IMPACT OF INTERVENTIONS BY ONE ACRE FUND ON MAIZE YIELD AND FARM PROFITS IN BUSIA COUNTY, KENYA

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A RESEARCH PROJECT SUBMITTED TO THE DEPARTMENT OF ECONOMETRICS AND STATISTICS IN THE SCHOOL OF ECONOMICS IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF ECONOMICS (ECONOMETRICS) OF KENYATTA UNIVERSITY.

JUNE, 2018
DECLARATION

This research project is my original work and has not been presented for a degree award in any other university or for any other award.

Signature .......................................................... Date ..............................................

Silvanus Opiyo Okumu (Bachelor of Economics)

K102/27913/2014

I confirm that the work reported in this project was carried out by the candidate under my supervision.

Signature.................................................. Date ..............................................

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DEDICATION

To my parents Paul Opiyo and Gladys Opiyo and my siblings Dalmas, Camilita, Dickson, Pius, and Joyce Opiyo.
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<td>AATF</td>
<td>African Agricultural Technology Foundation</td>
</tr>
<tr>
<td>ANOVA</td>
<td>Analysis of Variance</td>
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<td>ASAL</td>
<td>Arid and semi-arid land</td>
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<td>ATE</td>
<td>Average Treatment Effect</td>
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<td>ATET</td>
<td>Average Treatment Effect on the Treated</td>
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<td>ATEU</td>
<td>Average Treatment Effect on the Untreated</td>
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<td>CAN</td>
<td>Calcium ammonium Nitrate</td>
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<td>CIA</td>
<td>Conditional Independence Assumption</td>
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<td>DAP</td>
<td>Diammonium Phosphate</td>
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<td>DID</td>
<td>Difference-In-Differences</td>
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<td>FAO</td>
<td>Food and Agricultural organization of the United Nations</td>
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<td>IFAD</td>
<td>International Fund for Agricultural Development</td>
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<td>GDP</td>
<td>Gross Domestic Product</td>
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<td>KARI</td>
<td>Kenya Agricultural Research Institute</td>
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<td>Millennium Development Goals</td>
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<td>MLE</td>
<td>Maximum Likelihood Estimation</td>
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<td>NAAIAP</td>
<td>National Accelerated Agricultural Inputs Access Program</td>
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<td>NCPB</td>
<td>National Cereals and Produce Board</td>
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<td>NGO</td>
<td>Non-Governmental Organization</td>
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<td>OAF</td>
<td>One Acre Fund</td>
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<td>OLS</td>
<td>Ordinary Least Square</td>
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<td>Acronym</td>
<td>Description</td>
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<tr>
<td>PALWECO</td>
<td>Program for Agriculture and Livelihoods in Western Communities</td>
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<td>Propensity Score Matching</td>
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<td>ROI</td>
<td>Return on Investment</td>
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<td>United States Agency for International Development</td>
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<td>USDA</td>
<td>United States Department of Agriculture</td>
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<td>WFP</td>
<td>World Food Program</td>
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OPERATIONAL DEFINITION OF TERMS

**Extremely poor:** people living on less than $1.25 a day.

**Food security:** implies attributes of food such as sufficiency, reliability, quality, safety, timeliness and other aspects of food necessary for health and thriving population.

**Gross Domestic Product:** it is the total monetary value of goods and services produced within a nation’s geographical boundary for a certain period usually one year.

**Improved inputs:** are measures of technological advancement in agriculture using certified seeds and chemical fertilizers as key proxies for such technologies.

**One Acre Fund:** it is a Non-governmental organization founded by Andrew Youn and launched in 2006 with the Headquarter in Bungoma (Kenya) that supports smallholder farmers with inputs, extension and marketing services in loan form.

**Poor:** people living on less than $2.00 a day

**Propensity score:** the probability that a unit in the combined sample of treated and untreated units receives the treatment, given a set of observed variables.

**Ultra-Poor:** refers to those people living on less than half the $1.25 a day extreme poverty line
ABSTRACT

Maize is a staple food and its adequacy is a measure of food security in Busia County and across Kenya. Despite myriad efforts to increase its yield, the national level has remained low at 1.6 tons/ha relative to world average of 5.5 tons/ha and Busia County experiences much lower yield of 1.2 tons/ha. This low yield in the county coupled by high population growth rate arising from a fertility rate of 6 percent in the county when national level is 4.6 percent and a large population of women within productive age puts the county’s food security at stake. The County’s proximity to Uganda also contributes to inflow of cheap maize from Uganda making the crop less viable for agribusiness within this County. In attempts to support maize farming, One Acre Fund, a non-governmental organization has intervened through provision of farm inputs such as fertilizer and seeds as well as extension services among others. Thus this study sought to investigate the impact of interventions by One Acre Fund on maize yield and profit from maize farming in Busia County in Kenya. The study used primary data collected from a sample of 264 maize farmers’ family heads using questionnaires with both closed and open ended questions. The county was first stratified into constituent sub-counties out of which two sub-counties of Nambale and Teso North were randomly selected. The study sample was then drawn randomly from these two sub-counties. Robust regression result showed that improved inputs (using certified seeds and organic fertilizers as proxies) had the effect of increasing maize yield. In addition regression adjustment results showed that maize yield increases with increase in level of education of farm family head. More so, profit was noted to rise as more inorganic fertilizer is used in planting as well as with increase in manure usage. Nevertheless the increase in the application of chemical fertilizer (inorganic fertilizer) was estimated to lower profits. Propensity score matching estimation results using three matching algorithms interchangeably which are: nearest neighbor, kernel matching and radius matching with a radius of 0.01 indicated that One Acre Fund farmers managed to achieve significantly higher yields than similar non-members. The effect of One Acre Fund on profit was positive but insignificant. The study recommends expansion of One Acre Fund membership and increased use of organic and inorganic fertilizer.
CHAPTER ONE
INTRODUCTION

1.1. Background

Maize is also known as corn and scientifically referred to as Zea Mays. It is traced to have originated from Mexico in Europe and taken to America in around 1494 before it spread to Africa through different routes in 16th Century (Miracle, 1966). Corn is believed to have been in Kenya by 1880s but its transition to a major crop in the country occurred during the World War 1, a period within which diseases struck out millet (the then stable food in Kenya) resulting to millet seed being eaten instead of being planted (Smale, De Groote & Owuor, 2006). Maize has since then become a key crop to Kenya’s economy and beyond especially in Sub-Saharan Africa (SSA) and other developing nations. In Kenya, it is a staple food for about 96 per cent of Kenyans with one of the world’s largest per capita consumption that has over time averaged around 125kg (Byerlee & Eicher, 1997; Gilbert et al., 1994; Kirimi et al., 2011). Other than being used as a staple food, it is also used as fodder, industrial raw materials for products like cooking oil, breakfast cereals and exported for bio-fuel production among other uses (National Cereals and Produce Board (NCPB), n.d).

1.1.1. Maize Yield and Hunger Prevalence a Global Outlook

Food and Agriculture Organization of the United Nations (FAO), International Fund for Agricultural Development (IFAD) and World Food Program (WFP) (2015) reports that the world’s population had ballooned by 1.9 billion in 2015 from early 1990s, a period within which those hungry globally reduced by 216 million (21.4 percent) to 795 million, 780 million of whom resided
in the developing regions. This also harbors a fall in those undernourished from 18.6 percent in 1990-92 to 10.9 percent in 2014-2016. As such by 2015, 72 developing countries had achieved the 2015 Millennium Development Goal 1 (MDG1) of halving the proportion of those in hunger. This reflected a fall in undernourishment level by 167 million in a span of ten years. Hunger prevalence had reduced rapidly in Central, Eastern and South Eastern Asia and in Latin America. North Africa had less than 5 percent of hungry people. Southern Asia tops the list of hunger prevalence with 281 million people undernourished. In SSA, about one in every four people (23.2 percent) is in hunger (FAO et al., 2015). According to FAO et al. (2015) and Fischer, Byerlee and Edmeades (2014), this hunger prevalence is majorly attributed to the large potential yield gap in wheat, maize and rice production across the globe but majorly in SSA. FAO et al. (2015) associates this yield gap with failure to adopt optimal input usage and inadequacy in embracing most productive technologies.

Sub-Saharan Africa has a rapid population growth which consumes maize heavily. In the contrary, this region has most of its nations experiencing maize yield below the world’s average of 5.5 ton/ha and much below the 10 ton/ha for the leading producer, United States (US). This is due to low adoption of improved inputs and lowly mechanized agriculture in SSA (USDA, 2015; 2016). Maize yield is noted to vary considerably across and within continents and even among regions of a country. Table A1 in the Appendix I shows maize yield for some selected regions and nations across the world.
1.1.2. **Trends in Maize Yield, Hunger Prevalence and Climatic Hazards in Kenya**

Kenya has an approximate area of 580, 367 km$^2$, of which 567, 137 km$^2$ is Land surface and the rest occupied by inland water bodies. Arid and semi-arid land (ASAL) accounts for 80 percent of the land mass with only 20 percent being arable out of which 12 percent is classed as high potential (adequate rain) and 8 percent as medium potential. Arable land supports about 80 percent of the entire population with nearly 80 percent of the work force being either in agriculture or food processing. Averagely, 3 million families are smallholder farmers accounting for 75 percent of total corn production (Ojwang, Agatsiva, & Situma, 2010; Kenya Agricultural Research Institute (KARI) & African Agricultural Technology Foundation (AATF), 2010; Kirimi et al., 2011). Maize crop takes 56 percent of Kenya’s cultivatable land with 98 percent of the small scale farmers planting it (Jayne, Myers & Nyoro, 2008).

Achieving high economic growth is one of the key macroeconomic goals of all economies. More so, all economies that have ever experienced rapid and sustained economic growth have done so by first curbing food insecurity menace (Juma, 2011). Availability and sufficiency of corn in Kenya is an indicator of food security (Schroeder et al., 2013; Republic of Kenya, 2013). Nevertheless Kenya has over years failed to be self-sufficient in corn production and thus remaining a net importer of the crop with the import rising gradually from 2.71 million 90kg bags in 2008 to 3.3 million bags in 2012, a period within which the export of corn dropped from 0.21 million bags in 2008 to 0.02 million bags in 2012 (Republic of Kenya, 2013). This importation can also be associated with the fact that corn is the most purchased food item by all households in Kenya. The country’s poorest farming households are also net food purchasers with food expenditure taking greatest shares of their budgets. The ultra-poor spend 65-80 percent of their
total expenditure on food (Ahmed et al., 2007; FAO, 2015). Averagely about 57 percent of Kenyans are poor with majority depending on rain fed agriculture (Ojwang’ et al., 2010).

Despite numerous interventions like provision of subsidized fertilizer, better maize prices, improved seeds as well as input support through National Accelerated Agricultural Inputs Access Program (NAAIAP) to boost agriculture (Republic of Kenya, 2012; 2013), food shortage catastrophe is rampant within the country as shown in Table A2 in the Appendix. The situation may worsen given the rapidly expanding population yet the average yield of corn is too low at 1.6 tons/ha nationally (Republic of Kenya, 2012; 2013), relative to the world’s average of 5.5ton/ha (United States Department of Agriculture (USDA), 2015; 2016). Low yield is attributed to harsh climate, low rate of improved inputs usage due to financial constraints, poor infrastructure among others (Onono, Wawire & Ombuki, 2013). Kenya has continued to be a hunger victim with at least 10 million of its residence being food insecure and nutritionally poor out of which 2-4 million are in need of emergency food at a particular time (Busia County Government, 2013). Other than agricultural prosperity and food security in the country being curtailed by resource constraints like inputs quality and availability which many interested parties have strived to address, natural calamities have aggravated the menace. Thus Kenya has experienced a volatile trend in maize production and yield as shown in Figure 1.1 and Table A3.
Figure 1.1: Maize Production in Tons, Acreage and Yield in Kenya 1975-2012

Source: Author’s computation and compilation from Kenya agricultural sector compendium (KASDC) 2010 and Economic Review of Agriculture various years

From Figure 1.1, it is evidenced that Kenya experiences a volatile pattern in its maize production. Regardless of other factors like increased access to inputs through NAAIAP, subsidized fertilizer among others being in play that resulted to increase in yield and output between 2011 and 2012, the maize trend is largely attributed to climatic patterns. Harsh weather conditions shown in the appended Table A2 have been largely to blame for poor maize output since Kenya’s agriculture is majorly rainfed. The troughs in production and yield for 1984, 1994-1995 as in Figure 1.1 can be associated with droughts while El Nino floods explain the trough of 1997-1999. These catastrophic episodes coincide and/or may account for four major food crises in Kenya from 1990: in January 1997, the government of Kenya declared a state of national disaster when severe droughts threatened the livelihood of around 2 million Kenyans. Later in December 2000, 4 million of Kenya’s population was in need of food aid after the country was hit by its worst drought in 37
years. Another food crisis stormed in 2004 that resulted from failure of long rains (March-June) and 2.3 million Kenyans needed food assistance. In December 2005 President Kibaki declared another national food catastrophe in regard to famine that struck 2.5 million people in Northern Kenya (Kandji, 2006; Huho & Kosonei, 2014).

Other than climatic hindrances, Onono et al. (2013) and Republic of Kenya (2007) among others point out high input cost as deterrent against maize productivity. The general output price for the crop has been unfavorable with several cases of price falling even as output falls, for example in 1978-1779, 1992-1993 and 1995-1996. More so output price elasticity is also less than unit. These are shown in Table A3. The implication of this is that the crop has not been successful in earning farmers good return or profits as an agribusiness commodity except for subsistence.

1.1.3. Maize Yield in Busia County and other Counties of Western Province in Kenya

Western province constitutes four counties; Bungoma, Busia, Kakamega and Vihiga. All the four counties cultivate maize which is milled into flour for making ‘ugali’ a staple food for most residents in the region. Maize trend in western province of Kenya has experienced similar volatile trend as the nationwide trend. Such a trend is displayed in Table A4 and Figure A1 in the appendix. The trend being majorly associated with the unfavorable climatic extremes depicted in Table A2. Nevertheless other factors are also responsible. For example an upward trend witnessed from 2009 all through to 2011 was due to increased use of fertilizer and farmers shifting from tobacco to maize farming (Republic of Kenya, 2012) while a slight fall in maize production between 2011 and 2012 was due to opening up of new sugar factory in Matete which reduced area under maize (Republic of Kenya, 2013).
Busia County, one of the constituent counties of Western region of Kenya is situated between latitude $0^\circ$ and $0^\circ 45$ North and longitude $34^\circ 25$ with an approximate area of $1,830$km$^2$ (1686km$^2$ land and 144km$^2$ water mass) (Republic of Kenya, 2015). It borders three counties; Bungoma to the North, Kakamega to the East and Siaya to the South. Figure A2 in the appendix shows Busia County map. The county has an undulating altitude rising from about $1130$M above sea level at the shores of Lake Victoria to a maximum of about $1,500$M in the Samia and North Teso Hills. Sandy-loam soil covers a large portion of the county although the Northern and Central parts are covered by dark clay soils. It receives annual rainfall between 760mm and 2000mm, 50 percent of which falls during long seasons with peak between March and late May while short rains accounting for 25 percent occur between August and October. December to February experiences dry spell with scattered rains. The annual maximum temperatures range between $26^\circ c$ and $30^\circ c$ with minimum ranging between $14^\circ c$ and $22^\circ$. These conditions make most of the county’s regions suitable for varieties of agricultural activities such as growing of maize, cassava, cotton, sugarcane etc (County Government of Busia, 2013; 2014a).

The national population census of 2009 placed the county population at 743,946 in 2009 and was projected to be around 953,337 in 2017. The county has a fertility rate of 6 percent which is above the national average of 4.6percent (County Government of Busia, 2013). This quickly escalating population exposes the County to further population related crisis like poverty and hunger when already 64.2 percent of its population is in poverty and 34 percent of its children below 5years are undernourished while the average national levels of poverty and undernourishment are estimated at 45.7 percent and 30 percent respectively. Out of the total population in Busia County, only 9.1 percent reside in the urban areas with the rest being in the rural. Proportion of the Labor force
engaged in family farms is estimated at 71 percent while the remaining 29 percent participate in other activities like fishing, trading and employed in formal and informal sectors. Given that arable land is not big enough to support majority of labor force, it implies that most of them are not gainfully employed and increased unemployment is a challenge too. Generally land ownership is on small scale with each holding on average 2.34 Ha, with minimum of 0.4 Ha and maximum of 6 Ha (County Government of Busia, 2013).

Due to the similarities in myriad agricultural aspects among the four counties, the yield is inclined to assume the same trend with minimal disparities. However, Busia County has experienced relatively lower yield for many periods (though marginally), a good example is from 1993-2006 and 2011-2012 as depicted in Figure 1.2.

![Figure 1.2: Trends in Maize Yield for Counties in Western Province of Kenya.](image)

Source: Author’s compilation from Kenya Agricultural Sector Data Compendium (KASDC) 2010 and Economic Review of Agriculture various years
The lower maize yield in Busia can perhaps be explained by relatively poor soils; many areas of the County especially in Teso North and Teso North Sub-counties are characterized by sandy soil which does not favor maize production and dark clay soils in the Central and Northern parts are relatively less suitable for maize farming compared to fertile soils of sister counties. In the contrary this sandy soil favors cassava production making the county a leading producer of cassava in Western region (former western province) (Republic of Kenya, 2012). In addition the county has had the least adoption of better farming techniques like fertilizer use (Ali-Olubandwa, Odero-Wanga, Kathuri, & Shivoga, 2010). The general variability in the yield for the four counties can be associated (though not wholly) to the destructive climatic variations depicted in Table A2.

Similar to unstable and unfavorable national prices for maize in Kenya as pointed out in Republic of Kenya (2012), farmers in Busia County who have attempted to commercialize the crop have faced stiff competition from cheap maize coming in across the border from Uganda and with trade liberalization the situation may aggravate. This has deprived maize farmers any attractive returns from the crop if they have to sell it to final consumers like it is the case for almost all farmers. This leaves corn farming in Busia justified only on subsistence grounds.

1.1.4. Busia County and One Acre Fund Interlinked

One Acre Fund is a Non-Governmental Organization (NGO) founded by Andrew Youn and launched in 2006 in Kenya and was headquartered in Bungoma (Kenya). Its main objective is to help smallholder farmers attain self-food sufficient and fight poverty. It does so by; creating producer groups through conversion of women self-groups into producer groups; providing quality farm inputs namely: seeds and fertilizer among others needed by farmers as shown in Figure A3;
giving extension services and training to farmers through OAF field staffs and sourcing better markets for farmers. However, its package is a loan where it takes a portion of the output in repayment of the services it offers (OAF, 2014). In addition, it is broadening its scope to provide input/drought and funeral insurance, cash loans, drying and storage bags, energy loans (solar lamps and improved jikos), Artificial Insemination in Kakamega district etc. Clients were earlier restricted to land size between 0.4 and 1.5 acres (OAF, 2015) but currently permitted to a maximum of 2 acres. It has also partnered with respective governments in areas it operates where the partnership includes: input (fertilizer and seeds) distribution, improve extension and training and market stimulation partnership aimed at fostering farmers understanding of input market and supply chain (OAF, 2014). Since its conception in Kenya OAF has extended to Tanzania, Rwanda, Burundi (OAF 2013a; 2014) and is carrying out pilot program in Uganda and Malawi (OAF, 2014). In Kenya, it exists in Bungoma where it started in 2007 with passion fruits, Busia from 2010, Vihiga and Kakamega counties of western province and in Nyanza province.

According to Nyoro (2002), agricultural productivity is affected by seed quality, fertilizer, credit and financial services, land preparation cost, price stability, technological development and extension services. The county government in collaboration with other partners like United States Agency for International Development (USAID), Program for Agriculture and Livelihoods in Western Communities (PALWECO) have tirelessly strived to support agriculture through measures like input provision, acquiring machines for mechanized agriculture, promotion of poultry, dairy and fish farming. PALWECO which is one of the organization with enormous coverage of all sub counties of the entire Busia County had its inception in 2010 and implemented in 2012. This organization receives its funding from joint effort of the governments of Kenya and
that of Finland with the prime objective of poverty reduction and improving livelihoods and standards of living of the people of Busia. The primary beneficiaries of PALWECO (estimated at 480,000 in 2012) are poor families. The activities of PALWECO are skewed towards agricultural and livestock support, water and rural infrastructure namely market places and roads (PALWECO, 2012). It is thus apparent that OAF operates besides other organizations in the region.

Despite several interventions, Busia County Government admits that challenges of monitoring, evaluation system and inadequate infrastructure in addition to high farm input cost, adverse marketing infrastructure, deteriorating soil fertility, poor linkage between farmers and research and extension services and climatic dynamics still persist (County Government of Busia, 2014b; 2015). Thus One Acre Fund is well placed to address most of these challenges especially through its close conduct with farmers via its widespread field staffs.

In its view, OAF has made a great milestone in shaping the lives of its clients and achieving its goals. Statistics show that the OAF is self-sustainable, its clients have recommendable returns on investment (ROI) exceeding non-members by far and the number of farm families supported is rising rapidly (OAF, 2013a; 2014). One Acre Fund and entire agricultural community believe that being mindful of environmental impacts and mitigation of climatic change risk via sustainable intensification can see acreage yield of food in rural Kenya matching that of the United States (US) (OAF, 2013b). Motivated by the dire need of food, poverty and low maize yield in Busia County, there was need to understand the dynamics behind maize yield and profit.
1.2. Problem Statement

Maize is a staple food for most Kenyans especially in the rural areas with Western part of the country being a heavy consumer of this cereal. Its availability is a measure of food security. However, Kenya is a net importer of the cereal. Despite efforts at all levels by government and other stakeholders to support maize production, the country has not been self-sufficient in corn production (Republic of Kenya, 2012). The country’s average yield of 1.6 ton/ha is far below the world average of 5.5 ton/ha (USDA, 2015; 2016) while Busia County yield is even much less at around 1.2 ton/ha (Republic of Kenya, 2012; 2013). This low yield at national level has been attributed to poor infrastructure, low quality inputs like seeds and fertilizer, climatic shocks among others (Onono et al., 2013). Busia County Government (2014b; 2015) also point out such similar hurdles at County level in addition to monitoring problems.

Given high population growth rate in the county coupled by both low maize yield and price put the county’s food security and income from maize farming at stake. In this regard and with its optimism of improving yield among small-scale farmers, One Acre Fund supports rural economy through interventions in several agricultural activities including maize farming. The organization specifically avails inputs, agricultural training and helps in market sourcing for farm produce. Despite the perceived importance of maize and efforts by OAF to support the crop, no evidence exists explaining the contribution of OAF intervention on maize yield in Busia. To close this gap, the study sought to investigate the impact of the OAF interventions on maize yield and profits from maize farming in Busia County.
1.3. Research Questions

This study sought to respond to the following research questions:

i. How does the use of improved inputs affect maize yield among all farmers in Busia County?

ii. How does the usage of improved inputs affect profit from maize farming among all farmers in Busia County, Kenya?

iii. How does maize yield vary between One Acre Fund members and non-members in Busia County?

iv. How do profits from maize farming vary between One Acre Fund members and non-members in Busia County?

1.4. Study Objectives

The general objective of this study was to establish the impacts of interventions by OAF on maize yield and profit among maize farmers in Busia County. Specific objectives were:

i. To establish effect of improved inputs on maize yield in Busia County among all farmers.

ii. To evaluate the effect of improved inputs on profit gain by all maize farmers in Busia County.

iii. To examine the variation of maize yield between One Acre Fund members and non-members in Busia County.

iv. To establish the variation of profits from maize farming between One Acre Fund members and non-members in Busia County.
1.5. **Significance of the study**

The understanding of how the use of various agricultural inputs affects maize yield and profits from such practices is important in designing policies that help farmers achieve optimal results. The study results inform farmers in deciding whether joining OAF is a right decision. In addition, this study forms a scholarly bedrock upon which future studies attempting to evaluate effectiveness of OAF in supporting maize farmers achieve higher yields and profits will be build. The study further extends on existing literature where in some cases evokes empirical debates with some findings contradicting those of the antecedent researchers.

1.6. **Scope of the study**

This study investigated the response of maize yield and profits to the use of improved inputs and OAF membership for farmers within Busia County. Two sub-counties of Nambale and Teso North were selected. This County formed the study area given that it is among the operational areas of OAF and also a heavy consumer of the cereal yet it experiences relatively lower maize yield compared to other counties in the Western Kenya region. The study covered the March to August maize season of 2016.

1.7. **Organization of the study.**

Chapter one presents the background to the study, chapter two reviews both theoretical and empirical literature while chapter three presents research methodology. Presentation and discussion of empirical results is offered in chapter four. Chapter five summarizes the paper, concludes it and gives policy recommendations.
CHAPTER TWO
LITERATURE REVIEW

2.1. Introduction

The chapter presents theoretical literature, empirical literature and an overview of literature.

2.2. Theoretical Literature

This section presents theories that guided the study.

2.2.1. The Diffusion Model

The formulation of this model started in 1940s by Bryce Ryan a rural sociologist based at Iowa State University who studied how Iowa farmers learned about hybrid corn varieties in 1930s and adopted them. There was a core group of farmers who were innovative and experimented with this new technology which was then emulated by their neighbors after seeing how such varieties were blossoming. The social and psychological processes which involved adopting new technology was studied by other scientist who developed a theory of technological adoption. The model was then formalized by Everett Rogers in his classic book in 1962 (Rogers, 1962).

According to this model, different farmers and/or regions exhibit substantive disparities in land and labor productivity. Thus in view of this model, agricultural development arises from the effective diffusion of technical knowhow and narrowing differences in productivity among these farmers and regions. Dissemination of better husbandry techniques formed a major source of growth in productivity even in pre-modern societies. Evidence of this theory at work can for example be seen even in developed nations through efforts tailored at testing and refining farmers’
innovation, testing and adapting exotic species of crops and animals (Ruttan 1977, Ruttan & Hayami, 1971; 1972). According to Ruttan (1977), using this model as a basis of making agricultural development designs failed to deliver expected outcomes; it could neither generate rapid modernization of traditional farms nor inspire rapid growth in agricultural output. To the far extreme it is also questionable if diffusion of technology alone is a sufficient path to guide agricultural productivity, perhaps just a necessary one. More so such technologies are not private goods tradable in the market and even if they were, most poor peasant farmers would not easily afford it and perhaps could not be aware of it or both. As much as this study was not guided by this theory, evaluating OAF contribution was as good as testing validity of this model since OAF diffuses similar technology to its operational areas.

2.2.2. The High-Payoff Input Model

This theory was formulated by Schultz in 1960s. The model regarded the peasants especially in traditional agricultural set ups as rational and efficient resource allocators who only languished in poverty because their hands were tied up in terms of technical and economic opportunities to which they could respond (Schultz, 1964; Ruttan, 1977; Ruttan & Hayami, 1971; 1972).

One of the tenets of the model is that agricultural development can be accelerated through generation of new inputs and techniques via public investment in scientific research and education. According to Ruttan (1977), this model can be decomposed into three major constituent components namely the capacity of institutions of research both by public and private sectors to generate new technical knowledge, the ability of industrial sector to develop and produce new technical inputs and bring them to the market and the ability of farmers to acquire new knowledge
and effectively utilize new inputs. Acceptance of this model garnered support when studies reported amazing rates of return to public investment in agricultural research. In addition, development of new varieties of grain that were highly productive and suitable for the tropics heightened its acceptance. Good examples are the development of high yielding varieties of wheat in Mexico in early 1950s and those of rice in Philippines that took place in the 1960s. These varieties responded impressively to industrial inputs like fertilizer among other chemicals and to more effective soil and water management. Indeed this is what was hailed as “green revolution”. This model is impressively good but not independently adequate in explaining agricultural development as demonstrated by the induced innovation mode that follows. This theory was relevant the proposed study since OAF has introduced new technologies in Busia County.

### 2.2.3. Induced Innovation Model.

Ruttan & Hayami (1971; 1972) hailed The High-Payoff Input Model for its recognition of the role played by education and research in agriculture. They however, argued that the Shultz model is incomplete in guiding agricultural development on the grounds that both research and education are public goods not traded in market place. More so, the High-Payoff Input Model fails to incorporate a mechanism by which allocation of resource among education, research and other alternative activities is made in addition to its failure to illustrate how development and adaption of efficient technology are induced by economic conditions. Moreover, it gives no account of how the relationship between factor and output prices helps shape the path taken by investment in research. This paved way for the formulation of Induced Innovation Model. Like The High-Payoff Input Model, this model endorses the need for education and research in revitalizing agricultural prosperity. This will generate two key taxonomic strands of technology namely mechanical (which
substitutes labor with machines) and biological or biological and chemical technology which facilitates substitution of land with industrial inputs like fertilizers, insecticides and high quality varieties of crops. The two technologies are in John Hicks’ terminology referred to as labor-saving and land-saving respectively (Ruttan, 1977).

The dichotomy between this model and the High-Payoff Input Model is that the induced innovation model recognizes the fact that different regions followed different agricultural evolution paths and thus need area specific technology. Labor-saving and land saving technologies should also be substituted for each other basing on their relative expensiveness. In addition, the Induced Innovation model postulates that farmers’ are profit maximizing agents and should be modeled in the context of the “Theory of the Firm” which is presented hereafter. The analogy behind this is that the technological innovation and inventions should not only increase yield but also be cost effective to earn higher profits to the farmers and thus agricultural researchers and educational centers should be conscious of this (Ruttan 1977, Ruttan & Hayami, 1971; 1972). Based on this theory, this study assessed if technologies introduced by OAF in Busia County increase yield and profitability among maize farmers.

2.2.4. Theory of the Firm

A firm is an entity which acquires input(s) and converts them to output. Although a firm has several other objectives like maximization of sales and market shares, it has become a universal norm for economist to model a firm as a profit maximizing agent. Profit maximizing factor input demand can be computed by either treating a firm as a cost minimizing entity or an output maximizing one. Fortunately, as demonstrated based on duality concept by Varian (1992), Jehle and Reny (2011)
among others, either of the two approaches yields same value for input demands. They exemplify that a production function can be recovered from a cost function using the shepherd lemma and the reverse is also true.

According to Jehle and Reny (2011) a firm can be thought of as having production possibility set, with a production plan being a vector given as $y = (y_1, ..., y_m) \in Y$ whose elements reflect the quantity of various inputs and outputs. In most empirical cases however we consider production situation with only one output from a vector of inputs, thus describing technology using a production function is the best way. A production function can be expressed as $y = f(X)$ where $y$ is output and $X$ is a vector of inputs such that; $X = (x_1, ..., x_m)$. We require non-negativity constrained on both input vectors and output such that $X \geq 0$ and $y \geq 0$ implying that given the input vector $X$, no more output is visible than $y$.

A production function is evident to have three main features namely: continuous, strictly increasing and strict quasiconcave. Continuity sees to it that if input vector changes by a small amount, then output should also change by a small amount. The second property ensures that if inputs are increased then output must also increase so that marginal product of any input $i$ given by: $\frac{\partial f(X)}{\partial x_i} > 0$. Strict quasiconcavity implies that inputs must have at least some level of complementarity. Strict quasiconcavity can as well be interpreted to mean that the average of two extreme input vectors should produce more than at least one of the two extreme input vectors or both (Jehle & Reny, 2011).

Production functions take at least four forms namely; Max Leontief form, linear form, constant elasticity of substitution (CES) and Cobb-Douglas production. The first three are too restrictive;
the Max Leontief with L-shaped isoquants has complimentary inputs with zero elasticity of substitution; the linear one has inputs that are perfect substitutes with infinite elasticity of substitution; for CES, inputs have constant degree of substitutability at all input and output levels (Jehle & Reny, 2011; Varian, 1992). This study dropped these three production forms and adopt the Cobb-Douglas form. The Cobb-Douglas form is preferred because it fulfills all the assumptions of a well behaved production function and it also allows a wide range of elasticity of substitution (\(\sigma\)) so that \(0 < \sigma < \infty\) (Jehle & Reny, 2011).

The general Cobb-Douglas function can be expressed as

\[
A\Pi_i^n x_i^\alpha_i e \quad \text{where } i = 1, \ldots, n \text{ generalizing to }
\]

\[
f(X) = Ax_1^{\alpha_1} x_2^{\alpha_2} \ldots x_n^{\alpha_n} \quad (2.1)
\]

Where \(A\) is an efficiency parameter and \(\alpha_i, \ldots, \alpha_n\) captures respective input elasticities (Jehle & Reny, 2011). The theoretical model to address the first objective for this study was developed from equation (2.1).

Now consider modeling the firm’s profit. With the assumption of a bivariate input production function and following the work of Nicholson, Snyder, Luke and Wood (2009), it is justified to say;

\[
Total costs (TC) = wL + rK \quad (2.2)
\]

and

\[
Total Revenue (TR) = py \quad (2.3)
\]
so that the profit function $\pi$, becomes;

$$\pi = py - wL - rK = pf(K, L) - wL - rK$$  \hspace{1cm} (2.4)

Where $w$ and $r$ are prices for Labor and capital respectively and $p$ is output price. Intuitively profit is purely a function of input quantities (Nicholson et al., 2009) so that;

$$\pi = f (K, L)$$  \hspace{1cm} (2.5)

From equation (2.5), a general production function with an $X$-input vector gives a profit function expressed as:

$$\pi = f (X)$$  \hspace{1cm} (2.6)

Equation (2.4) formed the basis on which theoretical model for second objective was build.

### 2.3. Empirical Literature

This section presents a review of some relevant literature related to maize production and or yield.

De Groote et al. (2005) relied on nationwide unpublished data for 1992 and 2002 from a survey conducted by International Maize and Wheat Improvement Centre to examine how use of improved inputs including fertilizer among other variables affect maize yield in Kenya. Variables of interest were personal characteristics of farmers and those of their farms, their usage of improved inputs (seeds and fertilizer) and their access to credit and extension services among other agricultural services. Logistic regression results showed that fertilizer use relates positively and significantly with extension services but this relationship is negative for the case of cattle
ownership and farm size. On the other hand, Ordinary Least Square (OLS) results revealed that high fertilizer usage led to high yields. Nevertheless, the results were mixed for improved seeds; in some regions it was positive and negative in others; implying that seed variety is soil-type sensitive. Expansion of extension services and development and use of area-specific seeds was recommended to increase yield. However, their work neglected profit arising from the improved inputs.

In the inquiry into the merits of using improved inputs on maize productivity in Uganda, Okoboi (2010) interrogated the 2005/2006 Uganda Nationwide data collected at household and community level by Uganda Bureau of Statistics (UBoS) and obtained from Uganda National Household Survey (UNHS). A total of 1888 farms were considered and both yield and gross profit functions modeled as stochastic frontier functions were estimated using the Maximum likelihood Estimation (MLE) technique. The study findings revealed that although the use of improved inputs such as seeds and fertilizer boosted yields significantly, marginal cost of such inputs was much higher relative to the additional revenue derived from the increased output arising from the use of these improved inputs. In addition, farmers who used improved but home-saved seeds without fertilizer registered lower yields but rather higher gross profits. Even though econometric results revealed inverse relationship between land size and yield, extension services were noted to significantly boost yield. This study was in Uganda but there was need to conduct country and region specific study. Furthermore, OAF is an emerging issue that was not considered in this study.

Ali-Olubandwa et al. (2010) carried out a study aimed at establishing how adoption of improved maize production practices relates to maize yield among smallholder farmers in Western province of Kenya during an agricultural reform era. Four districts of Lugari, Bungoma, Busia and Mt.
Elgon were selected purposively and a sample of 200 smallholder farmers drawn from these districts using systematic sampling criteria. Data was obtained with the help of open and closed ended questionnaires. Descriptive, correlation, multiple and stepwise linear regression analysis established that maize yield responds positively and significantly to adoption of improved inputs. Lugari district portrayed the highest yield probably because; most farmers had attained secondary education and above, had adopted the technology as a package and not partially and most farmers relied purely on farming for a living. Again profit was not given consideration in their study.

Kipng’eno (2012) investigated how the NAAIAP influences maize production among farmers in Nyamarambe Division in Kisii County of Kenya. The researcher examined the extent to which farmers’ group training affects maize production, how farm follow up visits, access to free agricultural inputs and holding of farmer field days shapes maize production. Questionnaires were administered to a sample of 120 beneficiaries of NAAIAP selected randomly. The responses were subjected to descriptive analysis. Results indicated that maize production is positively influenced by access to free inputs, farm field days, group training and farm follow up visits. However, pure descriptive analysis is inferior to justify if the influence was statistically significant or not and neither is it justified as to whether this correlation was due to causality or a mere coincidence.

Schroeder et al. (2013) explored the reason behind low rates of adoption of hybrid maize varieties among smallholder farmers in marginalized areas of Kenya. Data collected from 200 households in the Kilifi and Kwale Districts of the former Coast Province of Kenya was subjected to logistic regression to analyze explanatory variables that affect adoption of improved maize varieties. The regression output revealed that contact and proximity to extension center, listening to agricultural radio programs, credit availability and participation of farmers in training positively and
significantly favored adoption of improved maize varieties. However, insignificant effect was noted in household size and literacy level. Adoption of the improved inputs was also recommended for it was argued to increase yield. The study was aimed at examining adoption of inputs with little attention on their effects on the yield and profitability.

Onono et al. (2013) investigated how maize production in Kenya responds to both price and non-price incentives using 1972-2008 published secondary data obtained from various sources. The least square regression results revealed positive response of maize output to own price, agricultural development expenditure, sale of maize to marketing board, inflation, per capita growth in Gross Domestic Product (GDP), liberalization, favorable weather, governance reform of 2003-2008 and the access to cheap fertilizer. However, negative response was noted on the failed coup d’état attempt of 1982. Elasticity estimates revealed elastic response of maize to inflation and real per capita GDP but inelastic to the rest of the variables. Inelastic response to fertilizer price was argued to be due to low uptake of fertilizer while from output price is due to lagged effect. They recommended that both price and non-price factors be addressed to catalyze maize production. Unlike least square estimation used in their study, this study in addition to robust linear regression used PSM and also integrates OAF in its analysis. More so they were interested in maize output while this study addressed yield in addition to profit.

Mucheru-Muna et al. (2014) investigated how the application of organic and inorganic fertilizer enhanced maize productivity and profitability among small scale farmers in Central Kenya. With the help of analysis of variance (ANOVA) approach, the results showed that those farmers who used organic manure and inorganic fertilizer improved their yields much more than those who used either organic or inorganic separately. However, those who applied organic manure alone had
better yields and returns than those that relied purely on chemical fertilizer; indicating superiority of organic manure over chemical one. Results also showed serious cases of soil degradation among users of chemical fertilizers, thus endorsing use of manure if soil management and conservation is of interest. The current study evaluated effect of OAF which is an emerging issue in Western Kenya.

Ogada and Nyangena (2014) used improved maize varieties and inorganic fertilizers as proxies of advanced technology to examine how such inputs affect maize yield in Kenya. The study relied on Kenya’s panel data for 2004 and 2007 adapted from Tegemeo Institute pertaining 1342 agricultural households. The data was nationwide excluding Nairobi and North Eastern province where farming is hardly done. Propensity score matching (PSM) and Difference-in-differences (DID) results showed that embracing improved technologies increases yield. Moreover it was noted that adopters of a complete package namely; planting fertilizer, improved maize varieties and top dressing fertilizer outdo their partial-adopter counterparts who also get more yields than total non-adopters. They inferred that package adoption is highly effective among medium yielding groups but any form of adoption may not be appealing to high yielding groups for they are already at the upper brink of productivity. On the other extreme, low yielding groups can use partial adoption just as an interim and start point move but not as a sustained approach. The study failed to incorporate profitability of such inputs.

Adebayo and Olagunju (2015) sought to establish the extent to which the use of innovation in agriculture impacts on the productivity outcomes and improved livelihoods among smallholder farmers in Rural Nigeria. They relied on Primary data obtained with the aid of structured questionnaires backed by personal interview collected from a sample of 360 households (120 yam
farmers, 120 maize farmers and 360 cassava farmers) selected using multistage sampling technique among residents of entire Oyo state in South West region of Nigeria. The study relied on PSM model and first differencing. The findings of this study indicated that agricultural research interventions driven by agricultural innovation significantly impacted on both rural incomes and outputs and still have the potential of doing so. The study recommended for intensified capacity building of the local extension agents and heightened budgetary allocation so as to enhance agriculture research program that will spur improved productivity and better livelihoods. Nevertheless, the findings of their study could not be generalized to everywhere. In addition since OAF has expanded rapidly in Western Kenya, there was need to examine its contribution.

2.3. Overview of Literature

The diffusion theory recommends for transmission of technology from one area to another in enhancing agricultural productivity but fails to account for how such technology should be generated and diffused. The High-Payoff Input and Induced Innovation model of agricultural development are well designed in guiding agricultural path due to their inclusion of the need for research and education in addition to access to high technology (improved seeds and fertilizers among other inputs) and extension services as complimentary paths towards agricultural blossoming. They thus formed a good basis for this research since they guided on variables to consider. Theory of the firm was then used to guide in the specification of how these variables relate.

Many reviewed studies did a recommendable work in making enquiry into how interventions such as enhancing adoption of high quality seeds and fertilizer, access to extension services and training
among others affect maize yield among smallholder maize farmers. They provided an insightful guide on key variables included and methodological approach to adopted in the current study; for example, like Ogada and Nyangema (2014), this study specified a treatment effect model to measure the effect of the One-Acre-Fund program on the yield and profit of the participants of the program. The model was estimated using the PSM approach. In addition the use of inorganic fertilizer and improved maize varieties was introduced as part of interventions and as proxies for advanced technology. Most of the reviewed studies however limited their scope on productivity with no concern on profitability associated with adoption of this technology. More so OAF had hardly been considered by most of them (if not all). This study thus sought to close these gaps.
CHAPTER THREE
METHODOLOGY

3.1 Introduction

This chapter focuses on the methodology used in the study. It covers research design, theoretical framework, model specification, definition and measurements of variables, study area, population studied, sampling frame, research instruments and pilot study used and procedure used to collect data. In its later part, the chapter also presents how data was processed and analyzed including the diagnostic tests conducted.

3.2 Research Design

In order to achieve the objectives specified in Chapter one, this study relied on non-experimental quantitative research design using cross-sectional primary data. The beauty of non-experimental research is the inability of the researcher to control, manipulate or make alter the exogenous variables or subjects. This design also has high rates of external validity which paves way for expanded generalization to large population Data was collected using well-structured questionnaires from sampled maize farmers both under OAF program and those not in the program.

3.3 Theoretical Framework

This study relied on both the high-input matrix and induced innovation theories together with the theory of firm to formulate the production and profit models. The former motivated the inclusion of, among others, improved inputs and training of economic agents, in this case farmers. The study
also drew heavily from the theory of the firm especially in specification of the profit functions, which is the profit maximization. Evaluation of OAF effect on both maize yield and profit was modelled under treatment effect framework.

3.3.1 The Production Model

The study adopted a Cobb-Douglas technology form of production since the other models are restrictive. With two inputs the production function specified in equation (2.1) can generally be written as:

\[ Y = AK^\alpha L^\beta \]  

(3.1)

Where \( Y \)- output, \( K \)-capital, \( L \) labor, \( A \) is technology while \( \alpha \) and \( \beta \) are respective elasticities or factor shares. According to Ghura and Hadjimichael (1996), technology evolves in the form:

\[ A = A_0 e^{gt + Z\theta} \]  

(3.2)

Where \( Z \) is a vector of variables affecting growth of technology with \( \theta \) capturing a vector of respective coefficients, \( t \) is time, \( g \) is the level of technological progress (Horndal Effect).

Plugging equation (3.2) into (3.1) and taking logarithms gives;

\[ logY = logA_0 + gt + Z\theta + \alpha logK + \beta logL \]  

(3.3)

Where \( Y \) is maize yield, \( K \) and \( L \) are capital and labor respectively while \( Z \) is a vector of other maize production inputs (determinants of yield) with \( \theta \) as respective coefficients and \( gt \) is level of technology.
3.3.2 The Profit Function

Based on profit maximization theory, and assuming a linear relationship between inputs and profits with producers (maize farmers) indexed by \( i = 1, \ldots, n \), profit \((\pi)\) was compactly expressed as;

\[
\pi_i = Z_i \beta
\]  
(3.4)

Which can be expanded into,

\[
\pi = \beta_0 + \beta_1 Z_1 + \cdots + \beta_K Z_K
\]  
(3.5)

Where \( Z \) is a \( 1 \times K \) vector of maize production inputs quantities, \( \beta \) is a \( K \times 1 \) vector of parameters.

3.3.3 The Treatment Effect Model

In the formulation of economic model, the main assumption is that economic agents are rational. In this study, therefore, it was assumed that farmers are rational and seeks to maximize profit or wants to improve production yield through various means. Through the introduction of the One-Acre-Fund (OAF) project, a farmer was expected to have fulfilled this objective.

In this study, farmers who joined or participated in the OAF program were assumed to have improved their profit or have higher yield compared to the situation if they could not have participated in this program. In other words, had these farmers not participated in OAF, then the outcomes for their profits would have been lower than when they participated in the program. This
theory is based on the independent treatment effect approach. Consider a general hypothetical illustration in Figure 3.1.

![Figure 3.1: Effect of Participation in Program](image)


In reference to Figure 3.1, the program is initiated at time \( t - 1 \). In the absence of the program, growth in outcome of interest between participants and non-participants is assumed to have followed the same rate of responses represented by lines \( A'B' \) and \( AB \) respectively. However, once the program is in place, participants’ growth path in output of interest tilts as shown by line \( A'C \). At the time \( t \) when evaluation is done, it is expected that in absence of the program the difference between these two groups could have been \( B'B \), nevertheless, with the program, the

\[\text{-----------------}\]

\(^1\)In this discussion the terms impact and effect will be used synonymously. OAF members are the participants.
difference becomes \( CB \) implying that \( CB^i = (\bar{\alpha}) \) estimates the impact of the program or otherwise known as the average treatment on the treated (ATET).

The treatment impact for an individual farmer \( i \), who participated in the OAF program defined as the difference between the potential outcome with and without treatment was denoted as \( \delta_i \) and mathematically expressed as:

\[
\delta_i = Y_{1i} - Y_{0i}
\]

Where \( Y_{1i} \) is the yield (profit) for the \( i^{th} \) farmer who is an OAF member while \( Y_{0i} \) is the yield (profit) that particular farmer would have had if he/she had not joined OAF. \( Y_{0i} \) is referred to as the counterfactual yield (profit). According to Cameroon and Trivedi (2005) and Heinrich, Maffioli and Vazquez (2010), similar intuition implies that the mean impact of the program obtained by averaging impact across the entire population (i.e. average treatment effect (ATE)) can be expressed as:

\[
ATE = E(\delta) = E(Y_1 - Y_0)
\]

On the other hand, program’s impact on the participant, a key interest to this study, is called average treatment effect on the treated (ATET) and can be expressed as:

\[
ATET = E(Y_1 - Y_0 | D = 1)
\]

In addition, measuring the impact which the program could have had on non-participants had they participated is at times desirable. This effect is called the average treatment effect on the untreated (ATEU). Let \( D = 1 \) for participants and \( 0 \) for non – participants, then:

\[
ATEU = E(Y_1 - Y_0 | D = 0)
\]

Here, the ATE, ATET and ATEU are not directly observable since they rely on counterfactual outcomes. Counterfactual outcome is the participants’ (non-participants’) outcome of the variable
of interest in the absence (presence) of the program. Given that the expected value of the
differences is the difference of the expected values, equation (3.8) can be expressed as:

\[ ATET = E(Y_1 | D = 1) - E(Y_0 | D = 1) \] (3.10)

The terms \( E(Y_1 | D = 1) \) and \( E(Y_0 | D = 0) \) are observed but not \( E(Y_0 | D = 1) \). Now, consider
equation (3.11) that follows where both terms are observed.

\[ \Delta = E(Y_1 | D = 1) - E(Y_0 | D = 0) \] (3.11)

Modifying equation (3.11) by subtracting and adding the term \( E(Y_0 | D = 1) \) gives:

\[ \Delta = E(Y_1 | D = 1) - E(Y_0 | D = 1) + E(Y_0 | D = 1) - E(Y_0 | D = 0) \] (3.12)

\[ \Delta = ATET + E(Y_0 | D = 1) - E(Y_0 | D = 0) \] (3.13)

\[ \Delta = ATET + SB \] (3.14)

The term SB is the selection bias which measured the difference between the counterfactual for
the treated group and the observed outcome for the control group (those who were not members
of the OAF). If SB=0 then the difference between the means of those outcomes for the treated and
untreated should efficiently estimate ATET. In experimental research designs, sample selection is
purely random hence eliminating the sample selection bias so that SB=0. A noteworthy fact is that
in purely random cases, it is justified to say;

\[ E(Y_0 | D = 1) = E(Y_0 | D = 0) \] (3.15)
If equation (3.15) holds, then its observable right hand term becomes a good substitute for the unobserved left hand term as a counterfactual for the treated group.

To address the issues in the preceding discussion in a more technical way, let $Y_1$ and $Y_0$ denote observed outcomes for treated and control groups, respectively. The participation $D$ is binary in nature with $D = 1$ if treated and $D = 0$ for non-participant. The observed outcome can then be generalized as

$$ Y = (1 - D)Y_0 + DY_1 $$

(3.16)

Consider a treated unit, $D = 1$, so then from equation (3.16) the observed outcome $Y$ becomes;

$$ Y = 0 \cdot Y_0 + 1 \cdot Y_1 = Y_1 $$

(3.17)

Similar analogy holds if a control unit is considered so that with $D = 0$, equation (3.16) becomes;

$$ Y = Y_0 + 0 \cdot Y_1 = Y_0 $$

(3.18)

Based on equation (3.15) above, $Y_0 | D = 0$ maybe used as counterfactual for the treatment group, that is $Y_0 | D = 1$. With the assumption that participation into OAF was as good as random, then the treatment effect on one participant farmer, $i$ would have been the difference between equations (3.17) and (3.18). This can be expressed as:

$$ \delta_i = Y_{1i} - Y_{0i} $$

(3.19)

Which replicates equation (3.6) above. Based on equation (3.19), the average treatment effect on the farmer who participated in the OAF is given as:
The estimated treatment effect model was developed from the preceding discussion and it replicated equation (3.20).

3.4 Specification of Estimated Models.

3.4.1 Estimated Production and Profit Functions

To estimate the effect of improved input on maize yield, land and labor entered directly into equation (3.1) while capital (using seed type as a proxy) and other independent variables were introduced through a technological component \( Z \). So that the corresponding econometric model for equation (3.3) can be written as:

\[
\log Y = \log A_0 + gt + Z\theta + \alpha_s \log LS + \alpha_l \log L + u_i
\]  

(3.21)

Since this study is cross-sectional, a static model was assumed so that \( \log A_0 + gt = \psi \) and by substituting \( Z \) with variables specific to this study, equation (3.21) translated into

\[
\log Y_i = \psi + \theta_1 S_i + \theta_2 D_i + \theta_3 D_i^2 + \theta_4 C_i + \theta_5 M_i + \theta_6 T_i + + \alpha_s \log LS_i + \alpha_l \log L + \mu_i
\]  

\( i = 1, 2, ..., 264 \)  

(3.22)

Where; \( Y \) is the yield, \( S \) captures seed type, \( LS \) – land size, \( T \) – training, \( D \) – fertilizer for planting (all farmers who had used inorganic fertilizer during planting had used diammonium phosphate (DAP)) and \( D^2 \) is its square, \( C \) – top dressing fertilizer which was mainly calcium ammonium nitrate (CAN), \( M \) – manure, \( L \)-labor and \( \mu \) is an error term while the parameters \( \theta_1 to \theta_6 \) were respective coefficients, \( \alpha_s \) and \( \alpha_l \) measured respective elasticities 264 was the
sample size. Estimation of equation (3.22) helped to achieve the first objective. This model did not restrict any parameter within any bound.

Consider now achievement of the second objective. Equation (3.5) formed the basis for the profit function for this study, substituting in it variables for this study gives:

\[ \pi_i = \beta_0 + \beta_1 S_i + \beta_2 D_i + \beta_3 D_i^2 + \beta_4 C_i + \beta_5 M_i + \beta_6 T_i + \beta_7 L S_i + \beta_8 L + \epsilon_i \quad (3.23) \]

\( \beta_1 \) to \( \beta_8 \) Captured respective marginal effects and \( \epsilon_i \) is a white noise process, the rest of the variables are as defined in equation (3.22). Estimating equation (3.23) achieved the second objective.

### 3.4.2 Estimated Treatment Effect model using Propensity Score Matching

In the estimation of the treatment effect, individual specific characteristics of prospect program participants are observed prior to program implementation. At the end of the program, the impact of the program is then evaluated by comparing the outcome in the variable of interest between participants and non-participants. In this study, a three step PSM was used to estimate ATET.

According to Heinrich et al. (2010), in PSM estimation, first, propensity scores (probabilities of farmers participating in OAF) are estimated by a binary choice model logit or probit which yield same results. With \( x \) capturing a set of pretreatment observable covariates; which are attributes that determine the probability of a unit getting the treatment (joining OAF), the binary model can be specified as;

\[ P(D = 1 | x) = G(x\gamma) \quad \text{where} \quad 0 < G(x\gamma) < 1 \]

\[ G(x\gamma) = G(\gamma_0 + \gamma_1 x_1 + \cdots + \gamma_n x_n) \]

Where \( x\gamma = \gamma_0 + \gamma_1 x_1 + \cdots + \gamma_k x_k \quad (3.24) \]
Assuming a logistic distribution, a logit model can be specified as

\[ G(xy) = \frac{\exp(xy)}{1 + \exp(xy)} = \Lambda(xy) \]

Where \( y \) is a \( K \times 1 \) vector of coefficients \( (3.25) \)

Substituting in equation (3.25) the specific covariates for this study yielded equation (3.26) which can be expressed as

\[ \Lambda(xy) = \frac{\exp(y_0 + y_1x_1 + \cdots + y_7x_7)}{1 + \exp(y_0 + y_1x_1 + \cdots + y_7x_7)} \]

\[ \text{where } 0 < \Lambda(xy) < 1 \]

(3.26)

Where \( x_1 \) to \( x_7 \) represent maize farmer’s sex, age, age squared, marital status, household size, residence and level of education respectively. Estimation of equation (3.26) gave propensity scores.

Second step involved matching of treated and control units to create a counterfactual based on output of equation (3.26). Three matching algorithms namely; nearest neighbor, radius and kernel matching were used interchangeably to ensure consistency. With successful matching, it was assumed that selection into OAF was as good as random so that in equation (3.14) \( SB = 0 \) and thus equation (3.15) holds. Consequently equation (3.16) was modified to capture all matched farmers so that;

\[ ATET = \frac{1}{n-\tilde{n}} \left[ \sum_{i=1}^{n-\tilde{n}} (1 - D)Y_0 + DY_1 \right] - \frac{1}{\tilde{n}} \left[ \sum_{i=1}^{\tilde{n}} (1 - D)Y_0 + DY_1 \right] \]

(3.27)

Where \( Y_1 \) is maize yield or profit (whichever was under estimation) for a farmer who is OAF member and \( Y_0 \) is respective counterfactual while \( ATET \) is the average treatment effect due to OAF. \( \tilde{n} \) Represents units (farmers) in control group that were successfully matched with \( n - \tilde{n} \).
units in treated group and \( \tilde{n} \) is the total number of farmers who were successfully matched. \( \tilde{n} \) is not necessarily equal to the sample size \( n = 264 \); so that \( \tilde{n} \leq 264 \). Note that \( D=1 \) for the first right hand term of equation (3.27) while \( D=0 \) for the second term. Thus equation (3.27) simplifies to;

\[
ATET = \frac{1}{n-\tilde{n}} \left[ \sum_{i=1}^{n-\tilde{n}} Y_{1i} \right] - \frac{1}{\tilde{n}} \left[ \sum_{i=1}^{\tilde{n}} Y_{0i} \right]
\]

Equation (3.28) is a replication of equation (3.20) whose estimation gave ATET. To achieve the third objective, estimation of equation (3.28) was done with \( Y \) being maize yield. This is identical to estimation of equation (3.22) for OAF members and non-members and getting the difference of the averages while controlling for the pretreatment covariates. Similarly estimating equation (3.28) with \( Y \) as profit in the place of yield achieved the fourth objective which was simply estimation of equation (3.23) for OAF members and non-members and averaging the differences while controlling for pretreatment covariates.

The estimations of the production and profit functions achieved the first and second objectives respectively while the treatment effect model estimation achieved the last two objectives.

3.5. Definition and Measurement of Variables

**Yield:** is the quantity of maize produced per a unit area of land. It was measured in 90kg bags/acre

**Land size:** is the area covered by maize plantation measured in acres cultivated farmers during March to August 2016 season.

**Planting fertilizer:** is the quantity of chemical fertilizer in kilograms used for planting
**Top dressing fertilizer**: is the quantity of chemical fertilizer in kilograms used subsequently during maize crop growth after germination.

**Manure**: is the quantity of organic fertilizer used in maize planting and was measured in kilograms.

**Labor**: is manpower hours used. It was measured using on farm labor hours used in weeding

**Seed type**: Maize seed variety planted. Was be treated as a dummy (1= hybrid and 0=otherwise).

**Profit**: is the excess of the maize’s total sales over total cost measured in ksh.

**Age**: is the length of time a maize farm head (who is synonymous to household head) has lived and was measured in years.

**Age squared**: is the square of age of a farm head in years

**Sex**: is the farm head’s biological set up defined as either male or female. Was measured as dummy; 1= male, 0= female.

**Level of education**: the highest level of formal schooling attained by a farm head and was measured as dummy (0= none, 1= primary, 2= secondary, 3= post-secondary).

**Residence**: is sub-county a maize farmer’s residence. It was measured as dummy (1= Nambale Sub – county, 0= Teso North Sub – county).

**Training**: indicates the number of times a farmer attended training related to maize farming. Was be captured by actual number of times a farmer attended the training on maize production by OAF.

### 3.6 Study Area

The study was undertaken within Busia County in two Sub-counties of Nambale and Teso North. The study was motivated to be conducted in Busia because, other than the county being a heavy maize reliant and with the least productivity relative to other constituent counties of former
Western province of Kenya, it is among the OAF operational zones. Furthermore, the county had sufficient sample size to facilitate the study.

### 3.7 Target Population

The study targeted maize farmers (both OAF members and non-members) in Busia County during March – August 2016 season. Based on the Busia County profile of 2016, the county was estimated to have a total 98,099 farm families. The distribution of farm families across the county is: 13,826, 15,705, 20,000, 12,750, 8,700, 5,985 and 21,133 in Matayos, Nambale, Butula, Samia, Bunyala, Teso North and South respectively. Among these about 97 percent (95,156) farm families carry out maize farming.

### 3.8 Sampling Techniques and Sample Size

Initially, a representative sample of 100 respondents was to be selected based on the method suggested by Cochran (1963) given as:

\[
n = \frac{N}{1 + N(e^2)} \tag{3.29}
\]

Where \(n\) is the sample size, \(N\) population size and \(e\) is level of significance.

For this study, \(N=95,156\), and the margin of error, \(e\) was 10 percent. Substituting respective values in equation (3.29) gave:

\[
n = \frac{95,156}{1 + 95,156(0.1^2)} = 100
\]
In order to facilitate drawing up of study sample, the county was first stratified into the seven constituent sub-counties among which two (Nambale and Teso North) sub-counties were randomly selected. The 100 respondents were then to be apportioned proportionately between the two sub-counties with 70 respondents from Nambale and 30 from Teso North. However, according to Heinrich et al. (2010), PSM is a “data hungry” method in both the covariates and sample size and as such the study expanded purposively the sample size in the two sub-counties in proportions nearly equivalent their ratios to the tune of 174 farm families from Nambale Sub-county and 90 from Teso North sub-county.

3.9 Data Type and Source

The study relied on qualitative and quantitative primary cross-sectional data which was collected from maize farmers’ family heads in Busia County, Kenya.

3.10 Data collection

Data was collected in May 2017 from 264 maize farmers’ family heads with the help of questionnaires with both open and closed ended questions which were dropped and collected by research assistants. A total of 275 questionnaires were issued to ensure that even with less than 100% response rate compounded by other data collection anomalies, a sufficient sample size could still be feasible.

3.11. Pilot Study

A pilot study was conducted in Matayos and Teso South where 7 and 8 (a total of 15) respondents were arbitrarily and randomly selected. Based on the piloted data, validity and reliability of
questionnaires were tested using Cronbach’s alpha method. A questionnaire with Cronbach’s alpha of at least 0.8 is considered reliable (Field, 2009). The test gave Cronbach’s alpha of 0.87, which implied that the variations in the responses were due to difference in opinion but not that questions were confusing. Hence the questionnaires were justified to be reliable.

3.12. Data Cleaning, Coding and Refinement

Collected data was subjected to verification and cleaning. Qualitative data was coded appropriately. Disparate data was then refined from its raw state to integrated form before being entered into spreadsheet document in readiness for analysis.

3.13. Data Transformation and Analysis

Most of the data on variables was used in its raw form without transformation. However, relevant transformations such as logarithmic transformation of some variables and interaction of existing variables to generate new ones was conducted. It should be noted that yield in 90Kg bags per acre was estimated by dividing quantity of maize harvested by the size of land in acres. To estimate labor used, the number of times a farmer did the weeding was used as a proxy for labor since it was noted that weeding takes the greatest portion of the total time spent on maize farming. The challenge to this is that “weedings” are independent of land size but depends on the magnitude of labor force employed. Thus labor hours were standardized into 1 unit of time (hour) per acre per weeding. Consequently, the study estimated labor hours by multiplying land size by “weedings”.

Several farmers could not recall their costs for labor used in land preparation, planting, weeding and harvesting while others neither explicitly experienced these costs as they depended on either
group labor or family labor. As such per acre averages for the available costs were taken. These means were then multiplied by land size to get respective costs. These transformations were justified on the grounds that across the 264 farmer, there was no evidence of significant differences in labor costing.

To achieve the first objective which was to examine how improved inputs affect maize yield across all maize farmers, a robust linear regression estimation was conducted on equation (3.22). Similar estimation technique was applied in estimation of equation (3.23) as it was for equation (3.22) so as to achieve the second objective which was to find out how improved inputs affect profit from maize farming across all farmers. To achieve the last two objectives, propensity scores were estimated by equation (3.26). Based on the propensity scores results of equation (3.26), farmers from the control group (OAF non-members) were matched with OAF members using nearest neighbor, radius matching and kernel methods interchangeably. After matching, ATET was estimated on equation (3.28) twice; in the first scenario with \( Y \) representing yield while in the second case profit was used in the place of yield. These helped to achieve the third and fourth objectives respectively.

### 3.14 Diagnostic Tests

Test for model specification was conducted. Shapiro-Wilk W test and Skewness/Kurtosis tests for normality were carried. Heteroscedasticity check was conducted using Cook-Weisberg test and White's test. To test for multicollinearity; variance inflation factor, pairwise correlation and regressing one of the predictor variable on the rest was performed as suggested in (Gujarat, 2004).
Estimation of the ATET using PSM was done after balancing test had been conducted and overlap/common support assumption using visual inspection of plots and Kolmogorov-Smirnov (KS) test for equality of two distributions verified as guided by Caliendo and Kopeinig (2008) and Heinrich et al. (2010). This was to ensure ATET estimates are efficient and reliable.
CHAPTER FOUR
EMPIRICAL FINDINGS

4.1 Introduction

This chapter presents the empirical findings of the study. The chapter starts by highlighting the response rate before a brief outline of characteristics of the respondents and eventually turn focus to the detailed analysis of the impact of improved inputs and OAF on both maize farmers’ profit and yield tapped from maize farming. Robust linear regression estimation and treatment effect results are presented and discussed. Descriptive statistics were also used to compliment the quantitative results.

4.2 Response Rate

A total of 275 questionnaires were issued, 95 of these to maize farmers in Teso North sub-county and the remaining 180 to those maize farmers in Nambale sub-county. Out of the possible 95 questionnaires issued in Teso North, 93 were collected which marked a 97.89 percent response rate. On the other hand Nambale sub-county recorded a response rate of 98.33 percent. This corresponds to 177 questionnaires that were successfully filled and collected. On overall, 270 questionnaires were filled and collected back. This implied an entire response rate of 98.18 percent. After data collection, the collected questionnaires were subjected to scrutiny so that only questionnaires with correct and proper entries in regard to key variables under investigation be used. This led to discarding of 6 questionnaires, 3 from each sub-county which had been wrongly filled or had missing variables or both. Thus the analysis was based on data collected from 264 respondents.
4.3. Characteristics of Respondents

Table 4.1 summarizes the social demographic features of the respondents studied. These include sex, age category, education, marital status and their place of residence. These features among others variables were used in calculating propensity scores.

Table 4.1: Characteristics of Respondents

<table>
<thead>
<tr>
<th>CHARACTERISTICS</th>
<th>OAF MEMBERSHIP</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OAF NON-MEMBER</td>
<td>OAF MEMBER</td>
<td>TOTAL</td>
<td></td>
</tr>
<tr>
<td>SEX</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>51 (42.50*)</td>
<td>69 (57.50*)</td>
<td>120 (45.45**)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>75 (52.08*)</td>
<td>69 (47.92*)</td>
<td>144 (54.55**)</td>
<td></td>
</tr>
<tr>
<td>EDUCATIONAL LEVEL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>20 (58.82*)</td>
<td>14 (41.18*)</td>
<td>34 (12.88**)</td>
<td></td>
</tr>
<tr>
<td>Primary</td>
<td>55 (45.45*)</td>
<td>66 (54.55*)</td>
<td>121 (45.83**)</td>
<td></td>
</tr>
<tr>
<td>Secondary</td>
<td>40 (45.98*)</td>
<td>47 (54.02*)</td>
<td>87 (32.95*)</td>
<td></td>
</tr>
<tr>
<td>Postsecondary</td>
<td>11 (50.00*)</td>
<td>11 (50.00*)</td>
<td>22 (8.33**)</td>
<td></td>
</tr>
<tr>
<td>MARITAL STATUS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>100 (44.05*)</td>
<td>127 (55.94*)</td>
<td>227 (85.99**)</td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td>11 (100.00*)</td>
<td>0 (0.00*)</td>
<td>11 (4.17**)</td>
<td></td>
</tr>
<tr>
<td>Divorced/Separated</td>
<td>4 (80.00*)</td>
<td>1 (20.00*)</td>
<td>5 (1.89**)</td>
<td></td>
</tr>
<tr>
<td>Widowed</td>
<td>11 (52.38*)</td>
<td>10 (47.62*)</td>
<td>21 (7.95**)</td>
<td></td>
</tr>
<tr>
<td>SUBCOUNTY OF RESIDENCE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nambale Sub-County</td>
<td>98 (56.32*)</td>
<td>76 (43.68*)</td>
<td>174 (65.91**)</td>
<td></td>
</tr>
<tr>
<td>Teso North Sub-County</td>
<td>28 (31.11*)</td>
<td>62 (68.89*)</td>
<td>90 (34.09**)</td>
<td></td>
</tr>
<tr>
<td>AGE GROUP (IN YEARS)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-29</td>
<td>18 (64.29*)</td>
<td>10 (35.71*)</td>
<td>28 (10.61**)</td>
<td></td>
</tr>
<tr>
<td>30-39</td>
<td>36 (48.00*)</td>
<td>39 (52.00*)</td>
<td>75 (28.41**)</td>
<td></td>
</tr>
<tr>
<td>40-49</td>
<td>34 (39.08*)</td>
<td>53 (60.92*)</td>
<td>87 (32.95**)</td>
<td></td>
</tr>
<tr>
<td>50-59</td>
<td>25 (48.08*)</td>
<td>27 (51.92*)</td>
<td>52 (19.70**)</td>
<td></td>
</tr>
<tr>
<td>60-69</td>
<td>9 (52.94*)</td>
<td>8 (47.06*)</td>
<td>17 (6.44**)</td>
<td></td>
</tr>
<tr>
<td>70-79</td>
<td>4 (80.00*)</td>
<td>1 (20.00*)</td>
<td>5 (1.89**)</td>
<td></td>
</tr>
</tbody>
</table>

Percentages in parenthesis: *percent of OAF member/non-member as a proportion of that particular membership category; **as a percent of the entire 264 respondents.

Source: Author’s Computation from the Study Data.
Table 4.1 shows that among the 264 respondents, 45.45 percent were female and the remaining 54.55 percent were male. In addition, for the female respondents, 57.50 percent were members of OAF while 42.50 percent were not members. The values for male respondents were 47.92 and 52.08 percent for OAF members and non-members respectively. Farmers with only primary education recorded 45.83 percent which was the highest proportion of the total respondents. The second, third and fourth ranked in descending order were those with secondary education, no formal education and post-secondary education with respective proportions of 32.95, 12.88 and 8.33 percent. It should however be noted that within class examination revealed that farmers without any formal schooling recorded the least proportion of enrollment into OAF. This was equivalent to 41.18 percent. It was then in ascending order followed by those with education beyond secondary level (50.00%) and then farmers with just secondary education (54.02%). Those with primary education (54.55%) topped as well in regard to within category for OAF enrollment rate.

From Table 4.1, it can also be shown that the largest number of respondents were married farmers, followed by widowed farmers, then single farmers and lastly those farmers who had either been divorced or separated with respective proportions of 85.99, 7.95, 4.17 and 1.89 percent. Furthermore, single farmers recorded a 0.00 percent enrollment into OAF. The respective enrollment rates among those married, widowed and divorced and/or separated were 55.94 percent, 47.62 percent and 20.00 percent. 65.91 percent of the respondents were from Nambale sub-county while the rest were from Teso North sub-county. The later region recorded a 68.89 percent enrollment in OAF among the interrogated farmers while the former had 43.68 percent enrolment rate. Farmers within the age bracket of 40 – 49 years recorded the highest proportion both in terms
of entire respondents sampled and in regard to OAF enrollment. This could be explained by the fact that this age category is likely to contain majority of individuals who are either household heads, have many dependents and/or own land. Farmers within the age bracket of 70 – 79 years had the least proportion pertaining both enrollments into OAF and in the overall sample. No respondent was either below 18 years or above 79 years of age. Absolute values and proportions for other age groups and other characteristics are also displayed in Table 4.1.

4.5. The Relationship between Improved Inputs and Maize Yield

The discussion in this sub-section covers how the first objective of this study which was to establish how improved inputs affect maize yield in Busia County, Kenya among all maize farmers was achieved. This objective was achieved by using a robust regression estimation techniques after several diagnostics on classical linear assumptions faulted the viability of OLS. In addition, multivalued analysis for some selected factors affecting yield was also conducted. The results for diagnostic tests are discussed below.

4.5.1. Results for Diagnostic Test for Classical Linear Assumptions

Model specification test was conducted and the results were as shown in Table A5. A p-value of 0.698 corresponding to “hatsq” implies that the null hypothesis that the model had been correctly specified could not be rejected at 1 percent, 5 percent and 10 percent levels of significance. In addition, as shown in Table A6, both Shapiro-Wilk W test and Skewness/Kurtosis normality test results indicated that the null hypothesis was rejected at 1 percent, 5 percent and 10 percent levels of significance. Leading to the conclusion that residuals were not normally distributed. The
respective p-values for the two tests were 0.00062 and 0.0026. Even with non-normal error terms, OLS estimators are still unbiased but resulting inferential statistics are always unreliable.

Cook-Weisberg test and White's test for heteroscedasticity results are presented in Table A7. The p-values of 0.0460 and 0.0297 respectively led to the rejection of the null hypothesis of constant variance of the error term at both 10 percent and 5 percent significance levels. These p-values are however greater than 0.01 implying that at 1 percent level of significance, residuals were homoscedastic.

Multicollinearity tests were also conducted using various diagnostics. The variance inflation factor (VIF) test gave VIF of greater than 10 corresponding to the log of land size under maize which signified likelihood of multicollinearity. That is the log of land size was suspected to correlate with at least one of the other predictor variables. Running a regression of log of land size on other exogenous variables which were the quantity of DAP fertilizer used in planting, log of labor hours, the square of DAP used in planting, quantity of chemical fertilizer used in top dressing, the numbers of times a farmer received training regarding maize farming, seed type and quantity of organic fertilizer used gave results with an Adjusted R-squared of 90.30 percent and a t-value (p-value) of 35.79 (0.000) corresponding to log of labor hours. These were other probable indicators that caused suspicion for multicollinearity especially between log of land size and log of labor hours. In addition, higher pairwise correlation coefficients indicated likelihood of collinearity between log of labor hours and log of land size and between DAP quantity and its square. These results did not however come as a surprise since the second variable in each pair emanated from interaction involving the first variable as discussed in subsection 3.13 under data transformation and analysis. All multicollinearity test results are summarized in Table A8.
Attempts to eliminate multicollinearity by approaches such as centering of the interaction variables using mean subtraction did not proof to cure the menace. The researcher had no sufficient convincing reason to drop either log of land size or log of labor hours or both as alternative remedial mechanism since these were considered as key factors of production. Great concern about multicollinearity only arises when correlated predictors are supposed to be different (uncorrelated), the standard errors are substantially high, coefficients exhibit magnitudes and signs that are contrary to the expectation, and such coefficients are insignificant while R-squared is high. Fortunately, the estimation results herein did not conform to any of this anomalies.

Evidence for non-normal error term, heteroscedasticity and existence of collinearity between predictors necessitated the use of robust linear regression as it relaxes the strict assumptions underlying the classical linear regression estimation techniques.

4.5.2. Robust Regression Estimation Results for Effect of Improved Inputs on Maize Yield

In order to achieve the first objective for this study, equation (3.22) was estimated and the results presented in Table 4.2.
Table 4.2: Regression Results of Effects of different inputs on Maize Yield

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficients</th>
<th>Z-Value</th>
<th>P-Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of maize seed</td>
<td>0.1714773</td>
<td>1.42</td>
<td>0.158</td>
</tr>
<tr>
<td></td>
<td>(0.121017)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantity of DAP used in planting</td>
<td>0.0173162***</td>
<td>3.17</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td>(0.005458)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Square of quantity of DAP used in planting</td>
<td>-0.0001931***</td>
<td>-3.69</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>(0.00005)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top-dressed quantity of inorganic fertilizer</td>
<td>0.0030419</td>
<td>0.98</td>
<td>0.327</td>
</tr>
<tr>
<td></td>
<td>(0.0031007)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantity of organic fertilizer used</td>
<td>0.0002426***</td>
<td>4.83</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>(0.00005)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of times a farmer was trained on maize farming</td>
<td>-0.0180005*</td>
<td>-1.72</td>
<td>0.086</td>
</tr>
<tr>
<td></td>
<td>(0.010459)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log of land size</td>
<td>-0.7767971***</td>
<td>-6.09</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>(0.12754)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log of labor hours used in maize farming</td>
<td>0.5044082***</td>
<td>4.17</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>(0.120989)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>1.285475***</td>
<td>7.05</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>(0.1823397)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F-statistic</td>
<td>8.34</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prob &gt; F</td>
<td>0.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-squared</td>
<td>0.186</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Robust standard errors in parenthesis.

***significant at 1%, *significant at 10%

Source: Author’s Estimation from the Study Data

From the estimation results in Table 4.2, maize yield is positively affected by the quantity of DAP fertilizer used in planting. An addition of one kilogram of DAP used for planting was estimated to increase maize yield by 0.0173 percent. The p-value of 0.002 corresponding to this coefficient was a clear indication that using DAP during planting significantly improves maize yield. Similar findings were found by De Groote et al. (2005), Okoboi (2010), Ogada and Nyangena (2014) and
Ali-Olubandwa et al. (2010) who also found positive effect of inorganic fertilizer use on maize yield. An alternative estimation of equation (3.22) using DAP usage as discrete value where 1 was used to represent a case where any level (> 0) of DAP quantity had been used and zero otherwise showed that farmers who used DAP got relatively higher yield than their counterparts who never used it at all (see Table A9). It is worth noting that inclusion of the square values of DAP was to capture a quadratic relationship between DAP and yield because highly extreme levels of DAP would be unfavorable for maize farming and thus assuming a linear relationship at all levels of DAP use would be inappropriate.

The quantity of fertilizer used to top-dress maize was estimated to influence maize yield positively but insignificantly at 10 percent, 5 percent and 1 percent levels of significance as suggested by the p-value of 0.327. It was estimated that whenever a farmer increased the quantity of chemical fertilizer (majorly CAN) used to top-dress by 1 Kg, such a farmer would experience an increase of 0.00304 percent in the yield of maize holding all other factors constant. Estimation of equation (3.22) using fertilizer for topdressing as a binary variable indicated that farmers who used this fertilizer raised their yield (see Table A9). Furthermore, the application of organic fertilizer (manure) was estimated to influence maize yield positively and significantly as evidenced by a p-value of 0.000. The estimated coefficient shows that an increase in manure use by 1 Kg would increase the yield by approximately 0.000243 percent; this finding confirmed the work of Mucheru et al. (2014) who also found positive effect of manure use on maize yield.

The results further showed that yield would drop by 0.018 percent whenever a farmer attended an additional training session. These results were in conflict with those of Kipng’eno (2012) who noted a positive effect of training on yield. Informed by a p-value of 0.086, training was a
significant predictor of maize yield at 90 percent but insignificant at 95 percent and 99 percent levels of confidence. The descriptive results however opposed this regression estimate. Out of the entire 264 maize farmers studied, 73.48 percent strongly agreed that training helps to improve yield, 21.21 percent agreed, 3.03 percent were neutral (not sure), 2.27 percent disagreed and none was noted to strongly disagree. For a comprehensive coverage of these descriptive findings, see Table A10 in the appendix. It is worth noting that further estimation of equation (3.22) using training as binary variable instead showed that farmers who had not received training were more productive than their counterparts who had been trained. Training was still an insignificant explanatory variable in this context. The study did not get a substantial justification for this unexpected direction of causation. However there was suspicion that insignificant effect due to training was likely to have arose from farmers being trained unconsciously. Some farmers were reported to have learned some farming practices by seeing what their neighbors were doing. This insignificance effect could also be associated to the fact that training only facilitates use of appropriate input but cannot independently affect maize yield.

The estimated coefficient corresponding to log of land size shows that a 1 percent increase in the land size under maize lowers the yield by 0.776797 percent. Based on the inferential statistics shown in Table 4.2, this effect is substantially strong. Production theory hypothesizes that output and land are positively correlated. The theory does not however impose any restriction that yield or productivity should follow similar analogy. In deed this estimation result is a clear indicator that farmers are experiencing decreasing return to scale based on land size. The researcher through interaction with farmers and interrogation of the data revealed that farmers manage small sizes of land with much ease. They give it more attention such as during land preparation, weeding and
general crop management which include per acreage use of fertilizer. This finding is in agreement with that of Okoboi (2010) who found a negative effect of land size on yield.

The estimation results in the current study also showed that whenever a farmer increased the quantity of labor by 1 percent, yield would go up by 0.5044 percent. As the p-value of 0.0000 infers, the coefficient is significant and labor was thus confirmed to be a very important input in maize production.

4.5.3. Multivalued Treatment Estimation of Effect of Selected Factors on Maize Yield

The findings in this subsection concentrates on how some other selected subsidiary factors affect maize yield (which not necessarily part of improved inputs except effect of fertilizer type).

4.5.3.1. Effect of Educational Level on Yield

The ATEs of the different levels of education using regression adjustment (RA) was estimated. It was done while controlling for each farmer’s sex, age, marital status, household size, ward of residence, OAF membership, size of land under maize, seed type, quantity of inorganic fertilizer used for planting, manure usage, soil type and labor. Since yield is strictly positive, the poison specification was used inside the model and the results summarized in Table 4.3.
Table 4.3: Average Treatment Effect of Education Level on Yield

<table>
<thead>
<tr>
<th>Education Level Compared</th>
<th>Coefficient/Ate</th>
<th>Z-Value</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>None Vs Primary</td>
<td>1.216771 (1.071653)</td>
<td>1.14</td>
<td>0.256</td>
</tr>
<tr>
<td>None Vs Secondary</td>
<td>3.322538** (1.614085)</td>
<td>2.06</td>
<td>0.04</td>
</tr>
<tr>
<td>None Vs Postsecondary</td>
<td>4.43322** (1.86653)</td>
<td>2.38</td>
<td>0.018</td>
</tr>
</tbody>
</table>

Robust standard errors in parenthesis

***significant at 1%, **significant at 5%

Source: Author’s Estimation from the Study Data

The potential outcome model results displayed in Table 4.3 show that maize yield increased from those farmers without any formal education all through to those who had attained education beyond secondary levels. The estimated ATE of moving from completely no education to primary education was 1.2168 (109.512) bags (Kgs) per acre. This effect was not significant. Moreover, the estimated ATEs of moving to secondary and postsecondary education levels starting from a level of no formal schooling were 3.322 (298.98) and 4.4332 (398.988) bags (Kgs) per acre respectively. Note also that maize farmers who had completely no education had the potential of recording a mean maize harvest of 10.036 (903.24) bags (Kgs) per acre. Attainment of secondary and post-secondary education levels among those farmers with no education were both significant in affecting maize yield at 5 percent level of significance (see Table 4.3 for respective p-values).

The increase in yield as a farmer scaled up academically was associated with probable increased
adoption of better farming practices like fertilizer use and hybrid seed among others as illiteracy level reduces.

4.5.3.2. Effect of Soil Type on Yield

Analogous to the estimation of the effect of schooling on the maize yield, effect of soil type on maize yield was also estimated. The regression adjustment (RA) estimation of a parsimonious model gave the results shown in Table 4.4.

Table 4.4: Average Treatment Effect of Soil type on Yield.

<table>
<thead>
<tr>
<th>Soil Types Compared</th>
<th>Coefficient/Ate</th>
<th>Z-Value</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Treatment effect of Soil Type</td>
<td>sandy vs loam</td>
<td>-5.121859*** (1.623798)</td>
<td>-3.15</td>
</tr>
<tr>
<td></td>
<td>clay vs loam</td>
<td>-2.41377*** (0.6934011)</td>
<td>-3.48</td>
</tr>
<tr>
<td>Potential Outcome Mean</td>
<td>Loam Soil</td>
<td>12.66767*** (0.4273119)</td>
<td>10.43</td>
</tr>
</tbody>
</table>

Robust standard errors in parenthesis

***significant at 1%,

Source: Author’s Estimation from the Study Data

The estimates showed that on average, the potential mean yield for maize grown under loam soil was 12.668 (1140.12) bags (Kgs) per acre. In treatment effect jargon, the ATE of soil as it moves from loam to clay was $-2.41377 (-217.242)$ bags (Kgs) per acre and $-5.121859 (-460.98)$ bags (Kgs) per acre as soil type changes from loam to sandy. In the layman’s language, the average farmer planting maize in areas with loam soil harvests 5.121859 bags and 2.41377 bags more than
such a farmer planting maize in sandy and clay soils respectively. The effect of soil type on maize is highly significant as indicated by extremely low p-value.

**4.5.3.3. Effect of Fertilizer Type on Yield.**

The regression adjustment estimation of the effect of fertilizer type used on maize yield following an intuition similar to that on education and soil type gave the results shown in Table 4.5.

**Table 4.5: Effect of Fertilizer Type on Maize Yield**

<table>
<thead>
<tr>
<th>Average Treatment Effect of fertilizer type</th>
<th>Fertilizer type Compared</th>
<th>Coefficient/Ate</th>
<th>Z-Value</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Both organic and inorganic vs inorganic</td>
<td>3.283547*** (0.8895007)</td>
<td>3.69</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>Organic vs inorganic</td>
<td>-1.562012 (2.62078)</td>
<td>-0.60</td>
<td>0.551</td>
<td></td>
</tr>
<tr>
<td>None vs inorganic</td>
<td>-8.883282*** (0.4737549)</td>
<td>-18.75</td>
<td>0.000</td>
<td></td>
</tr>
</tbody>
</table>

| Potential Outcome Mean                      | Inorganic                | 10.90335*** (0.4717085) | 23.11   | 0.000   |

Robust standard errors in parenthesis

***significant at 1%, **significant at 5%

Source: Author’s Estimation from the Study Data

The average treatment results shown in Table 4.5 indicate that an average farmer who used only chemical fertilizer had the potential mean yield of 10.903 (981.27) bags (Kgs) per acre. Furthermore, an average farmer who used inorganic fertilizer alone recorded a yield of 3.283 bags less than such a farmer who used a combination of both organic and chemical fertilizer. The findings also showed that an average farmer who used inorganic fertilizer harvested 8.8832 bags...
per acre above a similar colleague who never used any fertilizer at all. These effects were highly significant. Moreover, an average farmer who used purely inorganic fertilizer recorded an average yield of 1.5620 bags more than that who had relied singularly on organic manure. This effect was however not significant. This result contradicts that of Mucheru-Muna et al. (2014) who in their work, organic fertilizer was proved superior to inorganic fertilizer in improving yield. On overall, the results Tabulated in Table 4.5 indicated that farmers should embrace a mix of both organic and inorganic fertilizer to improve their yield significantly and discourage complete disuse of fertilizer.

4.6. Effect of Improved Input on Profit from Maize Farming

4.6.1. Regression Estimates of how various Inputs Affect Profit

To achieve the second objective for this study, equation (3.23) was estimated. Before this estimation, tests for model specification, heteroscedasticity, multicollinearity and normality of the residuals were conducted using similar statistical tests as in section (4.5.1). The results were similar in aspects except for multicollinearity where in this scenario, there existed no evidence for collinearity between any pair of predictors. Following similar intuition as in the estimation of equation (3.22), robust regression option was applied. The estimation results are summarized in Table 4.6.
Table 4.6: Effect of various Inputs on Profit

| Variable                                           | Coefficients/Model       | t-value | P>|t| |
|----------------------------------------------------|--------------------------|---------|-----|
| Type of maize seed                                 | -7310.441 (4704.435)     | -1.55   | 0.121 |
| Quantity of DAP used in planting                   | 681.6999*** (210.3984)   | 3.24    | 0.001 |
| Square of quantity of DAP used in planting         | -8.08769*** (1.837178)   | -4.40   | 0.000 |
| Top-dressed quantity of inorganic fertilizer       | 64.36271 (133.3039)      | 0.98    | 0.630 |
| Quantity of organic fertilizer used                | 8.905008*** (3.035867)   | 0.48    | 0.004 |
| No. of times a farmer was trained on maize farming | -526.4786 ** (264.7169)  | 2.93    | 0.048 |
| land size                                          | -3911.144 (3106.718)     | -1.26   | 0.209 |
| labor hours used in maize farming                  | 5390.809*** (1366.759)   | 3.94    | 0.000 |
| Constant                                           | 957.0609 (2585.341)      | 0.37    | 0.712 |
| F                                                  |                          | 8.34    |     |
| Prob > F                                           |                          | 0.0000  |     |
| R-squared                                          |                          | 0.4307  |     |

Robust standard errors in parenthesis.

***significant at 1%, *significant at 10%

Source: Author’s Estimation from the Study Data

From Table 4.6, an increase in the amount of DAP fertilizer used for planting by 1 Kg was estimated to increase profit by ksh 681.70. Similar direction of effect but with a lesser magnitude of a profit of Ksh 8.91 was noted in the use of organic fertilizer. Note also that an increase in labor employed by 1 unit was noted to raise profit by Ksh 5390.81. The study however cautions against strong relies on these magnitude of change since labor used here is not strictly in hours but was rather standardized. All these three variables namely DAP used, manure and labor were highly
significant as evidenced by inferential statistics. On the other hand, both the amount of inorganic fertilizer top-dressed and the number of training a farmer attended affected profit negatively but insignificantly. Okoboi (2010) also found negative effects of both inorganic fertilizer and improved seeds on profit. The current study however refrains from concluding with certainty that top dressing reduces profit because estimation of equation (3.23), using top-dressed fertilizer as a categorical binary variable (1 if top-dressed and 0=otherwise) showed a positive effect of this fertilizer on profit. This influence was still insignificant. The study speculated that the negative effect of top-dressed fertilizer on profit could probably have emerged from fertilizer usage experiencing a cost function which is increasing in quantity and thus beyond an optimal level, profit due to its use are eroded by high costs.

4.6.2. Effect on Profit due to use of different Fertilizer types

As a subsidiary analysis of the effect of fertilizer use on profit, a multivalued analysis using regression adjustment based on linear distribution was done. Use of linear regression as opposed to logit, probit and hetprobit (used for binary outcomes) and Poisson (used for non-negative outcomes) was because it does not impose non-negativity restriction and also preferred for continuous outcome as in the case of profit where losses (negative profits) is a possibility. The estimated results for the effect of fertilizer use on profit are tabulated in Table 4.7.
Table 4.7: Effect of Fertilizer Type on Profit

<table>
<thead>
<tr>
<th>Fertilizer Types Compared</th>
<th>ATE</th>
<th>Z-Value</th>
<th>P-Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Treatment Effect of Fertilizer Type</td>
<td>both organic and inorganic vs inorganic</td>
<td>14054.16*** (2999.623)</td>
<td>4.69</td>
</tr>
<tr>
<td></td>
<td>organic vs inorganic</td>
<td>13016.11** (5944.165)</td>
<td>2.19</td>
</tr>
<tr>
<td></td>
<td>none vs inorganic</td>
<td>-12364.71*** (1453.882)</td>
<td>-8.50</td>
</tr>
<tr>
<td>Potential Outcome Mean</td>
<td>Inorganic</td>
<td>9999.632*** (1450.925)</td>
<td>6.89</td>
</tr>
</tbody>
</table>

Robust standard errors in parenthesis

***significant at 1%, **significant at 5%

Source: Author’s Estimation from the Study Data

The results tabulated in Table 4.7 show that the average potential profit for farmers using only inorganic fertilizer was Ksh. 9999.632. An average maize farmer who did not use any fertilizer at all recorded a profit of Ksh 12364.71 less than a similar farmer who used inorganic fertilizer alone. More so, an average farmer who applied both organic and inorganic fertilizer reaped a profit of Ksh 14054.16 more than an identical farmer who applied singularly inorganic fertilizer. These effects were highly significant. Unlike in the case of yield where farmers using inorganic fertilizer registered higher yield than those relying on manure alone, outcomes were in the contrary regarding profit as indicated by an ATE of 13016.11. This implies that an average farmer who applied manure only tapped a profit of Ksh 13016.11 above such a farmer who used only inorganic fertilizer. The study associated this to the fact that manure was not purchased but came from own animal waste.
4.7. Effect of One Acre Fund activities on Maize Yield

The influence OAF has on maize yield was investigated using the PSM estimation. This was in line with achievement of the third objective was to examine how maize yield vary among OAF members and non-members in Busia County, Kenya. Before estimation of ATET, a logistic estimation of a binary model for OAF participation was estimated based on equation (3.26) to reveal how different covariates affected the probability of a farmer joining OAF and the results presented in Table 4.8. This estimation yielded propensity scores as a complementary output.

Table 4.8. Logit Estimate of how various factors affect One Acre Fund Membership (n= 264)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficients</th>
<th>Z-Value</th>
<th>P-Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex of farmer</td>
<td>-0.4217932</td>
<td>-1.59</td>
<td>0.112</td>
</tr>
<tr>
<td></td>
<td>(0.2655567)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age of the farmer</td>
<td>0.2035283**</td>
<td>2.52</td>
<td>0.012</td>
</tr>
<tr>
<td></td>
<td>(0.08064)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age squared</td>
<td>-0.0020861**</td>
<td>-2.40</td>
<td>0.017</td>
</tr>
<tr>
<td></td>
<td>(0.0008707)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marital status</td>
<td>-0.3134709*</td>
<td>-1.93</td>
<td>0.053</td>
</tr>
<tr>
<td></td>
<td>(0.1622905)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household size</td>
<td>-0.0963832*</td>
<td>-1.89</td>
<td>0.058</td>
</tr>
<tr>
<td></td>
<td>(0.0508752)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>sub-county of residence</td>
<td>-1.08113***</td>
<td>-3.77</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>(0.2863971)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education level of the farmer</td>
<td>0.0807952</td>
<td>0.50</td>
<td>0.620</td>
</tr>
<tr>
<td></td>
<td>(0.1631552)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-2.749674</td>
<td>-1.53</td>
<td>0.126</td>
</tr>
<tr>
<td></td>
<td>(1.797452)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log likelihood</td>
<td>-167.37199</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: the common support option has been selected. The region of common support is [.19759392, .84603274]. Binary independent variable =1 if an OAF member and 0 if not a member. Standard Errors in parenthesis. ***significant at 1%; **significant at 5% and *significant at 10%

Source: Author’s Estimation Based on Study Data
The logistic results for the model estimation of participation in OAF are shown in Table 4.6. Firstly, the result shows that male farmers had a lower probability of joining OAF as compared to their female counterparts. Furthermore, an increase in both age and education level had the tendency of increasing the likelihood of a farmer joining OAF. Age squared, marital status, household size and sub-county of residence (moving from Teso North to Nambale sub-county) all negatively affected the probability that a farmer would join OAF. Since age and OAF participation have a quadratic relationship, age squared was introduced to capture this non-linear relationship.

4.7.1 Balancing Test Results and Verification of Region of Common Support

Efficient estimation of ATET can only be done by relying on matches that lie within the region of common support (balanced) and that there is overlap between OAF members and non-members. A description of the estimated propensity in the region of common support is displayed in Table 4.9.
Table 4.9: Description of Propensity Scores in Region of Common Support

<table>
<thead>
<tr>
<th>Estimated propensity scores</th>
<th>Percentiles</th>
<th>Smallest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1%</td>
<td>0.2087681</td>
</tr>
<tr>
<td></td>
<td>5%</td>
<td>0.2660902</td>
</tr>
<tr>
<td></td>
<td>10%</td>
<td>0.3294131</td>
</tr>
<tr>
<td></td>
<td>25%</td>
<td>0.411548</td>
</tr>
<tr>
<td></td>
<td>50%</td>
<td>0.5116806</td>
</tr>
<tr>
<td></td>
<td>Largest</td>
<td></td>
</tr>
<tr>
<td></td>
<td>75%</td>
<td>0.6750138</td>
</tr>
<tr>
<td></td>
<td>90%</td>
<td>0.7727434</td>
</tr>
<tr>
<td></td>
<td>95%</td>
<td>0.7929387</td>
</tr>
<tr>
<td></td>
<td>99%</td>
<td>0.8253331</td>
</tr>
<tr>
<td>Obs</td>
<td>260</td>
<td></td>
</tr>
<tr>
<td>Sum of</td>
<td>260</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0.5285804</td>
<td></td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>0.1608531</td>
<td></td>
</tr>
<tr>
<td>Variance</td>
<td>0.0258737</td>
<td></td>
</tr>
<tr>
<td>Skewness</td>
<td>0.1070088</td>
<td></td>
</tr>
<tr>
<td>Kurtosis</td>
<td>2.147105</td>
<td></td>
</tr>
</tbody>
</table>

Source: Author’s Estimation from the Study Data.

From the results in Table 4.9, the average probability of an individual farmer joining OAF was 0.52858 (52.858 %) with the standard deviation of 0.16085. Note also that with imposition of the common support assumption, some block identifiers are missing for those control observations that were lying outside the region of common support. Thus only 260 observations are displayed and not the entire 264. Ideally the main aim of balancing test was to ensure that OAF membership is independent of farmers’ characteristics after conditioning on the observable features as estimated by the propensity scores. To ensure that this common support region was satisfactory, observations lying outside this region were trimmed off. Table 4.10 shows the inferior bound, the
number of treated (OAF members) and the number of controls (OAF non-members) in each of the five blocks.

**Table 4.10: One Acre Fund Members and Non-Members Distribution in the Five Blocks**

<table>
<thead>
<tr>
<th>Inferior of block of pscore</th>
<th>Farmer's membership in OAF</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OAF non-member</td>
<td>OAF member</td>
<td>Total</td>
</tr>
<tr>
<td>0.1975939</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>0.2</td>
<td>38</td>
<td>18</td>
<td>56</td>
</tr>
<tr>
<td>0.4</td>
<td>63</td>
<td>61</td>
<td>124</td>
</tr>
<tr>
<td>0.6</td>
<td>19</td>
<td>52</td>
<td>71</td>
</tr>
<tr>
<td>0.8</td>
<td>2</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>122</td>
<td>138</td>
<td>260</td>
</tr>
</tbody>
</table>

Note: the common support option has been selected

Source: Author’s Estimation from Study Data

The estimation gave the final number of blocks as 5. In these blocks, the average of the propensity scores was not different among OAF members and non–members within a block. The result also indicated that balancing property had been achieved.

Common support assumption was also verified. The overlap density plots to verify common support assumption were as shown in Figure 4.1.
Figure 4.1: Distribution of Propensity Score across One Acre Fund members and Non-members

Source: Author’s Plot based on Study Data.

Figure 4.1 shows the estimated density of the predicted probabilities that a farmer participating in OAF is a non-member and the estimated density of the predicted probabilities that an OAF non-member is actually a non-beneficiary. Neither of the two plots shows too much probability mass near zero or one and the two densities estimated show most of their respective masses within regions in which they overlap with each other. This implies non-existence of evidence that the overlap assumption was violated. This ensured that farmers with the “same” values of covariates had positive probabilities of either being OAF members or non-members.

Having fulfilled the overlap assumption, balancing test was done to ensure that matching balanced covariates so that selection into OAF was as good as random to enable the treatment and control
groups be comparable. This density plots based on the computed propensity score were done for both groups before and after matching and the result shown in Figure 4.2.

![Balance plot](image)

**Figure 4.2: Propensity Score Distribution before and after Matching**

*Source: Author’s Plot based on Study Data*

Figure 4.2 shows that there existed a difference in propensity scores’ distribution between members in the OAF and non-members before matching. The implication of this is that comparison based on unmatched propensity scores would have caused unreliable results associated with selection bias. However after matching, the two groups were “similar” as the after matching plot in Figure 4.2 shows. A complementary test using Kolmogorov-Smirnov (KS) test for equality of two distributions failed to reject the null, leading to the conclusion that after matching, the overlap assumption was intact.
4.7. 2. Estimation Results for the Effect One Acre Fund on Maize Yield in Busia County

The estimation of the effect One Acre Fund has on the yield of maize was done on equation (3.28) (where Y denoted yield) using three matching algorithms namely nearest neighbor with replacement, kernel method and finally radius matching using a radius of 0.01. The results are summarized in Table 4.11. This was used to achieve the third objective for this study. Estimation was only based on observable covariates that affected membership or yield but were independent of membership status of a farmer.

Table 4.11: Results for Estimation of ATET of One Acre Fund on Maize Yield

<table>
<thead>
<tr>
<th>Matching Algorithm</th>
<th>N</th>
<th>ATET</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nearest neighbor with Replacement</td>
<td>137</td>
<td>54</td>
<td>4.061** (1.312) [1.421] 2.857</td>
</tr>
<tr>
<td>Radius matching with a radius of 0.01</td>
<td>130</td>
<td>79</td>
<td>2.482** (1.110) [1.115] 2.227</td>
</tr>
<tr>
<td>Kernel method</td>
<td>137</td>
<td>88</td>
<td>2.115** (0.972) [0.972] 2.176</td>
</tr>
</tbody>
</table>

Note: Each row reports estimates using a different matching algorithm; (1) nearest neighbor using one neighbor; (2) radius matching using a radius of 0.01; (3) Kernel matching using normal density function. Respective values for n represent number of farmers in OAF and those not in OAF that were successfully matched.

Standard errors in parenthesis and bootstrapped clustered standard errors at parroquia level in brackets. T-values are based on bootstrapped method.

**significant at 5%.

Source: Author’s Estimation based on Study Data
The three matching algorithms were used to provide robustness checks and ensure that results do not depend on estimation method. The estimates of all the three matching approaches show that OAF member farmers experienced higher maize yield compared to their comparably similar non-members. In the terminologies of treatment effect, the average, ATET due to OAF were 4.061, 2.482 and 2.115 bags per acre using nearest neighbors, radius matching and Kernel matching respectively. In the ordinary terminology, the ATETs presented indicate the yield an average farmer who is an OAF member gets above a similar non-member. These effects were all significant at 5 percent. From the results, it should be noted that One Acre Fund was estimated to help farmers increase their maize yield significantly. In addition to these quantitative findings, out of the 264 members studied, 61.74 percent strongly agreed that OAF helps increase yield, 30.30 percent just agreed, while the proportions for those who were undecided, disagreed and strongly disagreed were 4.17 percent, 3.03 percent and 0.76 percent respectively.

4.7.3. Descriptive Findings on how to Increase Yield

Though not one of the prime focus of this study, the researcher also cross-examined the respondents on how to increase maize yield. When asked how to increase maize yield, 26.52 percent proposed increased use of fertilizer and hybrid seeds, 8.33 percent added to the proposition of the aforementioned group the need for timely land preparation and planting. 27.27 percent recommended for training as a complimentary package to the views of the preceding two groups while 23.48 percent suggested several combinations of strategies put forth by the first three groups. Those who advocated for irrigation where the rains were not adequate to sustain maize plant to maturity and use of manure as additional ingredient to the soil were 2.65 percent for each category. The remaining 9.09 percent proposed other complimentary options such as joining agricultural
organization like OAF and formation of maize farmer cooperative societies that support farmers in various ways. All these finding were in line with quantitative findings except on training where there existed a contradiction.

4.8. Effect of One Acre Fund on Profit;

The results and discussion presented under this sub-section were used to achieve the fourth objective of this study which was to estimate how profits from maize farming vary among OAF member and non-member maize farmers in Busia County, Kenya.

4.8.1. Treatment Effect results on how One Acre Fund Affects Profit from Maize Farming

The treatment estimation under this section was based on propensity scores calculated in section (4.7) and relevant diagnostic tests conducted and verified therein. The estimation was also based on equation (3.28) with the only dichotomy between this estimation and that used to achieve the third objective being in the outcome variable. Here the outcome variable of interest Y was used to denote profit instead yield but the estimation criteria including covariates considered were all a replica of each other. Table 4.12 presents the estimated results.
Table 4.12: Results for Estimation of ATET of One Acre on profit

<table>
<thead>
<tr>
<th>Matching Algorithm</th>
<th>N</th>
<th>OAF member</th>
<th>OAF non-members</th>
<th>ATET</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nearest neighbor with Replacement</td>
<td>137</td>
<td>54</td>
<td></td>
<td>2410.403</td>
<td>1.017</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(3155.523)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>[2369.770]</td>
<td></td>
</tr>
<tr>
<td>Radius matching with a radius of 0.01</td>
<td>130</td>
<td>79</td>
<td></td>
<td>1174.599</td>
<td>0.521</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(2587.471)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>[2252.999]</td>
<td></td>
</tr>
<tr>
<td>Kernel method</td>
<td>137</td>
<td>88</td>
<td></td>
<td>642.177</td>
<td>0.344</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1866.436)</td>
<td></td>
</tr>
</tbody>
</table>

Note: Each row reports estimates using a different matching algorithm; (1) nearest neighbor using one neighbor; (2) radius matching using a radius of 0.01; (3) Kernel matching using normal density function. Respective values for n represent number of farmers in OAF and those not in OAF that were successfully matched.

Standard errors in parenthesis and bootstrapped clustered standard errors at parroquia level in brackets.

Source: Author’s Estimation based on Study Data.

The estimates reflected in Table 4.12 show that ATET of OAF is positive for all the matching techniques. The results imply that an average farmer who belonged to OAF was estimated to get a profit higher than such a farmer in the control group by Ksh 2410.40, Ksh 1174.60 and Ksh 642.177 using the nearest neighbor matching, radius matching and kernel matching respectively. As inferred by the t – values, neither of the matching algorithm produced significant ATET. This shows that OAF helps to increase profit from maize farming but such an impacts is not significant.
4.7.4. Descriptive Findings on how to Increase Profit from Maize Farming

As a subsidiary but not one of the main ventures of this study, the researcher also sought for the opinions of the respondents on how to increase sales and profits from maize farming. 42.42 percent of the respondents recommended that farmers who wish to get better sales and profits from maize farming should wait until when the price of the crop goes up especially between February and April and at times to June. 40.15 percent had the proposal of decentralizing cereal boards to eliminate maize brokers and also to ensure maize price are standardized in addition to enabling ease of access to cheaper and certified seeds and fertilizer among other inputs. 9.47 percent advocated for the formation of farmers cooperatives and intensive government involvement in supporting maize farmers. The remaining 7.95 percent had additional views such as opening up of foreign markets for those with surplus and institute strict measures to eliminate weighing machines that are sub-standard.
5.1 Introduction

This chapter summarizes the study, makes conclusions and gives policy recommendation based on the study findings. The chapter also suggests areas future studies should consider.

5.2 Summary

This study was conducted with the overall aim of establishing the effect of One Acre Fund on maize yield and profit among smallholder farmers in Busia County, Kenya. The specific objectives were to: find out the effect of improved inputs on maize yield in Busia County; and effect of such inputs on profits from maize farming within the County (the first two objectives did were general without considering whether such farmers were or were not One Acre Fund members. The third and fourth objectives were to examine the impact of One Acre Fund on maize yield and profit among maize farmers in Busia County, Kenya respectively. This study was motivated by the fact that maize is an important crop in Kenya and Busia County in particular. The sufficiency of the crop is a measure of food security in Kenya and Busia County. Indeed, Busia County region has continued to experience low maize yield relative to several regions in the country despite varied measures to boost the crop’s production. More so, the County is among the regions covered by OAF.

Several studies that had been conducted earlier had narrowed their scope on yield. This study deviated from this norm and introduced profit in its discussion. The study also complimented quantitative results with qualitative ones unlike most of the previous ones that had used only one
between the two approaches. The key contribution of this study to the body of existing literature is its evaluation of One Acre Fund in regard to how it influences maize yield and profit from maize farming. One Acre Fund is an intervening organization that had not been given consideration by earlier researchers. Another dichotomy exists in estimation methods; many previous studies had used either purely OLS or binary choice model especially logit while others relied singularly on descriptive statistics. This study relied on robust linear regression estimation which has the advantage of relaxing linear classical assumptions. In addition this study used Propensity Score Matching which eliminates selection bias and makes selection into the treatment group as good as random. This is a superior approach to those used in many other studies as it ensures that comparison is only between similar units.

To facilitate achievement of objectives of this study, primary data on various variables was collected from maize farmers in Busia County by research assistants using questionnaires. Several appropriate transformations were made on the data to generate variables appropriate for this study. The transformations involved dividing the harvest with size of land to get the yield ratio before further conversion into logarithms to be used in the estimation of the production function. To estimate labor hours to be used in the analysis, the study assumed that all farmers employed labor with identical work rate. Further, the study standardized labor hours into one unit of time per acre per “weeding” so that the actual labor hours were computed by multiplying land size with the number of “weedings”. Profit used in the regression was calculated by subtracting the sum of labor cost, seed cost and fertilizer costs from sales.

To find out the effect of improved input on yield and profit, robust regression estimation was conducted. This was after the model had been tested for specification, normality, multicollinearity
and heteroscedasticity. ATET of OAF on maize yield and profit were estimated using the PSM. Average treatment effect on the treated (ATET) on the yield was identical to averaging the yield among OAF members and doing the same for similar OAF non-members and taking the difference between the two averages. Similar intuition was followed while estimating ATET of OAF on profit where profit was used in the place of yield. Estimation of ATET was preceded by density plots tests to ensure matching had balanced the covariates. In addition overlap assumption was verified by visual plots and affirmed by use of KS test for equality of two distributions.

The first objective for this study was to examine how improved inputs affect the yield of maize among all maize farmers in Busia County, Kenya. From regression results, planting maize using inorganic fertilizer majorly DAP was noted to increase yield significantly up to an optimal level. Similar direction of influence was noted on the use of top-dressing fertilizer except that the effect was insignificant. Use of organic fertilizer was found to increase maize yield. This effect was highly significant. Increase in land size (a subsidiary factor) had the tendency of lowering yield significantly. In a complimentary, descriptive statistics showed that training increases yield; which contradicted regression results that indicated such effect to be negative but insignificant. Estimation based on regression adjustment following a Poisson distribution showed that maize yield increased with educational levels from none all-through to post-secondary. Multivalued analytical results also revealed that maize perform best in loam soil but relatively dismally in sandy soil (soil was as well used as a subsidiary factor to supplement improved inputs).

In this study, the second objective was to find out the effect of improved inputs on profit from maize farming among all maize farmers in Busia County, Kenya. Robust regression results indicated that use of improved maize seed lowered profits. On the other hand, both the use of
chemical fertilizer during planting and organic manure were noted to increase profits significantly. Training and use of top-dressing fertilizer were noted to reduce profit insignificantly. Note however that estimation using top-dressing fertilizer as a binary variable indicated that those who added this fertilizer got more profits than those who did not, the effect was still insignificant.

The third and fourth objectives were concerned with examining the effect of One Acre Fund on yield and profit respectively among maize farmers in Busia County. The ATET estimation results showed that OAF members get considerably higher yields and profits as compared to their similar but OAF non-members.

**5.3. Conclusion**

The findings of this study indicated that use of hybrid seed, inorganic fertilizer in combination with organic manure increased maize yield. This implies that Busia County maize farmers have the potential of increasing their yield if they embrace use of these inputs. The low yield experienced in the county is likely to result from constrained access to modern farming requirements. More so, the low profits are likely to be experienced if the farmers are denied access to cheap improved inputs (chemical fertilizer and certified seeds) as well as constrained access and/or limited use of freely available organic fertilizer.

The findings of this study further indicated that members under OAF were doing better in terms of financial gains from maize farmers and maize yield relative to their similar non-member counterparts. The implication of this is that OAF is benefiting its members.
5.4. Policy Recommendations

In light of the findings of this study, the study recommends for use of inorganic fertilizer during planting and also top-dressing. The study further endorses the combined use of organic and inorganic fertilizer as the best alternative to maximize yield. In this line, total disuse of fertilizer should be discouraged and instead farmers utilize at least either organic or inorganic fertilizer if they cannot manage to use both. To ensure that farmers access these inputs with a lot of ease, the study recommends that several agents such as NGOs that can bridge this gap should take active part. Farmers are also advised to cultivate land size that they can manage efficiently. In addition, they should reconsider growing of maize in sandy soils.

To increase profits from maize farming, the study recommends increased use of manure as it mostly comes at no cost especially among those who own domestic animal like cattle was. Farmers should also apply inorganic fertilizer during planting of maize as well as apply certain type (mostly CAN) during the growth of the crop. The study however advocates for proper use of this fertilizer since beyond optimal levels, gains from this fertilizer are eroded by high costs (marginal cost exceeds marginal benefit). This study also finds it noble for making it possible for farmers to access marketing board for example through its decentralization so as to avoid exploitation from unscrupulous middlemen who buy maize at low prices. In the mean time before prices are standardized, the study recommends for farmers to store their produce as they await price increase during times of shortages majorly between January and April.

Informed by the research findings, this study proposes that farmers should be encouraged to join OAF since it was empirically shown to have the effect of increasing both maize yield and profit from the crop.
5.5. Areas for Further Research

Extensive researches have been done in the field of agriculture to examine how maize yield respond to several inputs. This study in addition to evaluating how these inputs affect maize profit and yield, also focused on how activities of OAF affect these two outcomes. It is however worth noting that several areas related to maize farming still need to be investigated. Thus this study suggests that future researchers should consider themes aimed at: replication of this study in other areas, comparison of OAF with other organizations among other areas.
Reference


Sustainable Development, Productive Sector Growth and Environment Division


## Table A1: Maize Yield for Selected Countries and Regions in the World (2013-2016)

<table>
<thead>
<tr>
<th>Country/Region</th>
<th>Yield In 2013/14</th>
<th>2014/15</th>
<th>2015/16 projected</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>World</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td>9.93</td>
<td>10.73</td>
<td>10.57</td>
</tr>
<tr>
<td>Total Foreign</td>
<td>4.39</td>
<td>4.47</td>
<td>4.32</td>
</tr>
<tr>
<td>China</td>
<td>6.02</td>
<td>5.81</td>
<td>5.89</td>
</tr>
<tr>
<td><strong>South America</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td>5.06</td>
<td>5.4</td>
<td>5.16</td>
</tr>
<tr>
<td>Argentina</td>
<td>7.65</td>
<td>8.18</td>
<td>7.94</td>
</tr>
<tr>
<td>Bolivia</td>
<td>2.3</td>
<td>2.3</td>
<td>2.31</td>
</tr>
<tr>
<td><strong>European Union</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>6.69</td>
<td>7.95</td>
<td>6.22</td>
</tr>
<tr>
<td><strong>Africa</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Africa</td>
<td>4.85</td>
<td>3.54</td>
<td>3.64</td>
</tr>
<tr>
<td>Nigeria</td>
<td>1.81</td>
<td>1.81</td>
<td>1.84</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>2.78</td>
<td>2.71</td>
<td>2.5</td>
</tr>
<tr>
<td>Egypt</td>
<td>8.12</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Tanzania</td>
<td>1.3</td>
<td>1.25</td>
<td>1.38</td>
</tr>
<tr>
<td>Malawi</td>
<td>2.17</td>
<td>2.25</td>
<td>1.64</td>
</tr>
<tr>
<td>Zambia</td>
<td>2.57</td>
<td>2.8</td>
<td>2.72</td>
</tr>
<tr>
<td><strong>Kenya</strong></td>
<td><strong>1.56</strong></td>
<td><strong>1.61</strong></td>
<td><strong>1.65</strong></td>
</tr>
<tr>
<td>Uganda</td>
<td>2.75</td>
<td>2.75</td>
<td>2.6</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>0.89</td>
<td>1</td>
<td>0.46</td>
</tr>
<tr>
<td><strong>Former Soviet Union-12</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ukrain</td>
<td>6.4</td>
<td>6.15</td>
<td>5.73</td>
</tr>
<tr>
<td>Russia</td>
<td>5.01</td>
<td>4.36</td>
<td>4.91</td>
</tr>
<tr>
<td><strong>South Asia</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>India</td>
<td>2.68</td>
<td>2.55</td>
<td>2.33</td>
</tr>
<tr>
<td>Pakistan</td>
<td>4.23</td>
<td>4.15</td>
<td>4.43</td>
</tr>
<tr>
<td>Nepal</td>
<td>2.52</td>
<td>2.54</td>
<td>2.22</td>
</tr>
<tr>
<td><strong>Southeast Asia</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indonesia</td>
<td>2.92</td>
<td>2.99</td>
<td>3.06</td>
</tr>
<tr>
<td>Philippines</td>
<td>2.91</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Vietnam</td>
<td>4.4</td>
<td>4.47</td>
<td>4.62</td>
</tr>
<tr>
<td>Thailand</td>
<td>4.38</td>
<td>4.36</td>
<td>4.31</td>
</tr>
<tr>
<td>Mexico</td>
<td>3.24</td>
<td>3.48</td>
<td>3.36</td>
</tr>
<tr>
<td>Canada</td>
<td>9.59</td>
<td>9.36</td>
<td>10.38</td>
</tr>
<tr>
<td>Turkey</td>
<td>8.79</td>
<td>8.73</td>
<td>9.68</td>
</tr>
<tr>
<td>Others</td>
<td>2.26</td>
<td>2.47</td>
<td>2.34</td>
</tr>
</tbody>
</table>

Source: USDA 2016. Foreign Agricultural Service/USDA February 2016 Office of Global Analysis
Table A2: Climatic Hazards and Population Affected in Different Parts of Kenya from 1970-2012

<table>
<thead>
<tr>
<th>Year</th>
<th>type of disaster</th>
<th>area of coverage</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>Floods</td>
<td>Nyanza/Western</td>
<td>84 people killed, 30,000 displaced About 280,000 people affected countrywide</td>
</tr>
<tr>
<td>2012</td>
<td>Drought</td>
<td>Widespread</td>
<td>3.75 million people in dire need of food by July 2012</td>
</tr>
<tr>
<td>2011</td>
<td>Drought</td>
<td>Garissa,Isiolo,Wajir,Mandera Mombasa,Marsabit,Nairobi,Turkana Samburu and Turkana Counties</td>
<td>4.3 million people were in dire need of food</td>
</tr>
<tr>
<td>2010</td>
<td>Floods</td>
<td>Budalangi, Tana river, Turkana</td>
<td>73 killed, 14,585 people affected</td>
</tr>
<tr>
<td>2009</td>
<td>Droughts</td>
<td>Widespread</td>
<td>70-90% loss of livestock by Maasai pastoralists</td>
</tr>
<tr>
<td>2007/2008</td>
<td>Drought</td>
<td>Widespread</td>
<td>4.4 million people affected, 2.6 million people at risk of starvation, up to 70% loss of livestock in some pastoral communities</td>
</tr>
<tr>
<td>2006</td>
<td>Drought</td>
<td>widespread</td>
<td>3.5 million in need food by September, 40 human lives lost and about 40% cattle, 27% sheep and 17% goats lost</td>
</tr>
<tr>
<td>2006</td>
<td>Floods</td>
<td>Widespread</td>
<td>7 deaths, 3,500 people displaced</td>
</tr>
<tr>
<td>2005</td>
<td>Drought</td>
<td>Widespread</td>
<td>2.5 million People close to starvation. Declared a national disaster</td>
</tr>
<tr>
<td>2004/2005</td>
<td>Floods</td>
<td>Budalangi, Nyando</td>
<td>34000 people affected</td>
</tr>
<tr>
<td>2004</td>
<td>Drought</td>
<td>Widespread</td>
<td>About 3 million people in need of relief aid for 8 months to March 2005</td>
</tr>
<tr>
<td>2003</td>
<td>Floods</td>
<td>Nyanza/Westen, Tana River Basin</td>
<td>60,000 people affected by severe floods (28000 in Budalangi’)</td>
</tr>
<tr>
<td>2002</td>
<td>Floods</td>
<td>Nyanza, Busia, Tana River Basin</td>
<td>150,000 people affected</td>
</tr>
<tr>
<td>1999/2001</td>
<td>Drought</td>
<td>Widespread</td>
<td>4.4 million people affected</td>
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<tr>
<td>1997/1998</td>
<td>El nino floods</td>
<td>Widespread</td>
<td>1.5 million people affected</td>
</tr>
<tr>
<td>1995/1996</td>
<td>Drought</td>
<td>Widespread</td>
<td>2 million people affected (1.41 million in ASAL). Declared a national disaster</td>
</tr>
<tr>
<td>1991/1992</td>
<td>Drought</td>
<td>ASAL zone</td>
<td>1.5 million affected</td>
</tr>
<tr>
<td>1985</td>
<td>Floods</td>
<td>Nyanza/Western</td>
<td>10000 people affected</td>
</tr>
<tr>
<td>1983/1984</td>
<td>Drought</td>
<td>Widespread</td>
<td>200000 people affected</td>
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<td>1982</td>
<td>Floods</td>
<td>Nyanza</td>
<td>4000 people affected</td>
</tr>
<tr>
<td>1980</td>
<td>Drought</td>
<td>Widespread</td>
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<td>1977</td>
<td>Drought</td>
<td>Widespread</td>
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<tr>
<td>1975</td>
<td>Drought</td>
<td>Widespread</td>
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<tr>
<td>1971</td>
<td>Drought</td>
<td>Widespread</td>
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Source: Author’s compilation from ojwang’ et al (2010) and Huho& Kosonei(2014)
### Table A3: Kenya National Maize Production, Acreage, Yield and Price 1975-2012

<table>
<thead>
<tr>
<th>years</th>
<th>Area(000' ha)</th>
<th>Total Production (000' tons)</th>
<th>yield (ton/ha)</th>
<th>Price(ksh/90kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975</td>
<td>1162</td>
<td>1267</td>
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<td>1976</td>
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<td>1597</td>
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<td>1978</td>
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<td>1671</td>
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<td>1620</td>
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<td>1980</td>
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<td>1607</td>
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Source: Author’s compilation and computation from (KASDC) 2010 and Economic Reviews of agriculture various years.
Table A4: Maize Production, acreage and yield for Western Province from 1971-2012

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<thead>
<tr>
<th>Year</th>
<th>Area (Ha)</th>
<th>Production (Tons)</th>
<th>Tons/Ha</th>
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<tbody>
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<tr>
<td>1974</td>
<td>139103</td>
<td>343428</td>
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<tr>
<td>1975</td>
<td>125842</td>
<td>273728</td>
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<td>137662</td>
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<td>596896</td>
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Source: Author’s compilation and computation from (KASDC) 2010 and Economic Reviews of agriculture various years

Note: ...Data not available
Table A5: Model Specification Test Results

| Variable  | Coefficients/Model       | t-Value | P > |t|  |
|-----------|--------------------------|---------|-----|---|
| _hat      | 0.5579625 (1.144031)     | 0.49    | 0.626 |
| _hatsq    | 0.1050128 (0.2700362)    | 0.39    | 0.698 |
| _constant | 0.4531265 (1.203124)     | 0.38    | 0.707 |

Number of obs: 264
F (2, 261) = 29.91
Prob > F = 0.0000
Adj R-squared = 0.1802

Source: Author’s Estimation from Study Data

Table A6: Test for Normality

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<tr>
<th>Variable</th>
<th>obs</th>
<th>Pr (skewness)</th>
<th>Pr(kurtosis)</th>
<th>Adj chi2 (2)</th>
<th>Joint prob&gt;chi2</th>
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<td>0.2513</td>
<td>11.88</td>
<td>0.0026</td>
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<table>
<thead>
<tr>
<th>Variable</th>
<th>obs</th>
<th>W</th>
<th>V</th>
<th>Z</th>
<th>Prob &gt;z</th>
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Source: Author’s Estimation from Study Data
Table A7: Heteroscedasticity Test Results

<table>
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<tr>
<th>Breusch-Pagan/Cook-Weisberg Test For Heteroskedasticity</th>
<th>Ho: Constant Variance</th>
<th>Variable: Fitted Values of Logyield</th>
</tr>
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<tbody>
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<td>Chi2(1)</td>
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<td>Prob&gt;chi2</td>
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<tr>
<th>Whites’s test for Ho: homoscedasticity</th>
<th>Against Ha: unrestricted Heteroskedasticity</th>
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<tr>
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<th>Cameron &amp; Trivedi’s decomposition of IM-test</th>
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<td>Skewness</td>
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<tr>
<td>Kurtosis</td>
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Source: Author’s Estimation from Study Data
### Table A8: Multicollinearity Test Results

**Multicollinearity test using VIF**

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<td>Mean VIF</td>
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**Multicollinearity test by regression using loglansize as dependent variable**

| Variable      | Coefficient | t-value | \( P > \ |t| \) |
|---------------|-------------|---------|-----------------|
| Seedtype      | -0.0283113  | -0.60   | 0.548           |
|               | (0.047008)  |         |                 |
| DAPplanting   | 0.0035424   | 1.52    | 0.129           |
|               | (0.0023287) |         |                 |
| DAPsq         | -7.34e-06   | -0.34   | 0.735           |
|               | 0.00000217  |         |                 |
| Topdress      | 0.0027866   | 2.16    | 0.032           |
|               | (0.0012893) |         |                 |
| organicfertil | 0.0000634   | 1.52    | 0.129           |
|               | 0.0000417   |         |                 |
| trainedtimes  | -0.0128281  | -2.77   | 0.006           |
|               | (0.0046364) |         |                 |
| loglaborhrs   | 0.8234985   | 35.79   | 0.000           |
|               | (0.0230124) |         |                 |
| Constant      | -0.9636698  | -23.69  | 0.000           |
|               | (0.040686)  |         |                 |

Prob > F = 0.0000  
Adj R – squared = 0.9030

**Multicollinearity test by pairwise correlation**

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<th>DAPsq</th>
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<th>Loglaborhrs</th>
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<td>0.7492</td>
<td>0.6050</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>organicfertil</td>
<td>0.0395</td>
<td>-0.1442</td>
<td>-0.1264</td>
<td>-0.0720</td>
<td>-0.1204</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>trainedtimes</td>
<td>0.0865</td>
<td>0.3712</td>
<td>0.2437</td>
<td>0.1022</td>
<td>0.2306</td>
<td>-0.0987</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>loglandsize</td>
<td>-0.2260</td>
<td>-0.0025</td>
<td>0.4532</td>
<td>0.4434</td>
<td>0.4318</td>
<td>0.2306</td>
<td>-0.2279</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>loglaborhrs</td>
<td>-0.0148</td>
<td>-0.0146</td>
<td>0.4057</td>
<td>0.4032</td>
<td>0.3809</td>
<td>0.2407</td>
<td>-0.2218</td>
<td>0.9458</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Source: Author’s Estimation from Study Data
Table A9: Estimation of how Yield is affected while using some Inputs as Binary Variable

| Variable            | Coefficients/Model   | t-value | P>|t| |
|---------------------|----------------------|---------|-----|
| Seedtype            | 0.1743593 (0.1151834)| 1.51    | 0.131 |
| dapcat1             | 0.191647 (0.1549352)| 1.24    | 0.217 |
| topdresscat1        | 0.4380146** (0.2136055)| 2.05    | 0.041 |
| Organicfert         | 0.0002646** (0.000053)| 4.99    | 0.000 |
| Trained             | -0.0436304 (0.000053)| -0.50   | 0.616 |
| Loglandsise         | -0.6229832*** (0.1169157)| -5.33   | 0.000 |
| Loglaborhrs         | 0.4745637*** (0.120792)| 3.93    | 0.000 |
| Constant            | 1.060779*** (0.231227)| 4.59    | 0.000 |

F (7, 256) = 9.46, Prob > F = 0.000
R-squared = 0.1787

Note: Standard errors in parenthesis.

***significant at 1%, **significant at 5%

Source: Author’s Estimation from the Study Data.

Table A10: Farmers’ Opinions on the Effect of Training on Maize Yield

<table>
<thead>
<tr>
<th>In your own opinion training help improve yield</th>
<th>Frequency</th>
<th>Percent</th>
<th>Cumulative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly agree</td>
<td>194</td>
<td>73.48</td>
<td>73.48</td>
</tr>
<tr>
<td>Agree</td>
<td>56</td>
<td>21.21</td>
<td>94.70</td>
</tr>
<tr>
<td>Neutral</td>
<td>8</td>
<td>3.03</td>
<td>97.73</td>
</tr>
<tr>
<td>Disagree</td>
<td>6</td>
<td>2.27</td>
<td>100.00</td>
</tr>
<tr>
<td>Total</td>
<td>264</td>
<td>100.00</td>
<td></td>
</tr>
</tbody>
</table>

Source: Author’s Estimation from the Study Data.
Figure A1: Trends of Maize Yield and Production in Western Province of Kenya

Source: Author’s computation and compilation from Kenya agricultural sector compendium (KASDC) 2010 and Economic Review of Agriculture various year
Figure A2: Busia County Map

Source: Kenya Mpya, 2012
Figure A3: One Acre Fund Delivering Inputs to Its Clients in Tanzania

Source: One Acre Fund Annual report 2013
Appendix II: Research permit

THIS IS TO CERTIFY THAT:
MR. SILVANUS OKUMU OPIYO
of KENYATTA UNIVERSITY, 42-50226
MYANGA, has been permitted to conduct
research in Busia County

on the topic: IMPACT OF
INTERVENTIONS BY ONE ACRE FUND ON
MAIZE YIELD IN BUSIA COUNTY, KENYA

for the period ending:
8th May, 2018

Applicant’s Signature

[Signature]

Permit No: NACOSTI/P/17/71487/16964
Date of Issue: 9th May, 2017
Fee Received: Ksh 1000

Director General
National Commission for Science, Technology & Innovation

[Signature]
Appendix III: Research Questionnaire

My name is Silvanus Okumu a Master’s student at Kenyatta University taking Economics (Econometric option). A research project is one of our course requirements; as such I’m interested in examining the response of maize yield on various farming practices among One Acre Fund members and non-members. The information requested here is purely for academic purposes and will be handled with a lot of confidentiality. Kindly respond with a lot of honesty.

SECTION A: FARMER’S PERSONAL INFORMATION

1. a. Name…………………………………………..Mobile Number…………………………

b. Sex (tick appropriately). Male [ ] Female [ ]

c. Age in years) [ ]

d. Marital status (tick appropriately): Married [ ] Single [ ] Divorced/Separated [ ] Widow/widower [ ]

e. Total Household size:……………………(specify)

f. Area of residence: Sub-county…………………… Division……………………………

Ward…………………………Location………………………… Sub-Location………

g. Level of education:

None [ ] Primary [ ] secondary [ ] college and above [ ]

2. a). Are you a member of one acre fund? Yes [ ] No [ ]

b) If yes which year did you join? 2016 [ ] 2015 [ ] 2014 [ ] 2013 or before [ ]
c) If not a member, have you ever been a member before? (Chose appropriately).

Yes [ ]     Why did you quit it?............................................................... 

...........................................................................................................

No [ ]     Why haven’t you joined?...........................................................

...........................................................................................................

Section B: On Farm Activities For 2016 March-September Season

1. (a). what size of land was under maize? ...............Acres.

   (b)(i) what was the source of labor?  Family labor [ ]  Hired [ ]  Group labor [ ]

   (ii) How much did the labor cost you for:

       Land Preparation?.........................ksh.

       Weeding?.....................ksh.  Harvesting.....................ksh

   (c)(i) what type of seeds did you plant?  Hybrid [ ]  Local [ ]

   ii) Where did you get your seed? One Acre Fund [ ]  subsidized government agents [ ]

       others [ ]  .........................  (Specify).

   (iii) How much did the seed cost?..............................ksh.

   iv) Specify spacing between two maize stems.............. (Centimetres)

   v) How many times did you do the weeding? ............... 

   vi) Did you inter-crop maize with other crops?     Yes [ ]     No [ ]

       If yes with which crop(s)?................................................................. Why?..............

...........................................................................................................
d) Fertilizer details:

<table>
<thead>
<tr>
<th>Activity/others</th>
<th>Fertilizer Type</th>
<th>Quantity(Kg/litre)</th>
<th>Cost(Ksh)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planting</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top dressing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Folia feed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

e) What was the soil type under which maize was grown? ............................................

2. What was your maize harvest in 90Kg bags ...................

SECTION C: POST HARVEST ACTIVITIES

1. a) Did you sell any of your maize produce? Yes [  ] No [  ]

   b) i) If Yes, what quantity did you sell? ...............kg.

      ii) What was the selling price? .................ksh/kg or for how much? .................ksh

      iii) Where did you sell your maize?  Through One Acre Fund [  ]

      Direct to market [  ]  Kenya Marketing and cereals board [  ]

   c) If you didn’t sell your maize at all, explain briefly why.................................

      .........................................................................................................................

2. In your own opinion how can the sales from maize be improved? Explain briefly

   ..............................................................................................................................
Section D: Additional Information

1. Did you receive any training on maize farming during or before 2015 March-September season? Yes [ ] No [ ]

2. i) If yes from whom? One Acre Fund field staff [ ]

                   Others [ ] specify .................................................................

                   How many times did you attend the training?..........................

3. In your own view (chose appropriately):

   i) Training helps improve yield. Strongly agree [ ] Agree [ ]

                   Somewhat [ ] Disagree [ ] strongly disagree [ ]

   ii) One Acre Fund helps increase yield. Strongly agree [ ] Agree [ ]

                   Somewhat [ ] Disagree [ ] strongly disagree [ ]

4. Does One Acre Fund generally help improve farmers’ lives? Yes [ ] No [ ]

                   Explain briefly........................................................................................................

4. Does One Acre Fund generally help improve farmers’ lives? Yes [ ] No [ ]

                   Explain briefly........................................................................................................

5. Other than One Acre Fund, do you belong to any other organization that supports farmers?

   Yes [ ] No [ ] If yes

   a) Specify...........................................................

   b) Lists ways in which it supports farmers.................................................................

                   ......................................................................................................................

6. In your own view what can be done to improve the yield of maize?...........................

                   ......................................................................................................................

END