EFFECT OF IMPROVED SWEET POTATO VARIETIES ON HOUSEHOLD FOOD SECURITY IN BUNGOMA COUNTY, KENYA

Victor Kilui Wabwile

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DECLARATION AND APPROVAL

Declaration

This research thesis is my original work and has not been submitted for an award of any degree in any other University.

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Signature Date

Kilui Victor Wabwile

KM17/3585/13

Approval

This research thesis has been submitted with our approval as Supervisors.

_  _ _____

Signature Date

Professor B.K Mutai (PhD)

Professor Department of Agricultural Economics and Agribusiness Management, Egerton University, Njoro (Kenya)

__  __ _____

Signature Date

Dr Jackson K Langat (PhD)

Department of Agricultural Economics and Agribusiness Management, Egerton University, Njoro (Kenya)

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DEDICATION

This book is heartily dedicated to my lovely parents and all my relatives and friends, especially my father Dr. Kiiya Wycliffe, my mother Gladys Wabwile and the people who helped in making my life joyful.

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ABSTRACT

Kenya's Agricultural Sector Development Strategy (ASDS), envisions a food secure and prosperous nation with the overall goal of the agricultural sector to achieve an average growth rate of 7 percent per year. The strategy has, among others, target to reduce food insecurity by 30 percent to surpass the MDGs by the year 2015. About 60 per cent of households in western Kenya live below poverty line an indication of a high proportion of the population without adequate quantity and quality of food intake. With the adoption of agricultural intensification strategies which entails investments in modern inputs and technologies, the development of the (ISVs) improved sweet potato varieties by Kenya Agriculture and Livestock Research Organization(KALRO) is better option to increase agricultural production and quality produce and reduce food insecurity. However, before undertaking any impact assessment, it was imperative to establish whether the participation by farmers was instrumental in the adoption of technologies and innovations. This study aimed at shedding light on the potential contribution of improved sweet potato varieties on food security in Bungoma East Sub county, Bungoma County. The analysis was based on the data collected from a sample of 164 farm households in the sub county. A multistage sampling procedure was used to arrive at the sample, with semi structured questionnaires employed as the research instrument to collect qualitative and quantitative data through face to face interviews. Household Dietary Diversity Index (HDDS) method was used to measure food security (assess the access and quality of food intake). I used descriptive statistics, Heckman two step model and endogenous switching probit model to analyse. SPSS and STATA computer programs were used to process the data. The results show that adoption of improved sweet potato varieties were largely influenced by extension contact and also education level but negatively influenced by farming experience as expected. However the adoption of ISVs (Improved Sweetpotato Varieties) had a robust and positive effect on farmer's household food security. In counterfactual case, adopters have 7.8% probability of being food secure while non adopters would have 6.8% probability of being food insecure hence better-off not adopting the ISVs through reduced food security. The need to strengthen extension services by the government since farmers get most of their information about new technologies from them, diversifying farm income through creation of sustainable off-farm activities and strengthen contractual agreements in marketing to wipe out middlemen in the process and assure farmers constant market for their produce are among the public policy recommendations that would help increase probability of being food secure.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

CBO:	Community Based Organizations
FAO:	Food and Agricultural Organizations (United Nations)
GOK:	Government of Kenya
KARI:	Kenya Agricultural Research Institute
KACE:	Kenya Agricultural Commodity Exchange.
MDG:	Millennium Development Goals
MOA:	Ministry of Agriculture
NGO:	Non-Government Organizations
OFSP:	Orange Fleshed Sweet Potato
OAF:	One Acre Fund
USAID:	United States Agency for International Development
HCDA:	Horticultural Crops Development Authority
KNBS:	Kenya National Bureau of Statistics
CBS:	Central Bearue of Statistics.
IAR4D:	Integrated Agricultural Research for Development
CREADIS:	Community Research in Environment and Development Initiatives
ISVs:	Improved Sweet potato Varrieties.

CHAPTER ONE
INTRODUCTION

1.1 Background Information

Achieving food security is a prerequisite to realizing the first and the third United Nations MDGs (Millennium development Goals) that are concerned with reducing the proportion of people who suffer from hunger and is the major objective of the Kenya government. The scarcity of productive land is a central issue in agricultural policy (GOK, 2004). Agricultural production is concentrated in high potential areas where population density is high. Nevertheless 80% of the country is classified as semi arid. At low levels of income, the paramount concern for the human being is to meet the energy needs to overcome hunger. Cereals provide the cheapest source of energy but with the increasing population and decreasing farm sizes, farm households have diversified to other crops like the sweet potato (*Ipomoea batatas l*). Generally, traditional foods are used to fill in the gaps and in so doing they contribute to the food security and also provide dietary diversity for the people (Musinguzi *et al*., 2006).

The nutritional aspect of food security is often overlooked in favor of simply ensuring people are eating regular meals. However, an important part of food security is access to "nutritionally adequate and safe foods" (Radimer, 2002). International studies report that healthy food is more expensive than unhealthy food, and local studies have shown that people in welfare or low-income categories are less likely to buy and eat healthy food (Kettings and Voevodin, 2009). In Kenya, over 75% of sweet potato production is concentrated in western, central and coastal areas of the country. Out of this, over 80% is grown in the Lake Victoria basin (Gruneberg *et al*., 2004). In western Kenya, farmers grow landrace varieties that are preferred locally but lack consumption appeal for distant markets.

The food crop come in a range of skin and flesh colors, from white, to orange, to deep purple fleshed roots. New and improved high-yielding varieties have been introduced to farmers throughout Kenya, the orange fleshed sweet potato (OFSP) has a lot of nutritional benefits and it has a high content of β-carotene (a chemical element used by the body to generate Vitamin A) and sufficient dry matter to satisfy consumer preferences and taste. Subsequent studies demonstrated that the consumption of just small amounts of foods derived from the new OFSVs could eliminate or greatly reduce Vitamin A deficiencies in both young children and pregnant and lactating women (Harvest Plus, 2003). The most traded variety is the red skinned and yellow fleshed (RSYF) sweet potato, due to its high consumer demand. It

has the highest market share of 73% (USAID, 2012), especially in Nairobi and Kisumu, where it is traded mainly in the informal markets. The red and white skinned sweet potatoes (RWSWF) are more popular in Mombasa, where the agro-ecological factors favor its production.

It is among the world's most important, versatile, and underexploited food crops with more than 133 million tons in annual production. Worldwide, sweet potato is the sixth most important food crop after rice, wheat, potatoes, maize, and cassava while in most of the developing nations sweet potato is the fifth most important food crop (CIP, 2013). It is an important food security crop for rural household and has a high yield potential that may be realized within a relatively short growing season. It is also adaptable to a wide ecological range of 0 to 2000 meters above sea level. Sweet potatoes is grown in a wide range of soil type, but does best on soils of friable/loose nature, which permit expansion of tubers. Sweet potatoes grow best in fertile sandy loams and do poorly in clay soils. The crop does poorly in water logged, too shallow or stony soils. Poorly aerated and bulky soils retard tuber formation and reduced yields. The crop is sensitive to saline and alkaline soils and they should be avoided. Too high fertility may result in excessive vegetative growth at the expense of tuber and starch formation. It grows best at 24 0C, when temperatures fall below 120C or exceeds 350C growth is retarded. 750 – 1000mm ideal but crop can withstand drought though under drought conditions, yield s are drastically reduced if drought occurs in the first 6 weeks after planting and also during root formation and development.

The area under production grew from 20,181 hectares yielding 527,470 tons (valued at KSh 4 billion) in 2009 to 22,989 hectares in 2011 yielding 1,000,267 tons valued at KSh 7.6 billion (HCDA, 2012). Sweet potato is the third most important food crop in Kenya after maize and Irish potato (CIP, 2013). It is a low-input crop making it ideal for many smallholder households. Its contribution to nutrition security has increasingly been recognized, prompting several entities to support tailor-made interventions specifically targeting the sweet potato value chain. The sweet potato is widely enjoyed, and with increasing awareness of its nutritional value and the steadily growing Kenyan population, demand is expected to increase significantly. This presents increased production potential for domestic consumption and subsequent marketing opportunities that cannot be satisfied by the prevailing production levels. The crop is mainly consumed fresh, with negligible exploitation of processing opportunities due to lack of consumer awareness on utilization of sweet potato in processed form.

Generally, production of sweet potato in Kenya has steadily increased over the years as shown in Figure1 below. According to the MOA (2011), sweet potato production increased by 89% between 2004 and 2009, a scenario attributed to use of improved cultivars and farming methods which have helped increase yield per unit area (MOA, 2010; Kenyon *et al*., 2006). In the recent past, there have been renewed efforts by the government and other players in the agriculture sector to promote production of traditional high value crops of which sweet potato is among them. For example, through the traditional high value crops (THVC) programmed, the government distributes to farmers improved planting materials for the crops as one of the activities in efforts to promote their production.

Important research efforts have been devoted to select, breed, and disseminate new sweetpotato varieties that enhance the productivity and quality of food crops, alleviating poverty and food insecurity. The crop is considered as one of the "orphaned" crops along with cassava, amaranth and millet among others because less research and promotion has been accorded to them compared to crops like maize and rice ,but increasingly more such crops are being liberated from their orphaned nature as their qualities of nutrition; low input requirements and drought tolerant are being appreciated in the face of population pressure increase need for food (KACE, 2012). These efforts are a result of the recognition of the important role of these crops in contributing to food security through increasing food supply to both the producers and consumers and generating income to the producers.

It is produced on small scale in a household based subsistence economy in Africa (Kisiangani and Pasteur, 2008). The crop is typically a small farmer crop and often grown on marginal soils with limited outputs. Sweet potatoes can be boiled, roasted, fried, creamed or baked in their skins (Tewe *et al*., 2003). They are easily combined with both sweet and savory dishes and are mostly grown on small scale in compound gardens. Research has developed utilization methods like making of chips, blending of sweet potato flour with wheat flour for products like *chapati, mandazi* or porridge (Nungo *et al*., 2007). These different methods are intended to increase utilization hence, increasing sweet potato production leading to improve incomes and food security among the poorer segments of the rural population. However, there is limited documentation of farmers' dietary habits and consumption patterns.

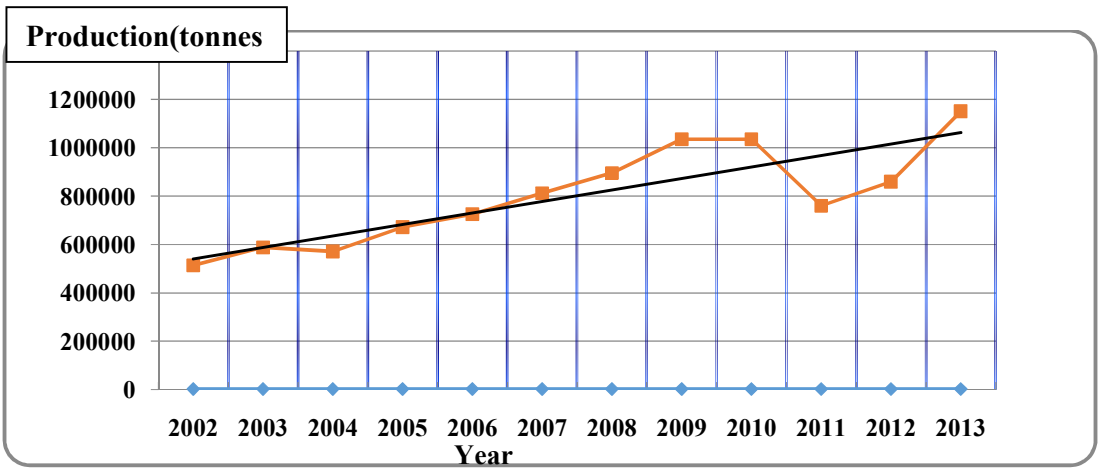

Figure 1: Sweet Potato Production Trend in Kenya.
Source: FAOSTAT (2013).

The use of sweet potato flour blended with wheat flour for *chapati* has been adopted in the north rift (Rono *et al*., 2006). Thus, sweet potato is an important tropical food crop with versatile utility. The tubers are used as a subsidiary food after boiling, baking and frying. Tubers also form an industrial raw material for the production of starch; alcohol, pectin etc. and the surplus as well as culled tubers can be used fresh or dehydrated in rations for livestock (Nedunchezhiyan *et al*., 2006).

In Kenya, sweet potato is recognized as an alternative food crop among many households, whose main staple food is maize (Low *et al.,* 1997). It is often considered "subsistence", "food security" or "famine relief" crop (Günter *et al*., 2010). Its importance is evident when there is shortage in maize supply, usually when there is shortfall in production or immediate time before harvest of maize. In such cases, sweet potato and other indigenous tubers such as cassava become very important in the diet of many rural households. On the other hand, demand for sweet potato among the urban population is growing rapidly due to changing consumption patterns and population growth. Therefore, the importance of sweet potato in Kenya cannot be overemphasized due to the potential that it holds for both producers (as an income generating enterprise) and consumers (as a source of nutritious staple food). There millions of dollars invested in sweet potato research, but very little is known about their impacts and whether these improved varieties are widely adopted and their distributional impacts on the poor. Policy makers and donors need information on these impacts to allocate resources to fruitful lines of research and to strengthen the role of agricultural research in fighting poverty, hunger, and malnutrition.

International organizations and governments expect improved varieties to alleviate malnutrition and hunger, but, to date, impact assessment studies have mainly focused on productivity and aggregate welfare measures. Fewer studies document the impact of technology adoption on household food security (Kabunga *et al*., 2014; Rusike *et al*., 2010 and Shiferaw *et al*., 2014). Various reasons explain the limited number of studies on food security. Nutrition is one of the last outcomes to be affected along the long adoption impact pathway (Chung, 2012). Because of the important lag between adoption and improvement in nutritional status, one might fail to detect impact. Moreover, measuring food security, due to its multidimensionality, is challenging and consensus on the methodology to use is lacking (Barrett, 2010; Coates, 2013).

1.2 Statement of the Problem

The new improved sweet potato varieties (ISVs) were developed by KARI (Ndolo, 2011) with several objectives: to increase household income and reduce poverty, reduce household food insecurity, improve nutrition and health and increase production through sound agricultural practises. More farmers are increasingly adopting the improved varieties (KARI, 2014). Despite this adoption rates food insecurity in the Bungoma county still high, with statistics showing 60% of the population largely exposed to food insecurity and same percentage of households in the large western Kenya living below poverty line (CBS, 2008). However, the potential of the crop's contribution to food security, increased incomes and reduction of nutritional deficit is unclear since the food crop has yet to be fully exploited in this part of the country. NGOs and governments expect improved varieties to alleviate food insecurity, but, to date, impact assessment studies have mainly focused on productivity and aggregate welfare measures.The increasing sweet potato production was therefore likely to offer farmers an escaping route to increased food security in the near future. This study therefore was aimed to fill this knowledge gap by examining if the adoption of this improved varieties plays a role in contributing to food security.

1.3 Objectives of the Study

1.3.1 General Objective

To contribute towards food security by examining the contribution of the improved sweet potatoes varieties on household food security in Bungoma County.

1.3.2 Specific Objectives

a) To characterize the household socio-economic attributes of sweet potato farmers.
b) To determine factors influencing adoption and the extent of adoption of the ISVs.
c) To determine the effect of the improved sweet potato varieties on household food security.

1.4 Research Questions/Hypothesis

To achieve the objectives of the study the following research questions were asked:

a) Socio-economic attributes do not significantly differ amoung sweet potato farmers in Bungoma county?
b) What factors influence adoption and the extent of adopting the improved sweet potato varieties?
c) There is no significant effect of improved sweet potato varieties effect on household food security.

1.5 Justification of the Study

Maize is the strongly preffered main staple food and also the most common crop grown by rural poor households in Bungoma county. With the recent challenges specifically the maize lethal neucrosis disease (MLND) and sugar sector, households are largely exposed to food insecurity (OAF, 2013). Agricultural technologies are aimed at improving quality and increasing yields in terms of production. The improved sweet potato varieties are said to be drought resistant, rich in vitamin A, high quality and high yielding. Therefore the adoption of this sweet potato varieties by farmers is likely to have a positive impact on household food security in terms of utilization, access, availabilty and stability. This study adds to the thin literature on food security impacts of technology adoption by rigorously documenting the linkages between adoption of improved sweet potato varieties and household dietary diversity other than focussing on outcome and production.

1.6 Scope and Limitations

The study was confined to Bungoma East Sub-County where the scope covered sweet potato farmers in this area. It is a small geographical area of the country; hence the results may not apply to others areas. The period of study under consideration was limited to 2014. Variables on socio economic, institutional are only selected and not necessarily mean that all variables are included.

1.7 Definition of Terms.

Food Security: Food security in this case is defined as " a situation in which all people, at all times, have physical, social and economic access to sufficient food which meets their dietary needs and food preferences for an active and healthy life"

Improved variety: New seed varieties that result in outputs that are of higher quality in some respect, even if yield does not improve.

Agricultural technology: Risk mitigating, quality improving, yield increasing and cost saving technologies.

Dietary diversity: It's the economic ability of a household to consume a variety of foods.

Adoption: Process in which farmers make decision to acquire and use new agricultural technology.

Household : Defined as an independent male or female producer and his/her dependants who must have lived together for a period not less than six months. The members are answerable to one person as the head and share the same eating arrangement.

Staple Food: Type of food that is eaten regularly and in such quantities as to constitute the dominant part of the diet and supply a major proportion of energy and nutrient needs.

Availability of food: It relates to volume of supply derived from domestic agricultural output and net food imports at the national level.

CHAPTER TWO
LITERATURE REVIEW

2.1 Household Food Security in Relation to Income

Temporary food insecurity is the result of short term fluctuations in production and consumption brought about by fluctuations in household incomes and availability of food at the household level. Temporary food insecurity is thus a manifestation of temporary lack of access to sufficient food, (Obasanjo *et al.,*1992). The analysis of food security has a long history in research on poverty, living standards and income distribution, (Hadaad, 2000). Relevant issues in this study were the share of specific items across different income levels, and the importance of child nutrition in poor families. Lundberg *et al.*(1996) discusses a number of studies that show that control over both earned and unearned income results in different expenditure patterns.

Rural food consumption patterns are substantially more diverse. It involves consumption of several crops including cassava, sorghum, millet, rice, bananas, maize etc(Alberto, 1981). Access to food encompasses physical and economic aspect. Physical access to food relate both to the adequacy of supply and to the efficiency of the distribution system, including storage, preservation, transport, marketing and processing. Economic access to food relates to the ability of group of people to establish entitlements over a requisite amount of food (Obasanjo *et al.,*1992).

Jacoby (1992) states that the farm - household is conceptualized as being endowed with a stock of resources termed the household resource base. These resources are allocated to a range of activities that are required to maintain the household's level of subsistence consumption and possibly to generate a surplus. More so, a remarkable division of labor based on gender characterizes production at all levels within the household. Furthermore, Maxwell *et al*. (1992) postulated that most families access food by consuming what they produce or by purchasing food in the growing season from income earned from their harvest time sales or from off farm work. Therefore, farmers are expected to generate income from the sale of their produce which can be used to purchase food besides consuming what they produce from any farming activity. The income generated can also be used to serve as capital for the production of other commodities such as livestock, hence diversification of farm enterprise and increased food base.

We hypothesize that the adoption of improved sweet potato varieties can lead to greater diet diversity and improved food security through various ways. First, adoption is

expected to have a direct and positive impact on farm income. As a result of this income growth, we expect a shift away from staples and greater consumption of meat, dairy products, fresh fruits and vegetables. In low-income countries such as Kenya, a large share of income is spent on food and food consumption is highly responsive to changes in income. Thus, food consumption patterns should adjust quickly to income growth by moving from a staples-based diet and more towards a diverse diet. Moreover, income increases can enable precautionary savings and allow the household to take steps to insure itself against food-related shocks (Alwang' *et al*., 2001).

Second, adoption of improved varieties, through higher yield, can indirectly affect food consumption patterns and food security through changes in production patterns. This pathway is complex and depends on factors such as household structure and market orientation. For a household involved in the sweet potato market as seller, adoption of improved varieties might result in more land being allocated towards sweet potato production, augmenting the income effect of adoption on food security. Because of greater sweet potato production due to adoption of improved varieties, a household might move land away from sweet potato towards a more diverse production system. This substitution effect is expected to improve food security as greater agricultural production diversity should lead to greater diet diversity (Jones *et al*., 2014). The direction of changes in production patterns following adoption is unclear, but the expected effects (either income or substitution) should lead to improved diet and food security among rural households.

2.2 Indicators of Food Insecurity

There are approximately 200 definitions and 450 indicators of food security (Hoddinott, 1999) and like the concepts of health or social welfare; there is no single, direct measure of food security- that can effectively capture the multiple dimensions to the problem (Riely *et al.,* 1999). Consensus has still not been reached on acceptable indicators and methods of measuring household food security (Haddad *et al*., 1994). No method has been accepted as a "gold standard" for an analysis of household food security (Maxwell, 1996). The choice of a particular indicator must be based on the specific objectives of the research, and the trade-offs between resource constraints and information needs.

Export horticulture farming was established to have a positive impact on food security on small holder farmers in Mbooni and Kirinyaga counties in Kenya (Jane *et al.,*2013). Small holder farmers (both growers and non- growers) in Mbooni however were consuming less than the recommended per capita calorie intake. The study recommends that policies aimed at

encouraging smallholder farmers to participate in export horticulture farming should be promoted in after the household surpass the minimum recommended caloric intake.

In the work by Maxwell *et al*. (1992), a distinction is made between "process indicators"— those that describe food supply and food access—and "outcome indicators" that describe food consumption measurement. These include dietary diversity, household caloric acquisition, and food balance sheet. These are necessary to identify the food insecure, to assess the severity of their food shortfall and to characterize the nature of their insecurity (seasonal versus chronic). Maxwell *et al.* (1992) lists 25 broadly defined indicators. Riely *et al.* (1995) list 73 of such indicators, somewhat more disaggregated than those found in Maxwell and Frankenberger.

Dietary diversity is one of the outcome indicators of food security. This is the sum of the number of different foods consumed by an individual over a specified time period. According to Hoddinott (1999), households become better-off if they consume a wider variety of foods.In the study conducted by Hoddinott *et al.* (2002) in 10 countries (India, the Philippines,Mozambique, Mexico, Bangladesh, Egypt, Mali, Malawi, Ghana, and Kenya), levels of caloric acquisition was found to be correlated with dietary diversity. Dietary diversity was also found to track seasonal changes in food security. Dietary diversity is highest just after harvest time and lowest during the hunger season; and also appears to capture differences in distribution within the household.

2.3 Impact of Agricultural Technologies on Food Security

In sub-Saharan Africa, where questions are often raised about the adoption and impact of agricultural technology, quantitative evidence of the relationship between agricultural technology and household welfare is scarce (Minten and Barrett, 2008). In more recent studies in Tanzania, Amare *et al*. (2012) found that maize and pigeon pea intensification results in higher per capita income and per capita expenditure on food. However, they used a binary treatment effect approach, which does not account for the heterogeneous effects of adoption. Asfaw *et al*. (2012) in Tanzania found that adoption of improved varieties of pigeon peas significantly increased per capita consumption expenditure and reduced poverty. Kassie *et al*. (2011) assessed the link between the adoption of improved groundnut varieties and poverty, and found that poverty was significantly reduced when improved varieties of groundnut were adopted. Similarly, Kijima *et al*. (2008) in Western Uganda found that the introduction of a new variety of rice for Africa (NERICA) decreased poverty to a significant extent without worsening income distribution. Alene *et al*. (2009) found that adoption of

improved maize varieties in West and Central Africa increased from less than 5% in the 1970s to 60 % in 2005, significantly reducing poverty. Karanja *et al*. (2003) also showed that the adoption of maize technologies in areas of Kenya with high agricultural potential is likely to have a substantially greater positive impact on household incomes than in areas with a low agricultural potential.

Adoption of improved bean varieties led to high farm income among the household interviewed in Rwanda (Larochelle, 2014). This resulted to more available food channels hence more food secure households. Food security was measured by use of HDDS (Household Dietary Diversity Score) while the GMM Poisson model was used to control for the endogeneity of the adoption decision and identify the treatment effects. A study done in the Rift Valley of Ethiopia, found out that the use of improved agricultural technologies resulted in positive and negative impacts. The positive impacts are related to economic and social improvements: increased yield of crops, increased production and income of the beneficiary households. Improved technologies also led to diversification of production, change in food habits particularly of irrigation adopters, improved health, increased asset building and better living conditions. Moreover, the use of improved agricultural inputs enhanced the market integration and induced a high demand for farm activities (Bezabih *et al.,* 2010).

The impact of OVOP(one village one product) on household food security in Thyolo district, Malawi found that household farm income for OVOP beneficiaries was higher than their counterpart non beneficiaries(Juliana, 2007). The OVOP beneficiaries were also found to be better off in terms of household food security through increased food basket, enterprise diversification and food access which was attained through higher farm income. However, farmers' socio-economic characteristics did not adequately explain the disparity in household farm income. This implies that there are some other factors that are closely associated with agricultural production and participation in programs such as OVOP, which may require further investigation. Participation in OVOP and household size were found to be positively associated with household farm income.

The propensity score matching (PSM) approach showed that the impact of the Girinka one cow per poor family program has a positive impact on household income and crop production at the household level (Mutarutwa, 2014). The study objectives were to analyze the impact of the program on household income, on crop production at the household level and to evaluate the constraints facing the implementation of the program. Logistic regression

results of the factors that influence the participation in Girinka programGatsibo, Rwanda identified gender, household size, land size and crop input to be significant.

Direct effects of adoption of *Bacillus thuringiensis* (Bt) cotton on yields, pesticide demand, household income and poverty in the Punjab province of Pakistan were examined through a propensity score matching approach. Their findings reveal that adoption of the new technology exerts a positive and significant impact on cotton yields, household income and poverty reduction, and a negative effect on the use of pesticides. The positive and significant impact of the technology on yields and household income is consistent with the potential role of new agricultural technology in directly reducing rural poverty through increased farm household income (Ali and Abdoulai, 2009).

Impact of the IAR4D on Enhancing Smallholder Farmers Income and Food Security through Agricultural Research and Development in West Africa by Adeolu *et al.* (2013).Using propensity score (PSM) and double-difference methods (DDM) to control for project placement and self selection biases, showed that IAR4D increased participants' income by about 13.9%, and improved food security by about 22.9%. The PSM results indicated that participants in the IAR4D will likely be farmers with small household size, and considerable farming experience, with some level of productive assets, who reside near all weather roads, have low level of education. It can be safely concluded from the results that the IAR4D enhances the income and food security status of the participants.

Access to formal credit has a marginally beneficial effects on household annual income in that it enables households to reduce their borrowing from informal sources.However, these effects are very small and do not cause any significant difference between the per capita incomes, food security, and nutritional status of credit program members and non members (Diagne, 2001). This study assesed the impact of access to credit on income and food security in Malawi.

Technology adoption also reduces relative food insecurity in a significant way (Kabunga *et al.,* 2014). The study on Impact of tissue culture banana technology on farm household income and food security in Kenya employed the Household Food Insecurity Access Scale (HFIAS) – a tool that has not been used for impact assessment before. Estimates of treatment-effects models show that tissue culture (TC) banana adoption, combined with improved crop management, causes considerable increases in farm and household income. These results indicate that TC technology can be welfare enhancing for adopting farm households.

2.4 Factors that Influence Adoption of Agricultural Technologies

Knowledge on value addition and nutritional benefits, availability of vines were the key factors affecting adoptionin a study on Factors influencing adoption and intensity of adoption of orange flesh sweet potato varieties in Nyanza and Western province (Kaguongo *et al.*, 2010). This study applied Logit and Logit transformed regression to examine factors affecting the adoption of orange flesh sweet-potatoes (OFSP), and intensity of such adoption. The study also found out that the intensity of adoption, was affected by factors such as value addition, vines availability, level of commercialization and having a child of up to five years. The results also suggest that participation in a value chain extension programme enhanced the probability of adoption.

A study that evaluated and analyzed factors influencing the incidence and intensity of adoption of improved cassava (*Manihot esculenta*) varieties. Major adoption limitations include the lack of information on technology package, susceptibility of improved cassava varieties to Cassava Mosaic Disease and low starch contents. Age, formal education level, farmer's experience in farming and acreage of land owned significantly influenced intensity of adoption of improved cassava varieties. The importance of extension services, cassava surplus sold in influencing adoption was also underscored. Emphasis was put on the role of cassava producers' information on cassava agronomic management and, hence, the need for more investment on information dissemination to cassava producers (Kavia *et al.,*2007)

Socio-economic factors: education, contact with extension agent, farming experience and farm size were found to significantly influenced the adoption of soil conservation measures among farmers in three Local Government Areas selected from Ibadan/Ibarapa agricultural zone of Oyo state (Adeola, 2010). The analysis underscored the need for consideration of the socio-economic environment of the farmers in designing appropriate soil conservation technologies to encourage adoption.

Adoption of soya bean production technologies in Takum Local Government Area of Taraba State in Nigeria found out that major constraints to adoption of soya bean production technologies were poor extension services and lack of credit facilities (Mustapha, 2012). The study revealed that majority of the respondents adopted the recommended technologies with respect to improved seeds, planting time and harvesting time. While on the other hand, majority of the respondents did not adopt the recommended technologies with regards to fertilizer application, spacing, weeding frequency and the use of chemicals.A multiple regression analysis revealed that educational level, farming experience and sources of

information had significantly and positively influenced the adoption of improved soya bean production technologies by respondents. The study recommends that agricultural extension services should adequately be provided with input support services in the form of credit facilities among others.

Technology adoption can be increased by increases in: access to extension services, amount of land owned, and diversity of farm tools owned by farmers. However, some farmers are not well endowed with regard to the agricultural assets and services alluded to. (Barungi *et al.,* 2012). His study that aimed at determining factors that influence the incidence and intensity of technology adoption Bukwo and Kween districts, on the slopes of Mt. Elgon in eastern Uganda was analyzed using descriptive statistics and double hurdle models. The findings revealed further that on average, the incidence of technology adoption is appreciably high and the intensity of use is moderately high. Nonetheless, a considerable percentage of farmers are using the technologies on small scale. We note that Thus, the study recommended support to farmers by both Government and non-Government actors in line with the factors identified as potential catalysts of adoption of soil erosion control technologies.

A study to identify the socio-economic factors that influence farmers' decision to adopt hybrid maize indicates that the mean predicted probability of technology adoption to be age, income, education and extension visits (Ebojei *et al.,* 2009). On the contrary, farming experience, family size, farm size had no significant influence on participation in hybrid maize. This study done in Giwa Local Government Area of Kaduna state, Nigeria suggests the need to bring more area under hybrid maize cultivation. Furthermore, there is a need for special training, seminars, field demonstrations and technical support for the maize farmers. As most of the households had no formal education, the extension program should be intended to the less educated farmers. In addition, the credit facility particularly the procedure for loan should be made simple to improve the adoption rate of hybrid maize in the study area.

Factors including farm size, education level of farmers and access to extension services to significantly influence adoption of improved maize varieties (IMV). This study examined factors influencing adoption of IMV among farmers in Nigeria (Olusegun *et al.,* 2011).The results also indicate that farmers across the entire agro-ecological regions of country share some negative sentiments regarding adoption of IMV. Renewed emphasis on interventions that would enable farmers gain more access to farmland, and promote formal

education and extension service are advocated. An attempt to incorporate variables that capture farmers' perception/experience on agro-climatic/ecologically related concerns in adoption study could aid better understanding of what drives farmers' adoption decisions across the country especially in the light of the emerging climate change issues and its implication on food production.

2.5 Theoretical Framework

This study assumes that there is potential for the households adopting the new sweet potato varieties to increase their purchasing power due to increase in income and food security thus impacting positively on their livelihoods. Farmers make choices of what to grow and which technologies to adopt with the goal to maximize their expected utility. The decision to adopt the new sweet potato varieties is predicted by perceived utility which is expected to be higher. Profit maximization framework was used to examine the decision to adopt or not (Pryanishnikov and Katarina, 2003). It is assumed that sweet potato farmers will only adopt the improved varieties if the expected net benefit from this option is significantly greater than is the case without it. Suppose that U_i and U_j represent a household's utility for two choices, then the model is specified as;

$$U_i = \beta_n X_n + \varepsilon_i \text{ and } U_j = \beta_n X_n + \varepsilon_j \quad \text{----------(1)}$$

Where U_i and U_j are perceived utilities of adopters and non adopter's choices and j, respectively,X_n is the vector of explanatory variables that influence the perceived attractiveness of each choice, βi and βj are parameters to be estimated, ε_i and ε_j are error terms assumed to be independently and identically distributed (Greene, 2000). In the case of improved sweet potato varieties, if a household decides to use option i, then the expected utility from option i is greater than the utility from option j, which is defined as;

$$U_{ni}(\beta_i X_n + \varepsilon_i) > (U_{nj}(\beta_j X_n + \varepsilon_j)) \qquad i \neq j \quad \text{---------- (2)}$$

The probability that a farmer adopts improved varieties and chooses option i instead of j, is then defined as:

$$\left.\begin{aligned} &P(Y=1|X) = P(U_{ni} > U_{nj}) \\ &P(\beta'_i X_n + \varepsilon_i - \beta'_j X_n + \varepsilon_j > 0|X) \\ &P(\beta'_i X_n - \beta'_j X_n + \varepsilon_i - \varepsilon_j > 0|X) \\ &P(X^* X_n + \varepsilon^* > 0 X = F(\beta^* X_n)) \end{aligned}\right\} \quad \text{---------- (3)}$$

where P is a probability function, U_{ni}, U_{nj} represent a household's utility for two choices and X_n is the vector of explanatory variables that influence the perceived attractiveness of each

choice, $\mathcal{E}^*=\mathcal{E}i-\mathcal{E}j$ is a random disturbance term, $\beta^*=(\beta i-\beta j)$ is the net influence of the vector of independent variables influencing adoption of improved varieties, and $F(\beta^* X_n)$ is a cumulative distribution function of ε^* evaluated at $\beta^* X_n$. The exact distribution of F depends on the distribution of the random disturbance term, ε^*. Depending on the assumed distribution that the random disturbance term follows, several qualitative choice models can be estimated (Greene, 2003). This theoretical framework emphasizes any household decision on the alternative choices.

2.6 Conceptualization Framework

Conceptual framework serves as a simplification to the understanding of the relationship between the dependent and independent variables. The change in the independent variable has an effect on the dependent variable. The variable in the dependent variable is countered by the independent variable.

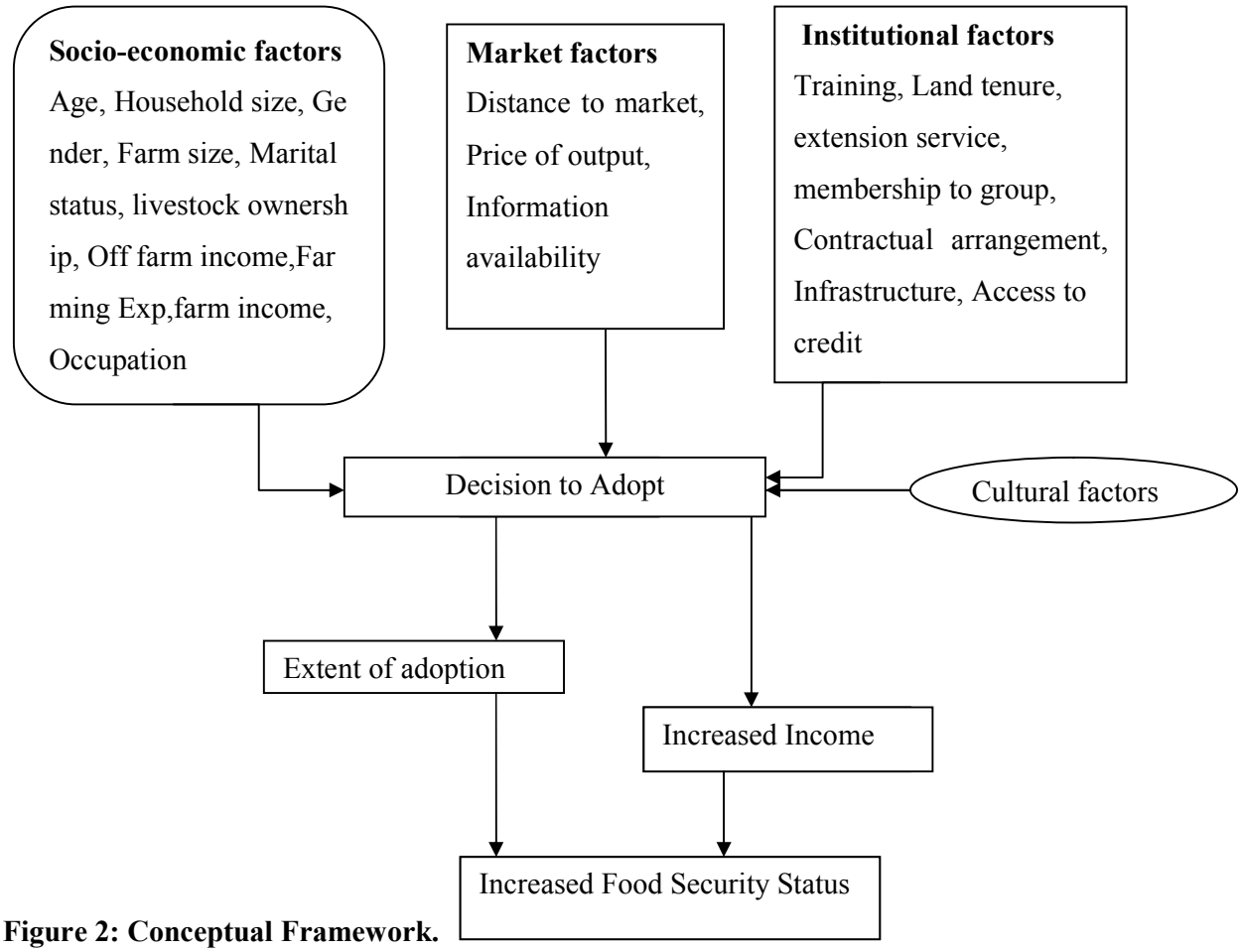

Figure 2: Conceptual Framework.

Source: Author

CHAPTER THREE
METHODOLOGY

3.1 Study Area

The study was conducted in Bungoma East sub county, Bungoma County. The county borders the Republic of Uganda to the West, Teso and Busia districts to the South West, Mumias to the South, Trans-Nzoia to the North East. The population of Bungoma is estimated at 1,630,934 (KNBS, 2009) of which female constitute 52% while male are 48% whilePoverty level index stand at 53%. The County has an area of 3,032.2 sq. Km and a population density of 453.5 people per sq. Km. Itlies between 1,200 and 1,800 meters above sea level and experiences mean temperatures of 23^{o}C. Its latitude stands at 1^{0} 13' with the longitude of 34^{0}56'North East of the equator in Western Kenya. It also experiences a bimodal type of rainfall with the average annual rainfall ranging from 1200mm to 1800mm per annum. Most of the rain fall is experienced in the months of April-May and July-August. The coldest months are July, August and September. Bungoma is divided into nine administrative and political divisions: Bumula, Kanduyi, Kimilili, Sirisia, Kabuchai, Webuye East, Webuye West, Tongaren, and Mt. Elgon which are further divided into 46 political wards and 88 administrative Locations.

The main economic activity in most part of Bungoma County is subsistence agriculture. Main crops grown in the area are Sugarcane, Maize, Sunflower, and Coffee, Tobacco, Potatoes, Beans and cotton. The population of sweet potato farmers in Bungoma County is estimated at 102,682. Of the total labour force of about 565,000, 52% are engaged in agricultural production accounting for 60% all household incomes;19% wage employment, 13% urban self employment. Agriculturally potential land is estimated at 183,800 ha with Sugarcane, the main cash crop occupying 27,000 ha (KNBS, 2004) . The county has good physical and varying soil type'sproperties, with inherently fertile deep rich Andosols and Nitisols towards the slopes of Mt. Elgon. The western part of the district has Acrisols, while the centre of the district is predominantly Feralsols. The eastern part of the district comprises Acrisols and Feralsols. Figure 2 below shows the study area.

3.2 Sample Size Determination

The required sample size was determined by proportion sample size formula by (Anderson *et al*., 2007). $n = \frac{pqz^2}{E^2}$

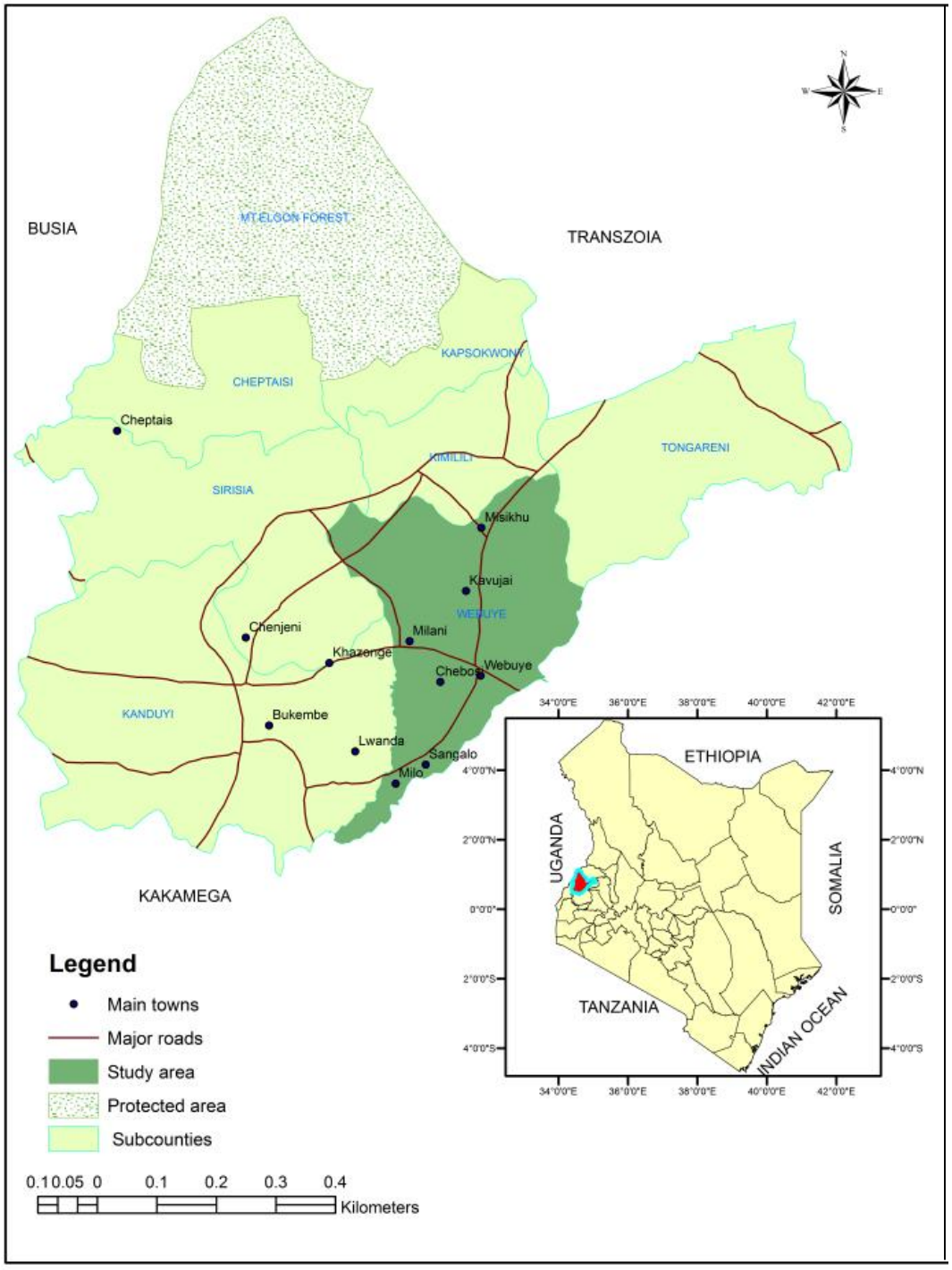

Figure 3: Map of Bungoma County.

Source: World Resource Institute.(2013)

Where n = sample size, p = proportion of the population containing the major interest, q = 1-p, z= confidence level (α = 0.05), E = acceptable/allowable error. Since the proportion of the population was not known, p=0.5, q = 1-0.5= 0.5, Z = 1.96 and E = 0.08. This resulted to a sample population of 164 respondents.

3.3 Sampling Procedure

The target population was sweet potato farmers within Bungoma East Sub-County, Bungoma County. Multi-stage sampling method was used to select appropriate sample size. Bungoma East Sub-County was purposively selected because of the majority of adopters of ISVs farmers in the county. Three locations in the sub-county including Sitikho, Matulo and Bokoli were also purposively selected. The farmers in the area were then stratified into two groups: those who have adopted the new improved varieties and those who are still using the local varieties (non adopters). With the adopters, purposive sampling farmers who have been in existence for more than a year was done using a source list obtained from the extension officer from Ministry of Agriculture and Fisheries Offices containing sweet potato farmers both adopters and non adopters. From each of the group, farmers were selected proportionate to the size of the group using a systematic random sampling procedure to select a total sample of 164 farmers (93 adopters and 71 non adopters).

3.4 Data Collection Method

A cross sectional data was collected from a sample of sweet potato farmers. The methods for data collection included observations, semi-structured questionaire were used by use of face to face interview. Primary data was collected through the administration of semi-structured questionnaire to the 164 respondents in the study area. The pre-tested semi-structered questionnaire were administered to the farmers by team of trained enumerators.

3.5 Methods of Data Analysis

Data from the field was edited, coded to ensure consistency, uniformity, and accuracy, and then entered into SPSS for analysis. Both qualitative and quantitative techniques were used to analyze the data collected. Qualitative data for objective one was analyzed using descriptive statistics such as mean, percentage, standard deviation, tabulation, ratio and frequency distribution. Both SPSS and STATA computer programs were used to process the data.

3.6 Measurement of Food Security

Diet diversity is usually measured as the count of the number of food items or food groups consumed over a predetermined period of time (Ruel, 2003). Measures of dietary diversity based on the number of food groups consumed, rather than food items, are likely to more accurately reflect the diversity of macro and micronutrient intakes. Diets consisting of a limited number of food items, especially starchy staples, can lack the macro and micronutrient adequacy despite meeting calorie requirements (Kennedy*et al*., 2011).This study measured food security status using indicators of food consumption which is an outcome indicator of food availability, access and other underlying factors. This was done using 7 day recall where Household Dietary Diversity Score (HDDS) (Hoddinott and Yohannes, 2002). Dietary diversity defined as the number of different foods or food groups eaten over a reference time period without regard to the frequency of consumption was used to assess quality of food intake. The food groups considered were as follows: Cereals, Milk and milk products, Fish and seafood ,Fruits **,**Root and tubers, Eggs, Oil/fats, Vegetables, Pulses/legumes, Meat, Sugar/honey

A food group is counted only once, regardless of the number of times it was consumed over the last seven days, our reference period. This means that the HDDS ranges for a minimum of one and to a maximum of 12. A high HDDS reflects a diverse diet and suggests food security while a low HDDS is indicative of food insecurity. HDDS is an attractive proxy indicator because; Obtaining these data is relatively straightforward, It is associated with a number of nutrition indicators such as birth weight, child anthropometric status, hemoglobin concentrations and protein adequacy (Swindale and Bilinsky, 2006) and a more diversified diet is highly correlated with such food security indicators as household per capita consumption (Hoddinott and Yohannes, 2002).

In order to distinguish between different levels of food security, the following cut-off values are set for the HDDS. Households consuming less than 6 food groups are considered to be food insecure; those consuming 6 to 12 food groups are food secure. A shorter recall period would risk missing foods served habitually but infrequently at the household level or it would overestimate the consumption if the survey is done over those special days.

3.7 Analytical Framework

3.7.1 Characterization of Sweet Potato Farmers

Descriptive statistics was used to analyse this objective. These was captured through quantitative and qualitative variables that are important in understanding the socioeconomic characteristics of sweet potato farmers. Mean, frequencies and standard deviations of various variables were obtained. The *t-test* and Chi-square tests were used to compare the selected household and farm characteristics between the two categories of farmers (adopters and non adopter's farmers).

3.7.2 To Determine Factors Influencing the Extent of Adoption of the Improved Sweet potato Varieties

Previous studies on adoption have typically adopted a Heckman two-step analytical approache involving the unobservable decision to adopt and the observed degree or extent of adoption (Vance and Geoghegan, 2004; Alene *et al*., 2008). In the second step, an additional regressor in the equation was included to correct for potential selection bias. This regressor is Inverse Mills Ratio (IMR). IMR is computed as:

$$\lambda = \frac{\varphi\,(h(w_i,\tilde{a}))}{\varphi(w_i,\tilde{a})} \text{---------- (9)}$$

Where, φ is the standard normal probability density function. The second-stage equation is given by:

$$E = (Y_i|Z = 1) = f(x_i) + \lambda\frac{\varphi\,(h(w_i,\tilde{a}))}{\varphi(w_i,\tilde{a})} \text{---------- (10)}$$

Where E is the expectation operator, Y is the (continuous) proportion of land allocated on improved sweet potato production, x is a vector of independent variables affecting the extent of adopting the, and β is the vector of the corresponding coefficients to be estimated.

So Y_i can be expressed as following:

$$Y_i^* = \beta' x_i + \gamma\lambda_i + u_i \text{---------- } (11a)$$

Where $u_i \sim N(0,\sigma_u)$

Y_i^* is only observed for those farmers who have adopted the ISVs

($Z_i = 1$), in which case $Y_i = Y_i^*$.

Heckman Two Step model

Step 1: Selection Equation

$$Y = \beta_0+\beta_1X_1+\beta_2X_2+ \ldots\ldots\ldots +\beta_nX_n+\varepsilon$$

$$Y(0,1)=\beta_0+\beta_1age+\beta_2gend+\beta_3Educ+\beta_4Hsize+\beta_5Output+\beta_6OffFmInc+\beta_7creditamt+\beta_8 Nolvstck+\beta_9Swtprce+\beta_{10}Trnct+\beta_{11}extct+\beta_{12}farmexp+\beta_{13}lnwealth+\beta_{14}+\varepsilon\text{----------(10a)}$$

Step 2: Outcome Equation

$$Y(Extadpt)=\beta_0+\beta_1age+\beta_2gend+\beta_3Educ+\beta_4Hsize+\beta_5Occup+\beta_6OffFmInc+\beta_7credit+\beta_8 Distmkt+\beta_9FmInc+\beta_{10}grpmshp+\beta_{11}extsrvce+\beta_{12}farmsize+\beta_{13}lnwealth+\beta_{14}IMR+\varepsilon\text{-------(11b)}$$

Table 1: Description of variables used in Heckman Two-Step Procedure

Variable	Description of the variables	Measurement
Dependent	**Variables**	
Extadpt	Extent of adoption	Proportion of land allocated
Independent	**Variables**	
Ageyrs	Age in years	Household head age in years
Gnder	Gender	Sex of the household head (Dummy 1=Male 0=Female)
Hsize	Household size	The size of households members
Edulevel	Education level	Farmers level of education
Offincm	Off farm income	Off-farm income in KES
Dstmkt	Market distance(km)	Distance to the near markets(km)
lnwealth	Wealth in Kshs	Value of household assets in KES
Creditamt	Credit amount Kshs	Amount of credit borrowed in KES
Extcnct	Extension Contact	Number of extension contact with farmer
Trncnct	Training Contact	Number of training contact with farmer
Grpmbshp	Group membership	Membership (Dummy 1=yes, 0=otherwise)
swtprice	Sweet potato price (Kshs)	Price paid for sweet potato in KES
Occupation	Farmers occupation	Occupation of the farmer (Dummy)
Nolvstock	Number of Livestock	Number of livestock owned
Farmexp	Farming Experience (yrs)	Years
Output	Output (kg)	kilograms
Landtnr	Landtenure	0=without title deeds, 1= with title deeds
Grphtrgty	Group heterogeneity	Group heterogeneity index

3.7.3 To Determine the Effect of the Improved Sweet potato Varieties on Household Food Security.(ibid)

In assesing the effect of ISVs on household food security, a model that can be employed is the following: $F = P'X + \gamma I + \varepsilon$, Where *F is* the food security status of a certain household, **X** is a vector of exogenous household characteristics, and *I* is a dummy variable *(I* = 1 if the individual has adopted ISVs, and 0 otherwise). However, this model is subject to misinterpretation because the adoption decision is voluntary, thus resulting in the familiar problem of self-selectivity bias (Maddala). If the adoption decision is based on individual self-selection, it is likely that ISVs adopters have systematically different characteristics from non adopters. This subsample heterogeneity is econometrically problematic when unobserved characteristics are distributed differently across adopters and non adopters. Thus, unobserved variables may influence both the adopters' decision and food security status, resulting in inconsistent estimates of the effect of ISVs on household food security. A more general model for econometric analysis is the endogenous switching regression model (Gould and Lin; Lee; Maddala; Willis and Rosen).

Endogenous Switching Probit Model

The aim of the study was to provide empirical evidence on the effect of improved sweet potato varieties on household food security. Endogenous switching regression model is used, where both observable and unobservable characteristics are accounted for, thus controlling for a 'hidden bias' which could arise when unobservable variables are not taken into account. Ignoring the endogeneity of adoption of improved sweet potato varieties would result in biased estimated parameters. To address the endogeneity problem, this study used the endogeneity switching probit model, which accounts for the correlation in the unobserved characteristics in the decision to adopt the ISVs and food security status, which is the outcome variable. Following Lokshin and Sajaia (2011), we consider a household with two binary outcome equations (whether food secure or not) and the criterion function I_i (binary variable of household adoption of improved sweet potato varieties) that determines the regime faced by the household. The potential values are represented as;

$Ii = 1\ if\ \boldsymbol{\gamma Z i} + \boldsymbol{\mu} > 0$ ---------- *(12a)*
$Ii = 0\ if\ \boldsymbol{\gamma Z i} + \boldsymbol{\mu} \leq 0$ ---------- *(12b)*

Regime 1: $Y^*_{1i} = \beta_1 X_{1i} + \varepsilon_{1i} I_i = 1$ if $(I^*_i > 0)$ ---------- *(13a)*
Regime 2: $Y^*_{0i} = \beta_0 X_{0i} + \varepsilon_{0i} I_i = 0$ *if otherwise* ---------- (*13b)*

Where Y^*_{1i} and Y^*_{0i} are latent variables (household food security status) that defines observed food security status Y_1 and Y_0 (whether the household is food secure or not, respectively), Z is a vector of exogenous variables determining adoption of ISVs, X_i is a vector of exogenous variables determining food security status, γ and β are the vector of parameters estimated while μ_i, ε_{1i} and ε_{0i} are disturbance terms. Equation (12) is a probit specification for ISV use. The observed food security status Y_i is defined as $Y_i=Y_1$ if $I_i=1$ and $Y_i=Y_{0i}$ if $I_i=0$. With the assumption of joint normal distribution of μ_i, ε_{1i}, and ε_{0i} with mean of zero, the correlation matrix written as;

$$\Omega=\begin{pmatrix} 1 & \rho_0 & \rho_1 \\ & 1 & \rho_{10} \\ & & 1 \end{pmatrix} \text{---------- (14)}$$

Where ρ_0 is the correlation between ε_0 and μ, ρ_1 is the correlation between ε_1 and μ while ρ_{10} is the correlation between ε_0 and ε_1. Consequently, the log likelihood function for the model is given by;

$$\begin{aligned} Ln(\xi) = & \sum_{ci\neq 0, Yi\neq 0, \omega_i} \ln\{\phi_2(X_{1i}, \beta_1, Z_i\alpha, \rho_1)\} \\ & + \sum_{ci\neq 0, Yi\neq 0, \omega_i} \ln\{\phi_2(-X_{1i}, \beta_1, Z_i\alpha, \rho_1)\} \\ & + \sum_{ci=0, Yi\neq 0, \omega_i} \ln\{\phi_2(-X_{1i}, \beta_1, Z_i\alpha, \rho_1)\} \\ & + \sum_{ci=0, Yi=0, \omega_i} \ln\{\phi_2(-X_{1i}, \beta_1, -Z_i\alpha, \rho_1)\} \end{aligned} \text{---------- (15)}$$

Where ω_i is an optional weight for the i^{th} household and ϕ_2 is cumulative function of bivariate normal distribution (Lokshin and Sajaia, 2011). Previous studies have used the switching probit regression model in social research (Ayuya et al., 2015; Floro and Swan, 2013; Gregory and Coleman-Jensen, 2013; Lokshin and Glinskaya, 2009).The advantage of endogenous switching probit model specification in Eqtn (15) is the possibility of deriving probabilities in counterfactuals cases for household's food security status on adoption of ISVs. Following Aakvik, Heckman, and Vytlacil (2000) and Lokshin and Sajaia (2011) two cases are defined as;

$$\begin{aligned} TT(x) &= \Pr(Y_1 = 1 | I = 1, X = x) - \Pr(Y_0 = 1 | I = 1, X = x) \\ &= \frac{\phi_2(X_1\beta_1, Z\alpha, \rho_1) - \phi_2(X_0\beta_0, Z\alpha, \rho_0}{F(Z\alpha)} \end{aligned} \text{---------- (16a)}$$

$$TU(x) = \Pr(Y_1 = 1 | I = 0, X = x) - \Pr(Y_0 = 1 | I = 0, X = x)$$

$$= \frac{\phi_2(X_1\beta_{1,} - Z\alpha, -\rho_1) - \phi_2(X_0\beta_{0,} - Z\alpha, -\rho_0}{F(-Z\alpha)} \text{ ----------(16b)}$$

Where F is the cumulative function of the univariate normal distribution, Eqtn (16a) computes the effects of treatment on the treated (TT), which is the difference between the predicted probability of being food secure for adopters of ISVs and the probability of being food insecure had they not adopted the ISVs. Computing the average of TT(x) on households that have adopted the ISV, results in the average treatment effect on the treated (ATT). The effect of the treatment on the untreated (TU) was computed by Eqtn (16b), which is the expected effect on food security status if the non adopters' households had adopted the ISV. Computing the average of TU(x) of households that did not adopt the ISVs results in average treatment effect on the untreated (ATU) (Aakvik *et al*., 2000; Lokshin and Sajaia, 2011).

Table 2: Description of Variables used in the Endogenous Switching probit Model

Variables	**Description of the variables**
Food security status	(Food insecure =0, Food secure =1
Off farm income	Off-farm income
Market distance	Distance to the near markets(km)
Wealth	Value of household assets Kshs
Information about group	Source of information about groups
Sweet potato price	Price paid for sweet potato(Kshs)
Number of groups	Number of groups farmer belong
Number of livestock	Number of livestock owned
Output	Output from last season(kg)
Group heterogeneity	whether members were from same neighborhood, occupation, relative, friends.
Household head	Household head gender (Female=0, Male=1)
Education head	1 = not gone to school; 2 = primary; 3 = secondary; 4 = university
Marital status of head	1 = single; 2 = married; 3 = widowed; 4=separated.
Farmer to Farmer extension	Dummy = 1 if the household head got information from fellow farmers, 0 otherwise
Non-governmental extension	Dummy = 1 if the household head got information from non governmental organization extension workers, 0 otherwise
Government extension	Dummy = 1 if the household head got information from government extension workers, 0 otherwise

CHAPTER FOUR
RESULTS AND DISCUSSIONS

This chapter presents the results of the analysis of the data obtained. It has been subdivided into sections according to the objectives of the study. The discussion of results is presented while making a comparison of the findings with those of other studies.

4.1 Descriptive Results

4.1.1 Socio-Economic Characteristics of Adopters and Non Adopters Sweet Potato Farmers

The results of gender and occupation of farmers are presented in Table 3. A large proportion of adopters farmers (61%) were females while males constituted only 39%. However, among non adopters females were 51%, while males were 49%. The chi square test however indicates that there was no significant association between gender and decision to adopt. The type of occupation revealed (40%) of adopters and 56% of non adopters derived their livelihoods from farming. The results also indicated that 15% of the adopters engaged in business activities compared to 8% of non adopters. A slightly higher percentage of adopters (24%) were engaged in off-farm employment compared to 11% of non adopters. However, the chi square test reveals that these association was not significant.

Most non adopter households (42%) owned land without titles. The remainder 58% were distributed between those that owned land with title deed, rented, inherited and communal land at 15%, 22%, 18% and 1% respectively. On the other hand most (40%) adopter farmers owned land with titles. The remainder 60% was distributed between those that owned land without title deed, rented, inherited and communal land at 38%, 11%, 9% and 2% respectively. This means that households that had secure land can undertake long term plans and also try out new technologies such as planting improved sweet potato varieties. The chi square results confirmed that the association between adopter and non adopter farmers in terms of land tenure was significant 1% level.

The marital status of the household head revealed that a high proportion of the farmers (71%) were married, for adopters and 64% for non adopters farmers. However, majority of single farmers (14%), were adopters members while 7% were non adopters. A greater percentage of the single farmers in terms of marital status were youths, explaining why majority were non group farmers. Married households are able to make up rational

decisions because of different ideas in the family compared to single, divorced or separeted households.

Table 3: Association of Household Characteristics by Farmer Type (Dummy Variables)

		Adopter	Non-Adopter	
Variables		**%**	**%**	**Chi^2**
Gender	Female	61.29	50.70	1.8379
	Male	38.71	49.30	
Land tenure	With title	39.78	15.49	14.2224***
	Without title	57	42.25	
	Rented	36	22.54	
	Inherited	37	18.31	
	Communal/Government	2.15	1.41	
Education level	Tertiary education	30.11	9.86	11.9130***
	High school	23.66	21.13	
	Primary school	35.48	49.30	
	No formal education	10.75	19.72	
Marital status	Single	13.98	7.04	6.7577**
	Married	70.97	63.38	
	Widowed	15.05	28.17	
	Divorced	0	1.41	
Occupation	Farming	39.78	56.34	6.2980
	Business	16.13	8.45	
	Salaried Employed	25.81	15.49	
	Casual labour	2.15	2.82	
	Other	16.13	16.90	

Note: ** and *** = significant at 5%, and 1% level, respectively.

Source: Data 2014

Among the potential adopters, those who attained no formal education (not gone to school), primary and secondary were 10.8%, 35% and 24% respectively while those who attained university education were 30%. On the contrary, 20% of potential non-adopters attained no formal education, 49% primary education, 21% secondary education, 10% attained university education. The low percentage of farmers who had tertiary education can be attributed to the fact that farmers with higher levels of education have a tendency of involving themselves in other off-farm activities as their education level increases. Vink and VIlijoen (1993) concluded that low education level is the most limiting factor in the uptake of innovation among small scale farmers. Education level attained is often used to gauge the

level of technical skills acquired and hence a measure of the quality of human capital. There is, however, statistically significant association between the level of education attained by the household head and the adoption status of improved sweet potato varieties. Hence, it would be of interest to strengthen the extension services and trainings to bridge the skill gap. This is further supported by the fact that a greater proportion (30%) of the adopters have tertiary education qualification.

The mean difference of household characteristics by farmer type are presented in Table 4. The aggregated mean age was 45 years, while the mean age of adopters was 43 years and non adopters 48 years. The t-test result show a statical diffirence on age at 5% significance level. It shows that non adopters had statistically higher mean age than the adopters. Age of the household head plays an imperative role in the uptake of new technologies. This may be attributed to the failure of the older farmers to embrace new ways of doing things and thus still continue the old ways of doing things (Langyintuo and Mulugetta, 2005). The farming households in the county can therefore be regarded as young and who belong to economically active group.

The aggregate mean household size was 5 persons. However, the mean household size of non group farmers and group farmers was 4 and 5 persons respectively. Household size has been linked to the availability of "own" farm labour in adoption studies. Amsalu and De Jan (2007) found out that household size had a significant and positive effect among the determinants of adoption. The argument was that larger households have the capacity to relax the labour constraints required during the introduction of new technologies.

The aggregate years of experience of a sweet potato farmer was 3 years. Non adopter farmers had more years of experience at 4 years while the adopter farmers had experience of 2 years. The t-test results however revealed that the difference in years of experience was statistically significant at 1% between the two categories of farmers. However, non adopters can be assumed to be rigid to new technologies having adopted earlier. Adopters with less experience are able to give change a try. This result is in line with studies such as that of Kassie *et al*., (2013) in the adoption of improved wheat varieties who found same results.

Distance from the household to urban market is often used to proxy for the ease of access to market and the state of the road infrastructure and hence a measure of the transaction cost .The distance to the market shows that the adopters covered an average of 2.59 kilometers, and non adopters covered 2.65 kilometers. The t-test result indicates that there was a significant difference between non adopters and adopters farmers at 10% level in

terms of distance to market. This means that as distance to the market increases, the cost of accessing the information about the improved variety increases among farmers. Location from the trading centre here plays a role of a proxy for information access and the potential market for the purchase of farm inputs including vines.

The results of the sweet potato selling price shows that the aggregate sweet potato selling price was 29 Kenya shillings per 2kg. There were differences in prices because adopters sold their produce at a higher price of 38 Kenya shillings per 2kg, while the non adopters farmers sold at 18 Kenya shillings per 2kg. The t-test result at 1% level confirmed that there was strong significant difference between adopter and non adopters' selling price. Higher selling price of the ISVs farmers reveals the value and quality which increases the bargaining power of improved sweet potato in terms of output price. This high price is able to cover the cost of production.

Income from farming was found to have an aggregated mean of 575 Kenya shillings per season. However, the non adopter farmers had a lower mean farm income of Ksh 240 compared to ksh 1096 per season obtained by the adopters. The result show a statiscally strong significant difference at 1% that adopters had more incomes from their production than the non adopters. Serman and Filson, (1999) argue that high farm income improves the capacity to adopt agricultural innovations as they have the necessary capital to jumpstart the innovation. Morover, the adopters had slightly more off-farm income at Ksh 6,165 per season than the non adopter farmers who had a mean off-farm income of Ksh 3,311 per season . Off-farm income comprised of income from business, employment and other incomes apart from the farm income. The influence of off-farm income in the adoption of new technologies is derived from the fact that income earned can be used to finance the uptake of new innovation (Amsalu and De Jan 2007).

Farm size had an overall mean of 0.33 hectares. The potential adopters had relatively bigger size of land indicated by the mean of 0.43 hectares compared to potential non-adopters who had a mean of 0.23 hectares. The effect of land size on adoption of improved varieties in past studies has been that small sizes of land hinder adoption since farmers fear lose of agricultural land and large tracts of land encourages adoption due to the larger capacity in terms of resource base (Gebremedhin and Swinton, 2003).

The potential adopters were found to have a mean of 13 contacts with extension officers within the last 12 months as shown in Table 4. The potential non adopters had a mean of 5 contacts with extension officers. Extension contact was strongly significant at 1%

with an overall mean of 8 contacts. The number of contacts with extension officers was a proxy for access to information and thus according to the innovation diffusion theory it contributes to the awareness and subsequent adoption of the innovation (Dolisca *et al*., 2006).

Table 4: Mean Difference of Household Characteristics by Farmer Type (Continuous Variables)

	Adopter = 93		**Non Adopter = 71**		**Aggregat=164**	***t-test***
Variable	**Mean**	**Std.dev**	**Mean**	**Std.dev**	**Mean**	
Age	42.86	14.23	47.75	14.53	44.98	2.1591**
Household size	4.83	2.15	5.46	2.35	5.10	1.8017*
School years	12.56	6.66	9.35	6.13	11.17	-3.1630***
Experience(yrs)	2.17	1.01	4.45	2.19	3.16	8.9076***
Distance to market (Km)	2.59	2.36	2.98	2.65	2.76	0.9876*
Selling Price(KES)	37.88	20.34	18.07	11.24	29.30	-7.3882***
LogFarm Income	3.04	1.05	2.38	1.17	2.75	-3.8279***
Off-farm Income	3.79	0.62	3.52	0.44	3.67	-3.0680***
Farm Size(ha)	0.43	0.38	0.21	0.13	0.33	-4.7910***
Extension	12.97	7.09	5.49	6.33	9.73	-7.0050***

*, **, ***: significant at10%, 5% and 1% level respectively

Group membership positively and significantly contributes to the uptake of new innovation and also information sharing and resource mobilization and higher market bargaining power (Shiferaw *et al*., 2006) presented in Table 5 below. Among the non-adopters 53.52% of the respondents did not involve themselves in group activities while 46.48% were involved. Among the potential adopters 20.43% did not involve themselves in group activities compared to 79.57% who did. They get to exchange ideas and learn about the

benefits of various upcoming technologies. Group members also may easily organize and receive training on diverse agricultural technology issues that influences the adoption of the improved sweet potato varieties in view of sustainable agricultural production.

Majority (90.32%) of the adopters had access to extension services, (9.68%) of the potential adopters had no access to extension services On the other hand non adopters had a slightly lower almost equal number 53.52% and 46.48% of those who accessed and had no access on extension services respectively. Extension services positively and significantly influenced the level of adoption of the improved services. This is because extension services provide information, knowledge and skills that enable farmers to be aware and use the technology. Extension services plays a central role of providing support for institutional mechanisms designed to support the dissemination and diffusion of knowledge among farmers and demonstration of gains from new technologies (Baidu-Forson, 1999).

Access to trainings by the households was proportionally high (88.17% and 76.06%) for both the adopters of the improved varieties and the non adopters. On the adopters, the proportion of the households that had accessed trainings were 88.17% compared with 11.83% of their counterparts who did not (Figure 5). The proportions of households who had accessed trainings were 76.06% and 23.94% for the non-adopter farms respectively. There is however a statistically strong association between access to farmer trainings and adoption of the improved varieties.

Credit service is prior instrumental in the growth and development of farming enterprises just like any other entrepreneurial venture. Credit is necessary for enhanced expansion of business activities. On the adopters household, 52.69% had accessed credit whereas 47.31% had not (Figure 5). Non adopter households were less involved in credit with 26.76% accessing credit. It is apparent that access to credit is better for the adopter households than their non-adopter counterparts. The association between the adoption of improved sweet potato varieties in household and access to credit is statistically significant at 1%.

Table 5: Institutional Characteristics for Discrete Dummy Variables (Chi^2 test).

Variable		Adopter = 93	Non Adopter= 71	Chi^2
Livestock	Yes	87 (93.55)	58 (81.69)	0.019**
Ownership	No	6 (6.45)	13 (18.31)	
Group	Yes	74 (79.57)	33 (46.48)	0.000***
Membership	No	19 (20.43)	38 (53.52)	
Extension	Yes	84 (90.32)	38 (53.52)	0.000***
	No	9 (9.68)	33 (46.48)	
Training	Yes	82 (88.17)	54 (76.06)	0.041**
	No	11 (11.83)	17 (23.94)	
Credit	Yes	49 (52.69)	19 (26.76)	0.001***
	No	44 (47.31)	52 (73.24)	

, *: significant at 5% and 1% level respectively. Figures in parentheses are percentages

The main information source on existing groups is presented in Table 6. The results reveal that 64.38% of the respondents acknowledged that the main source of information is from fellow farmers followed by self initiative at 17.81%. Extension officers came third at 10.96% and self help groups at 7%. The implication of the results is that there is a strong social capital among the farmers and thus an approach that can be used to create awareness is to involve the model farmers and the communication can trickle down to the rest of the society.

Table 6: Main Source of Information about the Farmer Groups.

Variables	Adopter	Non Adopter
	Percent	**Percent**
Fellow farmers	64.38	48.48
Extension Officers	10.96	21.21
Self Initiative	17.81	15.15
Self help groups	6.85	15.15
Total	**100**	**100**

The main source of credit was found to be commercial banks with 36% followed closely by informal lenders with 32% for the potential adopters, the others includes farmer groups, SACCO and micro finance with 18%, 8% and 6% respectively. On the other hand more than half 57.89% of the non adopters accessed credit from the informal lenders. This results are consistent with the Tegemeo survey, (2004). It found out that the informal money lenders are more important than the formal banking institutions. They provide close to 20% of the agricultural credit in Kenya.

Table 7: Main Source of Credit Among the Farmer Groups

Variables	**Adopter**	**Non Adopter**
	Percent	**Percent**
Commercial banks	36	21.06
SACCO	8	5.26
Micro finance	6	10.53
Informal lenders	32	57.89
Farmer groups	18	5.26
Total	**100**	**100**

Source: Data 2014

A majority 64.29% of potential adopters accessed the extension service from the Non govermental extension service compared to 30.95% of the non adopters. This is however because of the accredited CREADIS limited which was contracted by KARI to distribute the improved sweet potato vines in the area on their behalf. NGOs play a very important role in ensuring adoption of new technologies by farmers in the rural areas. Moreover, non-governmental extension officers could be using other motivational factors to influence farmers to adopt the improved varieties since they have an interest of achieving such goals in the various projects they are undertaking in the country (Oscar *et al.*, 2015). On the other hand only 32.14% and 3.57% of the adopters accessed the extension service from Government and Farmer to farmer extension respectively.

Table 8: Main Extension Sources amoung the Farmer Groups

Variables	Adopter	Non Adopter
	Percent	Percent
Farner to Farmer Extension	3.57	0
Government Extension	32.14	69.05
Non Govermental	64.29	30.95
Total	**100**	**100**

4.2 Factors Influencing Adoption and the Extent of Adoption of the ISVs.

4.2.1 Factors Influencing Adoption of the Improved Sweet Potato Varieties.

To determine the factors influencing adoption of the improved sweet potato varieties, a probit model was estimated in the first step of the Heckman two step selection equations. The procedure was chosen for estimation to correct the sample selection bias as proposed by Heckman (1979).. Five variables (Education level, Farming experience, sweet potato price, Extension contact and Training contact) were significantly found to influence the farmers' decision to adopt the improved sweet potato varieties at different significant levels. The Inverse Mills Ratio (IML/Lambda) term was significant and positive at (0.058), which suggest that the error term in the selection and outcome equation are positively correlated. This implies that unobserved factors that influence adoption of improved sweet potato varieties are more likely to be associated with higher scores on the dependent variable. The marginal effects were used to interpret the results.

Unexpectedly, education level of the household head was found to have a negative significant influence on adoption of the improved sweet potato varieties. An increase in education of the household head by a level reduced the probability adopting the improved sweet potato varieties by 1.63%, all other factors held constant. This implies that as the education level increases, adoption of the improved varieties reduces. This can be explained by the fact that educated farmers are more likely to earn higher wages from off-farm work; they are expected to have a higher proportion of off-farm income to on-farm income given the same proportion of on and off farm work time. Therefore, it seems plausible if highly educated farmers, who are more reliant on off-farm income, have fewer incentives to spend time and effort on farming, including adoption of technology such as ISVs. However, this study is inconsistent with many other studies that suggest education empowers individuals

with technological skill and knowledge that will accelerate individual to adopt the technological (Faturoti *et al*., 2006).

Farming experience negatively and significantly influenced adoption of improved sweet potato varieties. One year increase in farming years increased the probability of not adopting the improved sweet potato variety by 4.94%, *ceteris paribus*. This implies that farmers with many years of adoption have already made up rigid decisions on what they know about the sweet potato varieties. These farmers have held on what they know since they started adopting the varieties, so any changes on the technology can no longer change their understanding further. Though older farmers might have more experience with traditional technologies they have a higher level of risk averseness towards technologies. These findings however are inconsistent with a study by Masuki *et al*. (2003).He found that older farmers were more receptive towards new agricultural technologies due to adequate experience and accumulation of capital.

As expected sweet potato price had a positive significant influence on the adoption of the ISVs. This implies that a one shilling increase in the price of ISVs increased adoption by 0.4%. the high quality and favourability in the market translates its high price than the local variety. This is however common with farmers in that with the existence of a new profitable technology, farmers would want to adopt the new technology so as to cover up there cost of production and yield enough profit in the market. The quil business in Kenya is an example of the above.

The result also suggested that adoption of ISVs could be motivated by frequent contacts with extension agents. Extension contact was found to be positively significant at 1%. Extension agents popularizes innovation by making farms exchange idea, experiences, and makes it cheaper to source information, knowledge and skills in order to enable farmers to improve their livelihood. Farmers who have frequent contacts with extension agents had a higher probability of adopting the improved varieties. This was presumed; as farmers were privileged with materials and managerial support, followed by cheap and timely availability of knowledge and skills, which apparently helped them, apply new technology. This finding is in conformity with Conroy (2005), Freeman and Omiti (2003) and Chirwa (2005).

Table 9: The Heckman Two-Step Selection Equation

Variable	dy/dx	Std. Err.	p>|z|
Genderhead	0.0136	0.3103	0.508
Household size	-0.0393	0.0821	0.218
Education level	-0.0163	0.1763	0.087*
Farming Experienc	-0.0494	0.1119	0.000***
No.Livestock	0.0346	0.0436	0.123
Swtprice	0.0018	0.0107	0.046**
Lnwealth	-1.1153	0.1781	0.916
Extension contact	0.0064	0.0271	0.001***
Training contact	-0.0686	0.0916	0.027**
mills lambda	0.3572	0.1887	0.008*
Rho	0.8820		
Sigma	0.4050		

*, **, ***: significant at 10%, 5% and 1% level respectively

4.2.2 Factors Influencing the Extent of Adopting the ISVs.

To determine the factors influencing the extent of adoption of the improved sweet potato varieties, OLS regression was estimated in the second step of the Heckman outcome equation. The Inverse Mills Ratio estimated from the first equation was added to the second equation as an independent variable so as to capture the selection bias effect. The variable was found to be statistically significant at 5% level justifying existence of selection problem and the use of the model.

The household size was significant at 5% with negative coefficient which indicates that there is a negative relationship between household size and adoption of improved sweetpotato technology. The larger the household size the lower the level of adoption of improved sweet potato varieties. This could be explained by the fact that the average agricultural land available per household is about 0.33 ha (Jaetzold *et al.*, 2006). However this was interesting and inconsistent with many past studies since sweet potato is far much labour intensive. This is concluded by the fact that a small household size is not pressured by the need of to produce more food for a large family size consumption, hence it open and willing to try out new technologies than a larger household size.

Table 10: The Heckman Two-step Outcome Equation

Variable	Coef.	Std. Err.	P>z
Genderhead	0.0136	0.090	0.880
Hhsize	-0.0393	0.0217	0.070*
Education level	-0.0163	0.0631	0.797
Group heterogeinty	0.0718	0.0392	0.067*
Occupation	-0.0165	0.0396	0.676
Off-farm	0.1081	0.0865	0.211
Output	0.0000	0.0000	0.026**
Landtenure	0.0972	0.0421	0.021**
Farming experience	-0.0494	0.0604	0.414
Number of livestock	0.0346	0.0142	0.015**
Market distance	-0.026	0.0188	0.167
Group membership	0.2419	0.1282	0.059*
Sweet potato price	0.0018	0.0034	0.605
Credit amount	0.044	0.0236	0.063*
LnWealth	-0.1153	0.0845	0.173
Extension contact	0.0064	0.009	0.478
Training contact	-0.0686	0.0334	0.040**

*, **, : significant at 10% and 5% level respectively

Group heterogeneity index had a positive significant influence on adoption of the improved sweet potato varieties. The level of heterogeneity shows a high level of diversity among the group members. Its role during group meetings is key since it determines variety and quality of information, knowledge and experiences to be exchanged among the group members. Hence, groups with members from different background are important during their formation. Social capital and networks were found to be important in influencing diffusion of most sustainable agricultural practices in Ethiopia as they exchange of information, facilitates timely input access including credit and loans (Teklewold *et al*., 2013).

Output of sweet potato was found to be a very important factor that influenced the adoption of improved sweet potato varieties among farmers in the study area. The yield variable was found to be positive and significant at 1% level of significance. Yield is a direct measure of seeds performance, and a crop variety that is high yielding stands to be adopted

by farmers since high yield would raise output and subsequent gross earning. This finding agrees with that of Ojiako *et al*. (2007) that yield of soybean was significant in influencing the adoption of improved soybean in northern Nigeria. Adesina and Zinna (1993) also reported that yield significantly influenced farmer's decision to adopt improved mangrove swamp varieties of rice in Sierra Leone.

As expected, land tenure had a positive significant effect with having land rights increasing the probability of adoption of the ISVs by 7.38%, all other factors held constant. Secure land tenure provides farmers with full rights of land ownership and usage thus influencing the decision to adopt a new technology. Land ownership with title deeds accords the farmers the right to usage (security of tenure) thus creating an incentive to the farmers to adopt new, long term and even riskier technologies. Similar results were found by Arellanes and Lee (2001) where they concluded that farmers with security of tenure were four times likely to employ more of the new techniques due to security of land access and usage.

The analysis shows that the extent of adoption increases with the livestock number. This probably is due to the fact that wealthier households are better able to bear possible risks associated with adoption of technologies. There was a positive association between adoption and livestock ownership, probably because wealthier households, and may be more able to finance the purchase of inputs, for example improved seeds. In addition, livestock may serve as a proxy for the availability of manure. Such kind of land fertility augmenting practice is important given that the adoption rate of commercial fertilizer is very low in our study area.

As expected group membership postively and significantly influenced the adoption of ISVs. According to Blackburn *et al*. (1982), participation in social groups is important because it indicates the extent of contact, which farmers have with organized groups and other public services and mass media. Groups provide forum for improving dialogue among farmers, thereby providing opportunity for efficient ways of ascertaining consensus on opinion about the relevance of technologies being presented to them (Norman *et al*., 1989). Farmers who are members of any local organization are more likely to be aware of new information and ISVs technologies (Wasula, 2000).

There is also that tendency that farmers will adopt new innovations because majority of them had access to credit which would enable them to purchase inputs and pay for labour required in the adoption of new varieties. Credit access enables the farmers get resources that they could invest in marketing activities such as value addition to improve incomes and transportation to better markets with better prices. The CREADIS program model also

incorporates a microfinance project whereby farmers can access loans to meet their daily needs. This could act as an incentive given the fact that rural farmers have limited access to finance. Availability of loan upon participation in the program therefore leads to increased probability of adoption.

Training contact negatively and significant influenced the extent of adoption of the innovation. This result is inconsistent with results of earlier studies (Baidu- Forson, 1999; Faturoti *et al*. (2006) and Mazvimavi and Twomlow, 2009). The negative effect of training contacts implies that most of the training done was general to all farmers, customizing the trainings to individual needs of each farmer would better improve extent of adoption. The more contacts the farmer has with officers they tend to reduce potential intensity of adoption. However, intensive discussions with farmers on the kind of training topics they receive revealed that agricultural training services are more focused on intensifying crop and livestock production and also value addition at the expense of adopting new technologies and techniques.

4.3 Effect of Improved Sweet potato Varrieties on Household Food Security.

4.3.1 Determinants of Food Security Status.

To determine the effects of ISVs on food security status, the endogenous switching regression probit model was used for analysis. The endogenous switching probit model is identified by functional form (Lokshin and Sajaia, 2011; Gregory and Coleman-Jensen, 2013). Hence, the study used exclusion restriction methodology to improve on identification. The study used gender head, sweet potato unit price, farmer to farmer extension and non-govermental extension as instruments. This study however is consistent and exclusive to studies such as Ayuya *et al.,* 2015, Di Falcao *et al*., (2011), Asfaw *et al*., (2012) and also Negash and Swinen (2013) who used agricultural information sources as intruments in their studies. However, sweetpotato and gender head are exclusive for this study. Table 11 presents tests that indicated the above variables as valid instruments. Sargan's test showed the correlation between the instruments excluded and error terms. Sargan test was $Pr>\chi^2(1)= 0.5745$ and $Pr>\chi^2(1)= 0.4520$ showing that the excluded instruments were uncorrelated with the error terms.

Table 11: Validity of Selected Instruments used in the Endogeneous Switching Probit Model

Variable	First stage		Second Stage	
	Farmer type		Food status	
	Coef	Std. Error	Coef	Std. Error
Genderhead	-0.3402	0.3416	-0.5568*	0.3297
Sweet price	0.0693***	0.0194	0.0129	0.0135
Farmer to farmer Extension	-0.4803	0.9921	-1.7451	1.0075
Non-govermental Extension	1.3843	1.0303	-1.9017*	1.1145
Constant	-1.3285	2.3308	-5.9924*	1.9204
Wald test	128.92		90.40**	

Note: *, **, ***= significant at 10%, 5% and 1% respectively.

The likelihood-ratio test for the joint independence of the equations was significant in both farmer types. Wald χ^2 test statistics (53.94) for the farmer type, indicates a joint significance of the intruments excluded helping in testing the hypothesis of weak instruments. Hence, we fail to reject the hypothesis of weak intruments. The determinants of food security status are shown in Table 12. The independent variables were selected from past studies on derteminants of food security status (Kassie *et al*., 2013; Shiferaw *et al*., 2014; Christian and Coleman, 2013). The ρ_0 and ρ_1 (measures of food security status) have opposite signs implying that differences in observed resource endowments and unobservable household characteristics are both important in explaining the difference in food security between the groups. The correlation coefficient of the adopter outcome equation is positive and significant. Suggesting that individuals who choose to adopt the ISVs would be more food secure than a random individual from a sample would have had they not adopted the ISVs.the likelihood ratio tests for the joint independence of equations was significant in validating the use the switching probit model as opposed to the bivariate probit model. This also justifies why we reject the null hypothesis that there is no significant effect of ISV effect on household food security and accept the alternative.

Participation of the household head in off-farm income-generating activities increase the likelihood of household being food secure in all the two household type. Results show the vital role of off-farm activities in enhancing household income diversification. These could be explained by the uncertainties and risks facing agriculture in most developing countries.

Additionally, participation in off-farm activities increases the access of the decision maker to more information on how to build their household human development indicators. Similar findings were reported by Krishna and Shariff (2011), where participation in off-farm reduced the likelihood of a household being multidimensional poor and increased the probability of escaping poverty in India respectively.

Table 12: Full Information Maximum Likelihood Estimates of the Switching Regression Model (Dependent variables: Food Security Status)

	Adopter		Non Adopter	
Variable	**Coef.**	**Std. Error.**	**Coef.**	**Std. Error.**
Marital status	0.2941	0.4300	0.4191	0.3222
Household size	0.0676	0.1361	-0.0617	0.0869
Off-farm income	1.4673**	0.7458	0.9798*	0.5303
Farm size	-1.7234**	0.8621	0.1405	0.2227
Output of sweetpotato	0.0009***	0.0004	0.0003	0.0002
Landtenure	-0.5533*	0.3025	0.1431	0.2068
Number of livestock	0.0329	0.1035	0.0540	0.0528
Market distance	-0.0986	0.1399	-0.0046	0.0821
Training contact	0.2304	0.1812	-0.0779	0.1213
Government extension	0.1413*	0.6473	0.7694	0.3980
Cultural belief	-0.1210	0.5069	0.3062	0.4276
Sweet potato buyers type	-0.4944***	0.1502	-0.2035**	0.0885
Constant	-3.9313	2.9448	-4.6600	2.1551
ρ_0			-0.4710	0.8893
ρ_1	0.9842**	0.8674		
Lr. Test for independent. Eqns. (rho 1= rho0) chi2(2)= 2.90 prob>chi2=0.0054***				

Note: *, **, ***= significant at 10%, 5% and 1% respectively

Landtenure had a negative and significant effect on food security at 10% level. This results justifies significant association of landtenure of sweetpotato farmers. A high number of farmers without tittle deed on both the adopters and non adopters with 38% and 42% are not able to undertake risk or enterpreneural ventures such as adopting of new technologies. This farmers have to be sure on the good perfomance of the technologies before adopting them since many of them have no secure rights on their land.

The output of sweet potatoes realised by an household, not surprisingly, had a positive impact on food security for adopter household. High output positively increased the likelihood of an adopter household being food secure. An increase in production leads to a substantial increase in food surplus and hence the surplus could be sold to earn extra income. These households can therefore buy other food groups and diversify their diet.

Surprisingly Sweet potato buyer type had a negative effect on food security (in favour of middlemen) in both the households but significantly on the adopter household. Hence where there was existence of middlemen the adopters sold their output to them. Middlemen are known to exploit the farmers by offering lower prices compared to the market prices and in turn farmers end up not breaking even in their enterprises. On the other hand, selling of the sweet potato on the market also attract dismal prices since it will be competing with the other local varrietis. These affects food security in the sense that the farmers will be dicouraged to produce for commercial purpose and just produce for subsistence. There would be low or no surplus produce for sell to get extra income to buy food. Hence consumers and farmers would no physical, social and economic access to sufficient food which meets their dietary needs.

Consistent with a study by Shiferaw *et al*., (2014) on Adoption of improved wheat varieties and impacts on household food security in Ethiopia, government extention contact positively and significantly at 5% increased the likelihood of the adopter household being food secure. Farmers who came to know improved varieties via extension agents are more likely to be more food secure compared to those who were informed by other dissemination pathways, probably because the predominant public extension system provides more reliable information on improved varieties and associated agronomic practices. However, constant visits by CREADIS extension officers on the adopters in the county led to farmers' willingness to learn a lot of the topics including value addition, Marketing and production techniques.

Cultural belief although not significant, its coefficient shows it could affect food security status negatively. This is a great concern in the study area; since farmers have negative belief in new technologies especially the improved varieties therefore they tend to stick on the local varieties.

4.3.2 Mean Treatment effects on Food Security

The effect of adoption of improved sweet potato varieties on food security is shown in Table 13, which was estimated by equation 16a and 16b as detailed by Lokshin and Sajaia (2011). The values across the diagonals (in cell (a) and (d)) represent the mean values of

participants and non- participants in the sample. The values in cell (b) and (c) are the counterfactual expected values. The average treatment effect on the treated (ATT) was 0.0778, which is the actual effect that adopters experience through adoption. This implies that among the adopters, their adoption of improved sweet potato varieties led to a higher probability or more likelihood of being more food secure compared to the counterfactual case of not adopting the ISVs. Hence, adoption of the ISVs substantially improved the food security of the adopter households.

Table 13: Mean Treatment effects on Food Security

Treatment effects	**Decision stage**		
	Adopter (ATT)	**Non adopter (ATU)**	**Average treatment effects (ATE)**
Adopter	(a) 0.7835(0.0330)	(c) 0.7057(0.0309)	0.0778**
Non adopter	(b) 0.5207(0.0489)	(d) 0.5885(0.0323)	-0.0678
Heterogeneity effects	0.2627***	0.1171**	

Notes: **,*** imply significance at 5% and 1% respectively. The stardard errors are in parentheses

In addition, results also confirm the presence of heterogeneity and sorting based on comparative advantages (differences in food security status between the adopters and non adopters caused by unobserved factors), the sample can therefore be concluded to the entire population. To the government agricultural policy makers and nongovernmental organizations, their interest is to understand what would be effects of ISVs on food security status on non adopter households if they were to adopt ISVs. The finding were interesting and is given by average treatment effect on the untreated (ATU) which shows that for non-adopters food security would decline if the non adopters were to adopt the ISVs. However, negative and insignificant, these households presumably have better alternatives than the improved sweet potato varieties and they fare better, atleast interms of food security, by not adopting. These findings are consistent with other studies' results (Negash and Swinnen, 2013; Suri, 2011; Zeitlin *et al*.,2010) that farmers with low expected net returns do not adopt a technology and the ones who have higher expected returns do apply them.

CHAPTER FIVE
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The study aimed to characterize sweet potato farmers, determine factors influencing adoption and the extent of adoption of the ISVs and lastly to assess the contribution of the ISVs on household food security in Bungoma county, Kenya. Majority (57%) of the sweet potato farmers had adopted improved varrieties while only 43% were still planting the local varrieties. This mainly is because of the location of the KARI which together with CREADIS which is a non govermental organization was contracted by KARI to distribute, contract and educate sweet potato farmers on the new improved varrieties in the area. Findings of the study revealed that household socio-economic characteristics, institutional factors and the social capital dimensions are very important in influencing the adoption of ISVs and its extent of adoption.

Specifically, five variables were found to be significant from the study that influence adoption. Education level, price of sweet potato and extension contact were found to positively influence the level of adoption while farming experience and training contact negatively and significantly affected adoption. Farming experience had a negative influence because older farmers tend to be conservative in their approach of doing things while training contact. Education level was positive since more skills and knowledge is gained with increase in level of education, while sweet potato price attracts more farmers since it's easy to break even. Extension agents popularizes innovation by making farms exchange idea, experiences, and makes it cheaper to source information, knowledge and skills in order to enable farmers to improve their livelihood.

Eight variables were significant in influencing the extent of adoption. Output, land tenure, number of livestock, group membership, credit amount, training and group heterogeneity index had a positive influence on the extent of adoption. Household size had a negative influence. The negative effect of training contacts implies the more the farmer has contacts with officers they tend to reduce potential intensity of adoption. Household size was also negatively significant. This is concluded by the fact that a small household size is not pressured by the need to produce more food for a large family size consumption, hence its open and willing to try out new technologies than a larger household size.

We find that adopting the improved sweet potato varrieties increased households' food security significantly. The effects are substantial. Our findings indicate improvements in

increased food diet diversity and household overall income. Adoption of the improved varrieties reduces liquidity constraints as they can be harvested at periods of food shortages and can contribute to mitigate seasonal gaps in food availability. In addition, adoption of the varriety improves access to other food groups and farm inputs for these households, which improves overall crop productivity. Our analysis also suggests that adoption of the ISVs is heterogeneous across households.We find rational sorting based on comparative advantage from the technology/crop where adopters gain significantly from adopting which they may not otherwise. Households who do not adopt, appear to do this because they would not benefit. This is in line with findings of other studies. We have found that non-participating households have made a rational choice not to participate in that they are better off without adopting the sweet potato improved varrieties.

5.2 Recommendation

The adoption analysis results show that prices of sweet potato, farming experience, extension contact, education level and training influence the adoption of improved sweet potato varieties. These results provide strong evidence for the positive impact of adoption of modern agricultural technologies for a major food staple on alleviating food insecurity in Kenya. However, exploiting the full benefits of the technology in improving food and nutritional security will require increased investments and policy support for improving sweet potato productivity through greater access to variety information from extension agents, persistent encouragement to farmer's education and also better producer prices.

Participation in off-farm income activities by the household head, high output, government extension, land tenure and sweet potato buyer type were important drivers in determining food security status. Participating in off-farm income activities increased the probability of being food secure in both the household types. This raises a policy concern on the importance of diversifying farm income through creation of sustainable off-farm activities. Of concern also is the effect of government extension which significantly increased the probability of being food secure. Farmers should be sensitized on socio-cultural aspects that hinder adoption of technologies in the county. This calls for the need to strengthen extension services by the government since farmers get most of their information about new technologies from them. Further, the choice of the sweet potato buyers should be cautious by the farmers since it negatively reduced the probability of the adopters being food secure. For public policy, these findings underpin the importance to strengthen contractual agreements in

marketing to wipe out middlemen in the process and assure farmers constant market for their produce.

5.3 Further Research

The main intention of the study was to examine the contribution of the improved sweet potatoes varieties on household food security. However, there are several areas for further research.

1. This study mainly focussed on food security in the county, it will be wise if further research largely focusses on the nutritional aspects and also income, since the improved sweet potato apart from enhancing the food security it also has effects on household income and nutritional status because of the existence high levels of vitamin A in the them in form of beta-carotene, vitamin B1 and B2.
2. The study has its limitations interms of the methodology and also data that are used. Methodologically, the use of survey data is an important contribution to the existing studies, and we have used advanced econometric techniques that are standard in the literature for the type of data set that we have, but it is well known that identification of causal effects based on cross-section data is difficult. Therefore future research should focus on collecting better data sets, including panel and time series data,and on using different methods, such a s field experiments.

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APPENDIX

QUESTIONNAIRE

The purpose of this study is purely academic and more so to contribute to the understanding of improved sweet potato varieties among farmers in the district. Respondents are requested to **VOLUNTARILY** participate in answering this questionnaire and are assured that any information shared will be strictly **CONFIDENTIAL.**

SECTION A: General Information

1. Date of interview _____
2. Name of enumerator_____
3. Sub county _____
4. Division_____
5. Relation to the household head……Age……..

SECTION B: SOCIO-ECONOMIC CHARATERISTICS OF THE RESPONDENT

1.0. Have you adopted the improved sweet potato varieties?

1. YES [ ] 2. NO [ ]

1.1. Gender		**1.2.** Age (Years)						**1.3.** Marital Status			
M	F	<18	19-29	30-39	40-49	50-59	>60	Single	Married	Widowed	Divorced

1.4. Household size (*number of people living and eating together*) ……

1.5. Number of schooling years……2……..

1.6. What is the education level of the household head? (*Tick appropriately)* 1= Not gone to school [ ]; 2= primary [ ]; 3= secondary [ ]; 4= college [ ]; 5= university [ ] University

1.7. What is your occupation?

1=casual laborer [ ]; 2=Salaried employed [ ]; 3=Business person [ ]; 4=Farming [ ]

Others, Specify……..

1.8. What was the estimated amount of income for the year (*in KES*)?

1=From farm production KES [ ]; 2= From off-farm KES [ ]; 3= From employment [ ]
Total income KES ……..

1.9.What is the size of the land under sweet potato (acres)……...?

1.10. Indicate the land tenure system on the land in use and how you acquired it?

Total Size	**Tenure System(Acres)**			
	Owned	**Rented in**	**Rented out**	**communal**
Acres [ ]				

1.11. Apart from sweet potato farming, of the total land can you tell us what other activity are engaged in the plot(s) and the number of acres under each enterprise? What is the tenure of each parcel of land (in case having several parcel of land)?

Plot/ parcel	**Land use**	**Acres**	**Land tenure**
1			
2			
3			
4			
5			

Land use1= Maize acres under each enterprise[ ]; 2=Bean farming (acres) [ ]; 3=Sugarcane growing (acres) [ ]; 4== Animal feed cultivation / Grazing [ ]; 5=Others specify [ ]

Land tenure: 1=owned with title deed 2=owned without title deed 3= Rented 4=owned by parents 5=Communal/ government/ cooperative

1.12. How long have you been living in Bungoma South Sub-County (in years).....

1.13 Of the years you have been living in Bungoma, how long have you been doing sweet potato farming (in years)? …….

1.14 Do you own any livestock ……..*(1=Yes, 0=No)*If yes tell me the type and number of livestock owned

Are there any cultures or belief that hinder you from adopting the improved varieties?

Livestock type	Number owned	Number sold	Gross income
Oxen			
Cows			
donkeys			
poultry			
goats			
sheep			
Total			

SECTION C: FOOD SECURITY

Dietary Diversity Data (24 hr. recall)

Did **YOU OR ANYONE ELSE IN YOUR HOUSEHOLD** eat any kind of the following foods yesterday during the day and at night?

Food group	**Examples (any other locally available food)**	**Code 1 Yes 2 No**
2.1. Cereals	millet, sorghum, maize, rice, wheat, or	
2.2 Root and tubers	potatoes, yams, manioc, cassava or any other foods	
2.3.Pulses/legumes	beans, peas, lentils, or nuts	
2.4. Milk and milk products	cheese, yogurt, milk or other milk products	
2.5. Eggs	eggs	
2.6. Meat	beef, pork, lamb, goat, rabbit wild game, chicken, duck, or other birds, liver, kidney, heart, or other organ	
2.7. Fish and seafood	fresh or dried fish or shellfish	
2.8. Oil/fats	Oil/ fat	
2.9. Sugar/honey	Sugar, honey	
2.10. Fruits	Mangoes, oranges, pineapples	
2.11. Vegetables	Kales, cabbage, carrots, French beans,	
2.12.Miscellaneous	coffee, tea	

This can be done manually or on a spread sheet. The HDDS variable will be calculated for each household. The value of this variable will range from 0-12.

HDDS (0-12)	The total number of food groups consumed by members of the household. Values for A through to L will either be "0" or "1"

The average HDSS indicator is calculated for the sample population

Average HDDS	$\frac{\text{Sum (HDDS)}}{\text{Total number of households}}$

HDDS target will be establishes by taking the average diversity of households with the highest diversity (Upper tercile of diversity)

Household food consumption diary.

*I would like to ask you about all the different foods that your household members have eaten in the **last 7 days**. Could you please tell me **how many days** in the past week your household has eaten the following foods? (For each food, ask what the primary source of each food item eaten that week was, as well as the second main source of food, if any)*

Food item	**DAYS eaten in past week (0-7 days)**	**Sources of food (see codes below)**	
		primary	**secondary**
1 – Maize			
2 – Rice			
3 – Bread/wheat			
4 – Tubers			
5–Groundnuts & Pulses			
6–Fish (eaten as a main food)			
7 – Fish powder (used for flavor only)			
8–Red meat (sheep/goat/beef)			
9–White meat (poultry			
10–Vegetable oil, fats			
11 – Eggs			
12–Milk and dairy products (main food)			
13–Milk in tea in small amounts			
14–Vegetables (including leaves)			
15 – Fruits			
16 – Sweets, sugar			

Food source codes:
Purchase =1 Own production =2 Traded goods/services, barter =3, Borrowed = 4 Received as gift= 5 Food aid =6, other (specify) =7

SECTION D: GROUP PARTICIPATION

3.1 Do you belong to a farmer group/organization in the community?

1. Yes ☐ 2. No ☐

3.2 If yes, how many groups do you belong to.....?

3.3 Give the names of the farmer group(s)

1. ……..
2. ……..

3.4 Are there any requirements before one joins a farmer group?

1. Yes ☐ 2. No ☐

3.5 If Yes, what are the requirements?

1=Pay membership fee [ ]; 2=Minimum farm size requirement [ ]; 3=Quality of the output [ ]

4=Declare your property[ ]; 5=Be from the same village[ ]; 5=Other,specify.....

3.6 What kind of relationship exists between the members of your group?

1. Relatives ☐
2. Neighbors ☐
3. Friends ☐
4. Farmers ☐

3.6 From a scale of 1-10 how do you rate your decision making in the groups?
3.7 From a scale of 1-10 how do you rate your trust on members on the group?
3.8 How did you get information about the farmer groups?
1=Fellow farmers [ ]; 2=Export agents [ ]; 3=Media advertisement [ ]; 4=Self-initiative [ ]

5=Friends [ ]; 6= Other (specify) ……

3.8 If **NOT** a group member, give reasons

.....
.....

3.9 Would you like to be a member?

1. Yes ☐ 2. No ☐

3.10 If Yes, what stops you from being a member?

1. Lack of trust with members ☐
2. Don't meet the quality standards ☐
3. Don't meet the minimum quantity delivery ☐
4. High membership fee ☐
5. Lack of time to attend meetings ☐
6. Distance with group members ☐

4.0 What is the approximate distance from your homestead to the market? _____ (Km)

5.0. How much do you sell your sweet potato produce (kg)…….

1. Goro goro (2.4kg)……
2. paper bags of (2kg)……
3. Numbers……
4. others specify……

5.1 What type of buyers do you sell your sweet potato to?

1. Middlemen
2. Individual Consumers
3. Retailers
4. Wholesalers
5. Trader groups
6. Others (Specify)_____

6.0 Why did you choose the buyer?

1. Gives better prices
2. Under contract
3. Consistent & pays cash
4. Only proximate trader
5. Others (Specify)

SECTION E: CREDIT ACCESS, EXTENSION AND TRAINING

7.1. Have you ever acquired any credit in the last one year?
1. Yes
2. No

7.2. What was your reason for borrowing?

1=Buy production inputs [ ]; 2=Medical bills [ ]; 3=School fees [ ]; 4= Others (Specify)

7.3. What was the source of the credit advanced and how much was it?
1. Commercial banks ……
2. SACCO ……..
3. Microfinance institutions…….
4. Informal lenders …….
5. Farmer groups……..

7.4. What was the approximate amount borrowed each source above? (KShs.)_____

7.5. How did you spend the loan last year on the total borrowed from each source, specify uses and amounts here in %……
1=Fees…….
2=Livestock….
3=Food……

4=Household items…..
5=Crops……..

7.6. If **No** in no. **7.1**, give reason (***please tick one that is most applicable***)
1. No collateral
2. Defaulted on previous loan
3. High interest rate
4. Not aware of credit facilities
5. Others (Specify)_____

8.Does your household own any of the following assets?

Asset Name	**Number**	**Current Unit value**	**Total Value**
Ox-Ploughs			
Ox-cart			
Panga Knife			
Hoes			
Wheel Barrow			
Bicycle			
Tractor			
Radio			
Mobile phone			
Television			
Other Specify			

8. Have you ever attended any training or seminar on sweet potato?
1. Yes
2. No

8.1. Did you pay for the training?
1.Yes
2.No

8.2. If yes in 7.1, then how much?.....

8.3. How long did the training take…….

9. If yes, which topics were discussed?

1. Production of sweet potato
2. Marketing of sweet potato
3. Sweet potato value addition techniques
4. Others_____
10. How many times are you visited per month by extension officer? _____
11. If yes,who provided the extension service or technical advice on sweet potato production?

1=Fellow farmer [ ]; **2**= Government officers [ ]; **3**=NGOs [ ]; officers [ ]; **4**=Other sources (Specify)_____
12. Do cultural belief hinder your adoption of ISVs----------

1.YES 2.NO

13. Have you been contracted by any organization…….

Your participation in this study is greatly appreciated.Thank you for your time!Once again, I assure you that your identity will remain ***STRICTLY CONFIDENTIAL.***