0.8

$$n = \frac{1.96^2(0.8)(1-0.8)}{0.05^2} = 245.8624 \qquad \text{Equation 3}$$

Therefore, 245 farmers were the basic sample size essential for the study according to the above calculation, but; this number was increased to 300 to give room for incomplete, unreturned questionnaires and increase the reliability of the data.

3.5 Sampling procedure

This study adopted a multistage sampling technique. Kakamega County was purposively selected because of the dominance of small-scale maize farmers, its high population, high maize consumption, and implementation of subsidy programs in all sub-counties. The clustered technique was employed to split the county into 12 clusters according to sub-counties boundaries. Out of the 12 clusters, Malava was selected due to the highest number of small-scale maize farmers, and Mumias East was chosen due to the lowest number of maize farmers. A list of beneficiary farmers was acquired from the County Ministry of Agriculture. Subjects were carefully chosen using simple random sampling techniques which ensured all maize farmers had the same opportunity of becoming a participant proportionately to farmers' number in clusters. This was done to get rid of the probability of selection biases since there is variation in the population of farmers between the two selected sub-counties. The sample size from the clusters was kept proportional to the cluster maize farming population using the formula adopted by Mead, (2017).

$$n_1, n_2, n_3, n_4 -------- nk = n.\frac{P_I}{N} \quad \text{Equation 4}$$

Where $n_1, n_2, n_3, n_4 ------- nk =$ sample size for every cluster

N = Total population, P_I =the proportion of the population included within the cluster (1), $n =$ study sample population.

Table 5: Number of sampled farmers

Sub-counties	Total number of farmers	Sample size
Malava	29,555	300/44,098*29,555=201
Mumias East	14,543	300/44,098*14,543=99
Total	44,098	=300

3.6 Research instruments and data collection procedure

The researcher sought permission from relevant authorities. Semi-structured questionnaires were adopted in primary data collection from farmers (Appendix II). A questionnaire is defined as standards prepared to fit a certain inquiry (Mugenda & Mugenda., 2003). The questionnaire was divided into sections. Section A had personal and household information about a farmer; section B had information about maize production and fertilizer usage. The third section contained information about the household social-economic characteristics of the farmer. The information about the farmers' social-economic factors, the quantities of fertilizers usage, maize productivity, and constraints hindering access to subsidized fertilizers was collected. Secondary data such as the list of beneficiaries was obtained from the County Ministry of Agriculture; prices were obtained from local retailers and the NCPB database and an extensive review of the existing documents. A questionnaire took a minimum of 40 minutes to be well covered by a respondent and a few respondents who wished to remain with them were assigned a special code for collection and confidentiality and given a day to complete. This was only allowed after confirming that the respondent was able to read and interpret questions on their own.

3.7 Ethical consideration

Since only a few farmers were sampled to participate, the questionnaires were numbered so that the analysis was based on questionnaire numbers and not the names of participants for anonymity, privacy, and confidentiality throughout the study. The information collected has not been linked to any individual but has been used collectively. An informed written consent note (Appendix I) was issued to all the participants to explain the purpose of the study, data collection procedures, type of the data, anticipated benefits, and rights to abstain from participation. In addition, withdrawal or terminating participation at any time involved no penalty. The proposal was also presented to Maseno University Ethical Review Committee for approval. The exercise was done with the approval of the local administration of the study area. A written consent was issued by County Commissioner Kakamega County for the study to be done.

3.8 Validity and reliability

3.8.1 Pilot Study

A trial of 30 farmers matching 10% of the study sample was interviewed randomly (Mugenda & Mugenda, 2003). A section of the questionnaire containing 16 questions on the subsidy program and maize productivity was administered. The questions were categorized on the level of agreement on a scale of 1-5 to assess the internal consistency. Lurambi Sub-county was selected for pilot study due to its central location, farmers are equally small-scale producers as the study site, the subsidy program is implemented in the sub-county, there is no significant difference in terms of climatic conditions and the farmers' characteristics are similar in the county (Mavuthu, 2017). Also, this was to avoid interviewing the subjects who participated in the pilot study.

3.8.2 Validity

The researcher tested the questionnaire before the study through a pilot study. The validity of the research instruments was tested through expert opinions. The consultation was first done with the supervisors, lecturers, and officers in the Ministry of Agriculture on whether the questionnaire was valid for data collection through a face validity process to establish content validity. Additional input was included and ambiguous and confusing questions were deleted from the questionnaire as per the guidance to assure the objectivity of the questionnaire.

3.8.3 Reliability

Reliability is uniformity in one's dimensions and the degree how which a tool measures in a similar way whenever it is used with undistinguishable subjects under the same state over some time (Mugenda & Mugenda, 2003). The researcher used the test-retest technique to assess the reliability of the research instruments. The researcher administered 30 questionnaires to the farmers. After one week, the researcher administered again similar questionnaires to 30 farmers. The data from the pilot study were separately analyzed in SPSS and an R^2 of 0.73 and 0.76 assured external reliability of the data. The questionnaire items were assigned arbitrary scores between 1 and 5. The scores obtained were used in a correlation test and Cronbach's Alpha Reliability coefficient value of 0.908 (Appendix III) assured the data's internal reliability as it was higher than the +0.7 required (Mugenda & Mugenda, 2003).

3.9 Data analysis techniques

3.9.1 Estimation of proportions of subsidized fertilizer utilization

The study adopted descriptive analysis focusing on frequencies, means, and percentage proportions. Comparisons of means in the quantity of fertilizer applied between the program participants and non-participants were done by Chi-square and t-test and the findings are presented in tables.

3.9.2 Analysis of factors hypothesized to influence proportions of subsidy fertilizer utilized

The study adopted one limit Tobit regression model in analyzing factors that influence the proportions of subsidized fertilizer usage in the overall fertilizer by a farmer. This model was preferred since the proportions of subsidized fertilizer were continuous variables; probit is preferred when the outcome is dichotomous or binary, Logit model when independent variables are categorical.

$(K/T)Q = \beta_0 + \sum_{j=1}^{n} \beta_j X_{ji} + \mu_i$ (Lwayo & Maritim, 2003) Equation 5

Q= proportions of subsidized fertilizer utilization (K/T-where K-subsidized fertilizer quantities and T is total inorganic fertilizer); While β_0 is a constant (unknown intercept) the value of the dependent variable when all regressors are zero, j=1,2,3… n, where n is the number of explanatory variables, β_j are slope coefficients of explanatory variables, X_{ij} are the explanatory variables for the i^{th} observation, n represent the number of independent or explanatory variables i =*1,2,3…m,* are observations on variables for the model, they are defined in Table 7, m is the sample size of 300 and μ is the standard error term for the i^{th} observation (Lwayo & Maritim, 2003).

X_1 farm size under production, X_2 Manure application, X_3 Household size, X_4 Seed rate per ha, X_5 Agricultural assets value, X_6 Age of the farmer, X_7 Farmers' education level, X_8

Gender, X_9 Occupation, X_{10} Distance to inputs market, X_{11} Amount of credit, X_{12} Group membership, X_{13} Location.

Table 6: Factors postulated to influence on proportions of subsidized fertilizer use

Variable	Description	Measurements	Expectation
X_1	Farm size under production	Hectares	-
X_2	Manure application	Nominal 1. Yes, 2. No	+
X_3	Household size	Continuous	+
X_4	Seed rate per hectare	Continuous (Kg)	+
X_5	Agricultural assets value	Continuous (Ksh. 1000)	+
X_6	Age of the farmer	Continuous (years)	+
X_7	Schooling years	Continuous (years)	-
X_8	Gender of the household head	Nominal 1.male 2.female	+
X_9	Farmers occupation	Ordinal 1. Farming 2. Business 3. Salaried	-
X_{10}	Distance to inputs market	Continuous (Km)	-
X_{11}	Amount of credit	Continuous (Ksh. 1000)	+
X_{12}	Group membership	Nominal 1. Yes, 2. No	+
X_{13}	Location	Nominal 1. Malava 2. Mumias East	+ -

3.9.3 Determination of the effect of the subsidized fertilizer program on maize productivity

First, a t-test was used to calculate the mean productivity and provide a statistical test on whether or not the means of the program participants and non-participants were equal in Malava, Mumias East, and the aggregate sample. In addition, a statistical t-test compared the mean productivity between Malava and Mumias East.

To analyze the impact of participating in the fertilizer subsidy program on maize productivity, the study employed Cragg's two-stage approach Cragg (1971) using the probit model in the first stage as many other studies analyzing uptake of technology in agricultural economics or a decision involving two outcomes and Tobit model in the second phase (Mal et al., 2012).

Goodness-of-fit was used to diagnose the accuracy of the models. To measure this, LR, which is also known as Pseudo R^2 was used. It is analogous to the R^2 in regression analysis. A zero LR indicates a perfect lack of fit while the LR value of one indicates perfect fitness. Evidence suggests that LR usually lies between 0.2 and 0.6 for cross-sectional data (Makau et al., 2016). In this study, Pseudo R^2 and LR were used to measure goodness-of-fit for the Probit and Tobit models.

The first analysis step determined factors that affect the likelihood of a farmer taking part in the program. Individual adoption of the program is a double outcome of a binary/dummy situation comprising two choices that are participating or failing to participate. Everyone involved in the selection process has a range of responses that are influenced by various factors. Probit regression was used to estimate and compute factors affecting the likelihood of subsidy program participation and the Cobb-Douglas production function employed at the second stage.

A Probit model was preferred due to its potential to lessen heteroscedasticity limitations and its aptitude for compelling the probability of adoption (P_i=(q=1|X) to increase or decrease only in an interval of 0 to 1 (Asante et al., 2011).

Several other models could have been used as an alternative for approximating the nominal response of this dichotomous variable such as the linear probability model and the Logit model. However, shortcomings such as the probabilities exceeding 1 or being less than 0 for the linear probability model make a probit the finest. Participating or not participating in the program cannot be defined on a definite scale. They are qualitative since they do not have any natural scale of measurements, they are, therefore, defined on a nominal scale. The decision of a household either to adopt a subsidy program or not is a result of the utility value q*****, which is the outcome of other variables. The household's adoption rate of the subsidy program is higher when the utility value q* is also high. The latent utility index is expressed as:

$q^* = X'\beta + \mu$ Equation 6

$q = 1 \; if \; q^* > 0; \; y = 0$ if $q^* \leq 0,$

A utility-maximizing (D^*) farm household decides to adopt if the satisfaction derived from adapting (U_{Ai}) exceeds the benefits of not adapting at all (U_{Ni}) for the *i*th farmer ($D^* = U_{Ai} - U_{Ni} > 0$) (Onzima, 2017). Therefore, $U_{Ai} = X_i'\beta_1 + \mu i_1$ and $U_{Ni} = X_i'\beta_0 + \mu i_0$ represent the utility for accessing subsidized fertilizer and not accessing respectively. Since the farmers only decide to assume the fertilizer subsidy program when the utility gained is greater ($U_{Ai} - U_{Ni} > 0$). The probability of i^{th} farmer accessing subsidized fertilizer is calculated as follows:

$\text{Prob}\,(D_i = 1|X) = P\,(U_{i1} > U_{i0})$ Equation 7

$= P\text{rob}\,(X_i'\beta_1 + \mu_{i1} > X_i'\beta_0 + \mu_{i0})$ Equation 8

$= P\text{rob}\,(\mu_{i0} - \mu_{i1} < X_i'\beta_1 - X_i'\beta_0)$ Equation 9

$= P\text{rob}\,(\mu_{i0} - \mu_{i1} < X_i'\,(\beta_1 - \beta_0)$ Equation 10

$= P\text{rob}\,(\mu_i < X_i'\beta)$ Equation 11

$= \phi\,(X_i'\beta)$ Equation 12

Thus the model that is used to estimate the probability of accessing subsidized fertilizer is $\phi\,(X_i'\beta) = P\,(D_i{=}1|X)$. Where ϕ (.) Is the standard normal distribution cumulative distribution function, X' represents a vector of independent variables, β is a vector of parameters P is the probability that the i^{th} farmer access subsidized fertilizer.

Because the interest is in a regression model, all explanatory variables must be quantitative. The functional form of the probit model equation that empirically explains factors affecting the decision to access or participate in the subsidy program was expressed as:

$D(0, 1) = \beta_0 + \sum_{j=2}^{n} \beta_j X_{ji} + \mu_i$ Equation 13

D (0, 1) = Variable describing decision on utilization of subsidized fertilizer (1) utilized subsidized fertilizer (0) did not utilize subsidized fertilizer; While β_0 is a constant (unknown intercept) the value of the dependent variable when all regressors are zero, *j*=1,2,3… *n*, where *n* is the total number of explanatory variables, β_j are slope coefficients of explanatory variables, X_{ij} are the explanatory variables for the i^{th} observation, *i =1,2,3…m,* are observations on variables for the model, they are defined in Table 8, *m* is the sample size of 300 and μ is the random disturbance for the i^{th} observation.

The next phase of the model used a censored linearized Tobit regression model in estimating the coefficients and the marginal effects for easier variable interpretation and determination of the influence of the subsidized fertilizer program on maize productivity with the program participation used as an independent factor. A binary variable D was introduced as a treatment on whether a farmer participated in a subsidy program or not forming a modified model that tested for the effects of the program on maize productivity controlling for actual fertilizer quantities, seed quality, and household socio-economic characteristics given that maize productivity is affected by several other factors apart from the subsidy program. The generated IMR in model stage 1 was inserted as independent factors to account for self-biasness in stage two of the Tobit model. Transformation of the function into a log-linear specification form as shown below was done for easier results interpretation in equation 15. The marginal effect of dummy variables was transformed before coefficient interpretation.

$Y_i = \begin{pmatrix} Y_i^C \ If\ D=1 \\ Y_i^T \ If\ D=0 \end{pmatrix}$ Equation 14

$InY_i = \beta_0 + \beta_1 . D_1 + \sum_{j=2}^{15} \beta_j InX_{ji} + \varphi\omega + \mu_i$ Equation 15

$InY_i^c = \beta_0 + \beta_1.(D_1 = 1) + \sum_{j=2}^{15} \beta_j InX_{ji} + \varphi\omega + \mu_i$ Equation 16

$InY_i^T = \beta_0 + \beta_1.(D_1 = 0) + \sum_{j=2}^{15} \beta_j InX_{ji} + \varphi\omega + \mu_i$ Equation 17

Explanatory variable D_1 is a dummy variable. In equation 16 D_1=1 when a farmer is a participant, in equation 17 D_1=0 when a farmer is not a participant. In equation 16, when a farmer is a participant, then a straight-line relationship is represented with an intercept ($\beta_0 + \beta_1$) and slope coefficients($\beta_{2....15}$), and in equation 17, when a farmer is not a participant, then a straight-line relationship is represented with an intercept (β_0) and slop coefficients($\beta_{2.....15}$).

$E\ (InY_i^c/D_1=1) = (\beta_0 + \beta_1) + \sum_{j=2}^{15} \beta_j InX_{ji} + \varphi\omega + \mu_i$ Equation 18

$E\ (InY_i^T/D_1=0) = (\beta_0) + \sum_{j=2}^{15} \beta_j InX_{ji} + \varphi\omega + \mu$ Equation 19

$[E\ (InY_i^c/D_1 = 1]$- $E\ [InY_i^T/D_1=0]$ - is the average response when an observation belongs to participants and non-participants. Thus

$\beta_1 = [E\ (InY.D_1 = 1] - E\ [InY.D_1 = 0]$ which has an interception as the difference between the average values of Y with D_1=1 and D_1=0.

Y_i= maize productivity for i^{th}; β_0 denotes unknown intercept, slope coefficients are represented by $\beta_1 \ldots . \beta_{14}$, In is a natural logarithm. $D_1$is a dummy variable, 1= when a farmer is a subsidy program beneficiary, 0=Otherwise, X_2 Fertilizer quantities kg per ha, X_3 Farm size under production, X_4 Labor man-day X_5 Household size, X_6 Manure application, X_7 Seed quality quantities per hectare, X_8 Seed quality, X_9 Age of the farmer, X_{10} Farmers' education levels, X_{11} Sex of the household head, X_{12} Farmers' occupation, X_{13} Credit accessibility, X_{14} Group membership, X_{15} Location, φω IMR (inverse mill ratio) and μ error term – representing unobserved factors.

Table 7: Variables description and anticipated signs in probit and Tobit two-stage models

Variable	Explanation	Measurements	Expectation	Expectation
Dependent				
STAGE 1 D	Subsidy program	Dummy;1=Yes,0=No	**Stage 1**	**Stage 2**
STAGE 2 Y	Maize grain productivity	Tons per hectare	**Probit**	**Tobit**
Independent				
D_1	Subsidy program	Dummy 1. Yes 0. No		+
X_2	Fertilizer quantities	Continuous (Kg/ha)	+	+
X_3	Farm size under maize	Hectares	+	–
X_4	Labor	Man-day per Ha		
X_5	Household size	Continuous	+	+
X_6	Manure application	Nominal 1. Yes 0. No	+	+
X_7	Seed rate	Continuous (Kg/ha)	+	+
X_8	Seed quality	Nominal 1. Certified 2. Own farm	+	+
X_9	Age	Continuous	+	+
X_{10}	Schooling years	Continuous	-	-
X_{11}	Gender of household head	Nominal 1. Male 2. Female	+	+
X_{12}	Farmers occupation	Ordinal 1. Farming 2. Off-farm (agricultural-related) 3.Off-farm (self-employment) 4.Salaried	+-	+-
X_{13}	Amount of credit	Continuous (Ksh.)	-	+
X_{14}	Group membership	Nominal 1. Yes 0. No	+	+
X_{15}	Location	Nominal 1. Malava 2. Mumias East	+-	+-
X_{16}	IMR	Continuous		+

CHAPTER FOUR

RESULTS

4.1 Introduction

This chapter presents the findings of the study based on the objectives. First, the descriptive characteristics of the farmers are presented comparatively in relation to the program participation. In addition, the result on the quantities of fertilizer usage, and maize output per hectare is presented. It also contains findings on analyzed factors affecting the proportion of subsidized fertilizer use, factors influencing adoption of the subsidized program, and also the findings on the effect of subsidy fertilizer program on maize productivity.

4.2 Descriptive information of maize farmers

4.2.1 Maize farmers' socioeconomic characteristics

As from Table 8, results indicate 46.85 years as the average age for the farmers sampled with the program participants having a higher average of 48.93 years compared to non-beneficiaries with an average of 44.76 years. Furthermore, the t-test was significant which shows that the program participants were significantly older. In addition, the average formal schooling years of 10.24 for the household heads with the subsidy program beneficiary farmers having higher and significant average schooling years of 10.6 than 9.88 years for non-participants. The average years of maize farming experience among the sampled farmers were 18.45. The participants in the subsidy program had significantly more experience in farming with a mean of 20 years than non-participants with 16.56 years. The average household size was 5 members. The program participants' households had a significantly higher average of 6.07 members compared to non-participants with a mean of 5.54 members.

Table 8: Socio-economic characteristics of sampled households

Variable	Aggregate		Beneficiary		Non-beneficiary		t-test
	Mean	Std dev	Mean	Std dev	Mean	Std dev	
Age	46.85	8.877	48.93	8.205	44.76	8.205	4.182**
Schooling yrs	10.24	3.401	10.6	3.619	9.88	3.139	2.841**
Experience yrs	18.45	7.687	20.33	8.503	16.56	6.824	4.832**
Labor man-day	60.2	10.56	58	9.45	54.67	15.07	1.567
Household size	5.0	1.689	6.07	2.111	5.54	1.982	4.842*
Off-farm income (Ksh)	130, 681	133,824	144,419	151,965	116,943	111,644	1.785
Other income	100,742	67,047	121,426	85,483	80,057	29,186	5.609*
Total income (Ksh.)	223,618	143,195	256,432	167,459	190,804	104,578	4.071**

		Aggregate	Beneficiary	Non-beneficiary	Perce (%)	Chi-square
Gender	Male	237	115	122	78.2	0.985
	Female	63	35	28	20.8	
Occupation	Farming	187	89	98	62.3	
	Off-farm (agro-related)	44	30	14	14.7	1.787
	Off-farm (self-employed)	26	12	14	8.7	
	Salaried	43	19	24	14.3	
Level of education	Primary	98	45	53	32.7	2.879**
	Secondary	159	83	76	53	
	College level	22	9	13	7.3	
	University	21	13	8	7	
Marital status	Married	253	129	124	84.3	
	Single	18	9	9	6	1.027
	Separated	8	3	5	2.7	
	widow/widowed	21	9	12	7	

*, ** Statistically sig at 95% and 99% confidence interval

The average off-farm income (salary, handouts, gifts, and rent) for the sampled farmers was Ksh. 130,681 annually (Ksh. 10,890 monthly). The program participants had an annual off-farm income of Ksh. 144,419 (Ksh. 12,035 monthly) compared to the non-participants who had Ksh. 116,943 (Ksh. 9,745 per month). The annual average farm-generated revenue was Ksh. 100,742 (Ksh. 8,395 monthly) for farmers. The subsidy program beneficiaries had a significantly higher average farm income of Ksh. 121,426 (Ksh. 10,118 per month) compared to non-program participants who had Ksh. 80,057 (Ksh. 6,671 monthly). The average annual household income for the sampled farmers was Ksh. 223,618 (Ksh. 18,634 per month). The program beneficiary households had a significantly higher average annual income of Ksh. 256,432 (Ksh. 21,369 monthly) than non-beneficiaries with an average annual income of Ksh. 190,804 (Ksh. 15,900 monthly).

The results indicate that 78.2% of the sampled families were led by males who were the chief decision-maker regarding maize production and only 20.8% were headed by a female. It further shows that 62.3% of the household heads were full-time farmers, those who engaged in off-farm agricultural-related activities were 14.7%, off-farm self-employed were 8.7% and the salaried employees comprised 14.3%. Most of the farmers had attained secondary education comprising 53%, those who attained primary education were 32.7%, middle-level college were 7.3% and university education level had been attained by only 7%. Moreover, 84.3% of the sample were married, 6.0% were single, divorced farmers were 2.7% and the widows/widowed were 7%. The gender of the farmer, marital status, and primary occupation had no significant relationship with the subsidy program participation.

4.2.2 Household institutional characteristics

Distance and credit access

The results in Table 9 show a 4.06 km mean distance to the most suitable market for the farmers. The program beneficiaries had a longer significant distance to the nearest convenient market with a mean distance of 4.8 km compared to 3.3 km for the program non-beneficiaries. The distance to the fertilizer deports or agro-dealers, where the collection is done, was not statistically different among the farmers' groups. However, the distance to the ward offices where program registration is done was significant to the program participation.

Table 9: Distance to market and access to credit

	Aggregate		Beneficiary		Non-beneficiary		t-test
	Mean	Std dev	Mean	Std dev	Mean	Std dev	
Distance to market (Km)	4.06	1.727	4.8	1.705	3.32	1.325	7.592**
Distance (Km) to fertilizer deport	5.2	1.009	5.5	1.465	4.9	1.234	0.528
Distance to WAO (Km)	4.0	1.569	3.9	1.185	4.1	1.714	4.321**
Credit (Ksh.)	16,656	12,603	20,229	14,675	13,083	8,814	5.609**

WAO Ward agricultural office, *, ** statistically sig at 95% and 99% confidence interval

Those who participated in the subsidy program had a shorter distance to the Ward agricultural offices where the registration was done. In addition, the average annual credit accessed among the sampled farmers was Ksh. 16,656. The program beneficiaries had a significantly higher annual average borrowing rate of Ksh. 20,229 compared to Ksh. 13,083 of non-beneficiaries.

Group membership and extension services

The results in Table 10 show that 51.7% of the sampled farmers were members of different farming groups. Out of the 51.7% who belong to different farmers' groups, 80% were subsidy program beneficiaries and only 20% were non-beneficiaries. In addition, 48.3% of the farmers were not members of any farming group. Out of the 48.3%, only 23% were subsidy program beneficiaries while 77% were non-beneficiaries. The Chi-square test shows that famers' groups influenced subsidy program participation. Furthermore, 53.3% of the sampled farmers accessed extension services in the previous year. Out of the 53.3%, subsidy program beneficiaries were 86% while only 21% were non-participants. Farmers who did not access extension facilities in the previous year were 46.7%. In addition, 14% were subsidy program beneficiary farmers while 79% were non-beneficiaries.

Table 10: Group membership and extension services

		Aggregate				Beneficiary		Non-beneficiary		Chi-square
		No.	Male	Female	%	No.	%	No.	%	
Group membership	Yes	155	119	118	51.7	120	80	35	23	8.624**
	No	145	36	27	48.3	30	20	115	77	
Extension service access	Yes	160	124	113	53.3	129	86	31	21	9.819*
	No	140	36	27	46.7	31	14	119	79	

*, ** Statistically sig at 5% and 1% levels

Most farmers who accessed extension services were subsidy program beneficiaries. Furthermore, Chi-square exposed a significant difference between the program participants and non-participants in access to extension amenities.

Effect of time, information access, and market availability on subsidy program participation

From Table 11, 50.7% of the sample stated that subsidy fertilizer is supplied on time before the onset of raining season. Only 7.3% received the subsidized inputs after the onset of raining season and 42% of whom the majority were subsidy program non-beneficiary were uncertain about the time when subsidized fertilizer was supplied. In addition, 34.7% of the farmers confirmed that the information about the subsidy program was not efficiently delivered to farmers. The majority of whom were program non-beneficiaries. Farmers who stated that the information delivery system was efficient were 23.7% of the sample. However, 23.1% of the sampled farmers confirmed that the system of communication was very efficient and the majority were program beneficiaries. Only 14% of the farmers were uncertain about the communication system and the majority were program non-participants. Furthermore, the Chi-square confirmed that the time of subsidy inputs supply and information delivery system had a significant influence on subsidy program participation.

Table 11: Timeliness, access to fertilizer information, and market availability

		Beneficiary	Non-beneficiary	Aggregate	Perce.	Chi-square
Timelines in subsidies supply	Before rain	130	22	152	50.7	
	Uncertain	2	124	126	42.0	20.377*****
	After rain onset	18	4	22	7.3	
Information access	Very efficient.	66	5	71	23.1	
	Efficient.	82	1	83	23.7	26.950*****
	Uncertain	40	2	42	14.0	
	Not efficient	99	5	104	34.7	
Maize market availability	Readily available	113	116	225	76.3	1.182
	Available	26	20	46	15.3	
	Not available	11	14	29	8.3	

*, ** Statistically sig at 5% and 1% levels

The results further show that 76.3% of the total sampled farmers confirmed the readily available market for maize grains. Only 15.3% of the farmers agreed that the market was partially available and 8.3% disagreed on the availability of the market for the output. The Chi-square confirmed that market availability for the maize grains was independent of subsidy program participation.

4.2.3 Maize production characteristics

Maize productivity farm factors

Table 12 presents the findings on maize productivity and farm-related factors affecting farmers' production among the sampled maize farmers. The average land owned by the farmers was found to be 1.14 ha. The program participants and non-participants had no significant difference in land ownership. Moreover, the average farm size under maize production for the sampled farmers was 0.59 ha having a mean of 0.6 ha for the program beneficiaries and 0.58 ha for the non-beneficiaries. The t-test was insignificant revealing that the program beneficiaries had no statistically larger acreage under maize production than non-program participants.

Table 12: Maize production factors

	Aggregate		Beneficiary		Non-beneficiary		t-test
	Mean	Std dev	Mean	Std dev	Mean	Std dev	
Land size (Ha)	1.14	0.477	1.16	0.483	1.12	0.472	0.546
Farm size (Ha)	0.59	0.239	0.6	0.224	0.58	0.255	0.090
Seeds (Kg/ha)	22.3	2.452	23.3	2.048	21.30	2.387	1.077
Assets value (Ksh.)	14,858	9,551	16,909	12,097	12,807	5,315	3.802**
Total sample							
Productivity (kg/ha)	2216	430.3	2460	421.9	1971	270.5	3.697**
Malava							
Productivity (kg/ha)	2265	410.2	2490	414.24	2039	431.7	6.144**
Mumias East							
Productivity (kg/ha)	2117	290.5	2386	294.9	1854	289.5	4.489**

Note: The raw data was collected in kg/acre for production factors. Conversion scale: 1ha=2.47 acres and 1000kg=1t

In addition, the average number of seeds planted for the sampled farmers was 22.3 kg/ha. The program participants and non-participants had no significant difference in the seeds planted. The average maize production agricultural assets value owned by sampled farmers was Ksh. 14,858. The program beneficiaries had significantly more assets valued at an average of Ksh. 16,909 compared to non-beneficiaries whose average value of assets was Ksh. 12,807.

The average productivity of maize for the sampled farmers was 2216 kg/ha for the two sub-counties (Malava and Mumias East). The subsidy program participants had significantly higher productivity (2460 kg/ha) compared to non-participants (1971 kg/ha). The average maize productivity among the sampled farmers from Malava was 2265 kg/ha. The subsidy program beneficiaries had significantly higher productivity (2490 kg/ha) compared to non-beneficiaries (2039 kg/ha). The average maize productivity in Mumias East was 2117 kg/ha. The program beneficiaries had (2385 kg/ha) significantly higher than non-participants with (1854 kg/ha). Malava had a significantly higher average productivity compared to Mumias East. There was no significant difference in productivity among the program participants. However, for non-participants Malava had a significantly higher average productivity.

Table 13: The productivity comparisons between Malava and Mumias East

	Aggregate		Malava		Mumias East		t-test
	Mean	Std dev	Mean	Std dev	Mean	Std dev	
Aggregate (kg/ha)	2216	430.3	2265	422.2	2117.	431.7	2.832**
Participants (kg/ha)	2460	421.9	2490	406.91	2386	444.06	1.243
Non-participants	1971	270.5	2039	290.66	1854	149.46	4.456**

** Statistically sig at 5% level

Fertilizer application information

Table 14 shows the types and quantities of fertilizer applied by farmers by the sampled maize farmers in Malava and Mumias East.

Table 14: Household fertilizer application characteristics in Malava and Mumias East.

Malava	Aggregate		Beneficiary		Non-beneficiary		t-test
	Mean	Std dev	Mean	Std dev	Mean	Std dev	
DAP (Kg/ha)	86.16	0.599	94.62	6.776	81.68	7.679	8.757**
CAN (Kg/ha)	81.01	0.562	85.49	5.595	76.48	6.572	9.711**
NPK (Kg/ha)	76.08	0.564	83.03	6.567	71.53	6.579	9.737**
Average fertilizer	81.07	0.561	85.51	5.517	76.58	7.762	9.599**
Mumias East							
DAP (Kg/ha)	82.72	0.502	88.67	8.151	76.90	4.026	9.140**
CAN (Kg/ha)	78.48	0.809	83.87	7.983	73.20	3.274	8.759**
NPK (Kg/ha)	73.43	0.804	81.17	8.025	68.50	3.571	7.326**
Average fertilizer	78.25	0.824	83.75	8.033	72.87	3.379	8.816**

Note: DAP, CAN, NPK, Di-Ammonium Phosphate, Calcium Ammonium Nitrate, Nitrogen, phosphorus and potassium

DAP fertilizer was highly applied, and CAN and NPK were also applied. The application rates per hectare were significantly different for DAP and NPK used for planting and also for CAN used for topdressing between farmers who participated in the subsidy program and those who did not. Moreover, the average quantities of fertilizer application were significantly different between the participants in the program and non-participants. The graph in Figure 3 shows the fertilizer application rates and maize productivity linear relationship for the farmers in the two sites combined.

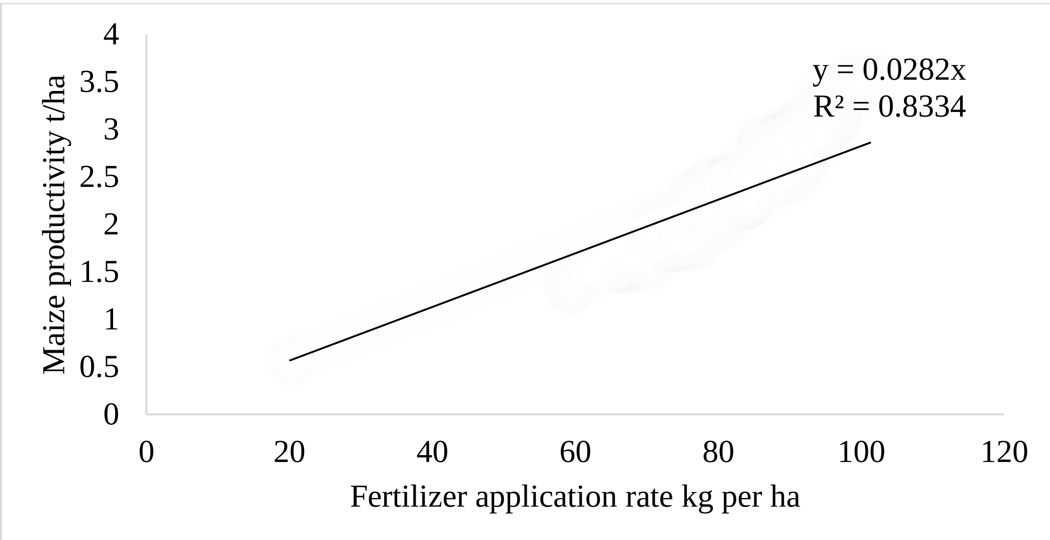

Figure 3: Relationship between fertilizer application rates and maize productivity

Percentage of farmers applying manure on the farm

Among the sampled farmers, 65% had applied manure on their farms. Out of these, the majority were beneficiaries of the program consisting of 88% and only 12% of the non-beneficiaries. The remaining 35% of the farmers did not use manure on farms. This comprised 41% of program beneficiaries and 59% of non-beneficiary. There was a significant difference in manure application between those who participated and those who failed to participate in the subsidy program at the 5% level. This was revealed by the Chi-square test.

Table 15: Percentages of farmers applying manure

		Aggregate		Beneficiary		Non-beneficiary		Chi-square
		No.	%	No.	%	No.	%	
Manure application	Yes	194	65	133	88.67	61	41	7.952*
	No	106	35	17	11.33	89	59	

* Statistically significant at 5% level;

4.2 Proportions of subsidized fertilizer utilization in overall inorganic fertilizer

The results from Table 16 show that 13 300 kg of subsidized fertilizer were utilized out of the 22,358 kg of overall inorganic fertilizer usage for planting and top-dressing among the subsidy program participants. In addition, they further utilized 9,058kg of commercial fertilizers. This translates to a proportion of 59.48% subsidized fertilizer and 40.51% market fertilizer.

Table 16: Subsidized fertilizer Proportions utilization in the overall inorganic fertilizer

	Aggregate		Beneficiary		Non-beneficiary		t-test
	Sum	Prop	Sum	Prop	Sum	Prop	
Subsidized fert (kg)	13 300	31.50%	13 300	59.48%	000	0	22.42*
Commercial fert (kg)	28 916	58.50%	9 058	40.51%	19,858	100%	6.451**
Total fertilizer (kg)	42 216	100%	22,358	100%	19 858	100%	2.278**
Average fertilizer application in Malava and Mumias East	Aggregate		Beneficiary		Non-beneficiary		t-test
	Mean	Std dev	Mean	Std dev	Mean	Std dev	
DAP (Kg/ha)	86.45	8.599	91.39	7.196	81.51	6.959	10.140**
CAN (Kg/ha)	81.50	7.978	86.50	6.986	74.10	5.813	11.794**
NPK (Kg/ha)	74.10	7.990	79.04	7.119	69.16	5.845	7.326**
Average fertilizer	80.68	8.038	85.64	6.988	74.92	5.964	9.816**

** Statistically significant at a 5% level. Note: DAP, CAN, NPK. Di-Ammonium Phosphate, Calcium Ammonium Nitrate, Nitrogen, phosphorus and potassium, respectively.

The average DAP fertilizer utilization among the sampled farmers (Malava and Mumias East) was 86.45 kg/ha. Participants' farmers had significantly more quantities of fertilizer usage averaging 91.39 kg/ha while the non-beneficiary had an average use of 81.51 kg per ha. In addition, the average CAN fertilizer usage was 81.5 and NPK was 74.1 kg/ha. The average fertilizer usage (NPK, DAP, CAN) for the sampled farmers was 80.68 kg/ha. The program participants had a significantly higher average application rate of 85.64 kg/ha compared to the non-beneficiary who had applied 74.92 kg/ha. The leakage of subsidized fertilizer was further noticed.

Table 17: Leakage from the subsidy program

	Sum (kg)	Percentage
Received	14, 275	100.00
Usage	13,300	93.17
Leakage	975	6.83

4.3 Factors influencing proportions of subsidized fertilizer utilization

One limit left-censored Tobit model was employed in estimating the variables that influence the proportions of subsidized fertilizer usage by smallholder farmers. The estimates of the factors are presented in Table 18. The model has a Pseudo R^2 of 79.84 %, showing that the model fitted the data well. This implies that factors fitted explained the disparity in the proportions of subsidized fertilizer utilized by 79.84%. In addition, the Chi-square was 59.88% and significant at a 5% level, showing that the model was correctly estimated.

As farm size under maize production increased by one hectare, the proportion of subsidized fertilizer usage reduced by 0.488% per ha. In addition, as the household size increased by one member, a corresponding increase of 0.112% per ha is experienced in the proportions of subsidized fertilizer use. Furthermore, a corresponding increase in the proportion of subsidized fertilizer usage by 0.211% per ha is experienced when the quantity of seed planted is increased by 1kg per ha. As indicated, an increase by one in years of formal schooling increased the proportions of subsidized fertilizer utilized by 0.078% per ha. Moreover, an increase in age by one raised the proportion of fertilizer subsidy usage by 0.073% per ha.

Table 18: Estimates of a Tobit model on factors influencing subsidized fertilizer proportions usage

Proportions of subsidized fertilizer	Coefficient	Std. Error	t-value	P>|t|
Farm size (Ha) (under maize production)	-0.488	0.081	-6.01	0.000**
Manure application (1. Yes, 2. No)	-0.027	0.042	-0.66	0.511
Household size	0.112	0.018	6.15	0.001**
Seed quantity ($KgHa^{-1}$)	0.211	0.042	5.01	0.000**
Agricultural asset value (Ksh. 1000)	0.047	0.083	0.57	0.566
Age (Years)	0.073	0.008	8.58	0.000**
Schooling (Years)	0.078	0.011	6.49	0.000**
Gender of household head (1. Male, 2. Female)	0.032	0.026	1.22	0.223
Occupation (1. Farming, 2. BR, 3. Salaried)	0.013	0.011	1.17	0.241
Distance to inputs market (Km)	0.228	0.016	13.98	0.000*
Amount of credit (Ksh. 1000)	-0.098	0.055	-1.77	0.077
Group membership (1.Yes, 0. No)	0.050	0.043	1.16	0.246
Location (1. Malava, 2. Mumias East)	-0.021	0.024	-0.90	0.368
Log-likelihood	-45.181	LRchi^2(13)	59.885	
Pseudo R^2	79.84	Prob>chi^2	0.000	

*, ** Statistically significant at 5% and 1% level. Km, Kg, Ha^{-1}, Bus, kilometer, kilograms, per hectare of land, business-related respectively.

More findings indicate that when the distance from the inputs market is increased by 1km, caused a corresponding increase in the quantities of subsidized fertilizer utilized in the total inorganic fertilizer by 0.228% per ha at a 5% significant level. Lastly, an increase in the probability of borrowing by 1000 units decreased the proportion of subsidized fertilizer usage by 0.228% per ha at a 5% level.

4.4 Effect of the subsidized fertilizer program on maize productivity

The results in Table 19 show the estimates from the probit model of the selected variables influencing the likelihood of participating in a fertilizer subsidy program. Having a Chi-square of

33.37, significantly at a 5% level, the model was well approximated. The variation in the probability of farmers participating in the program was explained by 81.39% since this was the model Pseudo R^2 which is relatively high. In addition, the Log-likelihood of -37.28 was highly negative indicating that the model was well specified with a good fit.

Table 19: Probit regression estimate of factors influencing subsidy fertilizer program participation

Program participation	**Coefficient**	**Std. Error**	**t-value**	**P>|t|**
Farm size (Area under maize production)	-3.494	2.614	-1.32	0.186
Manure application (1. Yes, 0. No)	-0.864	0.689	-1.25	0.209
Labor (man-day Ha^{-1})	0.197	0.189	1.04	0.298
Household size	0.749	0.292	2.56	0.010**
Seed quantities (Kg Ha^{-1})	0.793	0.45 8	1.73	0.230
Age (Years)	1.205	0.225	5.35	0.000*
Schooling (Years)	1.485	0.314	4.72	0.000**
Gender (1. Male, 2. Female)	0.201	0.023	0.86	0.391
Occupation (1. Farming, 2. BR, 3. Salaried)	0.313	0.185	1.69	0.091
Amount of credit (Ksh. '000)	2.688	0.757	3.55	0.000**
Distance to inputs market (Km)	1.669	0.616	2.71	0.007**
Distance to agriculture office (Km)	-0.274	0.012	-21.9	0.000**
Group membership (1. Yes, 0. No)	-0.283	0.855	-0.33	0.740
Location (1. Malava, 2. Mumias East)	0.002	0.021	0.10	0.918
Lambda	-0.391	0.482	-0.81	0.418
Rho	-0.304	waldchi^2(13)	68.40	
Sigma	0.275	Prob>chi^2	0.000	

Km, Kg, M, F, Ha^{-1}, BR, kilometer, kilograms, male, female, per hectare of land, business-related respectively)

When the size of the household increases by one, the likelihood of a farmer adopting a subsidy program corresponds by increasing by 0.749%. Results indicate that as a farmer grows older by one year, the probability of involvement in the program increases by 1.205% at a 5% level. In addition, as a farmer spends an extra year in a formal learning facility, the chances of engaging in a subsidy program increase by 1.485%. Furthermore, an increase of one unit of credit access increases the possibility of a farmer participating in the subsidy program by 1.669%. Moreover, as the distance enlarges by a kilometer from the market, the probability of one participating in the subsidy program goes up by 1.669%. However, on the contrary, an increase by one km from the word agricultural office reduces the likelihood of participating in the fertilizer subsidy program by 0.274%.

The results in Table 20 show the estimates from a censored Tobit regression model on the effect of the subsidy program on maize-grain productivity after controlling for actual fertilizer quantities, seed quality, and household socio-economic characteristics.

Table 20: Tobit regression estimates of factors determining maize productivity quantities

Log Maize productivity (t/ha)	**Marg. Effe**	**Std. Error**	**t-value**	**P>|t|**
Program participation (1. Yes, 0. No)	0.323	0.021	15.74	0.000**
Log Fertilizer quantities ($KgHa^{-1}$)	0.007	0.002	3.59	0.000**
Log Farm size (Ha under maize production)	0.229	0.079	2.88	0.004**
Log Labor (man-day Ha^{-1})	0.086	0.101	0.85	0.397
Log Household size	0.018	0.007	2.45	0.015**
Manure application (1. Yes, 0. No)	0.063	0.078	0.81	0.419
Log Seed quantities ($KgHa^{-1}$)	0.131	0.070	1.86	0.086
Seed quality (1. Certified, 2. Own farm)	0.037	0.006	6.85	0.000**
Log Age (Years)	0.020	0.003	6.55	0.000**
Log Schooling (Years)	0.001	0.005	0.20	0.841
Gender (1. Male, 2. Female)	0.008	0.011	0.73	0.454
Occupation (1. Farming, 2. BR, 3. Salaried)	0.002	0.004	0.46	0.643
Group membership (1. Yes, 0. No)	-0.064	0.017	-3.85	0.000*
Log Amount of credit (Ksh. 1000)	0.077	0.018	4.14	0.000**
Location (1. Malava, 2. Mumias East)	-0.004	0.010	-0.40	0.686
Inverse Mills Ratio (IMR)	0.059	0.041	1.43	0.153
Log-likelihood	-58.80	Pseudo R^2 of	94.14%	
LR Chi^2 (15)	35.92	Prob>chi^2	0.000	

*, ** Statistically significant at 5% and 1% level, Km, Kg, M, F, Ha^{-1}, BR, kilometer, kilograms, male, female, per hectare of land, business-related respectively)

The model was correctly estimated as it had a high Pseudo R^2 of 94.14% which indicates that independent variables of the model explained the variation in maize productivity by 94.14%. In addition, the Log-likelihood of -36.49 was a high negative number which shows the steadiness of the model specification. The model was well specified with a high goodness-of-fit. The model had a significant Chi-square of 35.73 at a 5% level. Fertilizer subsidy program participation increased maize productivity by 32.3%. The study investigated the effect of the subsidy program on maize productivity alongside other socio-economic variables. The consideration for these factors was for control purposes given that maize productivity is affected by several other factors apart from the subsidy program. One extra unit of fertilizer applied increased maize productivity by 7%. In addition, an increase in the cultivated farm size by one unit intensified quantities of maize productivity by 22.9%. Moreover, as the household size increased by one unit, maize productivity increased by 1.8%. Using certified seeds significantly increased maize productivity by 3.7% ceteris paribus. The findings indicate maize productivity increased by 2% as age increased by one unit. Furthermore, an increase in the amount of credit accessed by farmers by one unit increased the productivity of maize by 7.7%. However, active participation in the farmers' group decreased productivity by 6.4% keeping all other factors constant at a 5% level.

CHAPTER FIVE

DISCUSSION

5.1 Introduction

This chapter presents a discussion of the findings in chapter four. The discussion is organized according to the research objectives and research questions highlighted in chapter one.

5.2 Proportions of subsidized fertilizer utilization in overall inorganic fertilizer

The results in Table 16 showed that the proportion of subsidized fertilizer used among the program participants was 59.48%. In regards to fertilizer usage, the program participants utilized more quantities of fertilizer compared to non-participants. In specific, the average fertilizer application rates for the program participants were significantly higher at 85.64 kg/ha compared to 74.92 kg/ha for non-participants. The study revealed that the subsidy program was instrumental in increasing fertilizer usage rates from an average of 37kg/ha reported by Mavuthu (2017) to 80.68kg/ha. This is a reflection of the subsidy program reducing the cost of fertilizer, therefore, is very effective and an important contributor to fertilizer usage. The findings, therefore, established that farmers who benefited from the subsidy program were able to significantly utilize more fertilizer than those who did not participate in the program. This was an indication that the implementation of a subsidy program for resource-poor farmers influenced input access by lowering the costs and increasing affordability.

The target application rate for the program was set to attain 75kg/ha by 2015 for maize farmers by the county government (KCIDP, 2018). Despite this target being achieved by most farmers, the application rates are still below the recommended rates in the two sub-counties (NAAIAP, 2014). It is, therefore, suggested the government should continue to allocate more budget for subsidy programs to give relief to rural farmers who cannot afford to purchase fertilizer from the agro-dealers.

These findings build on the existing evidence of the previous studies by Dorward (2009); Minot et al. (2009); Druilhe & Hurle (2012); Jongare & Michael (2015); Zinnbauer et al. (2018), and Anago et al. (2020) who reported subsidy program being a cost-effective way of assisting poor rural farming households to acquire more fertilizer and achieve optimal application rates and can be justified on the ground of equality as it enables farmers to off-set financial constraints.

However, these results are contrary to Hanjra & Culas (2011); Liverpool-Tasie (2014) and Gignoux et al. (2021) who reported low fertilizer availability due to the subsidy program. They testified against subsidized fertilizer by revealing its potential to only expand the participation in and intensity of fertilizer procured from commercial dealers and the multifaceted delivery channels in acquiring subsidies which led to delayed planting and some cases missing the inputs by farmers.

5.3 Factors influencing the proportions of subsidized fertilizer utilization

The results in Tables 18 and 19 showed that household size significantly influenced the probability of a farmer participating in the subsidy program and also the proportions of subsidized fertilizer usage in the overall inorganic fertilizer. This might be attributed to the fact that, as a family grows, the need for more food arises and this, in turn, calls for more vibrant technologies in production which minimize the cost and increase the output. In agreement, Anago et al. (2020) & Makau et al. (2016), reported that the probability of adopting a fertilizer subsidy program and the intensity of usage highly depends on the household size. However, the results contradict Barasa et al. (2019) who attributed smaller households applying more fertilizer to higher obligations that come with an increase in the household size.

The seed rate planted significantly influenced the proportion of subsidized fertilizer usage in the quantities of inorganic fertilizer. Since seeds are also given to farmers through the program, beneficiaries could be acquiring the two inputs proportionately at affordable prices. This could imply that farmers who receive more proportions of fertilizers stand a chance of benefiting from more quantities of seeds at an affordable price.

Age significantly influenced the likelihood of a farmer participating in a fertilizer subsidy program and the proportion of subsidy fertilizer usage in the overall inorganic fertilizer. This is attributed to the fact that farmers establish social linkage with government officials and vetting committees over years, therefore, elderly farmers are given priority in the selection and allocation process. Moreover, the trust established with selecting committees could favor elderly farmers during inputs allocation. Similarly, according to Kariyasa & Dewi (2013), experience is gained as farmers grow and knowledge for better evaluation of technology information thus faster adoption.

However, on contrary, Enete & Igbokwe (2009); Martey et al. (2013); and Mwaura et al. (2021) reported that age negatively influenced the probability of fertilizer technology adoption. The authors attributed to the fact that young farmers are more dynamic, risk-takers, motivated to try new perceptions, and innovative, therefore, easy to adopt farming technology and participate in agricultural government-initiated projects.

Schooling significantly and positively influenced the probability of participating in the subsidy program and the intensity of the proportions of subsidized fertilizer utilization. This is accredited to the fact that highly educated farmers have improved know-how and make the decision on input use based on cost-benefit analysis. Therefore, they could be among early adopters of any technology as they are perceived as more informed. In agreement, Ajewole (2010; Kusumah &

Christianingrum (2018) and Vecchio et al. (2020), schooling had a stronger effect on organic fertilizer technology adoption. This agrees with the reports of Makau et al. (2016); Azumah & Zakaria (2019) & Alhassan et al. (2020) that suggested highly educated farmers acquire more subsidized fertilizer due to higher bargaining power with the vetting committees.

Distance from the market positively influenced the possibility of the farmer participating in the fertilizer subsidy program and the proportion of subsidized fertilizer utilized in the total inorganic fertilizer. This could be attributed to the fact that those close to input markets use more quantities commercial fertilizer because of accessibility. The findings are in agreement with Ariga & Jayne (2011) and Makau et al. (2016) who reported an inverse association between distance to inputs seller and the quantities of commercial fertilizer usage. However, on the contrary, Barasa et al. (2019) testified an undesirable relationship between distance to market inputs and the intensity of subsidized fertilizer utilization. The author attributed to the fact that the cost of fertilizer transportation is lower compared to the extra cost incurred in purchasing commercial inputs.

However, farm size negatively influenced the proportion of subsidized fertilizer utilized among the program beneficiaries. This could be related to the initial objective of the program of targeting resource-poor farmers. The results are in agreement with the researcher's earlier hypothesis that farmers owning large farm sizes might afford commercial fertilizer. In addition, the government policy might be restricting resourceful farmers from access to larger quantities of subsidized fertilizer. These findings tally with Martey et al. (2013) and Jongare & Michael (2015) who encouraged ownership of comparatively small controllable plots due to financial constraints to adopting modern technologies.

5.4 Effect of subsidized fertilizer program on maize productivity

From Table 20, results showed that fertilizer subsidy program significantly increased maize productivity. This was an indication that the implementation of a subsidy program for resource-poor farmers influenced their household maize productivity. The significant variation in maize yield for the farmers who participated in the subsidy program showed room for strategies and government policies to have an impact on resource-poor farmers' productivity as it encourages access and improves the usage of fertilizers. Therefore, when resource-poor farmers participate in the subsidy program, maize productivity increases by 32.3%. However, in Kakamega County, the fertilizer subsidy program has not been able to increase yields to potential production levels of 5.5 kg/ha despite achieving the county's target application rates of 75kg/ha since the average fertilizer usage is still low to make an impact on productivity as compared to what is recommended for the county (NAAIAP, 2014). A 6.83% deviation from what was received and what was utilized on maize crops was evident. The potential causes of this deviation were suspected to be side selling of the subsidized fertilizer by beneficiaries and diverting to other crops or unintended purposes. In addition, the farmers in Kakamega County highly used DAP as basal fertilizer for planting compared to the recommended non-acidic fertilizers such as NPK, CAN, and Mavuno in maize production. For Mumias East the application of 125 kg/ha CAN, and 250 kg/ha NPK: 17:17:17 for planting is recommended. For Malava, the application of 200 kg/ha CAN, and 200 kg/ha NPK: 23:23:0 for planting is recommended (NAAIAP, 2014).

The sum of the inputs (fertilizer, seeds, labor) coefficients in Table 20 is less than 1 for the elasticities, this implies that the production of maize is experiencing a decreasing rate of return to scale. A percentage increase in the factors of production combined will produce a smaller percentage increase in productivity holding all other factors as error terms. This is the reason why productivity is stagnating despite an increase in fertilizer usage in the County.

The results corroborate results from several other studies done across African nations and globally. It agrees with the findings of Gawamadzi & Kosura (2011) Dorward & Chirwa (2011); Welime (2014); Magut et al. (2019) and Alhassan et al. (2020) who reported Agricultural Input Subsidy Program to have a considerable increase in maize production that contributed to increased food availability, and reduced rural poverty as well as amplified real wages in different regions. The authors associated this increase in production with the high level of input usage as inputs offered through the program are affordable to most resource-poor households.

However, on contrary, Morris et al. (2007); Minot & Benson (2010); Dorward & Chirwa (2011) Azumah & Zakaria; (2019); Kinuthia (2020) exposes the weakness of the program. Productivity of maize stagnated in different regions as a result of the subsidy program implementation. The authors mentioned that the subsidy program is beneficial only where the technical efficiency especially the quality, timing, and appropriate application rates are considered. Also, the previous studies reported that subsidies had an initial increase in the productivity of maize, however, it failed in the long run raising doubts about the effectiveness of the program to achieve a sustainable food production system.

The potential source contradiction in the findings with the previous studies could be the study design implemented. The study adopted a cross-sectional design which only allows data collection over one year. However, some studies implemented time series analysis which evaluated the impact of the program over a period of time. In addition, most of the previous studies failed to control for the other factors affecting maize productivity in the analysis. This could be another potential source of contradiction in the findings.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The primary objective focused on by the research was determining the effect of subsidy program on fertilizer usage and maize-grain productivity in Kakamega County. Tobit model results showed that subsidy program participation led to an increase in maize-grain productivity by 32.3% after controlling for actual fertilizer quantities, seed quality, and household socio-economic characteristics.

From the findings, it was established that 13,300 kg of inorganic fertilizer usage among the program participants' farmers was from the subsidy program. In addition, they further applied 9,058kg of commercial fertilizers. This translates to 59.48% government-subsidized fertilizer and 40.51% commercial fertilizer. The findings also showed higher average fertilizer usage of 85.6 kg/ha among the program participants compared to 74.9 kg/ha for non-participants.

The factors that significantly and positively influenced farmers' participation in the subsidy program and the proportions of subsidized fertilizer used in overall quantities of inorganic fertilizer utilization were the size of the household, age of the family head, years of schooling, amount of money borrowed, and distance to inputs market. In addition, seed quantities influenced positively the proportions of subsidized fertilizer used. However, the size of the farm negatively influenced the proportions of subsidized fertilizer used among the program beneficiaries.

The study establishes that, despite average productivity being lower at 2.216 t/ha in 2020 compared to 2.26t/ha in 2017, farmers who participate in the fertilizer subsidy program have higher average productivity of 2.46t/ha as compared to 1.971t/h for non-participants. In summary, when priorities are given to the program, productivity has a probability of increasing by 32.3% which is quite impressive.

6.2 Recommendations

6.2.1 Policy recommendations

The study recommends the government to increase the amount of recommended fertilizer (non-acidic e.g. NPK, Mavuno) supplied to incorporate more farmers in the program to attain the 200 kg/ha (NPK) and 150 kg/ha (CAN) recommended fertilizer application rates for planting and top-dressing respectively and also farmers to reduce the usage of acidic fertilizer e.g. DAP.

The policymakers should consider the social-economic factors of small-scale farmers when formulating policies on recruitment and allocation as they are the main target of the program and also consider the region-recommended fertilizer type and application rates when setting targets for the social program involving fertilizer. This will ensure the program target matches the application rates recommended by the Ministry of Agriculture.

By the findings showing higher fertilizer usage and productivity for subsidy program beneficiaries as compared to non-beneficiaries, the study recommends a subsidy program as a good strategy to address low fertilizer usage and low maize productivity.

6.2.2 Areas for Further Research

Despite the study focusing on the effect of subsidized fertilizer programs on maize productivity in Kakamega County, similar studies are to be done in other counties to bring out the impacts of various fertilizer subsidy programs on crop productivity across the country.

The long-term period sustainability of the subsidy program on maize productivity could be evaluated by further studies as the study was based on cross-sectional data.

Other researchers to focus on assessing the impacts of leakages in the subsidy program on maize productivity at the counties and national levels and determining the economic effect of Stover production.

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APPENDICES

APPENDIX I: CONSENT NOTE

MASENO UNIVERSITY
SCHOOL OF AGRICULTURE, FOOD SECURITY, AND ENVIRONMENT SCIENCE

Title of Research: ***Effect of Subsidy Program on Fertilizer usage and Maize-grain Productivity***

Principal Investigator
Mulupi Dennis Kimoso (Tel:0727823207: mulupidennis@gmail.com)
Co-investigators
1. Phoebe Mose (Ph.D.) 2. Kenneth Sibiko (Ph.D.)

Dear Farmer,

REF: CONSENT LETTER FOR PARTICIPATION (*to be read and translated into Kiswahili by the researcher a widely understood and spoken language by most people in the study area*)

We request your participation in this study, to enable us to find out the effect of subsidy program on fertilizer usage and maize-grain productivity.

The study is being conducted in Kakamega County. The county has 12 sub-counties but we only focus on a few sampled farmers from Malava and Mumias East as they represent sub-counties with the largest and smallest number of maize farmers. The study consists of three objectives which are determining proportions of subsidized fertilizer utilization, socio-economic factors affecting these proportions of subsidized fertilizer usage, and determining the effect of the subsidized fertilizer program on maize-grain productivity. In this study, your participation will involve responding to a questionnaire divided into different sections on personal information, access to fertilizer, maize productivity, income, credit, extension services market, and input access. The study purpose is purely for academics and therefore outermost confidentiality and protection of the information collected is guaranteed and will not be disclosed to any unauthorized persons or used for any other purpose. The study is not expected to cause any potential risk or harm to the participants. There will not be direct benefits rather than the awareness creation of the program for you as a participant. The questionnaires are numbered so that the analysis is based on questionnaire numbers and no names of participants should be disclosed for anonymity and privacy throughout the study. The information collected will not be linked to any individual, but rather will be used collectively. The information will be important in deciding on the fertilizer subsidy program participation and maize productivity for the farmers. You have a right to abstain from participation or terminate participation at any time and will involve no penalty. The results of the study will culminate in a thesis and be disseminated through a publication thereafter which will be available to everyone.

Contact Information

Any concerns may be addressed to Mulupi D. Kimoso MSC/AF/00087/018 (Tel: 0727823207; email:mulupidennis@gmail.com; kimosodennis@gmail.com)

For any questions about rights as a research participant, please contact:

The Secretary, Maseno University Ethics Review Committee, Private Bag, Maseno; Telephone numbers: 057-51622, 0722203411, 0721543976; 0733230878; Email address: muerc-secretariate@maseno.ac.ke; muerc-secretariate@gmail.com.

Agreement

Given the information provided to you about the aim of this research are you willing to participate in the rest of the interview? 1=YES [ ] 2=NO [ ]

(If the answer is NO, end the interview and thank the respondent for their time. If the answer is YES, the respondent to sign the consent and be issued with a questionnaire for the study)

I have received this consent note to participate in research titled: Effect of subsidized fertilizer program among small scale maize farmers in Kakamega County. All that is entailed in this research has been read and translated to Kiswahili and I understand my responsibility in this research. I consent to participate without any kind of inducement and I understand that I am free to refuse or retreat from participation at any moment of my desire without any penalty.

Signature of Participant…………………………… Date…………………………………….

APPENDIX II: SEMISTRUCTURED HOUSEHOLD SURVEY QUESTIONNAIRE.

EFFECT OF SUBSIDY PROGRAM ON FERTILIZER USAGE AND MAIZE-GRAIN PRODUCTIVITY AMONG SMALL-SCALE FARMERS IN KAKAMEGA COUNTY
[Maseno University, P.O. Box, Private Bag Maseno, Kenya]

Dear Farmer, **(*everything to be read and translated by a researcher to Kiswahili a widely understood and spoken language by most people in the study area*)**

Food insecurity is a challenge in the country. Maize is an important food crop in the region and its productivity has stagnated over the past few years, despite the government intervening through the subsidized fertilizer program. The program was intended to raise soil fertility through affordable fertilizers. The research aims to find out whether the subsidy program has any way been beneficial to farmers as far as production is concerned.
Your responses to our questions will be very useful in this research.

> NB: The information obtained from you shall be treated with outermost confidentiality and the results will strictly be for academic purposes and to provide valuable information for policymakers.

In case of further queries about the research, please feel free to contact the researcher (cell: 0727823207; Email: mulupidennis@gmail.com)
Oral Consent:

Given the information provided to you about the aim of this research are you willing to participate in the rest of the interview? 1=YES [ ] 2=NO [ ]
Enumerator: If the response is NO, try to probe further to understand the concerns of the respondent. You may attempt to address their concerns and then seek their oral consent once again. If the answer remains NO, end the interview and thank the respondent for their time.

SECTION A: GENERAL STATISTICS

Note*:* kindly respond to questions below by marking (√) in the appropriate block or writing answers in a space provided after every question. Do not leave any blank space.

(a)1. Questionnaire Number…………………………………………………
(a)2. Sub-county ……………………………………………………………….
(a)3. Ward ………………………………………………………………………
(a)4. Village …………………………………………………………………….
(a)5. Location of the homestead 1=Town ;2=Per-urban ; 3=Countryside; 4= Near industry [ ]
(a)6. Enumerator name………………………………………………………

N/B- use code1if the answer is yes, code 2 if the is no, code77 if no answer is given code 99 if not applicable and use a conversion scale for appropriate units of measurement e.g. 90kg=1 bag of maize, 1 tin = 2kgs, 50kg of fertilizer=I bag of fertilizer, price is in KSH**.**

SECTION B: HOUSEHOLD HEAD CHARACTERISTICS

Question	***Code***	
(b)1. Age	***Definite years***	
(b) 2. Gender	***1: Male; 2: Otherwise***	

(b)3. Marital status	***1: Single ;2: Married; 3: Separated; 4= Widow 5. Others (specify)……………………………***	
(b) 4. Highest attained Education	***0=Non-formal;1= University;2= College; 3= Secondary; 4= Primary***	
(b) 5. Primary Occupation of the household head	***1= Farming; 2=Off-farm (agricultural-related); 3= Off-farm (self-employed business); 4=Salaried employment (non-agricultural); 5=others (specify)…………………………………..***	
(b) 6. Secondary Occupation of household head	***1=Farming; 2=Off-farm (agricultural-related); 3=Off-farm (self-employed business); 4=Salaried employment (non-agricultural); 5=Others (specify)………………………………..***	
(b)7. Maize Farming experience	***The actual number of years***	
(b)8. Is the household head the main decision regarding maize production? 1=YES[ ] 2=NO[ ] ***(If the response is NO, proceed with section C, if YES, skip to section D)***		

SECTION C: INFORMATION ON THE MAIN DECISION-MAKER

Question	***Code***	
(c)1. Age	***The actual number***	
(c)2. Sex of the decision-maker	***1: Male; 2: Otherwise***	
(c)3. Marital status of the decision-maker	***1=Married ;2=Single; 3=Separated; 4= Widow 5. Others (specify)……………………………***	
(c)4. Highest Education level of the decision-maker	***0=Non-formal;1= University;2= College; 3= Secondary; 4= Primary***	
(c)5. Primary Occupation of the decision-maker	***1= Farming; 2=Off-farm (agricultural-related); 3= Off-farm (self-employed business); 4=Salaried employment (non-agricultural); 5=others (specify)……………………………………….***	
(c) 6. Secondary Occupation of the decision-maker	***1=Farming; 2=Off-farm (agricultural-related); 3=Off-farm (self-employed business); 4=Salaried employment (non-agricultural); 5=Others (specify) ………………………………………………..***	
(c)7. Maize Farming experience	***The actual number of years***	
(c)8. What is the relationship of the decision-maker to the family head? 1=Husband; 2=Wife; 3= son/daughter; 4= Others ……………………………		

SECTION D1: HOUSEHOLD CHARACTERISTICS

Question	***Code***	
(d)1. How many people currently live within the household?	***The actual number of years***	
	Adults 59 years and above	
	Adults females aged between 17 and 58	
	Adults male aged below 17 and above 58	
	Children aged between 7-16	
	children below the age of 6	

(d)2. How many members are involved in maize farming	***Actual number of members***	

SECTION E1: LAND POSSESSION, TENURE SYSTEM, AND USAGE

Acreage	Owned	Rented from people	Rented out

E2. For each of the following agricultural assets, kindly specify its status.

Agricultural assets	***(i) asset ownership 1=YES 2=NO***	***(ii) asset usage in maize farming 1=YES 2=NO***	***(iii) Type 1=Dairy cattle 2=Other cattle***	***(iv) Number of assets***	***(v) Average price per asset***	***(vi) Value of the asset in Ksh.***
Livestock						
Tractor						
Plough						
Oxen						
Jembes						
Slasher						
Spraying pump						
Sheller						
Miller						
wheelbarrow						
Granaries						

SECTION F: MAIZE PRODUCTION INFORMATION

F1. How many planting seasons do you usually have 1=One [ ] 2=Two [ ] ***(If the response is one skip to F3, if two proceed with F2)***

F2. Inputs for Season 2 2019 Sep- December

Acreage under maize	**Seed**			**Fertilizer**					
	Certified 1=YES 2=NO	Quantity in kg	Price per kg	Planting			Topdressing		
				#Type	Quantity	Price per kg	#Type	Quan tity	Price per kg

(Code: # 1=Urea; 2=Mavuno 3=NPK; 4=DAP)

Manure	**Chemicals**

Usage 1=YES 2=NO	Quantity in wheelbarrows	Price per wheelbarrows		Usage 1=YES 2=NO	*Type	Quantity	Price per kg		

Code:* 1=Herbicides 2=Insecticides

Labor	***Number of workers***	***Hours per person per day***	***Number of days***	***Family members involved***
Clearing				
Ploughing				
Planting				
Weeding				
Spraying				
Harvesting				

Output of maize

Yields		**Other products**			
		Animal feeds(forage)		**Cobs**	
Quantity (90kg bag)	Price per bag	Quantity in tractors	Estimated price	Quantity in ox cart	Estimated price

F3. Inputs for Season 1 2020 March - July

Acreage under maize	**Seed**			**Fertilizer**					
	Certified 1=YES 2=NO	Quantity in kg	Price per kg	Planting			Topdressing		
				#Type	Quantity (kg)	Price per kg	#Type	Quantity (kg)	Price per kg

(Code: # 1=Urea; 2=Mavuno 3=NPK; 4=DAP)

Manure				**Chemicals**					
Usage 1=YES 2=NO	Quantity in wheelbarrows	Price per wheelbarrows		Usage 1=YES 2=NO	*Type	Quantity (ml)	Price per ml		

(Code:* 1=Herbicides 2=Insecticides)

Labor	**Number of workers**	**Hours per person per day**	**Number of days**	**Family members involved**
Clearing				
Ploughing				
Planting				
Weeding				
Spraying				
Harvesting				

Output of maize

Yields		**Other products**			
		Animal feeds(forage)		Cobs	
Quantity (90kg bag)	Price per bag	Quantity in tractors	Estimated price	Quantity in ox cart	Estimated price

SECTION G: FERTILIZER ACCESS AND AWARENESS

(Farmers who use fertilizer to provide the information. Those who don't use fertilizer skip to section H)

(G) 1. How often have you been using fertilizer?

1. Every planting season [ ]; 2. Not every planting season [ ]; 3. Only once [ ]

(G) 2. Are you aware of the subsidized fertilizer being supplied by the government? 1=YES [ ] 2=NO [ ] ***(If the response is no skip to the next section H).***

(G) 3. Have you ever registered for subsidized fertilizer? 1=YES [ ] 2=NO [ ] ***(If the response is no skip to G8).***

(G) 4. How did you register? *1. Through the MoA offices [ ]; 2. Through an extension officer [ ]; 3.Through the local leadership [ ]; 4. Through farming groups [ ]; 5. Through other farmers [ ]; 6. Others (specify) [ ]*

(G) 5. Did you access subsidized fertilizer in the period between June 2019 and June 2020 planting season? 1=YES [ ] 2=NO [ ] ***(If the response is no skip to G7).***

(G) 6 (i) what quantity of subsidized fertilizer did you receive? ....

. (ii) What quantity of the total inorganic fertilizer used was subsidized? ....

(G) 7. What was the reason for failing to use subsidized fertilizer?

1. No interest [ ]; 2. Poor fertilizer was quality fertilizer was supplied; [ ]
3. Less stock supplied [ ]; 4. Others [specify]……………………………………..

(G) 8. Is there any farmer in the homestead/ neighborhood/ village who is a beneficiary of subsidized inputs from whichever source? 1=YES [ ] 2=NO [ ]

Only those who used subsidized fertilizer in the period between June 2019 and June 2020 planting season to fill this part

(G) 9. Was there any limitations in accessing subsidized fertilizer? *1. Long queues [ ]; 2. Long distance [ ]; 3. Missing names of beneficiaries [ ]; 4. Stock out [ ]; 5. Inequity in distribution [ ]; 6. Late delivery [ ]; 7. Corruption at selling points [ ]; 8. Rudeness among clerks [ ]; 9. Complicated procedure [ ]*

(G) 10. Without subsidized fertilizer, could you have managed to plant? 1=YES [ ] 2=NO [ ]

(G) 11**.** Did your production increase after using subsidized fertilizer compared to the previous years? 1=YES [ ] 2=NO [ ] ***(If the response is no skip to G13).***
(G) 12. What was the average increase in 2019? ....
(G) 13. Were you able to implement anything new on your farm? 1=YES [ ] 2=NO [ ] ***(If the response is no skip to G15).***
(G) 14. Could you have implemented anything new without subsidized fertilizer? 1=YES [ ] 2=NO [ ]
(G) 15. Would you require subsidized fertilizer again? 1=YES [ ] 2=NO [ ] ***(If the response is no skip to G17).***
(G) 16. Give the reason 1. It is cheaper [ ]; 2. More productive [ ]; 3.Timely [ ]; 4.Accessible [ ]; 5. Others [ ]
(G) 17. Give the reason. 1. Late delivery [ ]; 2. Poor quality [ ]; 3.Corruption [ ]; 4. Not accessible [ ]; 5. Others [ ]
(G) 18. What other farm inputs would you like to be subsidized? 1. Seeds [ ]; 2. Machinery [ ]; 3. Pesticides [ ]; 4.Tools [ ]; 5. Others (specify) [ ]
(G) 19. Was the subsidized fertilizer received applied to the maize crops only? 1=YES [] 2=NO []
(G) I.20. If not, what other crops did you use subsidized fertilizer? 1=Beans [ ] 2=Sugar canes [ ] 1=Bananas [ ] 4. Others [specify]……………………………………..
(G) Ii. What quantities of subsidized fertilizer were applied to the other crops………………
(G) Iii. Did you sell any amount of the fertilizer? 1=YES [ ] 2=NO [ ] ***(If the response is yes)*** to whom Beneficiary [ ] non-beneficiary [ ]
(G) 21. What is your level of satisfaction in the program in this area? Respond by giving a level of on the following statement.

		1=agree	**2=uncertain**	**3=disagree**
1. registration process	Needy farmers were not registered			
	The registration process was free and fair			
	The people giving were well organized			
	The program was not convenient for the farmers			
Voucher system	The voucher system was effective			
	Fewer vouchers were supplied to the farmers			
	Vouchers were given to farmers who were not registered			
Availability of fertilizer	All farmers got the types of fertilizer they wanted			
	Fertilizer was not delivered to farmers on time.			
	The quantity supplied was sufficient			
	The quality of fertilizer was sub-standard			

SECTION H: HOUSEHOLD INCOME

(H) 1. Do you generate income from any other source? 1=YES [ ] 2=NO [ ] ***(If the response is no skip to the next section I).***

(H) 2. If yes in (1) above, specify.

Source	Tick (√)	Amount monthly
Other farm income		
Livestock production		
Salaried income		
Business income		
Gifts/ transfer earnings		
Loans/ borrowing		
Family assets rented out for income		
Others (specify		
Total		

SECTION I: CREDIT ACCESSIBILITY

(I) 1. Did you receive credit from a financial institution for agricultural purposes in the period between June 2019 and June 2020? 1=YES [ ] 2=NO [ ] ***(If the response is no skip to I4).***

(I) 2. What was the purpose of receiving the loan?

1. Buy farming inputs (fertilizer, Seeds, pesticides, tools and machinery) [ ];
2. School fee payment [ ]; 3. Hire labor [ ]; 4. Buying food [ ]; 5. Others (specify) [ ]

(I) 3. Did you use any portion of the loan in maize production activities? 1=YES [ ] 2=NO [ ]

SECTION J: EXTENSION ACCESS AND GROUP MEMBERSHIP

(j)1. Are you aware of any extension service in the county? 1=YES [ ] 2=NO [ ] ***(If the response is no skip to the next section K).***

(j)2. Did you ever access any extension services/ training in the period between June 2019 and June 2020? ? 1=YES [ ] 2=NO [ ] ***(If the response is no skip to the next section K).***

(j)3. Was the services/training content relevant and need-based for your production of maize?

1=YES [ ] 2=NO [ ]

(j)4. Which method of training was used in the service delivery? *1. Classroom lectures [ ]; 2. Farmer to farmer learning [ ]; 3. Visiting demonstration [ ]; 4. Field practice demonstration [ ]; 5. Others (specify) [ ]*

(j)5. Which organization provided the extension service/ training? 1=MoA [ ], 2= Agrics Kenya 3=One acre fund [ ] 4. Others (specify) [ ]

(j)6. Are you aware of any farmers' groups in the county? 1=YES [ ] 2=NO [ ] ***(If the response is no skip to the next section K).***

(j)7. Did you engage in any farmer association activities for the period between June 2019 and June 2020? 1=YES [ ] 2=NO [ ] ***(If the response is no skip to the next section K).***

(j)8. How long have you been a member? ....

(j)9. Which position did you hold?

1=Board member [ ] 2=Normal member [ ] 3= others (specify)………………

(j) 10. What are the primary objectives of the group?

1=saving [ ] 2=Training [ ] 3=Marketing [ ] 4=Welfare [ ] 5=others (specify)

(j) 11. Which type of association is it? *1=Maize producer group[ ]; 2=Other crop producer group[ ]; 3=livestock producer group, 4=Farmer marketing group[ ]; 5=Saving and credit group[ ], 6=Welfare group[ ]; 7=Purely religious church group[ ]; 8=Others (specify)………*

SECTION K: MARKET ACCESSIBILITY

(k)1. Did you sell any of your products? 1=YES [ ] 2=NO [ ] ***(If the response is no skip to K7).***

(k)2. How much did you sell a (90kg) bag in 2019? ……………..

(k)3. What could have been your preferred price for a (90kg) bag of maize? …………………….

(k)4. Where did you sell? 1. On-farm [ ]; 2. Roadside [ ] 3. Local market [ ]; 4. Towns [ ] 5. Others (specify) ……………………..

(k)5. Whom did you sell to? 1. Local traders [ ]; 2. Long-distance traders [ ] 3. Other farmers [ ]; 4. Institutions [ ] 5. NCPB deports 6. Others (specify) ……………………………

(k)6. In collaboration with other farmers, do you ever market your maize produce as a group? 1=YES [ ] 2=NO [ ]

(k)7. What is the distance in km and time?

		Distance in km	*Means of travel	Market name
Input market	Nearest			
	Most convenient			
Market for harvests	Nearby marketplace			
	Convenient market			
NCPB deport				
Agricultural office				

(*1. Personal car [ ]; 2. Rented car [ ]; 3. Motorbike [ ]; 4. Walking [ ]; 5. Others (specify)…

(k)8. Do you own any of the following? Tick appropriately on the transport assets you own. *1. Bicycle [ ]; 2. Motorbike; [ ] 3. Personal car [ ]; 4. Commercial vehicle [ ] 5. Others*

(k)9. What is the condition of the road? 1. Tarmac road [ ]; 2. All whether [ ]; 3. Impassable roads [ ]; 4. Others (specify) …………………………..

(k) 10. Have you ever practiced silage production? 1=YES [ ] 2=NO [ ] ***(If the response is yes)*** for how long? …………………….

APPENDIX III: RELIABILITY TEST

Table 21: Case Processing Summary

		N	%
Cases	Valid	30	100.0
	Excluded [a]	0	.0
	Total	30	100.0

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

Table 22: Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.908	.908	16

APPENDIX IV: CONTROLLED EFFECT OF THE PROGRAM PARTICIPATION

Table 23: Effect of the subsidy program participation on maize productivity when different factors are controlled.

	1	2	3	4	5	6	7	8	9	10	11	12	13
PGP	2.195*	1.793*	1.766*	1.557*	1.576*	1.644*	1.470*	1.507*	1.505*	1.504*	1.490*	1.365*	1.465*
	(.184)	(.056)	(.069)	(.070)	(.075)	(.088)	(.073)	(.078)	(.078)	(.078)	(.078)	(.065)	(0.065)
FRT													.023*
													(.004).
ACG												-.185	0.25*
												(.284)	(.002)
HHS											.267*	-.531*	.020*
											(.037)	(.267)	(.002)
MA										.051	.267*	-.517	.020*
										(.069)	(.037)	(.267)	(.002)
SPA									-0.095	.007	0.276*	-0.332	0.019*
									(.064)	(.075)	(.037)	(.293)-	(.002)
AGE								.141*	-.162*	.001	0.064	.778*	.012*
								(.011)	(.052)	(.061)	(.035)	(.242)	(.002)
SCH							0.028	0.130*	-.180*	0.007	0.063	-.779*	.012*
							(.022)	(.014)	(.054)	(.061)	(.035)	(.241)	(.002)
GND						0.040	0.028	0.130*	-.182*	-.003*	0.065	0.786*	.012*
						(.051)	(.022)	(.014)	(.054)	(.061)	(.035)	(.241)	(.002)
OCP					-0.003	0.040	0.029	0.129*	-.183*	-0.003	0.065*	-.788*	.125*
					(.020)	(.051)	(.022)	(.014)	(.054)	(.061)	(.035)	(.241)	(.002)
GMP				-.191*	-0.004	0.043	0.034	0.127*	-.244*	0.048	0.077*	-.776*	.012*
				(.079)	(.019)	(.050)	(.022)	(.014)	(.059)	(.064)	(.035)	(.239)	(.002)
CRD			0.006*	-.198*	0.006	0.017	0.044	0.049*	0.063	0.082	-.026	0.164	.006*
			(6.03)	(.066)	(.016)	(.042)	(.018)	(.013)	(.056)	(.053)	(.030)	(.215)	(.002)
LOC		-0.023	0.069*	-.197*	0.007	0.017	0.044*	0.049*	0.066*	0.084	-0.025	0.169	.006*
		(.038)	(6.03)	(.066)	(.016)	(.042)	(.018)	(.013)	(.056)	(.053)	(.030)	(.215)	(.002)
IMR	0.049	-0.004	0.066*	-.064*	0.002	0.009	-.004*	0.023*	0.037*	-0.023	0.229	0.001*	0.321*
	(.042)	(.038)	(6.03)	(.066)	(.016)	(.042)	(.018)	(.013)	(.053)	(.007)	(.015)	(.002)	(.022)

Log-likelihood	-58.80	Pseudo R^2	94.14%
LR Chi^2 (14)	35.92	Prob>chi^2	0.000

The number of observations is 300, coefficients of treatment models standard errors in parenthesis. PGP, FET, ACG, HHS, MA, SPA, AGE, SCH, GND, OCP, GMP, CRD, LOC, IMR,-Program Participation, Fertilizer application per ha, Acreage of production, Household Size, Manure Application, Seed planted per acre, Education, Occupation, Gender, Group membership, Amount of credit, Location, Inverse Mills Ratio.