AN ASSESSMENT OF THE EFFECT OF VARIETAL ATTRIBUTES ON THE ADOPTION OF IMPROVED CASSAVA IN HOMA-BAY COUNTY, KENYA

By

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Reg. No: A56/76800/2014

A Thesis Submitted in Partial Fulfilment of the Requirements for the Award of the Degree of Master of Science in Agricultural and Applied Economics

DEPARTMENT OF AGRICULTURAL ECONOMICS

FACULTY OF AGRICULTURE

UNIVERSITY OF NAIROBI

November, 2018

Declaration and Approval

Declaration

I declare that this thesis is my original work and has not been presented for an award of a degree in any other University. This thesis has been complemented by materials from other sources that are duly acknowledged. The APA reference system has been used in accordance with anti-plagiarism regulations.

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Publications

The following papers have been extracted from this thesis:

1) **Okuku, I. O.,** Nyikal, R. A. and Otieno, D. J. **(2018).** The Effect of Varietal Attributes on Adoption of Improved Cassava in Homa-Bay County, Kenya. The paper is currently under review in the **East African Agricultural and Forestry Journal.**

Dedication

This thesis is dedicated to my mother, Caren Anyango, brothers, sisters and friends for the continued encouragement, support and prayers. I also dedicate it to my late father, Tom Odhiambo Okuku.

Acknowledgement

I would like to convey my sincere gratitude to my family members for their moral and financial support during my pursuit of further studies. I also wish to thank the African Economic Research Consortium (AERC) for the sponsorship of my Masters studies; I will forever acknowledge your support. Secondly, I am sincerely indebted to my supervisors Prof. Rose Adhiambo Nyikal and Dr. David Jakinda Otieno for their guidance towards the completion of this thesis. I have benefited a lot from their pieces of advice, constructive criticisms, and comments from the beginning of this thesis to its completion. I would like to express my deepest appreciation to my uncle, Prof. Mark Odhiambo for the support, and mentorship during my studies as well as being a role model. I feel indebted to you always, thank you very much. Moreover, I am thankful to my colleagues for their fruitful, moral and material support. Last but not least, to all who assisted me in one way or the other, whom I have not mentioned by names, I wish to thank you all. Finally, I am grateful to my Creator for good health and the ability to complete this thesis, may the Glory be to His name, Amen.

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List of Abbreviations and Acronyms

AgGDP	Agricultural Gross Domestic Product
CKDAP	Central Kenya Dry Area Smallholder and Community Services Development Project
FAO	Food and Agriculture Organizationof the United Nations
FGDs	Focus Group Discussions
IITA	International Institute of Tropical Agriculture
KALRO	Kenya Agricultural and Livestock Research Organization
Kg	Kilogram, a measure of weight equivalent to 1000 grams
MALF	Ministry of Agriculture, Livestock and Fisheries, Kenya
MSc	Master of Science
MT	Metric Tons
NGOs	Non-Governmental Organizations
SSA	Sub-Saharan Africa
UN	The United Nations
USAID	United States Agency for International Development
WFP	World Food Program

Abstract

Improved cassava varieties are vital for ensuring food security in the rural households in the face of the changing climatic conditions, which have resulted to poor performance of the common staple food crops. In view of this, new cassava varieties such as TMS 30572 TM14, MH93/OVA and yellow cassava have been released and adoption is rated at 25 per cent in Homa-Bay County. However, there is little empirical insight on farmers' awareness and the effect of varietal attributes on the uptake of these varieties. While several previous studies have analysed adoption drivers of improved varieties, none has determined the influence of varietal attributes on the uptake of the improved varieties. The overall objective of this study was to assess farmers' awareness and the effect of varietal attributes on the adoption of improved varieties. The specific objectives were to: characterize farmers' awareness, perception and adoption of improved cassava varieties; determine the effect of varietal attributes on the adoption of the improved cassava varieties; and assess the influence of varietal attributes on the intensity of adoption of these varieties. A multi-stage sampling method was used to randomly select some 129 cassava farmers as respondents for the study. The study used both primary and secondary data. A semi-structured questionnaire was used to collect primary data from the respondents. The study used multivariate probit and Poisson regression models to analyse the determinants of adoption decision and the intensity of adoption, respectively.

The study found that six cassava varieties were grown in the study area, four of which were improved varieties, TMS 30572, TM/14, MH93/OVA and yellow cassava, while the rest were local varieties, *Selele* and *Obaro Dak*. Farmers were generally aware of the existence of these varieties. Results showed that 29.4 per cent, 25.7 per cent, 16.5 per cent and 14.3 per cent of farmers adopted TMS 30572, TM/14, MH93/OVA and yellow cassava, respectively while 38 per cent and 34 per cent still maintained *Selele* and *Obaro Dak*. Notably, the adoption of one cassava variety did not preclude the adoption of other varieties. The results revealed that improved cassava varieties were perceived to have desirable production attributes such as yield, early maturity, drought tolerance, and resistance to pests and diseases, whereas local varieties were grown due to their tastes and resistance to drought.

Likewise, the multivariate probit results demonstrated that the perceived desirable characteristics of yield, early maturity, resistance to pests and diseases and tolerance to drought positively influenced the adoption of the improved varieties, while their relatively blunt taste and lengthy cooking time reduced the adoption. Among the socioeconomic factors, household size, land size, access to extension services and group membership increased the likelihood of adopting these improved varieties. On the contrary, age of the household head had a negative effect on the probability of adopting MH93/OVA. The results of the Poisson model also revealed that the perceived yield potential and early maturity positively affected the degree of adoption of the improved cassava varieties, while the perceived dull taste and longer cooking time had negative effects on the same. Age of the household head also negatively influenced the degree of adoption, whereas household size, land size, level of education, access to extension services and group membership positively affected the extent of adoption of the improved varieties. Based on these findings, the study recommends that cassava breeders should not only focus on enhancing production attributes, but also consumption attributes so as to address farmers' different needs in adoption. Moreover, it is deemed appropriate that producers, processors and consumers should be involved in the evaluation process of the new cassava varieties so as to ensure acceptance by the end users.

Keywords: Improved Cassava Varieties; Varietal Attributes; Awareness; Adoption; Kenya.

CHAPTER ONE

INTRODUCTION

1.1 Background

Food insecurity is a major concern for Sub-Saharan Countries, where agricultural production is far much below the demand of the fast growing population. Nonetheless, the good news is that, African traditional root crops, especially cassava (*Manihot esculenta*) have been proven, through scientific research, to have a considerable potential to boost food security (Ogunlade et al., 2010). It has the ability to withstand prolonged drought periods by reducing its biomass production and remobilizing photosynthetic reserves in the roots and stems, depending on the season (Mbanzibwa et al., 2011). Studies on responsiveness to climate change have reported that it is the least affected crop compared to the common grain staples like maize, rice and sorghum, among others (Jarvis et al., 2012). It is also estimated that a temperature rise of 2° C by 2020 will be in favour of tuber and root crops like cassava as it is predicted that it will outperform cereal crops in productivity (Liu et al., 2008). Loss of African major cereals in such a situation, however, is projected to be about 13 per cent, 8 per cent, and 9 per cent for maize, rice and sorghum, respectively (Rowhani et al., 2011).

In Africa, Nigeria is the leading cassava producer. Latest available statistics show that in 2014, it produced about 57 million metric tons (MT) (FAOSTAT, 2016), while Kenya produced only 858,361 MT in the same period (FAOSTAT, 2016). Cassava is remarkably valuable and can substitute other crops in various uses depending on the preferences and customs of the local population. Its leaves can be cooked as a soup ingredient and consumed as a vegetable. It can also be dried and used as a supplement to feed livestock (Raviindram, 1992). Cassava roots can be processed for industrial and human consumption (International Institute of Tropical Agriculture - IITA, 2005). It can also be used in yeast and beer production. Its starch component is highly demanded by paper, plywood, pharmaceutical, textile industries, and ethanol for fuel (IITA, 2005). The success stories of cassava can be drawn from countries such as Brazil, Nigeria, Thailand and Vietnam. For instance, in Brazil, cassava has been used successfully in the confectionery and baking industry (Sanginga and Mbabu, 2015).

In Kenya, the numerous benefits of cassava remain untapped. Rather, it is still regarded as a poor man's crop (Mulu-Mutuku et al., 2013). Yet, the country has experienced successive seasons of low rains, and the number of food insecure population is estimated at 8 million (WFP, 2016). Most scientific innovations in agriculture that aim to restore household food security have only concentrated on increasing the production of wheat, maize, Irish potato, beans, rice and other imported technologies at the expense of cassava (Republic of Kenya, 2008). However, these crops hardly withstand prevailing climatic condition. In effect, cassava production has been limited over the past seasons.

In western Kenya, cassava was at one time a second-best food crop after maize in terms of consumption patterns and as a source of income (Obiero, 2007). Its consumption in this region was about 60 per cent of national cassava output. Nevertheless, cassava production in the region has been limited by the presence of biotic factors, lack of processing technologies, low agronomic practices and poor cassava varieties (Agwu and Anyaeche, 2007). The land under cassava cultivation in the region fell from 25,000 hectares in 2002 to 10,000 hectares as recorded in 2010 (Fermont et al., 2010).

One of the areas with major cassava growing potential in the country is Homa-Bay County. The regular long dry spells have, however, shortened the main growing season, to range between 90 and 120 days in the area. This has limited the productivity of the common cereals such as maize, and bean, among others. Cassava being a drought tolerant crop is favoured by the prevailing climatic condition. The paradoxical situation, however, is that cassava, which is the most suitable enterprise, has been replaced by maize, sorghum and millet that rarely do well. As such, the majority of the population is trapped in poverty, with the absolute poverty rated at 74 per cent and, an estimate of 81 per cent of the population experiences hunger for at least two months in a year (Nyasimi, 2014).

Through a strategic intervention, the IITA and Kenya Agricultural and Livestock Research Organization (KALRO) bred and released new varieties, TMS 30572, TM/14, MH93/OVA and yellow cassava in 2010, to address the aforementioned production challenges and food insecurity. These varieties are believed to be high yielding, early maturing, resistant to pests and diseases, and drought tolerant (Nyasimi, 2014). The introduction of improved cassava varieties was followed by intensive extension service delivery funded by the Ministry of Agriculture, Livestock, and Fisheries (MALF), Rheal Solutions (a non-governmental organization), and currently by Homa-Bay County Government. Farmers were trained on diverse farm management practices, value addition techniques such as preparation of cassava chips and cake, among other entrepreneurial skills (CKDAP, 2011). Lead farmers were also used in the targeted regions as trained-multipliers who sell planting materials directly to the neighbouring farmers. The goal is to increase smallholders' income, food security, and production to a level that can attract commercial entities within the County.

1.2 Statement of the research problem

Despite the introduction of improved cassava varieties, cassava production has remained low in Homa-Bay County. Food insecurity and high poverty levels are still major concerns within the county. A report by Kenya Integrated and Household Budget Survey (KIHBS) indicate that the poverty level is at 52.9 per cent (Nkonya et al., 2016). The absolute poverty is rated at 74 per cent, and an estimate of 81 per cent of the population experiences hunger for at least one to two months in a year (Nyasimi et al., 2014). Also, about 15 per cent of the children population are underweight, while 26 per cent have stunted growth. Most of the poor are women and youths. Interestingly, adoption of these improved cassava varieties has remained low at 25 per cent (Odero, 2010; Republic of Kenya, 2015). Whereas low adoption of improved cassava varieties has been documented, possible strategies for adequately addressing this challenge are not. The introduced improved cassava varieties are believed to be vital for rural economies and household food security and should not be ignored. Stakeholders have been focusing on generalised approaches rather than dealing directly with the core issues that limit adoption of the new varieties. Low adoption of the new varieties is likely to compound the already uncertain future of food security situation in the county.

Previous studies on improved cassava varieties have only assessed socioeconomic characteristics, institutional and policy factors determining adoption (Njine, 2010; Mulu-Mutuku et al., 2013; Mwang'ombe et al., 2013; Mutisya et al., 2013; Danda et al., 2014; Kamau et al., 2016). Participation on field days, access to extension services, group membership, farmer's education level, land size and farmers' own characteristics, are some of the factors identified to be influencing the uptake of improved varieties (Odero, 2010; Njine, 2010; Ndiema, 2013). The factors that are known to influence adoption were handled, yet adoption still remains very low, five years after the introduction of these varieties. It is, however apparent that none of the earlier studies determined the effect of varietal attributes on adoption of improved cassava varieties, which is a critical gap in knowledge. Varietal attributes are often known to influence choice, but in this case, the magnitude and direction, if any, are not yet documented.

1.3 Objectives of the study

The main objective of this study was to assess farmers' awareness and the effect of varietal attributes on the adoption of improved cassava varieties in Homa-Bay County.

The specific objectives were:

1. To characterise farmers' awareness, perception and adoption of improved cassava varieties.
2. To analyse the effect of varietal attributes on the adoption of improved cassava varieties.
3. To determine the influence of varietal attributes on the intensity of adoption of improved cassava varieties.

1.4 Research questions and hypotheses

The first objective was not subjected to statistical test, however, it sought to answer the following questions:

1. What is farmers' awareness and perception of improved cassava varieties?
2. What is the level of adoption of improved cassava varietes?

The last two objectives were subjected to statistical test and were hypothesized as follows:

1. Varietal attributes do not affect the adoption of improved cassava varieties.
2. Varietal attributes do not affect the intensity of adoption of improved cassava varieties.

1.5 Justification of the study

The government of Kenya and other stakeholders have shown that the country has the capacity of producing over 2 million MT of cassava annually (Republic of Kenya, 2007). Tapping this potential requires a proper understanding of the new varieties and the drivers of their adoption and use, a knowledge gap which the current study sought to fill. The major criticism of cassava breeders is the tendency to concentrate on improving yield while failing to integrate other desirable non-yield-related attributes into improved varieties. Non-yield-related attributes are important since cassava is grown mainly for subsistence in the rural society (Republic of Kenya, 2007). Identifying key varietal attributes driving adoption is thus necessary for designing cassava breeding programmes and informed breeding policy in light of the attributes preferred by cassava farming households. Further, the study considered the uptake of improved varieties, which would provide a strong case for channelling investment in improving their diffusion in Kenya.

Many of the previous adoption studies on improved cassava varieties have used simple probit and logit models that tend to generalize adoption based on one variety (see, for instance, Odero, 2010; Ndiema, 2013, Odendo and Abele, 2015; Khonje et al., 2015). Nevertheless, when several improved cassava varieties with varying production and consumption attributes exist, farmers are likely to adopt multiple varieties to address their different needs, which points to the likelihood of correlation in farmers' adoption decisions. Thus, use of conventional probit or logit models, which ignore the interdependencies in adoption decision-making process, may lead to biased and inconsistent estimates, and thus resulting to misleading policies (Greene, 2003). In light of this, the current study employed multivariate probit model to account for possible correlation in the uptake of the alternative varieties.

It is also envisaged that the study would contribute towards the objective of national cassava policy that aims to improve the standard of living, eliminate hunger and starvation through promotion of root and tuber crops such as cassava (Republic of Kenya, 2007). In doing so, cassava farming households will eradicate poverty in all its forms (**SDG1**), end extreme hunger and improve nutrition, ensure sustainable food production, and maintain the genetic diversity of seed and cultivated plants (**SDG2**) (Requejo and Bhutta, 2015). Finally, the study contributes to the existing literature by providing empirical evidence on the farmers' awareness, perception and adoption of improved varieties.

1.6 Study area

Several technologies that can enhance food security have been tried in various part of the country. The new cassava varieties are particularly important for Homa-Bay County that is plagued by frequent droughts and, hence high food insecurity. The County is located in the South western part of Kenya. The County consists of eight sub-counties, which include Rangwe, Homa-Bay Town, Ndhiwa, Rachuonyo North, Rachuonyo South, Suba, and Mbita sub-counties. It is located between longitudes 340° 12´ and 340° 40´ East and latitudes 00° 28´ and 00° 40´ South (Republic of Kenya, 2001). It sits in the rain shadow of Kisii hills and is on the Lower Midland (LM3) agricultural zones (Jaetzold and Schimidt, 1982). The altitude ranges between 1200 metres and 1400 metres above the sea level. It receives rainfall of about 1300mm on average in a bimodal pattern (Republic of Kenya, 2015). The County has three types of soils; silt loam, black cotton, and clay loam that have poor drainage (Jaetzold and Schimidt, 1982). The County's population is estimated at 1,038,858 and the growth rate is at 2.7 per cent annually (County Government of Homa-Bay, 2013). The population density is estimated at 325 people per square kilometre (Nyasimi et al., 2014).

Homa-Bay County's population derives its livelihood from three economic activities; which include, trade and commerce, agriculture, and formal or informal wage labour. Agriculture is the primary economic activity, employing about 60 per cent of the residents. Subsistence farming is the dominant land use practice, accounting for 86 per cent of the land cultivated annually (Okuthe and Akotsi, 2014). The major food crops produced include maize, sorghum, beans, kales, millet, peas, and sweet potatoes (Nyasimi et al., 2014). It has been estimated that about 86 per cent of the farmers produce maize and beans annually, however, in very small quantities. The main cash crops produced are sugarcane in Ndhiwa, sunflower in Suba, pineapples in Rangwe and sweet potatoes in Kasipul Kabondo (Nyasimi et al., 2014). Coffee and tea are also produced in the upper zones of the County. The productivity of these crops has been affected by the unreliable and poor weather conditions. The County Integrated Development Plan report of 2013 points out that the current climate conditions present a huge potential for tuber crops like cassava production in the County (Nyasimi et al., 2014). Other root and tuber crops like sweet potatoes have been adopted widely and commercialized while efforts on cassava adoption are still on. Consequently, the study targets to identify varietal attributes that promote or limit adoption of improved varieties in the region.

The map of Homa-Bay County in which the study was conducted is shown in Figure 1.

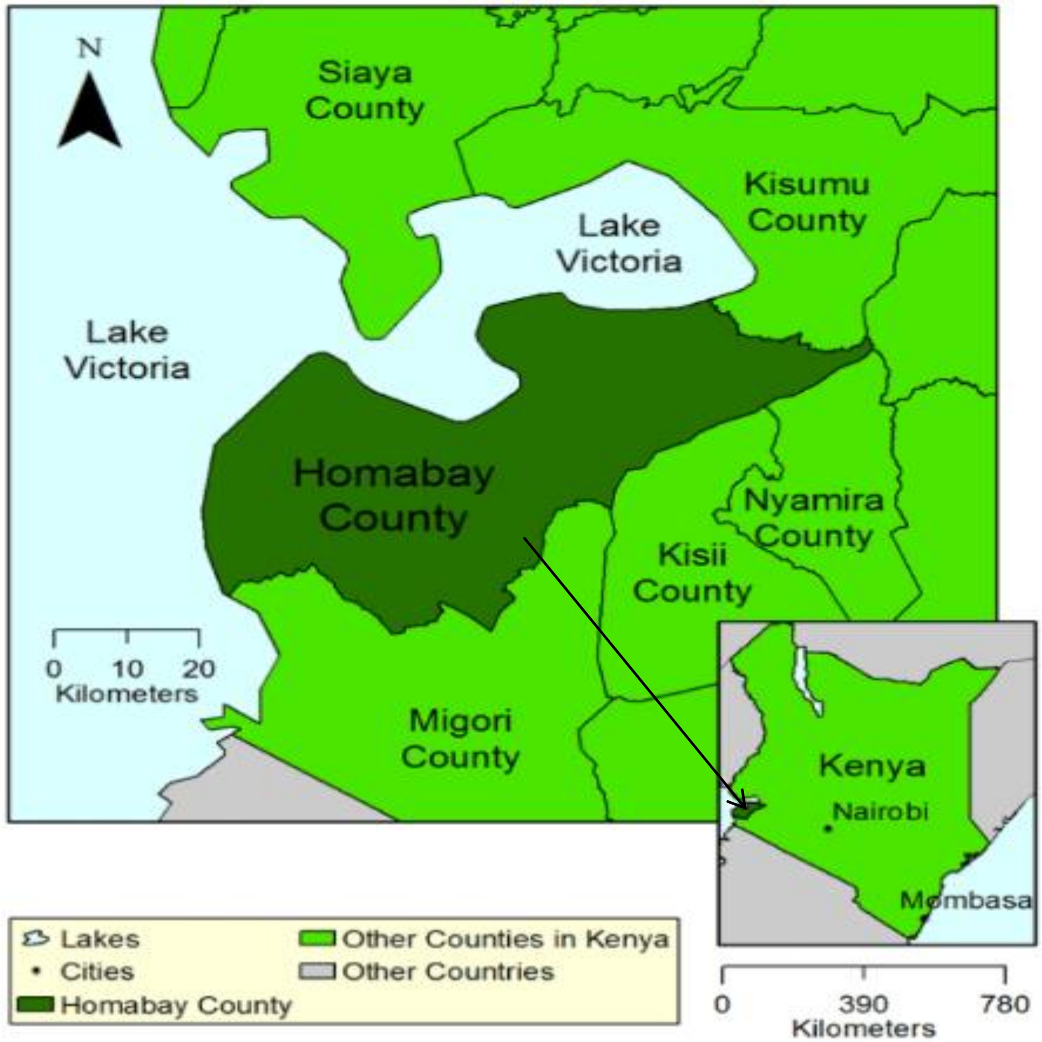

Figure 1: Map of Homa-Bay County
Source: The County Government of Homa-Bay (2013-2017).

1.7 Thesis organization

This thesis is organized into five chapters. The background of the study, the statement of the research problem, objectives, hypotheses, the rationale for the study, area of the study, and the organization of the thesis have been presented in chapter one. Chapter two provides a critical review of relevant literature. Chapter three discusses the methodology used in the study, while the results are presented and discussed in chapter four. Finally, summary, conclusion and recommendations, contribution to knowledge and suggestion for further research are presented in chapter five.

CHAPTER TWO

LITERATURE REVIEW

2.1 An overview of cassava production and consumption in Kenya

Kenya's agriculture is mainly practiced in small-scale, with a few cases of large-scale farming and medium-scale practices (Alila and Atieno, 2006). Cassava production is done entirely in small-scale practices. The contribution of the cassava output to Kenya's Gross Domestic Product (GDP) has been negligible over the past years; it is estimated to be less than 1 per cent annually (FAOSTAT, 2016). The pattern of national cassava output has not been stable. Its consumption has exceeded the production over the past years (FAOSTAT, 2016). The country has relied on the importation from the neighbouring counties to meet its consumption demand. The production steadily rose between 2011 and 2013, but drastically fell in 2014 as illustrated in Figure 2 below. Not much is known about the current production and consumption status, a phenomenon that is critical in development planning.

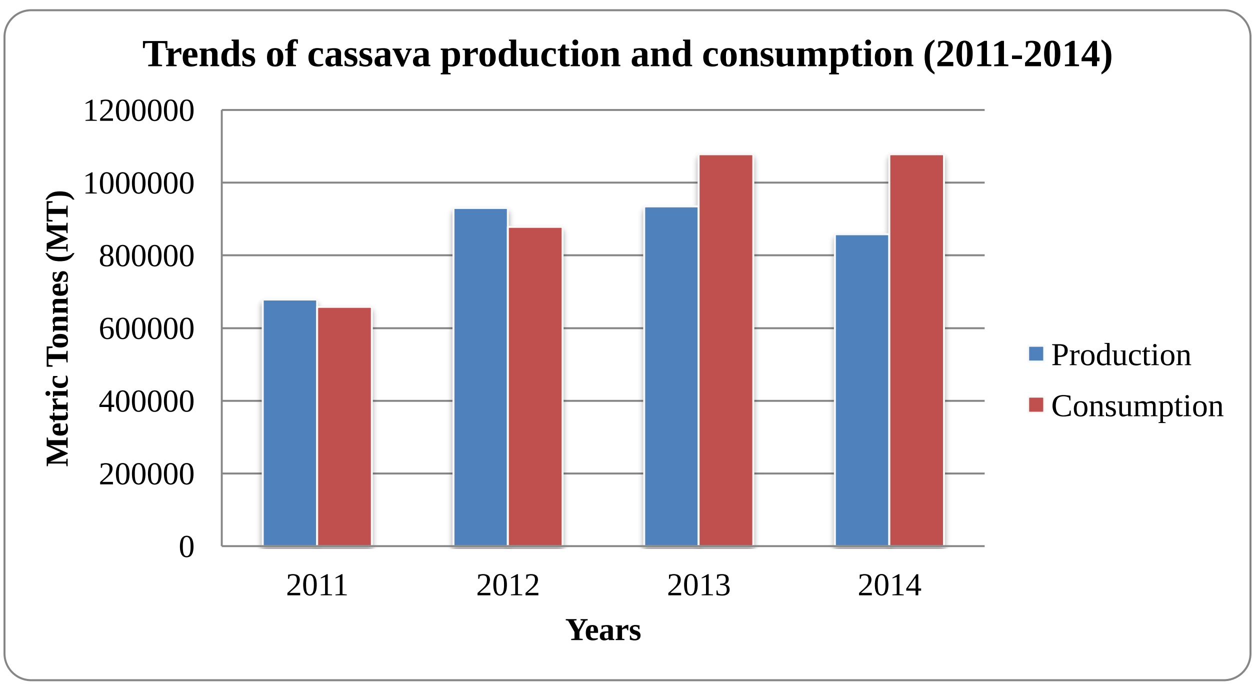

Figure 2: Trend of cassava production and Consumption in Kenya (2011-2014).
Source: Adapted from FAOSTAT (2016).

2.2 Cassava value chain in Kenya

Figure 3 presents a cassava value chain in Kenya. Analysis of the value chain has shown that almost all the national output is consumed locally. About 97 per cent of the national output is consumed locally while the rest either goes to waste or sometimes exported (Republic of Kenya, 2007). The local cassava value chain entails fresh roots and leaves, cassava flour, cassava starch and cassava in the animal feed industry.

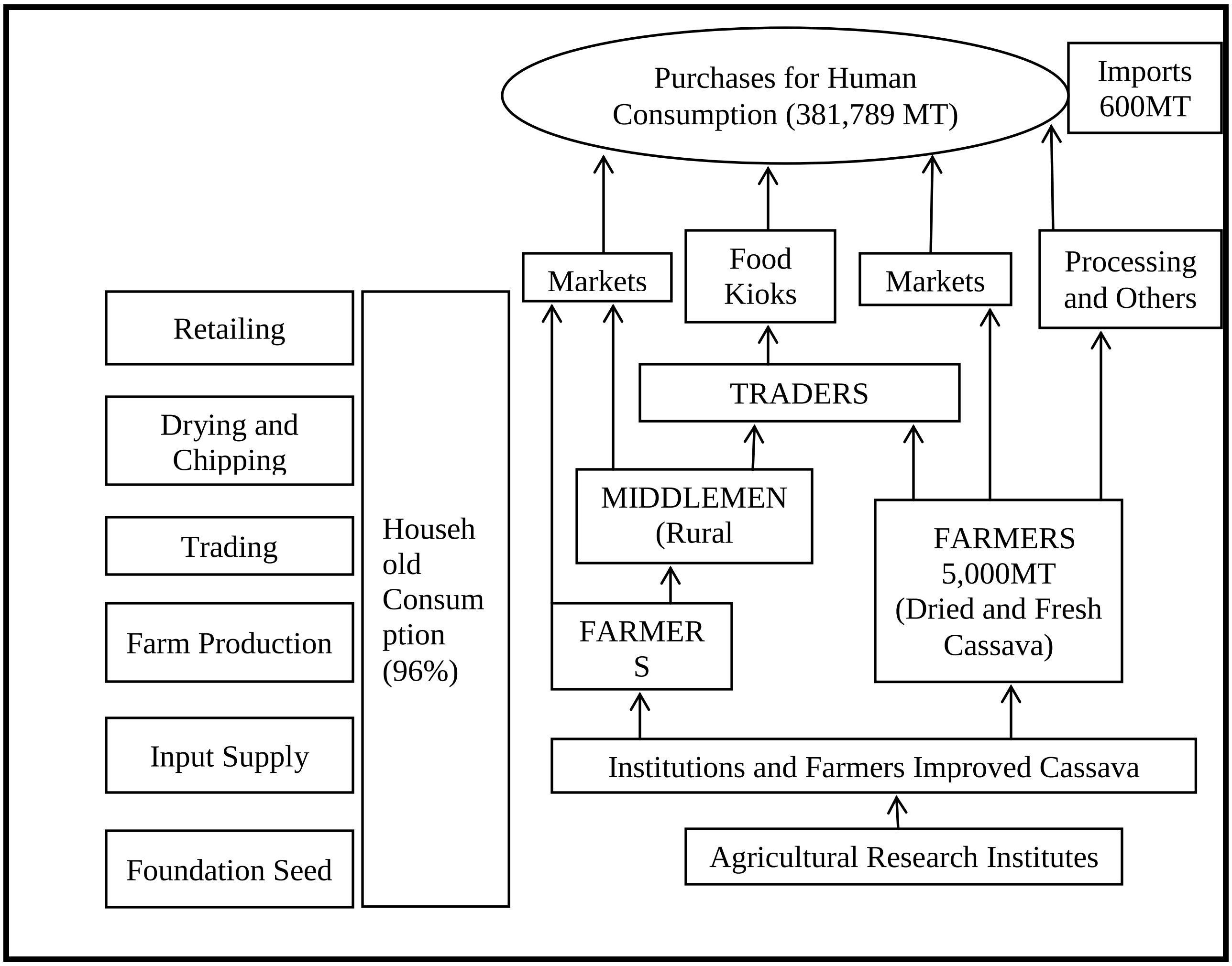

Figure 3: Cassava sub-sector value chain map
Source: Adapted from Republic of Kenya (2007).

2.2.1 Fresh cassava roots and leaves

In Kenya, many households consume fresh cassava leaves as vegetable, because of its nutritive value. The utilization of fresh cassava roots is mainly by boiling and roasting. They are consumed by both rural and urban dwellers as a snack and a main meal. Cassava is also used to make products such as fried chips and cassava crisps. The perishability of cassava in its fresh form has limited the extent to which it can be utilized and marketed, and dictates its movement from farmers to consumers (Ojiako et al., 2012).

2.2.2 Cassava flour

Cassava flour is obtained by milling both the fermented and unfermented dry chips (Republic of Kenya, 2007). The flour is combined with maize, millet or sorghum flour to make porridge or *ugali*, a local starch component of the diets for many communities. In Kenya, the potential of cassava flour in confectionary and baking industry remains unexploited. A composite of cassava flour and wheat flour can be used to produce high-quality cakes, bread, buns, and scones depending on the ratio of cassava and wheat used (Mwang'ombe, 2013).

2.2.3 Cassava starch

In Kenya, starch materials are normally produced from grains. However, there are over 100 starch derivatives that can be produced from cassava starch (USAID, 2010). The most common starch derivatives produced are maltose and glucose syrup. Malaysia and Thailand have developed high-quality starch for specific industrial applications for both local and export markets (Kuiper et al., 2007). Cassava starch has been applied in the manufacturing of cardboard, sandpaper, briquettes, charcoal, flashlights, dolls, photographic films, and batteries (Republic of Kenya, 2007). The starch has also been used in textile and laundry industries. The bland starch flavour and its freeze-thaw stability have made it a favourite for food and pharmaceuticals. Thus, it is widely used as diluent in drug and chemical manufacturing, and as carriers in pills, capsules, and cosmetics (Ajani, 2013). In Kenya, such entities remain unexplored.

2.2.4 Nutritional value in cassava roots

Cassava, just like other crops, is a nutrient-rich crop. The roots have high energy reserve with the carbohydrate content of about 35 per cent on fresh weights and 83 per cent on its dry weights

(Montagnac et al., 2009). The roots have more carbohydrate content than sweet potatoes and less carbohydrate than rice, wheat, sorghum and yellow corn on a 100-g basis (Charles et al., 2005). The content of fiber is about 1.5 per cent, while that of lipid is estimated at 0.3 per cent (Montagnac et al., 2009). Its lipid content is comparable to rice and sweet potatoes, but low compared to sorghum and maize. The protein content is much higher than that of maize. One kilogram of cassava contains 6 grams of protein, whereas maize of the same quantity has only 4mg of protein (Westby, 2008). Table 1 shows that improved cassava varieties can also play a significant role nutritionally, within the Homa-Bay County and the country at large.

Table 1: Nutrient composition of different foods in comparison to cassava roots

Food	Energy (Kcal)	Protein (g)	Lipid (g)	Carbohydrate (g)	Fibre (g)	Sugar (g)
Cassava root	667	6.36	0.28	38.06	1.80	1.71
Sweet potato	321	2,02	0.09	17.47	2.22	0.78
Wheat	1523	10.03	0.98	76.31	2.74	0.27
Rice	1506	6,61	0.58	79.34	-	-
Yellow/white corn	1527	4.32	4.74	74.26	7.33	0.64
Sorghum	1418	11.3	3.30	74.63	6.30	-

Source: Adapted from Montagnac et el., (2009).

2.2.5 Cassava in the animal feed industry

Cassava is widely used all over the world to feed cattle, pigs, poultry and sheep. However, its utilization in animal feed industry in Kenya remains low. Given the advanced poultry and dairy industry in the country, cassava chips have the potential of replacing about 30 per cent of maize grain in animal feed rations. Besides, Kenya has over 40 animal feed industries and 160 milling units mainly in urban areas. The concentrate feeds produced annually is about 470,000 MT (USAID, 2010). The current capacity for concentrate feed production is estimated at 800,000 MT out of which only 58 per cent is utilized locally. If well promoted, cassava could substitute the use of maize in the animal feed manufacturing industry, which is currently valued at Kshs. 1 billion

(Republic of Kenya, 2007). Japan and the Far East countries import about 24,000,000 MT of desiccated cassava for livestock from cassava producing countries annually (FAOSTAT, 2016).

2.2.6 Intra- and extra-EAC/COMESA cassava export and import trends

The cross-border trade in cassava is negligible in Kenya, even though it has numerous opportunities. The country's average import and export between 2010 and 2013 were at 98 MT and 4 MT per year respectively (USAID, 2010). According to the statistics, it is evident that Kenya's households have not focused much on intensive cassava production and trade. Therefore, export markets for dried cassava chips have not been exploited (Odendo et al., 2006). Figure 4 shows Kenya's importation and exportation trends for cassava and its products from 2010 to 2013.

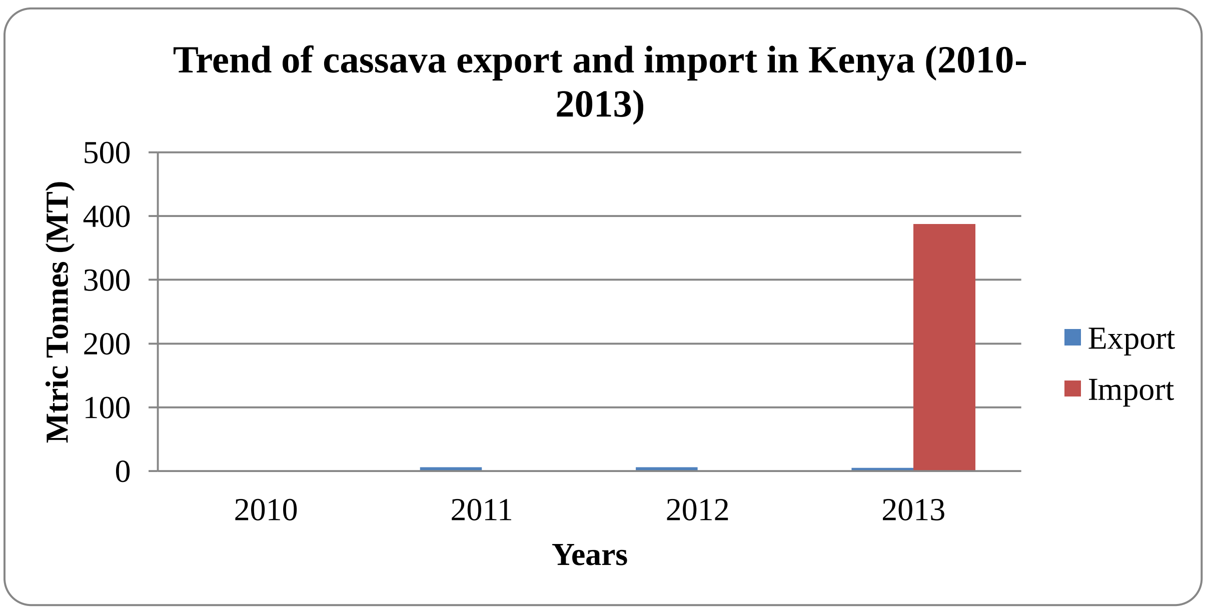

Figure 4:Trend of cassava export and import in Kenya (2010-2013).
Source: Adapted from FAOSTAT (2016).

Even though cassava has numerous potential economic uses, lack of an appropriate policy environment in Kenya has constrained cassava production and hence underutilization in the food, pharmaceuticals, animal feeds and paper industries, among other sectors (Republic of Kenya, 2007). It is, therefore, necessary to conduct production-related studies, with a view to identify constraints that hamper the production in this sub-sector, and establish a sound policy framework that can enhance production.

2.3 A Review of knowledge gaps on improved cassava varieties

A number of studies have been conducted on improved cassava varieties in Kenya, revealing a host of socioeconomic, technical and institutional factors affecting farmers' decisions to adopt new varieties. For instance, Odendo et al. (2015) used Tobit model to analyse the determinants of farmers' adoption and the impact of improved varieties in western Kenya. The study found that only about 25 per cent of the 350 surveyed households had adopted the new varieties. The age of the household head, level of education and farmers' participation in cassava projects significantly contributed to adoption. The study established that farmers' participation in the cassava projects enhances their knowledge on farm management and access to clean planting materials, hence increasing the uptake of improved varieties. As such, it recommended that policy should be designed to involve farmers in the dissemination of new varieties and other cassava projects. With regard to these findings, extension officers in Homa-Bay County have developed a policy framework of engaging farmers through seminars, workshops, field days and plot demonstrations to address identified knowledge and skill gaps. The demonstration model farms are managed by farmers themselves while the stakeholders only provide needed technical supervision. The County government has also organized several capacity building initiatives by conducting study tours for both extension staffs and lead farmers to various field stations of the cassava research institutions (County Government of Homa-Bay, 2013). Extension officers have been equipped with necessary training tools tailored towards different target groups of farmers. Farmers are also being involved in drawing up cassava project implementation plans, actual implementation and monitoring and evaluation of such projects (County Government of Homa-Bay, 2013). The end result is to promote the adoption of improved varieties and scale-up cassava production in the region.

Mulu-Mutuku et al. (2013) using descriptive statistics and a sample of 99 households, investigated the impact of commercialization and utilization efforts on the adoption of improved cassava varieties in Nakuru County, Kenya. The study established that only 6 per cent of the sampled farmers were actively engaged in entrepreneurial activities such as selling cassava snacks and dried chips. Cassava was largely grown by older farmers as compared to younger farmers. Constraints such as farmers' attitude on cassava as a poor man's crop and difficulty in identifying clean planting materials were reported as some of the factors limiting cassava production. The study noted that farmers' entrepreneurial skills and access to processing facilities needed to be improved so as to enhance adoption of improved varieties. In light of this, the County government of Homa-Bay and other stakeholders have trained farmers on identification of clean planting materials and better farm management practices to ensure maximum prodcution. They have also trained farmers on small-scale value addition techniques, for instance, preparation of crisps, and baking of high-quality cakes, bread, buns, and scones for household consumption and small-scale commercialization. Farmers have been encouraged to sell cassava leaves, fresh chips, cassava peels, and fresh cassava roots as feeds for pig, cattle, sheep, poultry and fish farmers so as to increase their farm income. The Homa Bay County Government is also currently drawing out plans to create markets for cassava-based feeds for livestock by collaborating with other counties which do not engage in cassava production to enable farmers export their products to those counties (County Government of Homa-Bay, 2013).

Njine (2010) assessed socioeconomic factors hindering the adoption of improved cassava varieties in Nyeri County, Kenya. The study was based on a sample size of 80 farmers and analysis was done using descriptive statistics. The study found that 32 per cent of the respondents were not growing improved varieties. The study also noted that farmers who were members of the extension groups cultivated cassava and introduced improved varieties at a higher rate of 35 per cent than non-members at 18 per cent. The result also showed that 87 per cent of farmers did not see cassava as a poor man's crop, indicating a positive perception. The policy implication was that extension agents needed to find more effective ways of reaching resource-poor farmers so as to enhance their production. In view of these findings, farmers have been encouraged to form groups in order to promote diffusion of improved cassava varieties. Farmers in groups have been urged to accept the social responsibility of sharing the cassava planting materials with non-members to help break the poverty cycle. Farmers in coordination with the County government have formed the Cassava Co-operative Society, which offers an immediate market to cassava farmers (County Government of Homa-Bay, 2013). Through the cooperative, farmers are also able to access clean planting materials, soft loans and grants to facilitate cassava production locally and expand producers' capacity to the level that can attract investments.

Mwang'ombe et al. (2013) employed descriptive statistics to evaluate challenges and opportunities in cassava production among rural households in Kilifi County, Coastal region of Kenya. Presence of pests and diseases, lack of clean planting materials, lack of a sustainable seed propagation system, inappropriate cropping systems, low soil fertility, and lack of a viable functional value addition techniques were identified as the main challenges facing farmers in cassava production. They recommended the need to improve existing value chain mechanisms by processing of cassava products and strengthening the linkages between smallholders and output markets. In addition, training farmers on farm management, identification of clean planting materials and building farmers' capacity to produce clean planting materials seemed an appropriate policy. In this regard, the County government of Homa-Bay has focused on post harvest handling, value addition, and marketing of farm produce. Currently, there are recognized commercialized entrepreneurs in multiplication and distribution of cassava planting materials who sell these planting materials at a affordable cost to farmers. All the cassava multiplication fields are subjected to a quality management protocol. Private partnerships in value addition are being encouraged with a view of building the County's capacity in cassava processing (County

Government of Homa-Bay, 2013). There are also plans to expand market of cassava dry chips by constructing cassava processing facility in the County (County Government of Homa-Bay, 2013). From the reviewed literature, it is apparent that the previous studies have paid much attention to socioeconomic characteristics, institutional and policy factors, whose findings have not scaled up the uptake of new varieties and cassava production in the County. It is also apparent that no study investigated the effect of varietal attributes on the adoption of improved cassava varieties. However, it is not possible to effectively transform cassava production as whole, without understanding the role of varietal attributes on adoption of these improved varieties. Wale and Yalew (2005) argue that failure to establish the influence of these attributes on adoption may misguide policy makers in identifying farmers' different needs in the uptake of improved crop varieties. Moreover, cassava breeders may not know the exact attributes to improve in order to promote adoption of improved varieties.

2.4 A review of methods for analysing farmers' decisions to adopt agricultural technologies

Several past studies have employed probit and logit models to analyse adoption of improved cassava varieties (see, for instance, Owusu and Donkor, 2012; Abdoulaye et al., 2014; Ainembabazi et al., 2015; Ozor et al., 2015). They assumed the non-existence of correlation in the adoption decisions, even in cases where multiple varieties of the same crop exist. Thus, use of conventional binary models would yield biased, inefficient and inconsistent policy recommendations (Greene, 2003). In the recent years, however, studies on adoption have established that in cases where several varieties of the same crop exist, as the case of the current study, there is the potentiality of simultaneous adoption of the new technologies and the possibility of the correlation of the adoption decisions (Teklewold et al., 2013). Hence, the need to employ a suitable econometric model that takes into account such issues (Gillespie et al., 2004).

Several studies have used multivariate probit to evaluate correlation in adoption of technologies (see for example Velandia et al., 2009; Tecklewold et al., 2013; Mittal and Mehar, 2015). For instance, Velandia used this approach and multinomial logit to assess factors affecting farmers' utilization of agricultural risk management tools, that is, crop insurance, forward contracting and spreading sales. Similarly, Tecklewold et al. (2013) used the same method to evaluate factors that influence adoption of multiple sustainable agricultural practices (SAPs). Such SAPs included conservation tillage, maize-legume rotation, improved seed, animal manure, and fertilizer use, and the analysis used data from multiple plot-level observations in rural Ethiopia. Mittal and Mehar (2015) also used this method to estimate factors affecting adoption of modern information and communication technology in India. In all these studies, the model accounted for simultaneity in the adoption of technologies and possible correlations among the farmers' adoption decisions. To cater for the problem of heterogeneity in farmers' decision-making processes, this study, therefore, employed multivariate probit in analysing the effect of varietal attributes on adoption of improved cassava varieties.

2.5 Overview of approaches of analysing the intensity of adoption of new technologies

Adoption intensity is either defined as the proportion of land in hectares allocated to new technologies or the number of new technologies adopted by farmers (Feder et al., 1985). The studies that have defined adoption intensity as the area of land under new technologies have used Tobit model for the analysis. For example, Akinola et al. (2010) used Tobit model to analyse the determinants of adoption and intensity of use of balance nutrient management systems technologies in the Northern Guinea Savannah of Nigeria. Chukwuji and Ogisi (2006) used the same method to examine fertilizer adoption by smallholder cassava farmers in Delta, State Nigeria. Alene et al. (2000) also applied the same model to evaluate the determinants of adoption and intensity of use of improved maize varieties in the Central Highlands of Ethiopia. Idrisa et al.

(2012) employed Logit and Tobit models to examine the determinants of likelihood of adoption and extent of adoption of improved soybean seeds in Borno State respectively, Nigeria.

Among the studies in which adoption intensity is defined as the number of improved technologies adopted by farmers, Poisson model has been used as the appropriate model. For example, Pedzisa et al. (2015) used a Poisson regression model to evaluate the intensity of adoption of conservation agriculture by smallholder farmers in Zimbabwe. Ramirez and Schultz (2000) also used the same method to explain the adoption of agricultural and natural resource management technologies by small farmers in Central American Countries. Nkegbe and Shankar (2014) used the model to analyse adoption intensity of soil and water conservation practices by smallholders in Ghana, whereas Obuobisa-Darko (2015) applied the same method to determine socioeconomic factors influencing the number of cocoa research innovations used by farmers in Ghana. In the current study, adoption intensity was defined as the number of improved cassava varieties adopted by farmers, and thus allowing the use of Poisson model in evaluating the role of varietal attributes on the extent of adoption of improved cassava varieties.

2.6 Summary

Reviews of literature outlining cassava production, exportation and importation have been presented. Kenya’s production, export and import position at the regional level has been highlighted. The economic significance and nutritional value of cassava, which Kenya and more specifically Homa-Bay County can benefit from, have also been explored. In Kenya, most of the previous studies have focused on the role of the socio-economic and institutional factors on the adoption of improved cassava varieties. However, no past study has been conducted on the effect of varietal attributes on the adoption of improved cassava varieties in Kenya. In most of the past studies, binary logit and probit models and descriptive statistics have been commonly used to assess the adoption of improved cassava varieties. The use of such analytical approaches are believe to conceal the interdependencies in farmers’ adoption decision and result to baised and misleading policies, more so in situations where multiple technologies exist. In view of this, the current study applied a multivariate probit to account for such interpendencies in farmers' adoption behaviours. Overall, there is a scanty informarion on the role of varietal attributes on the adoption of improved cassava varieties Homa-Bay County, Kenya.

CHAPTER THREE

METHODOLOGY

3.1 Conceptual framework

The conceptual framework presented in Figure 5 is based on the theory of induced innovation developed by Ahmad in 1966 and adapted from the theory of wages (Hicks, 1932). The theory postulate that change in population, demand for agricultural products and land pressure induces technological adoption and institutional innovations that intensify land use (Mercer, 2004). In the present study, deteriorating climatic condition and increasing food scarcity have forced researchers to look into alternative and introduce improved cassava varieties to increase food production and enhance household food security. When these varieties are presented to farmers, they do not adopt them immediately. They first have to know how these new varieties perform vis-a-vis the local varieties which they have been growing. The speed of adoption of new technologies is, therefore, gradual in the beginning, then takes off rapidly, and becomes stable before it finally declines. Adoption is based on five distinct stages and time (Nutley et al., 2002). The first stage is the awareness. Cassava farmers acquire the knowledge about the existence of improved cassava varieties. They are then persuaded by the extension officers and other communication channels to consider the new technologies based on the promoted merits. The farmers then consider the perceived attributes of the new technologies in their decision makings to adopt them or not. Finally, they make assessments of the new technologies based on their observed performance relative to the performance of the local technologies.

Cassava varieties incorporate different bundles of consumption and production attributes. These attributes include maturity period, yield potentials, tolerance to drought, pests and disease resistance, ease of cooking and taste. Every variety constitutes a unique composition of attributes and farmers express their preferences for specific bundles of different varietal attributes to maximize their utility (Edmeades et al., 2008). The implication is that farmers' demand for an improved cassava variety is based on the desirable consumption and production attributes. Besides, adoption is perceived to be contingent on personal, socioeconomic, and socio-cultural parameters (Babasanya et al., 2013). Factors affecting the adoption of improved cassava varieties can therefore be conceptualized to include socioeconomic factors, varietal attributes and institutional factors. Socioeconomic factors include age, education level, household size, land size. The institutional factors include access to extension services, access to market information and group membership while specific-varietal attributes included high yield, early maturity, ease of cooking, tolerance to drought, resistance to pests and diseases, and taste.

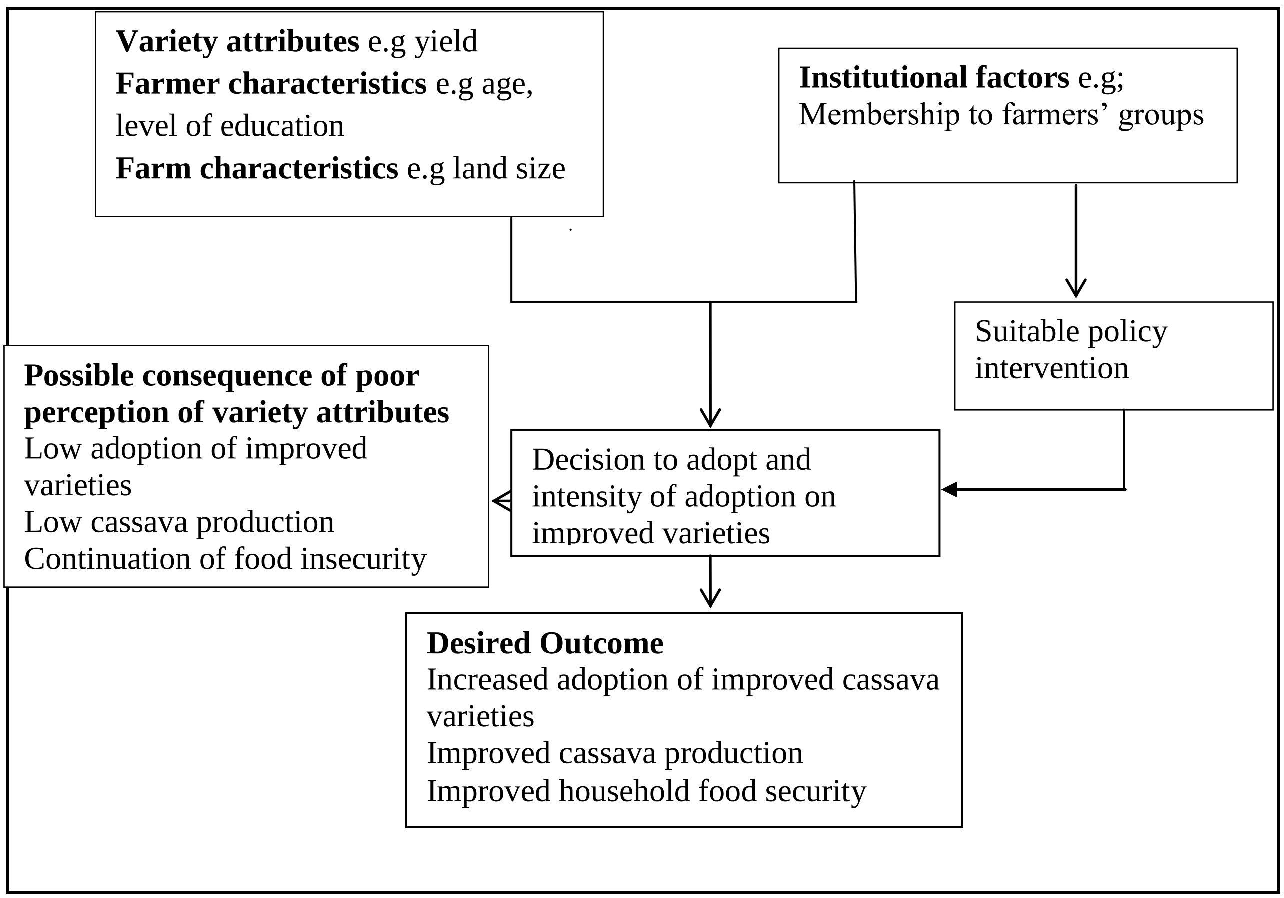

Figure 5: Conceptualizing factors affecting adoption of improved cassava varieties
Source: Adapted from Lu (2011).

3.2 Theoretical framework

The study applied random utility framework to model the decision to adopt improved cassava varieties. Under this framework, it is assumed that a decision maker is a rational economic agent and who, when faced with a set of alternatives, will choose the alternative that gives the best utility (Greene, 2003). Therefore, the decision to adopt is made when the perceived net return or utility from the adopted varieties significantly outweighs the actual net benefit without adopted technology. While utility is unobserved, the households' actions are observed through the selection they make. Suppose that U_j and U_k represent perceived utility of household from two technologies j and k respectively, and that X_j and X_k are vectors of independent variables that affect the perceived utility of technologies j and k, then linear random utility is specified as:

$$U_j = \beta_j X_j + \varepsilon_j \text{and} U_k = \beta_k X_k + \varepsilon_k \quad (1)$$

Where, X_i is a vector of independent variables affecting adoption of cassava varieties; B_i is a vector of parameter estimates; and ε_i is the error terms that is assumed to be independently and identically distributed.

It then follows that the perceived benefit for the i^{th} household from technology j is greater than the utilities from other technologies, for instance k

$$U_{ij}\left(\beta_j X_i + \varepsilon_j\right) > U_{ik}(\beta_k X_i + \varepsilon_k), k \neq j \quad (2)$$

In view of farmer i's adoption, the unobservable net benefit associated with the observable benefit can be expressed as:

$$P(Y = 1|X) \;\; = P\left(U_{ij} > U_{ik}\right) \quad (3)$$

$$= P\left(\beta_j' X_j + \varepsilon_j - \beta_k' X_i - \varepsilon_k > 0 \middle| X\right)$$

$$= P(\beta_j' X_i - \beta_k' X_i + \varepsilon_j - \varepsilon_k > 0|X)$$

$$= P(\beta^* X_i + \varepsilon^* > 0|X = F(\beta^* X_i)$$

Where P is the probability function; $\varepsilon^* = \varepsilon_j - \varepsilon_k$ is a random error term; $F(\beta^* X_i)$ is the cumulative distribution function of ε^* estimated at $\beta^* X_i$; and $\beta^* = (\beta_j' - \beta_k')$ is a vector of the net effect of the explanatory variables affecting adoption of improved varieties.

3.3 Empirical models estimated

Six cassava varieties were grown in the study area. Four were improved varieties: TMS 30572, TM14, MH93/OVA and yellow cassava, while the rest were local varieties, *Selele* and *Obaro Dak*. Improved varieties were perceived to be high yielding and early maturing. The local variety, *Selele* was included in the multivariate probit model analysis for comparison purposes. The specific objectives were achieved through the analysis presented below.

3.3.1 Characterization of farmers' awareness, perception and adoption of improved cassava varieties

Descriptive statistics was used to characterize farmers' awareness, perception and the current state of adoption of improved cassava varieties in the study area. Farmers' perception was evaluated on varietal attributes such as yield, early maturity period, pest and disease resistance, taste, drought tolerance and ease of cooking. The Statistical Package for Social Sciences (SPSS) version 22 was used to characterize cassava farmers and adoption in Homa-Bay County. SPSS was also used to compute percentages and sample mean for socioeconomic factors.

3.3.2 Evaluation of determinants of adoption of improved cassava varieties

Multivariate probit model was used to estimate factors affecting the uptake of improved cassava varieties. The model accounts for potential correlation among the farmers' decisions and simultaneous uptake of multiple improved varieties (Timu et al., 2014). The multivariate probit is an extension of bivariate probit model. The study follows Cappellari and Jenkins (2003) multivariate probit formulated as:

$$Y_{im}^* = \beta_{im} X_{im} + \varepsilon_{im} \qquad (4)$$

$Y_{im} = 1$, if $Y_{im}^* > 0$ and 0 otherwise

Where $Y_{im}^*(m = 1, \dots \dots, K)$ represent the unobservable latent variable of cassava varieties. The model included three improved varieties such as TMS 30572, TM/14, and MH93/OVA that were fairly adopted in the area. The most popular local variety, *Selele*, was also included in the model analysis for purposes of comparison as earlier indicated. Thus, in this case $k =$ TMS 30572, TM/14, MH93/OVA and *Selele* varieties. X_{im} is a vector of observable socioeconomic characteristics, institutional factors, and cassava varietal attributes. β_{im} is a vector of parameters to be estimated. The $\varepsilon_{im}, (m = 1, \dots \dots . M)$, random error terms are distributed as multivariate normal, each a zero mean, and variance-covariance matrix V, where V has a value of one on the main diagonal, for parameter identification, and correlation (Cappellari and Jenkins, 2006). Equation (4) can be expanded to a system of m equations as shown below:

$$\begin{Bmatrix} Y_1^* = X_1\beta_1 + \varepsilon_1 Y_1 = 1 \; if \; Y_1^* > 0, Y_1 = 0 \; otherwise \\ Y_2^* = X_2\beta_2 + \varepsilon_2 Y_2 = 2 \; if \; Y_2^* > 0, Y_2 = 0 \; otherwise \\ Y_3^* = X_3\beta_3 + \varepsilon_3 Y_3 = 3 \; if \; Y_3^* > 0, Y_3 = 0 \; otherwise \\ Y_4^* = X_4\beta_4 + \varepsilon_4 Y_4 = 4 \; if \; Y_4^* > 0, \; Y_4 = 0 \; otherwise \end{Bmatrix} \quad (5)$$

The adoption equations were jointly estimated by simulated maximum likelihood method. This gives consistent estimates and is asymptotically equal to the maximum likelihood estimators of larger samples. In this study, pair-wise correlation of the disturbance terms associated with adoption decisions of farmers was estimated and its significance was further tested to validate the use of multivariate probit model. The model was used to test the hypothesis that varietal attributes had no effect on the adoption of improved cassava varieties. The hypothesis was rejected if β_i (the coefficients of the model) was significantly different from zero and not rejected if the β_i equal to zero.

3.3.3 Evaluation of determinants of the intensity of adoption of improved cassava varieties

The study interpreted the intensity of adoption as the number of improved varieties adopted by farmers, thus suggesting the appropriateness of the Poisson model for the analysis as earlier stated. The application of Poisson model was anchored on four assumptions: first, all the improved varieties have equal probability of being adopted (Wollni et al., 2010). Second, adoption of one cassava variety would not preclude the use of other varieties. However, selection of a variety might not be independent of the choice of another variety, as many of them may be complementary or substitute of each other (Pedzisa et al., 2015). Third, adoption of a greater number of improved cassava varieties is assumed to be preferred by farmers. Nevertheless, the assumption may be limited by the fact that some varieties may be considered superior to others (Mazvimavi and Twomlow, 2009 and Pedzisa et al., 2015). Finally, there are no mandatory physical limits to the number of improved cassava varieties that can be adopted.

Greene (2003) shows that the basic Poisson regression model is specified as:

$$Prob(Y_i = y_i|x_i)\frac{e^{-\lambda_i}\lambda_i^{y_i}}{y_i!}, \lambda_i \in \mathrm{R}^+, y_i = 0, 1, 2, \ldots., n \quad (6)$$

Where $Y_1, Y_2, Y_3, \ldots \ldots \ldots Y_n$ are the predicted values of the number of improved cassava varieties adopted by a farmer and are assumed to have independent Poisson distribution with parameters $\lambda_1,\ \lambda_2,\ \lambda_3, \ldots \ldots., \lambda_n$ respectively (Greene, 2003).

The, $\lambda_i = E(y_i|x_i) = Var(y_i|x_i)$ and the mean is usually defined $\lambda_i = \exp(\ x_i\beta)$ where the x_i is a vector of independent variables and β is a vector of unknown parameters to be estimated.

The parameter λ_i is assumed to be log-linearly related to predictors x_i. Hence,

$$Ln\ (\lambda_i) = (\beta x_i) \quad (7)$$

The log-likelihood is given by:

$$LnL = \sum_i = 1, \ldots \ldots.., n[-\lambda_i + y_i\beta' x_i - Iny_i!] \quad (8)$$

The model was estimated using the same set of variables included in multivariate probit. The model was used to test the second hypothesis that varietal attributes do not affect the intensity of adoption of improved cassava varieties. The hypothesis was rejected if β_i was significantly different from zero and not rejected if β_i equal to zero. The two models were estimated using

STATA software version 13. Table 2 presents the dependent variables and the expected outcomes of the independent variables included in the two models.

Table 2: Description of expected explanatory variables

Variable	Description and Measurement of Independent Variable	Expected Sign
TMS 30572	Grew TMS 30572 cassava variety during 2016 season. (1=Yes; 0=Otherwise)	
TM/14	Grew TM/14 cassava variety during 2016 season. (1=Yes; 0=Otherwise)	
MH93/OVA	Grew MH93/OVA cassava variety during 2016 season. (1=Yes; 0=Otherwise)	
Selele	Grew *Selele* cassava variety during 2016 season. (1=Yes; 0=Otherwise)	
Number of varieties adopted	Number of varieties adopted by the cassava farming households	
Socio-economic variable		
Age	Age of the household head (Years)	+/-
Household size	Number of persons in the house in 2016	+/-
Land size	Land size owned by farmers in hectares	+
Level of education	Education level of the farmer (0= Primary education; 1=Post-primary education)	+
Institutional factors		
Extension contact	Farmer's contact with the extension agents in the past one year (1=Yes; 0=Otherwise)	+
Group membership	Farmer belongs to a group or association (1=Yes; 0= Otherwise)	+
Access market information	Farmer's access to market information (0=no, 1=yes)	+
Varietal attributes as perceived by the respondents		
High yield	The variety is perceived to be high yielding (1= Yes; 0= Otherwise)	+
Early maturity	The variety is perceived to be early maturing (1= Yes; 0 =Otherwise)	+
Pest and disease resistance	The variety is perceived to be resistant to pests and diseases (1=Yes; 0=Otherwise)	+
Drought tolerance	The variety is perceived to be drought tolerant (1=Yes; 0= Otherwise)	+
Taste	The variety is perceived to have desirable taste (1= Yes; 0= Otherwise)	+
Ease of cooking	The variety is perceived to be easy to cook (1 Yes; 0 =Otherwise)	+

Source: Survey Questionnaire (2016).

The general linear functional form of the multivariate probit and Poisson models are stated as:

$$Dec.adopt\ or\ numb.adopt = \beta_0 + \beta_1 age + \beta_2 Hhsiz + \beta_3 Lndsiz + \beta_4 Leduc + \beta_5 Extnsion + \beta_6 Gmember + \beta_7 Marktinf + \beta_8 Yield + \beta_9 Maturty + \beta_{10} Pestdisresistanc + \beta_{11} Drghttoleranc + \beta_{12} Taste + \beta_{13} Easecooking + \epsilon$$

Where *Dec.adopt* means farmers' decision to adopt new cassava varieties, and *numb.adopt* means the number of new cassava varieties adopted by farmers. The independent variables included in the models are explained in the following section.

Age of the household head (*Age*)*:* Age was a continuous variable measured in years. The expected effect of age of the household head on the adoption and the intensity of adoption of improved cassava varieties were deemed indeterminate. This may be because older farmers are more conservative towards new technologies. On the other hand, due to their experience in cassava farming, they are more aware of the deteriorating weather condition in the area and thus would to adopt new varieties that are early maturing over the conventional ones. Previous studies have reported mixed results on the relationship between age and adoption of improved crop varieties. For example, Yirga et al. (2015) found that the age of the household head had a positive and significant influence on the adoption of improved wheat varieties in the Ethiopian Highlands. This could be due to the fact that older farmers have more experience than young farmers in farming and have observed challenges with local varieties, hence would prefer the high yielding new varieties. In contrast, Larochelle et al. (2016) found a negative association between age and adoption of shyushya improved bush bean variety in Rwanda.

Household size (*Hhsize*)*:* Household size was the number of family members in the farming household. Household size was a proxy to availability of active labour force in the household and, therefore, large family members were expected to adopt the improved cassava varieties that are perceived to be high yielding. Alternatively, large family size could contribute to constrained house hold's resource allocations limiting the investment potential of such families, thus reducing the likelihood of adopting the new cassava varieties. Therefore, the expected effects of household size on the adoption and the intensity of improved cassava varieties were also indeterminate. Owusu and Donkor (2012) found that household size had a positive and significant effect on adoption of *Bankye afisiafi* improved cassava variety in Ghana. However, Abele et al. (2007) found that household size had a negative relationship with the adoption and intensity of adoption of improved cassava varieties in Uganda.

Level of education (*EducLevel*): This was the highest level of education attained by household head. The study measured education level as a dummy variable, that is, 1 if a farmer had post-primary education, and 0 if otherwise. Education is a human capital stock and is believed to increase farmers' self-awareness and managerial skill at farm level. Thus, household heads with higher education levels were expected to have the ability to accept new ideas and innovations, hence would be more willing to adopt new cassava varieties. In this study, therefore, household head's education level was hypothesized to have a positive effect on the adoption and level of adoption of improved cassava varieties. Alene et al. (2000) found that education had a positive and significant effect on the adoption and adoption intensity of improved maize varieties in the Central Highlands of Ethiopia. Timu et al. (2014) also found that education had a positive and significant relationship with adoption of *Gadam* improved sorghum variety in Kenya.

Land size (*Landsize*): This was measured in hectares as a continuous variable indicating the size land owned by the household. Total land size was expected to positively influence the adoption and the intensity of adoption of cassava varieties. The probable reason could be that large land size provides a household with an opportunity to adopt the new cassava varieties and increases their production. Ghimire et al. (2015) found that as the amount of land allocated to improved maize varieties increased in Nepal, the amount of improved varieties produced also increased.

Obuobisa-Darko (2015) also found that land allocated by the households had a positive and significant relationship with the adoption of cocoa research innovations.

Contact to extension services (*Externserv*): This was farmer's contacts with the extension agents in the past one year prior to the survey. Farmers' access to extension services was categorized as a dummy variable, that is, 1 if a farmer has accessed extension services, and 0 if otherwise. Farmers who have contact with extension officers are more likely to have knowledge about improved varieties, production, better farm management, market information and output prices. Hence, this study hypothesized that households that have contacts with extension agents would be more likely to adopt the newly released cassava varieties. Yirga et al. (2015) observed a strong relationship between access to extension and farmers' adoption behaviour in Ethiopia.

Access to market information (*Marktinf*): Access to market information was coded as a dummy variable, that is, 1 if a farmer received market information, and 0 if otherwise. The market information considered was on product prices, demand and other relevant information that could motivate farmers to adopt the new varieties and promote cassava production. The study, therefore, hypothesized that access to market information would affect positively adoption decisions and the extent of adoption of improved cassava varieties. Several studies have reported a strong positive and statistically significant relationship between access to market information and farmers' adoption behaviours (Dadi et al. 2001; Yirga et al, 2015).

Membership to farmers' group (*Grmember*): This is a case where a farmer has a membership in the local farmers' organization. Membership to farmers' group was measured as a dummy variable, that is, 1 if a farmer belonged to any farmers' association, and 0 if otherwise. Farmer groups are enterprises voluntarily owned and controlled by farmers themselves. Farmer groups are avenues of advisory services and alternative learning ground (Truong et al., 2011). Farmers who are members of farmer groups are more likely to access market information, planting materials and other farm inputs. In this study, therefore, it was expected that farmer's membership to a farmer group would positively influence adoption and the degree of adoption of improved cassava varieties. Larochelle et al. (2016) found that membership of farmers, organizations increases the probability of adopting improved bean varieties in Rwanda. Tshikala et al. (2015) also established that membership to farmer groups positively and significantly affect adoption of improved maize varieties in drought prone regions of Eastern Kenya.

High yielding at maturity (*Yield*): High yielding attribute is the ability of the improved cassava varieties to give higher output than the conventional ones. This variable was measured as a dummy variable, that is, 1 if a farmer perceived that improved cassava varieties are high yielding compared to the local ones, and 0 if otherwise. High yielding varieties are more likely to be adopted since they increase farm output and, subsequently household's income and food security. In this study, the perceived yielding attributet of new cassava varieties was, therefore, expected to have a positive relation with adoption and the extent of adoption of improved cassava varieties. Agwu and Anyaeche (2007) found that high yield attributes was significant in influencing adoption and the intensity of adoption of improved cassava varieties. Idrisa et al. (2012) also established that yield of soybean strongly influenced adoption and the extent of adoption of improved soybean varieties.

Resistance to pests and diseases (*Pestdisresistanc*)*:* Resistance to pests and diseases was measured as a dummy variable, that is 1 if a farmer perceived that improved cassava varieties are pest and disease resistant, and 0 if otherwise. Cassava is highly susceptible to pest and diseases. The biotic factors are believed to be the most critical constraints to cassava production. Moreover, the cost of chemical treatment for these pests and diseases remains out of reach for the smallholder cassava farmers. An attribute such as pest and disease resistance is, therefore, likely to be desirable to farmers and was expected to be positively related to adoption and the degree of adoption of improved varieties. A recent study found that pest and disease resistance is an important attribute to cassava farmers (Acheampong and Owusu, 2015).

Drought tolerant (*Drghttoleranc*): The improved cassava varieties' ability to withstand drought was measured as a dummy variable, that is, if a farmer perceived that new cassava varieties are drought tolerant, and 0 if otherwise. The frequent droughts in the area have resulted to serious crop failure, including cassava, posing a major challenge to cassava farmers. Thus, farmers would prefer cassava varieties that are perceived to be highly tolerant to drought. In this study, the improved varieties' ability to withstand drought was therefore hypothesized to have a significant and positive effect on adoption and the intensity of adoption of improved cassava varieties. A recent study established that farmers adopted TMS 30555, TMS 4(2) 1425 and Akpoucha varieties because they were believed to be tolerant to drought than the local varieties (Agwu and Anyaeche, 2007).

Early maturity period (*Maturty*): This variable was also coded as a dummy variable, that is, 1 if a cassava farmer perceived that the new cassava varieties are early maturing than the local ones, and 0 if otherwise.. Early maturity period was expected to positively affect adoption and the intensity of adoption of improved cassava varieties. This was expected since early maturity gives new crop varieties advantage over local ones, particularly in the study area that is prone to drought. Odendo et al. (2015) found that early maturity significantly influenced farmers' decision to adopt improved cassava varieties in Kenya. Otieno et al. (2011) also reported that early maturity was significant in influencing the adoption of improved pigeon pea varieties in Kenya.

Taste: This was coded as a dummy variable taking a value of 1 if farmers perceived that improved varieties have better taste than local varieties, and 0 if otherwise. Taste is an important attribute since farmers would prefer to grow cassava varieties that can be used for household consumption as well. So, in this study, it was also hypothesized that taste would have a positive effect on the adoption of improved cassava varieties. Otieno et al. (2011) observed that taste had a positive effect on the adoption of improved pigeon pea.

Ease of cooking (*Easecooking*): This was also coded as a dummy variable, that is, 1 if a cassava farmer perceived that fresh roots of the improved cassava varieties have shorter cooking time relative to those ones of local varieties. Ease of cooking is also likely to be an important attribute to cassava farmers and consumers because they believe that fire-wood supply is continuously declining in the region and they would prefer varieties that have less cooking time. In this study, ease of cooking was therefore expected to have a positive effect on farmers' adoption decisions and the extent of adoption of improved cassava varieties. Timu et al. (2012) found that majority of farmers' decision to adopt improved sorghum was determined by ease of cooking.

3.4 Sampling and data collection method

The study was carried out in Homa-Bay County between the months of 22nd October and 18th November, 2016. Homa-Bay County was purposively chosen because improved cassava varieties were largely promoted in the region. The study employed a multi-stage random sampling technique to select respondents for the survey. This is a probability sampling procedure which permitted subsequent sampling of elements of the population in their natural groupings, thus ensuring better representation. The method is appropriate where a comprehensive sampling frame does not exist, just like in the case of Allen et al. (2002). Within the County, Rangwe and Homa-Bay Town sub-counties were randomly selected from the list of all sub-counties. From each of the selected Sub-counties, three locations were randomly drawn, and then two sub-locations from each location. Next, two villages were randomly chosen from each sub-location. The primary sampling units were households that were in cassava farming.

A list of 600 cassava farming households was drawn from the randomly selected villages with the help of extension officers and local administration officials. From the list of cassava farming households, a random number table was used to select a sample of 129 cassava farmers for the study. The study used the sample size because it was time-consuming and costly to carry out a census. The study also purposefully selected 26 farmers’ representatives to participate in Focus Group Discussions (FGDs) for an in-depth interview to obtain preliminary insight into farmers’ views, opinion, and concern and to validate them before the actual survey. The data were collected using a semi-structured questionnaire through a face-to-face interview. The use of a questionnaire was considered ideal because of its ease of administration. The face-to-face interview has its strength in that it allows for immediate follow-up and clarification, unlike other means of interview (Mertens, 2005). A checklist was administered in the FGDs so as to validate the information that was to be provided by farmers. The primary data were complemented by secondary data that were obtained from the publications and policy briefs of the Homa-Bay County Agricultural Office. The secondary data were used to complement the primary data in the discussion of the results.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Characterization of socioeconomic of respondents in Homa-Bay County

Table 3 shows socioeconomic characteristics of adopters and non-adopters of new cassava varieties.

Table 3: Socioeconomic characteristics of the surveyed households

Variables	Adopters (N=71)	Non-adopters (N=57)	Pooled Sample (N=128)	t-value/
Average age of household head (years)	39.8	42.3	41.1	0.508
Average number of family members in the year 2016	5.0	4	4.5	2.153**
Average household income in dollars per month	40.1	27.5	33.8	2.291**
Average land owned in hectares	2.4	1.7	2.1	3.832***
Average number of phones	1.0	0.9	1.0	1.986**
Average number of radios	0.8	0.6	0.7	4.012***
Variables		**Per centage of farmers**		**χ2-value**
Post-primary education (% of respondents)	18.1	17.6	17.9	0.004
Percentage of male-headed households	49.2	49.0	49.1	0.032
Percentage of farmers with access to extension services	31.6	28.2	29.9	5.436**
Percentage of farmers who members of farmers' group	52.1	43.9	48.0	0.469
Percentage of farmers with access to market information	97.2	70.2	83.7	1.951

*Note: statistical significance levels ***1%, ** 5% and *10%, respectively*.

Source: Survey Data (2016).

The average age of the household head was 41 years while the mean household size was 5 persons per household, which is consistent with the national average in Kenya of about 6 persons (Kenya National Bureau of Statistics (KNBS), 2011). The average percentage of male-headed household was about 49 per cent, which is not comparable to the national average proportion of 69 per cent (KNBS, 2011). The probable reason could be that most male-counterparts may have migrated to cities in search of salaried employment, a phenomenon that is common in many rural societies. The result, however, shows that both female and male headed households were equal decision-makers in cassava farming. The results also reveal that a few farmers (18%) had post-primary education; whereas the average land size was two hectares per household, which is also comparable to the national average of about 3 hectares (KNBS, 2011). The small land holding is due to high population density, which stands at about 567 people per square Kilometre (County Government of Homa-Bay, 2013). The results further reveal that every farming household had at least one mobile phone and a working radio. The households also earned an average income of $33.78 per month, suggesting that majority of farmers are living close to the poverty line. The finding supports the Homa-Bay County government report, which indicates that about 74 per cent of the population is trapped in absolute poverty and an estimate of 84 per cent experiences hunger for at least one to two months in a year (County Government of Homa-Bay, 2013). Moreover, about 30 per cent and 84 per cent of farmers had access to extension services and market information respectively. Also, about half of the interviewed farmers also belonged to either farmer groups or cooperative society.

The results in Table 3 also show the tests of statistical significance on the equality of proportions and means for socioeconomic characteristics of non-adopters and adopters. There were no differences in age, gender, level of education, membership to farmer groups or associations and access to market information between the adopters and non-adopters. However, there was a significant difference in terms of household size between adopters and non-adopters, indicating that the former had relatively larger family sizes than non-adopters. Large household size among the adopters is a proxy for labour endowments, which would enable households to accomplish various farm tasks on a timely basis (Yirga et al., 2015).

Further, land owned by the household in hectares, number of phones, number of radios, household income and access to extension services indicated significant differences between these two groups. The difference in the amount of land owned shows that adopters owned large parcels of land compared to their counterparts, and therefore were more likely to try new farm technologies on their farms. The significant difference in income suggests that adoption of improved cassava varieties may have earned the adopters extra income, which may have enabled them to buy more mobile phones and working radios than their counterparts for agricultural information acquisition. Alternatively, their relatively higher income made it possible for them to be inquisitive and try new technologies. The significant differences in the ownership of communication equipment also posit that adopters were privy to information relating to new cassava varieties and cassava production than non-adopters. Finally, there was significant difference in access to extension services between adopters and non-adopters, with the former having more access to such services. Contact to extension workers was used as a proxy for awareness and subsequent adoption of improved cassava varieties.

4.2 Characterization of cassava production in Homa-Bay County

4.2.1 Cassava farming system

Table 4 presents the distribution of farmers according to the cassava cropping system. The results indicate that farmers majorly grew cassava as an intercrop and a few as a stand-alone crop. The majority of adopters (94.4%) and non-adopters (85.2%) intercropped cassava with other crops. Only a few of the adopters (5.6%) and non-adopter (14.8%) practiced cassava farming as a monocrop. The results were not statistically different between the two groups (χ^2 = 2.756). The intercrops were mainly cereal crops; maize, millet, groundnut, and beans that were mainly grown for subsistence with little surplus sold to earn households income.

Table 4: Distribution of respondents by cassava cropping system

Cropping System	Adopters of improved cassava varieties (N=71)	Non-adopters of improved cassava varieties (N=57)	Pooled (N=128)	
	%	%	%	χ^2 –Value
Intercropping	94.4	85.2	89.9	2.756
Mono-cropping	5.6	14.8	10.1	

Note: statistical significance levels ***1%, ** 5% and *10%, respectively.

Source: Survey Data (2016).

Table 5 further shows the intercrops of cassava in the study area. The results reveal that about 38 per cent of the respondents intercropped cassava with maize. While 25.5 per cent of respondents intercropped cassava with groundnut and maize, 14.6 per cent of respondents intercropped cassava with beans, and 14.2 per cent of farmers mixed cropped cassava with millet. Lastly, 8.1 per cent of the respondents intercropped cassava with beans and maize. This finding confirms the observation of Agwu and Anyaeche (2007) who also noted that intercropping is predominantly a normal cropping system among the small-scale rural farmers.

Table 5: Distribution of cassava farmers by various intercropping patterns practiced

Patterns of intercropping practiced	Percentage
Cassava + Maize	37.6
Cassava + Groundnut + Maize	25.5
Cassava + Beans	14.6
Cassava + Millet	14.2
Cassava + Maize + Beans	8.1

Source: Survey Data (2016).

4.2.2 Reasons given by farmers for intercropping cassava with other crops

In this section, farmers were asked to state the reasons for intercropping cassava with other crops. Figure 6 presents a summary of reasons stated by farmers for intercropping.

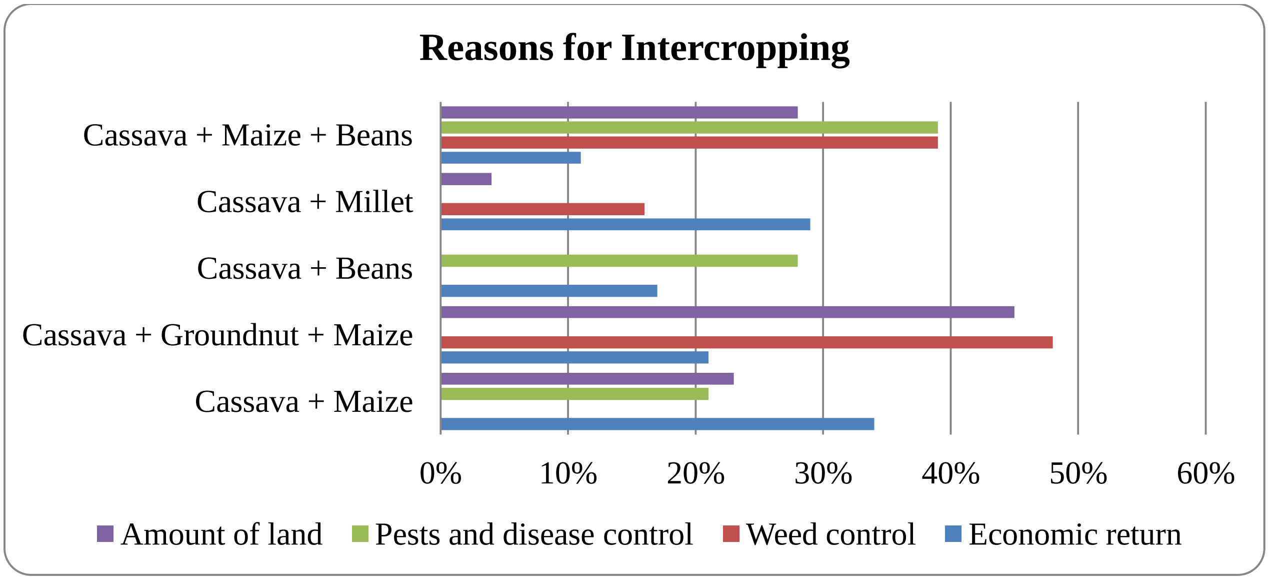

Figure 6: Reasons for intercropping cassava with other crops
Source: Survey Data (2016).

Farmers stated amount of land holding as a major constraint to cassava production. According to the result, cassava farmers were small-scale land holders, owning an average of two hectares of pieces of land (see Table 3). Farmers also reported that cassava crop is susceptible to numerous pests and diseases in the study area. Thus, they believe that crops in an intercropping system act as barriers, controlling the spread of common pests and diseases within their farms. Similarly, Ijoyah (2012) observed that pests and diseases were less prevalent in intercropping system compared to monocropping system. In addition, Amanullah et al. (2007) also noted that pest and disease infestations were few in cassava-maize intercropping compared to cassava monocrops. More than a half of farmers also considered intercropping as measure for better economic returns. Farmers stated that intercropping enhances greater utilization of land compared to growing one crop, hence providing a higher net return in terms of yield and cash return. Fukai et al. (1990) and Amanullah et al. (2007), independently, observed that intercropping cassava with millet, maize and legumes increased yields and gave farmers greater cash return than monocropping. Another reason commonly cited by about two-third of farmers was the weed control. Farmers surveyed reported that intercropping system reduces weed populations once the intercrops are well established. The finding is consistent with the observation of Akabundu (1980) and Ijoyah and Dzer (2012) who noted that intercrops control weeds by limiting the light available for their growth.

4.2.3 Sources of planting paterials

Figure 7 indicates sources of planting materials for both adopters and non-adopters of improved cassava varieties. Cassava planting materials are the primary input in cassava production. Majority of adopters (54.2%) and non-adopters (65.8%) sourced their planting materials from neighbours and previous harvest respectively. About 35.1 per cent of improved varieties adopters obtained their planting materials from neighbours, 34. 2 per cent of non-adopters got the planting materials from the previous harvest. Only 10.7 per cent of adopters got the planning materials from the research organization. From the study, neighbouring farmers and previous harvest were the dominant sources of planting materials for the adopters and non-adopters respectively. Probably, this could be one of the reasons why local cassava varieties were still popular in the region.

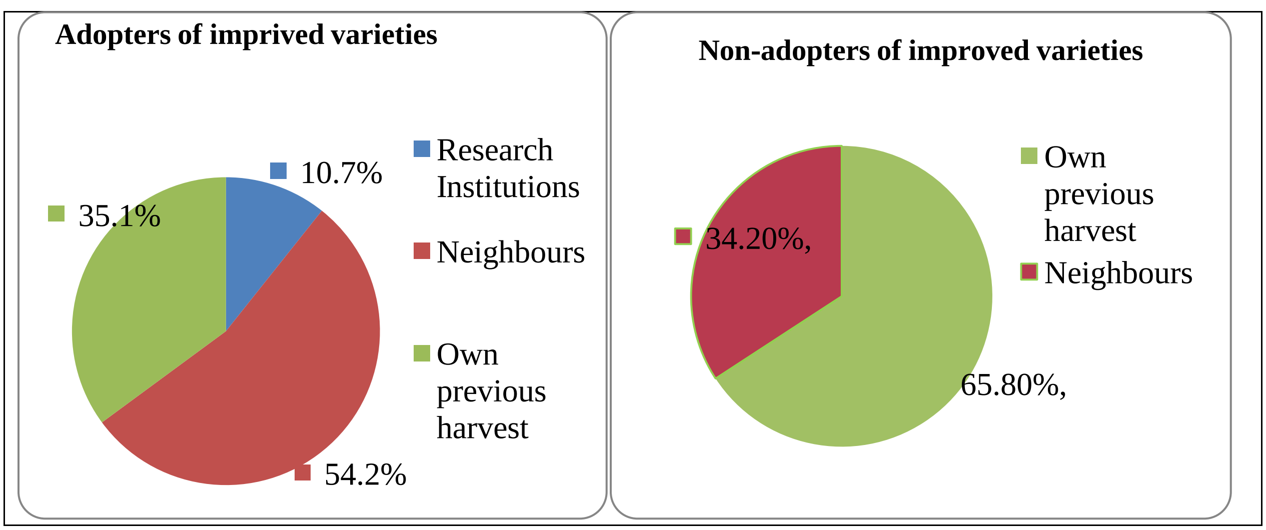

Figure 7: Sources of planting materials
Source: Survey Data (2016).

4.3 Farmers' awareness, perception and adoption of improved cassava varieties

Table 6 shows the farmers' awareness and adoption of cassava varieties that are grown by farmers in Homa-Bay County. The results indicate that, besides four improved varieties: TMS 30572; TM/14, MH93/OVA and yellow cassava that have been introduced in the area, there were also local varieties, '*Selele*' and '*Obaro Dak'* that are still grown by farmers.

Table 6: Farmers' awareness and adoption of cassava varieties

Cassava varieties	% Households aware of the varieties (N=128)	% Households growing the varieties (N=128)
TMS 30572	94.9	29.4
TM/14	83.7	25.7
MH93/OVA	69.3	16.5
Yellow cassava	56.8	14.3
Selele	87.5	37.8
Obaro Dak	79.3	33.6

Source: Survey Data (2016).

The results show that TMS 30572 was the most widely known improved variety in the study area followed by TM/14, MH93/OVA and yellow cassava varieties. Also, majority of farmers were aware that local cassava varieties *Selele* (85.7%) and *Obaro Dak* (79.3%) still exist in the study area. Further, TMS 30572 was the most adopted improved variety (29.4%), followed by TM/14 (25.7 %), MH93/OVA (16.5%) and lastly yellow cassava (14.3%). Most farmers reported that TMS 30572 is high yielding compared to other existing varieties. This study finding is consistent with Agwu and Anyaeche (2007) who noted that TMS 30572 was the most preferred variety among farmers in Anambra State, Nigeria owing to its high potential yields. With regard to local varieties, about 37.8 per cent of farmers were growing *Selele* while 33.6 per cent had planted *Obaro Dak*. The results generally reveal that there was low adoption of improved cassava varieties compared to local varieties.

Table 7 presents farmers' perception of varietal attributes and adoption of cassava varieties on case by case basis.

Table 7: Farmers' perception and adoption of improved varieties

Varietal Attributes	Improved Varieties						Local Variety	
	TMS 30572		TM/14		MH93/OVA		*Selele*	
	Perception (%)	Adopted (%)	Perception (%)	Adopted (%)	Perception (%)	Adopted (%)	Perception (%)	Adopted (%)
High Yielding	90.6	17.9	60.8	3.9	62.5	3.5	9.4	0.9
Early maturity	93.4	15.5	76.3	14.2	56.4	9.3	3.7	0
Drought tolerance	78.9	1.6	59.6	2.4	68.1	1.8	63.5	4.8
Pest and disease resistance	76.5	3.4	57.2	5.2	40.7	1.9	31.8	0
Good taste	16.8	0	28.9	0	11	0	75.3	18.3
Easy of cooking	23.1	0	9.6	0	15.3	0	58.6	13.8

Source: Survey Data (2016).

With respect to the yield of cassava varieties, all the improved varieties were perceived to be high yielding as compared to the local variety. The TMS 30572 variety was the most popular in terms of yield potential compared to the other varieties. Regarding the maturity period, majority of farmers interviewed said that TMS 30572 and TM/14 varieties had the shortest maturing period among the four cassava varieties. Very few farmers perceived the local variety, *Selele*, to be early maturing and high yielding. Tolerance to drought and resistance to pests and diseases are also important production attributes to farmers. In this regard, most farmers reported that all the cassava varieties had the ability to withstand environmental stress and pests and diseases.

Notably, in spite of their popularity, very few farmers mentioned that improved cassava varieties were of good taste and easy to cook. Nevertheless, contrary to our expectations, majority of farmers stated that the local *Selele* variety had the best taste and required the least time to cook, and therefore was preferred for household consumption. Overall, the improved varieties were perceived to be superior in production attributes such as yield, while local varieties were better in consumption attributes, for instance taste.

The results in Table 7 also show that improved varieties were largely adopted due to their yield, short maturity period, drought tolerance and resistance to pests and diseases. The results reveal that about 18 per cent, 4 per cent and 3 per cent of the interviewed farmers adopted TMS 30572, TM/14 and MH93/OVA varieties respectively due to their yielding attribute. Early maturity attribute contributed to about 16 per cent, 14 per cent and 9 per cent uptake of TMS 30572, TM/14 and MH93/OVA varieties respectively. A few farmers indicated that they adopted these new varieties because of resistance to pests and diseases and tolerance to drought. Interestingly, no farmer adopted improved varieties due to taste and ease of cooking. However, about 18 per cent and 13 per cent of the surveyed farmers hinted that they adopted local *Selele* variety because of good taste and ease of cooking respectively. About 5 per cent Selele local variety because of its ability to withstand the drought condition in the area. From the findings, it is apparent that only production attributes motivated farmers to use the new varieties, while local varieties were adopted because of the desirable consumption attributes and drought tolerance, a production attribute.

4.4 Evaluation of adoption of improved cassava varieties by demographic characteristics

Table 8 presents a cross-tabulation of adoption of improved varieties by farmers' characteristics and varietal attributes.

Table 8: A cross-tabulation of adoption of improved varieties by farmers' age, gender, education and income

	Varieties' adoption by farmers' age (%)		Varieties' adoption by gender (%)		Varieties' adoption by level of education (%)		Varieties' adoption by income categories (%)	
Varietal attributes	Below 35 years	Above 35 years	Male	Female	Primary Education	Post Primary education	Less than a dollar per day	Above a dollar per day
High yielding	24.6	40.2	53.4	22.7	28.6	59.1	18.4	46.9
Early maturing	37.3	58.7	21.8	49.4	23.1	42.6	10.2	45.7
Resistant to disease	22.1	49.6	36.2	29.9	18.2	53.9	17.6	53.1
Drought tolerance	6.4	29.3	12.7	23.1	2.7	18.3	14	11.5
Ease of cooking	0	0	0	0	0	0	0	0
Taste	0	0	0	0	0	0	0	0

Source: Survey Data (2016).

The results reveal that yield, early maturity, drought tolerance and resistance to pests and diseases induced farmers in the age group above 35 years to adopt improved varieties more than their counterparts in the age group below 35 years. It could imply that knowledge gained by older farmers over time from using local varieties in uncertain environment may have helped in assessing the information relating to new technologies thereby promoting their adoption. Another possible explanation could be that these households have a huge capital accumulation that has enabled them to acquire the new technologies. It may also be that some extension programmes use experienced household heads as lead farmers and in the plot demonstrations to increase the adoption.

Mixed results were observed with regard to gender; majority of male-headed households preferred high yielding varieties, whereas female-headed households adopted improved varieties due to their short maturity periods. Male-headed households probably prefer high yielding attribute for market sale, while their female counterparts may have preferred early maturity attribute for household food availability. The results further show that farmers with post-primary education relatively adopted improved varieties more than those with primary education. It is probable that education increases the probability of the household head earning off-farm income which would reduce the household's dependence on agricultural income, and thus raising the chances of adopting improved varieties. A relatively higher adoption was also observed among farmers with income greater than a dollar per day compared to those living below the poverty line. The low adoption among farmers earning less than a dollar is perhaps due to the high cost of the planting materials that is reported to be beyond reach for most farmers. Finally, taste and ease of cooking attributes did not contribute to the adoption of new varieties, which is consistent with the findings shown earlier in Table 7. Overall, the results show that poor farmers, those with low level of education and youths were the least adopters of improved cassava varieties,

4.5 Determinants of adoption and the intensity of adoption

The diagnostic tests for heteroskedasticity, multicollinearity and goodness of fit of the explanatory variables were done before conducting multivariate probit and Poisson regression analyses. The tests carried out are shown in the section below:

4.5.1 Test for multicollinearity

Pearson correlation matrix test and Variance Inflation Factor (VIF) methods were used to test for the multicollinearity among the explanatory variables. The VIF test was carried out by determining 'artificial' Ordinary Least Squares regressions with each independent variable being regressed against the rest of the explanatory variables. The results show that VIF of all the independent variables were below 3, as presented in Appendix 1. As a rule of thumb, if the VIF is greater than 5, then the variable is said to be highly collinear (Gujarati, 2003, pp. 328). Pearson's correlation matrix test also indicates that all the correlations between the independent variables were below 40 per cent, as indicated in Appendix 2, reaffirming non-existence of multicollinearity in the data. Following Gujarati (2003), explanatory variables with correlations less than 75 per cent are considered to have multicollinearity.

4.5.2 Test for heteroskedasticity

Heteroskedasticity is the situation where the variance of the error term varies across the observations (Gujarat, 2003). The study used Breusch-Pagan test to test for the heteroskedasticity. The principle is to test for the relationship between the residuals of the regression and indicator variables that were hypothesized to be related to the homoskedasticity (Baum et al., 2003). The regression model was run and then *hettest* was ordered on STATA version 13. The result presented in Appendix 3 show that there was no evidence of heteroskedasticity, since there was no significant p-value.

4.5.3 Assessment of multivariate probit and Poisson models' goodness of fit

The multivariate probit gives a Wald chi-square statistics of 168.441, the log pseudo likelihood is-192.721 and p-value of 0.000, indicating the overall significance of the model and the model fits of the data. For the Poisson model, estimated value of Pseudo R-squared is low (8.98%), however, the overall significance of Poisson model, as indicated by the value of Wald Chi-square ($\chi 2$ -137.05), is satisfactory. The goodness-of-fit tests shown by both Pearson statistic and Deviance were also not significant, hence supporting the relevance of the model specification. Moreover, the dispersion ratios also confirmed the appropriateness of the Poisson specification.

4.5.4 Determinants of adoption of improved cassava varieties

Table 9 shows the pair-wise correlation coefficients between various cassava varieties adopted by the households.

Table 9: Correlation coefficients of cassava varieties adopted by households

	Coefficients	**p-value**		**Coefficients**	**p-value**
TM/14 and TMS 30572	1.419	0.006	rho21	0.836	0.002
MH93/OVA and TMS 30572	0.743	0.000	rho31	0.629	0.000
Selele and TMS 30572	-0.810	0.034	rho41	-0.476	0.021
MH93/OVA and TM/14	1.203	0.000	rho32	0.798	0.000
Selele and TM/14	-0.355	0.000	rho42	-0.246	0.000
Selele and MH93/OVA	-0.317	0.013	rho43	-0.213	0.011

Likelihood ratio test of rho21= rho31= rho41= rho32= rho42=rho43=0 chi^2 (8) = 51.964
Prob>chi^2 =0.000

Source: Survey Data (2016).

All the pair-wise correlation coefficients of the error terms of the adoption decisions are significant, thus, supporting our hypotheses that the residuals in the adoption equations were correlated. These coefficients measure the correlation between adoption decisions, after controlling for the effect of all observed factors in the regression (Greene, 2003; Mittal and Mehar, 2016). The results reveal positive relationships between improved cassava varieties, for instance, between TM/14 and TMS 30572, suggesting that these varieties are complementing each other. The negative correlation coefficients between improved varieties and the local variety, for example, *Selele* and MH93/OVA, show the complementary between these two categories with respect to their attributes.

It can be argued that farmers normally depend on more than one cassava variety to satisfy their different production and consumption needs. Another explanation could be that the adoption behaviour of farmers is in the process of transition since they are switching away from local varieties to improved varieties. Pointing to the fact that, even though they are adopting the improved cassava varieties, they still depend on the local varieties to address other needs. During the focus group discussion, most farmers expressed that local varieties were the best for boiled cassava snack due to their taste, while improved varieties were solely preferred for market and household flour purposes because of their high yielding and early maturing attributes. Also, based on their local knowledge, farmers appear to understand the need to diversify cassava varieties as this can help during food scarcity. Therefore, indicating heterogeneity in farmers' decision to adopt new cassava varieties. This information justifies the use of a multivariate probit model in establishing the cassava farmers' adoption behaviour in a set-up where multiple crop varieties exist. These results also confirm that the use of independent logit or probit models would indeed result to biased, inconsistent and inefficient estimates and subsequent policy design.

Table 10 presents the parameter estimates and marginal effects of multivariate probit regression model on the factors affecting the adoption of improved cassava varieties. The analysis of the effects of varietal attributes on adoption of improved varieties included three improved cassava varieties TMS 30572, TM/14 and MH93/OVA that were significantly adopted in the County. *Selele*, a local variety, was also included mainly for purposes of comparison as mentioned earlier. The parameter estimates pointed to the direction of change, while the marginal effects (ME) measure the actual influence of a unit change in each of the independent variables on farmers' decisions to adopt improved cassava varieties.

Table 10: Determinants of adoption of improved cassava varieties

	TMS 30572			TM/14			MH93/OVA			Selele		
	Coeff	**p-value**	**ME**	**Coeff**	**p-value**	**ME**	**Coeff**	**p-value**	**ME**	**Coeff**	**p-value**	**ME**
Socio-economic Factors												
Age	0.025	0.112	0.009	0.187	0.572	0.004	-0.037	0.024	-0.012**	0.066	0.019	0.008**
Hhsize	0.123	0.081	0.013*	0.326	0.001	0.015***	0.178	0.045	0.018**	0.209	0.073	0.014*
Landsize	0.163	0.054	0.018*	-0.217	0.168	-0.033	-0.059	0.182	0.023	0.045	0.326	0.030
EducLevel	0.345	0.292	0.011	0.242	0.213	0.065	0.396	0.211	0.020	0.285	0.253	0.013
Institutional Factors												
Extenserv	0.113	0.001	0.022***	1.328	0.043	0.147 **	0.058	0.026	0.005**	-0.133	0.029	-0.070**
Marketinformatn	0.719	0.284	0.064	0.375	0.736	0.023	0.418	0.375	0.038	0.119	0.253	0.032
Groupmemb	0.508	0.121	0.046	1.027	0.013	0.012**	-0.040	0.645	-0.001	0.151	0.032	0.056**
Perceived Attributes												
Yield	1.192	0.001	0.023***	0.516	0.089	0.009*	0.176	0.000	0.086***	-0.213	0.003	-0.052***
Earlymaturity	0.080	0.014	0.031**	0.712	0.004	0.060***	0.336	0.254	0.107	-1.183	0.554	-0.084
Drotolerance	0.215	0.037	0.049**	1.445	0.123	0.027	1.072	0.065	0.143*	1.077	0.624	0.244
Pdiseresistance	0.834	0.000	0.071***	0.068	0.002	0.036***	0.566	0.011	0.258**	-1.301	0.986	-0.006
Ease of cooking	-0.300	0.186	0.543	-0.055	0.053	-0.028**	-1.647	0.008	-0.086***	0.942	0.031	0.015**
Taste	-0.261	0.008	-0.0138***	-1.583	0.005	-0.017***	-0.928	0.038	-0.045**	1.226	0.001	0.123***
Constant	0.456	0.678		1.429	0.223		0.988	0.131		0.202	0.394	

Number of observations = 128
Log pseudo likelihood = - 192.721
Wald chi^2 (81) = 168.441; Prob > chi^2 = 0.000
***, ** and * represent significance at 1%, 5% and 10% levels respectively

Note: statistical significance levels *** 1%, ** 5% and * 10%, respectively.

Source: Survey Data (2016)

The results show somehow peculiar results as far as the effect of age of the household head on the adoption of improved varieties is concerned. Unlike in the case of other improved varieties, age of the household head had a significant and negative effect on the likelihood of adopting MH93/OVA variety, contrary to our expectations. A unit increase in the age of the household head would reduce the chances of adopting MH93/OVA variety by 1.2 per cent, *Ceteris Paribus*. Perhaps, the reason could be that the variety is the poorest in terms of taste, ease of cooking and resistant to pests and diseases (see Table 7). On the contrary, the probability of using local variety, *Selele* is significantly and positively influenced by age of the household head. A unit increase in the age of the household head would raise the probability of adopting local *Selele* variety by 0.8 per cent, *Ceteris Paribus*, indicating the conservative and risk aversion nature of older farmers towards new technologies. It could also mean that local cassava varieties have certain desirable attributes that older farmers would not want to abandon. Elias et al. (2000) noted that whereas cassava farmers in Uganda generally prefer high yielding improved varieties, they retained low yielding local varieties because of cultural preferences such as cooking quality and taste. Also, Pickett et al. (2014) observed that maize farmers in western Kenya preferred Push-pull technology with local maize variety rather than a combination of Push-Pull with IR maize variety and fertilizer. Farmers argued that the former gave them more net return than the latter. The high net return of push-pull is related to low cost of inputs, since Desmodium and Napier are perennial crops, once planted, generate income for years.

Household size positively and significantly affected the chances of using all the four cassava varieties. The likelihood of adopting TMS 30572, TM/14, MH93/OVA and *Selele* varieties would be higher for households with larger family members by 1.3 per cent, 1.5 per cent, 1.8 per cent and 1.4 per cent respectively. The positive effect in the case of improved varieties could mean that larger households are likely to pool their economic resources together to acquire new technology and also provide the required labour for the innovation. Also, an increase in household size could mean more persons to feed and care for, therefore increasing the vulnerability of the household. Thus, taking into account the amount of uncertainty about the future, it is reasonable for large family sizes to adopt the improved varieties so as to safeguard their future welfare. This would be a kind of insurance of household members to the future food security status. The positive influence of the local *Selele* variety postulates that large households prefer varieties with desirable consumption attributes to address their household consumption needs. Table 7 indicates that majority of farmers perceived the local cassava varieties to have more desirable consumption attributes than improved varieties. These findings are consistent with Rahman and Chima (2016) that utilization by household formed a major reason in the adoption of crop diversity in Nigeria.

Land size also significantly increased the chances of selecting improved TMS 30572 variety. The marginal effect value indicates that a unit increase in land size would increase the probability of adopting TMS 30572 variety by 1.8 per cent, an indication of the competitive nature of TMS 30572 variety on land use against other varieties. The result also implies that large landowners are likely to allocate part of their land to try out the new technology. However, these findings present a grave challenge to policy makers and implementers in enhancing the uptake improved varieties in the study area since farmers are small-scale land owners, owning an average land size of two hectares (see Table 3). Land size is one of the economic indicators available to farmers. The findings can be supported from previous studies which have shown that land size has a positive correlation with adoption of diverse crop varieties (Otieno et al. 2011; Timu et al. 2014).

Another important result worth observing is the differential impact of access to extension services on the use of cassava varieties. All things held constant, access to extension services increases the likelihood of using improved varieties, TMS 30572, TM/14 and MH93/OVA by 2.2 per cent, 14.7 per cent and 0.5 per cent, respectively, while at the same time reduces the chances of using local *Selele* variety by 7.0 per cent indicating the role of proactive extension delivery in enhancing technology change among smallholder farmers. The differential impact could be due to the differences in yield potential and maturity period of cassava varieties. Yirga et al. (2015) and Mittal and Maher (2016), independently, also noted a significant positive effect of extension services on the use of crop diversity on farms in Ethiopia and India respectively.

The result also shows that, being that a farmer belongs to a farmer group increases the likelihood of using TM/14 and *Selele* varieties by 1.2 per cent and 5.6 per cent respectively, *Ceteris Paribus*. The possible reason could be that farmer group provides a platform for farmers to access financial support, farm inputs and information relating to the new technology. The empirical results concur with the findings of the study conducted in Nigeria (Donkor and Owusu, 2012) where membership to farmer-based organization positively and significantly affected the adoption of improved cassava varieties. In the case of local *Selele* variety, it could mean that farmer groups provide platforms for sharing planting materials of local varieties and information about their desirable attributes. During the survey, farmers in associations stated that once they discover that a variety has attributes of interest, they would ensure that it is not lost amongst them. They achieve this by planting it in several plots, replanting immediately after the previous harvest and sharing with other farmers in their groups to grow as backups. These findings emphasize the need to integrate farmer preferences in breeding strategies in order to increase adoption of improved varieties.

Among the varietal attributes, high yield attribute seems to be significantly and positively related to the selection of the improved varieties and negatively associated with the choice of producing the local *Selele* variety. Everything else being the same, the results of the marginal effects show that if a farmer perceives the yield attributes as good, then the likelihood of using TMS 30572, TM/14 and MH93/OVA varieties increases by 2.3 per cent, 0.9 per cent and 8.6 per cent, whereas that of local *Selele* variety reduces by 5.2 per cent suggesting that farmers prefer high yielding varieties that generate a marketed surplus. The findings support the results from the past study by Rahman and Chima (2016) who observed that high yield attribute had a significant and positive association with the uptake of improved crop diversity on farms in Nigeria. Idrisa et al. (2012) also observed that yield significantly affected farmers' decisions to use improved soybean seeds in Borno State, Nigeria.

Maturity period significantly influences the selection of TMS 30572 and TM/14 varieties. The results show that positive perception of maturity period would increase the probability of adopting TMS 30572 and TM/14 by 3.1 per cent and 6 per cent, *Ceteris Paribus*, indicating the role of maturity period on the adoption. The importance of early maturity may be because of the frequent droughts that have caused serious crop failure in the study area. It is interesting to see that drought tolerant attribute has a positive and significant relationship with the adoption of TMS 30572 and MH93/OVA varieties at 5 per cent and 10 per cent respectively, even though cassava is naturally perceived as a drought tolerant crop. This is an indication that farmers are not willing take chances with frequent drought occurrences in the study area; therefore they would want to give preference to a variety they believe is highly tolerant to drought. In this case TMS 30572 and MH93/OVA seem to have better ability to withstand environmental stress than the rest.

As expected, resistance to pests and diseases has been found to increase the likelihood of using the improved varieties TMS 30572, TM/14 and MH93/OVA, by 7.1 per cent, 3.6 per cent and 25.8 per cent respectively. The importance of resistance to pests and diseases could be due to severe economic damage otherwise caused on conventional varieties. Moreover, cost of chemical treatment of these biotic factors is out of reach for most smallholder farmers.

Contrary to our expectations, taste and ease of cooking have significant and differential influence on the decision to use cassava varieties. The results of marginal effects indicate that perception of taste of improved varieties lowers chances of using TMS 30572, TM/14 and MH93/OVA by 1.4 per cent, 1.7 per cent and 4.5 per cent respectively, whereas increases chances of using a local *Selele* variety by 12.3 per cent *Ceteris Paribus*. Taste is an important attribute because most farmers in the study area grow cassava mainly for household consumption mainly in its fresh form, boiled snack, roasted and cassava chips, not dried and processed into flour. A similar observation was made by Asiedu-Darko (2014) who reported that most farmers in Ghana do not want to neglect local varieties because they have better taste than improved varieties.

Finally, perception of ease of cooking also reduces the likelihood of adopting improved TM/14 and MH93/OVA varieties by 2.8 per cent and 8.6 per cent, whereas raises the probability of using local *Selele* variety by 1.5 per cent, holding other factors constant. Perhaps, this could due to the increasing scarcity of firewood in the region. These findings reinforce the results presented earlier in Table 7 which showed that taste and ease of cooking only contributed to the adoption of local *Selele* variety.

4.5.5 Determinants of the intensity of adoption of improved cassava varieties

Table 11 presents the results of the Poisson model on factors influencing the intensity of adopting improved cassava varieties. Factors that influence the degree of adopting improved varieties are of three categories, socioeconomic characteristics, institutional factors and varietal attributes.

Table 11: Determinants of the intensity of adoption of improved cassava varieties

Variables	Coefficients	p-value
Socio-economic factors		
Age	-0.102	0.049**
Hhsize	0.078	0.003***
Landsize	0.016	0.554
EducLevel	0.208	0.035**
Institutional factor		
Extenserv	0.268	0.036**
Marketinformatn	0.115	0.272
Groupmemb	0.238	0.039**
Perceived Attributes		
Yield	0.239	0.034**
Earlymaturity	0.268	0.026**
Drotolerance	0.001	0.992
Pdiseresistance	-0.151	0.170
Ease of cooking	-0.450	0.000***
Taste	-0.418	0.004***
Constant	0.462	0.299
Number of observations = 128	Log pseudo likelihood = -98.093363	
Wald chi^2 (13) =137.05	Pseudo R^2 = 0.0898	Prob > chi^2 = 0.000
Deviance goodness-of-fit = 25.1502	Prob > chi2(57) = 1.0000	
Dispersion ratio: 25.1502/57 = 0.441		
Pearson goodness-of-fit = 26.78143	Prob > chi2(57) = 1.0000	
Dispersion ratio: 26.78143/57= 0.452		

*Note: Statistical significance levels****1%, ** 5% and *10%, respectively.

Source: Survey Data (2016).

From the results in Table 11, household size, level of education, access to extension services, membership in farmer-based organization, high yield and early maturity are positive and significant determinants, while age of the household head, taste and ease of cooking are negative and significant determinants of the intensity of adoption decision. In relation to the age of household head, the results show that a unit increase in the age of the household head reduces the number of improved cassava varieties adopted by about 0.102, holding other factors constant. Abelel et al. (2007) attest to this finding when they observed a negative and significant effect of age of household head on the intensity of adoption of improved varieties. They noted that older farmers have conservative attitude towards intensive adoption of new technologies, that is, they tend to stick to old technologies rather than adopting more of improved ones, perhaps due to their tendency of being risk averse.

The parameter estimates for family size had the expected positive sign and was statistically significant at 1 per cent significance level. This result implies that household size was influential in the speed of adoption of improved varieties. This study posits that larger households have higher consumption and demand for food than smaller ones. Faced with food insecurity, larger households are likely to adopt more improved technologies faster than smaller households. The finding agrees with that of Idrisa et al. (2012) who reported that household size had a positive effect on the extent of adopting improved crop varieties.

As anticipated, the coefficient of level of education is positive and statistically significant at 5 per cent significance level. The results show that a higher level of education is expected to increase the likelihood of adopting more of improved varieties by 0.208, *Ceteris Paribus*. The result implies that more educated cassava farmers tend to intensify the uptake of improved varieties than their counterpart. This could be because education improves human capital and managerial skills of farmers. It also imparts the necessary knowledge on technological packages and provides the skills on how to use new technologies efficiently. Again, it increases farmer's ability to evaluate the merit of new technologies as a strategy to address the fluctuation in household income and food availability.

The empirical result concurs with Obuobisa-Darko (2015) who observed a positive relationship between the respondents' level of education and the intensity of use of cocoa research innovation in Ghana.

As expected *a priori*, access to extension services had a positive and significant relationship with the intensity of adoption of improved varieties. The results of the coefficients indicate that obtaining extension services would increase the intensity of adoption by about 0.268, holding other factors constant, a result which highlights the vital role of extension services in promoting sustainable cassava production practices in rural society. Households that had received technical advice were assumed to be knowledgeable about identification of planting materials as well as agronomic requirements. During the survey, it was observed that households in possession of this knowhow found it easier to cultivate these improved varieties than those devoid of this technical knowledge. This finding is consistent with that of Idrisa et al. (2012) who noted a positive effect of access to extension staff on the extent of adoption of improved cassava varieties among cassava farmers in Borno state, Nigeria, and that of Obuobisa-Darko (2015) in Ghana, reporting positive influence of contact with extension workers on the intensity of adoption of cocoa research innovations among cocoa farming households.

As hypothesized, membership in farmer-based organization had a positive effect on the adoption intensity and is statistically significant at 5 per cent significant level. The results show that being that a farmer belongs to a farmer group, the intensity of adoption increases by 0.238, *Ceteris Paribus.* This could be because farmers in associations are believed to be learning from others, and particularly the influential individuals within the groups, even if they do not have direct contact with extension workers. Nkegbe and Shankar (2014) and Ghimire et al. (2015) also found positive effects of social networks on the adoption intensity of soil and water conservation practices by smallholders in Ghana and improved crop varieties among Nigeria farmers, respectively.

Among the varietal attributes, the coefficient of yield is positive and statistically significant at 5 per cent significance level. The importance of yield to farmers is perhaps due to the existence of low yielding local varieties. Early maturity is statistically significant at 5 per cent significance level, indicating the role of maturity period on the adoption intensity. The significance of early maturity may also be because of the frequent droughts that have caused serious crop failure in the study area. Contrary to the expectation, the coefficients of taste and ease of cooking attributes are negative and statistically significant at 1 per cent significance level. The negative coefficients of taste and ease of cooking show the role of consumption attributes in promoting adoption intensity. The results postulate that farmers prefer to grow cassava varieties that have desirable consumption attributes. Notably, it is important to observe that tolerance to drought and resistance to pests and diseases did not have statistically significant influence on the number of improved cassava varieties adopted by farmers.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

Improved cassava varieties are vital for ensuring food security in dry areas in the face of the changing climatic conditions. Within the drier parts of Western Kenya, where poverty levels are relatively high such as Homa-Bay County, the adoption rates of new cassava varieties is estimated at 25 per cent. However, there is little empirical insight on the effect of varietal attributes on the uptake of these varieties. Therefore, the study focused to examine farmers' awareness and the role of the varietal attributes on the adoption of improved cassava varieties in Homa-Bay County. The study was guided by three specific objectives were to: characterize farmers' awareness, perception and adoption of improved cassava varieties; evaluate the effect of varietal attributes on the adoption of improved cassava varieties; and lastly, determine the influence of varietal attributes on the intensity of adoption of improved cassava varieties. The study used multivariate probit and Poisson models to assess the determinants of farmers' decisions to adopt and the intensity of adoption of improved cassava varieties, respectively. A multi-stage random sampling procedure was used to draw a sample of 129 respondents and primary data were collected using a semi-structured questionnaire.

Results indicate that six cassava varieties were grown in the study area. Four were improved varieties TMS 30572, TM/14, MH93/OVA and yellow cassava, whereas the other two were local varieties, *Selele* and *Obaro Dak*. Majority of farmers were aware that these varieties existed in the study area. Only about 14 per cent, 16 per cent, 25 per cent and 29 per cent of the respondents were growing TMS 30572, TM/14, MH93/OVA and yellow cassava respectively. Local varieties, *Selele* and *Obaro Dak* were also popular among the surveyed farmers.

The results also reveal that farmers generally perceived that improved varieties are high yielding, early maturing, drought tolerant and resistant to pests and diseases. Moreover, farmers also perceived that local varieties are easy to cook, have better taste and somehow drought tolerant. The results further show that farmers adopted improved varieties because of their yield potential, short maturity period, tolerance to drought and resistance to pests and diseases. No farmer attributed the adoption of improved varieties to taste and ease of cooking. Taste and ease of cooking, however, contributed to the continued use of local varieties. Results also show that the youth, farmers with primary level of education and poor farmers were the least adopters of new cassava varieties.

The multivariate probit model results confirm the existence of correlation in the farmers' decisions to adopt cassava varieties, which indeed points to the limitation of simple probit and logit models in this analysis. Among the varietal attributes, high yield, early maturity, tolerance to drought and resistance to pests and diseases significantly increased the likelihood of choosing improved varieties. Taste and ease of cooking significantly reduced the likelihood of using improved varieties. In contrast, taste and ease of cooking are the main motive for growing local variety, *Selele*. Among the institutions and services, access to extension services significantly increased the probability of selecting new varieties, while at the same time reduced chances of using *Selele* variety. Membership to farmer group had a positive and significant impact on the likelihood of adopting TM/14 and local variety, *Selele*. Additionally, age of the household head had a negative and significant influence on choosing MH93/OVA, but positively increased the probability of using *Selele.* Household size had significant and positive effects on the chances of using all the varieties. Land size owned by households also significantly increased adoption of TMS 30572.

The Poisson model results indicate that yield and early maturity significantly increased farmers' likelihood of intensifying the use of new varieties. However, taste and ease of cooking reduced the probability of adopting more of improved varieties. Household size, level of education, access to extension services and membership to farmers' groups also positively affected the extent of adoption. Age of household head, however, depicted a negative influence on the intensity of use of improved varieties.

5.2 Conclusions and policy recommendations

In Kenya, there is a huge potential for cassava production. In this regard, IITA and its partners introduced improved cassava varieties; TMS 30572, TM/14, MH93/OVA and Yellow varieties to tap into this potential. The new varieties are believed to be high yielding, early maturing, resistant to pests and diseases and tolerant to drought. Surprisingly, the adoption of these varieties has been relatively low over the past few years. Besides, traditional varieties (*Selele* and *Obaro Dak*), which are known to be low yielding and prone to pests and diseases are still common among the cassava farmers.

In Homa-Bay County, the majority of cassava farmers intercropped cassava with other crops at the establishment stage. The main intercrops were maize, groundnut, beans and millet. Own previous harvest, neighbours, and research institutions were the major sources of the planting materials. Farmers were generally aware of these improved varieties and perceived that they are high yielding, early maturing, drought tolerance and resistant to pests and diseases. They, however, reported that the varieties are blunt in taste and have longer cooking time, which was not the case for the local varieties. The study established that the poor, less educated farmers and youths were the least adopters of improved cassava varieties.

Evidently, the perceived high yielding attribute played an important role in the adoption of TMS 30572, TM/14 and MH93/ OVA. Early maturity attribute contributed to the uptake of TMS 30572 and TM/14. Drought tolerance was important in the adoption of TMS 30572 and MH93/OVA, while resistant to pests and diseases was vital in the adoption of TMS 30572 and TM/14. Noticeably, taste and cooking time reduced the uptake of the improved cassava varieties, whereas they promoted the selection of *Selele*, the local variety. Thus, the study findings point to the importance of taste and ease of cooking in shaping farmers' decisions to adopt new cassava varieties. The role the household size, extension services and farmers' networks were apparent in the adoption process.

In order to promote uptake of new varieties, policies should focus on youth, poor farmers and those with low level of education since they are the majority in the study area. An important policy implication is the need to provide practical education and technical programmes that will motivate these farmers to choose the new technologies and appreciate the benefits of growing cassava regardless of their social and economic status. Also, extension investment incentives can be an appropriate instrument for increasing adoption, especially for poor farmers and small land owners. Farmers' education and training can also be extended to farmers with larger household sizes in order to increase the use of new technologies.

There is also need to strengthen the social capital, in the form of cassava cooperative society and farmer groups to improve the design of rural development policies or at least maintain the current environmental condition for sustainable cassava production. Formulation of rural development policy that seeks to promote formation of vibrant farmer groups that will strengthen knowledge sharing among farmers is necessary. Farmers in groups should be encouraged to take the social responsibility to be trained to efficiently share with the worse-off farmers the materials and knowledge acquired. This is necessary because poor farmers normally suffer from low self-esteem and would rarely join any farmer group. Such strategy can help in enhancing reduction of the gap between poor farmers and rich farmers. This strategy can also be achieved by building the capacity of cassava farmers' associations by first demonstrating to them how new technologies are used so that they can adopt themselves, and then train them on how they should share knowledge gained with others. It is believed that farmer-to farmer diffusion reduces cost of technology diffusion and ensures financial sustainability that does not exist in other approaches.

Finally, the stakeholders should promote TMS 30572 and TM/14 variety that are high yielding, early maturing, tolerant to drought, and pest and disease resistant. The MH93/OVA should also be promoted due to its ability to withstand frequent droughts and diseases. In their effort to breed new varieties, cassava breeders should not only pay much attention to production attributes for instance yield and maturity period, but also to consumption attributes like taste and ease of cooking as they matter a lot to farmers during adoption. It is also the future breeding initiatives need to involve all cadres of stakeholders in the idenfication of their respective needs. This will guarantee that both consumption and production attributes are well assessed and accepted by the targeted end-users before being distributed to the market.

5.3 Contribution to knowledge and suggestions for further research

This study contributes to knowledge in that it provides insight on the effect of varietal attributes on the adoption and extent of adoption of improved cassava varieties. The study also contributes to the existing literature in the sense that it provides evidence on farmers' awareness, perception and adoption drivers of multiple cassava varieties. The results reveal that farmers not only prefer the high yielding, early maturity, drought tolerance and pest and disease resistance attributes of the new varieties, but also concerned about their taste and cooking time attributes during the adoption. The findings will help cassava breeders in identifying varietal attributes that should be improved so as to increase the adoption of new varieties. It has the potential to guide donor agencies in funding the initiatives that seek to promote the uptake of these varieties. The study also establishes an inverse relationship between improved and local cassava varieties, pointing out that two categories contain attributes that complement each other. Finally, the study is unique in that it employs multivariate probit, which accounts for the potential correlation in the farmers' decisions to adopt multiple cassava varieties. Future research on the productivity and welfare implication for the uptake of improved cassava varieties is vital in bringing profound effect to bear on the farm policy design.

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Appendices

Appendix 1: Pearson correlation coefficients for multicollinearity test

	Age	*Hhsize*	*Leveleduc*	*Landsiz*	*Extnserv*	*Gmember*	*Maktinf*	*Yield*	*Maturity*	*Eascook*	*Taste*	*PDesisresis*	*Drotoleranc*
Age	1												
Hhsize	0.18	1											
Leveleduc	0.16	0.07	1										
Landsiz	0.06	0.08	0.06	1									
Extnserv	0.03	-0.03	0.27	-0.02	1								
Gmember	0.18	0.08	0.22	0.06	0.06	1							
Maktinf	0.11	0.02	0.04	0.18	0.21	-0.04	1						
Yield	-0.08	0.10	-0.09	0.04	-0.13	0.06	0.03	1					
Maturity	-0.20	-0.14	0.03	-0.33	-0.05	0.09	-0.03	-0.05	1				
Eascook	0.11	0.14	-0.11	0.17	0.07	0.04	0.29	-0.11	-0.04	1			
Taste	-0.00	0.06	-0.00	-0.05	0.51	0.12	0.18	-0.07	-0.24	0.09	1		
PDesisresis	-0.07	0.00	0.06	0.12	0.41	0.11	0.30	0.10	-0.19	0.05	0.30	1	
Drotoleranc	-0.19	-0.14	0.00	-0.16	0.11	-0.19	-0.11	-0.19	0.07	0.06	0.00	-0.10	1

Source: **Survey Data (2016).**

Age= Age of household head, Leveleduc= Education level of the household head, Hhsize= Household size, Landsiz= Land owned by household, Gmember= Membership to farmers' group, Extnserv = Access to extension services, Maktinf= Access to market information, Yield= Yield potential, Maturity= Maturity period, Eascook= Ease of cooking, Taste= Taste of the variety, PDesisresis= Resistant to pests and diseases, Drotoleranc= Tolerant to drought.

***** Presence of value greater than 75 per cent indicates presence of Multicollinearity on the data set

Appendix 2: Description of variables used in the multivariate probit and Poissonmodels

Variable	VIF
Age of the farmer	1.46
Household size	1.17
Land size	1.03
Education level	1.19
Extension services	1.18
Access to market information	1.35
Membership to farmers' group	1.22
Yield	1.06
Early maturity	1.53
Resistant to pests and diseases	2.09
Drought tolerance	1.32
Taste	1.69
Ease of cooking	2.15

Source**: Survey Data (2016).**

Appendix 3: The result of heteroskedasticity test

Variable	Probability Breusch-Pagan Test
Age of the farmer	0.172
Household size	0.253
Land size	0.736
Education level	0.584
Extension services	0.468
Access to market information	0.194
Membership to farmers' group	0.337
Yield	0.228
Early maturity	0.116
Resistant to pests and diseases	0.154
Ease of cooking	0.301
Taste	0.183
Tolerance to drought	0.427

Source: **Survey Data (2016).**

- Presence of probability value less or equal to 10 per cent indicates the presence of heteroskedasticity in the data set

Appendix4: Questionnaire

SURVEY QUESTIONNAIRE
CAASAVA FARMERS' AWARENESS AND PERCEPTIONS ON IMPROVED VARIETIES IN HOMA-BAY COUNTY, KENYA

Questionnaire No:			

SURVEY QUALITY CONTROL

Part I. IDENTIFICATION OF PARTICULARS

Name of Respondent …………………………. Tel NO…………………………..
Name of the interviewer …………………………………………………………
Date of the interview……………………………………………………………..
Start Time: ……/…../……   End Time: …./…../…….
Approved by the supervisor: YES/NO
Name of the Sub-county……………………………………………………..…
Name of Division…………………………………………………………………
Name of the Sub-location……………………………………………………….
Name of Location……………………………..
Name of the village………………………………………………………………..
Name of the household…………………………………………………

1.0. Background information

1.1.Age of the respondent in years…………………

1.2.Gender of the respondent [1] Male ☐ [2] Female ☐

1.3.Marital Status: [1] Single ☐ [2] Married ☐ [3] Divorced ☐ [4] Widowed ☐

1.3 Highest level of education

[1] No formal education ☐ [2] Primary education ☐ [3] Secondary education ☐ [4] Post-secondary education ☐

1.4. What is your household size? ☐

1.5. How many years have you been in cassava farming? ………………….

1.6 Which cropping system do you practice?

1. Intercropping ☐
2.Monocropping ☐

1.7 You are intercropping, what are the reasons that have motivated you to do so?

1. ……………………………………………………………
2. …………………………………………………………….
3. …………………………………………………………….
4. …………………………………………………………….
5. …………………………………………………………….

2.0 Farmer's Income and Assets (Wealth) in 2016 production year

2.1. Farmer ownership of implements/tools

Table 1: Please complete the following table about your use of farm implements in 2016 production year

Table 1. Please complete the following table about your use of farm implements in 2016 production year. Tool /equipment	No owned at present	Unit price (Ksh)	Value of assets
2.1.1 Vehicles			
2.1.2 Motorcycle			
2.1.3 Bicycle			
3.1.4 Tractor			
2.1.5 Plough yoke			
2.1.6 Hoe			
2.1.7 Cutlass			
2.1.8 Sickle			
2.1.9 Axe			
2.1.10 Knapsack chemical sprayer			
2.1.11 Others (specify)			

2.2. Income from crops

Table 1: In the table below indicate the major crops you grew in 2016, how much was consumed, sold and the value

Consumed, sold and the value No	Crop	No of acres	Total yield per acre (local unit)	Total sale (local Unit)	Value of sale (Ksh)	Total consumed (local units)
2.2.1						
2.2.2						
2.2.3						
2.2.4						
2.2.5						
2.2.6						
2.2.7						

2.3. Do you own livestock? 1=yes 0=no2.3 Income from livestock

If yes proceed to table 5 and if no proceed to 2.4

Table 3: Livestock ownership and value in 2016 production season

Table 5. Livestock ownership and value in 2016 production season Livestock	Quantity owned	Quantity Sold	Unit Price(Ksh)
Sheep			
Goat			
Cattle			
Chicken			
Duck			
Donkey			
Pigs			
Other (specify)			

2.4 Non-farm employment

2.4.1 Off-farm wage employment

Table 4: Please indicate in the table below your other income generating activities in the 2016 production season

No	Question	Response
2.4.1.1	Were you involved in any off/non-farm activity in 2016?1=yes 0=no	
2.4.1.2	If yes, what activity were you involved in? Casual Labour.=1 ,Self-employment=2, Skilled labour =3, Salaried employment =4, Petty trading .=5 7= others (specify)	
2.4.1.3	Average no of months or days per year engaged in this activity?	
2.4.1.4	Average income per Month or day did you receive?	

3.0 Variety adoption

3.1 Knowledge, source of information and variety adoption (This will help evaluate the knowledge gap)

Table5: Knowledge and adoption of improved varieties

Main source of variety information **Codes A**	Ever planted? **Codes B**	If No, Why? **Codes C**	If yes, year of first planted	Main source of seed **Codes D**
A 1. County extension officers 2. Farmer club 3. NGO 4. Research centre 5. Another farmer 6. Radio/newspaper 7. Others, Specify ………..	B 1. Yes 2. No	C 1. Cannot access the planting materials 2. Lack of cash to buy the planting materials 3. Planting materials are expensive 4. No market 5. Poor taste 6. Susceptible to pests and diseases		D 1. Borrowed for other farmers 2. Previous harvest 3. Research institutions

3.2. For each variety you have grown in the past, score their performance based on your level of awareness using code A below.
(*Use Selelevariety as the reference group*)

Table 6: Performance of variety attributes

Attributes	Cassava varieties (Codes A)										
Agronomic											
Yield											
Drought tolerance											
Pest and disease resistance											
Early maturity											
Uniformity in maturity											
Cooking and utilization											
Taste											
Cooking time											
Overall variety score											

Codes A (Use the crop CODE SHEET)		Codes 1. Yes 2. No

4.0 Characterization of cassava production, inputs and output in 2016 season

Table 7: Cassava production, inputs and output

Cassava variety Code A	Plot size (hectares)	Soil fertility Code B	Soil depth Codes C	Soil type Codes D	Use fertilizer Code E	Use pest chemicals Codes F	Total labour	Production (Kg)
Codes A (*Use the Crop Code Sheet*)		Codes B **1.** Poor **2.** Medium **3.** Good	Codes C **1.** Shallow **2.** Medium **3.** Deep	Codes D **1.** Loam **2.** Sandy **3.** Clay	Codes E **1.** Yes **2.** No	Codes F **1.** Yes **2.** No		

5.0 Cassava marketing (Record of 2016 season)

Table 8: Cassava marketing

Quantity sold Kg	Price (Ksh/Kg)	Buyer Codes A	Output quality Codes B	Distance to point of sale (Km)	Mode of transport Codes C	Transport cost (Kshs)
		Codes A 1. Farmer club 2. Rural brokers 3. Consumers 4. Cooperative society 5. Urban traders 6. Others specify…………	Codes B 1. Below average 2. Fair 3. Above average		Codes C 1. Bicycle 2. Donkey/ ox cart 3. Hired trucks	

6.0 Comparison of cassava buyers

Table 9: Comparison of cassava buyers

Issues for comparison or elicitation of time preferences	1. Farmer cooperatives	2. Rural assemblers	3. Brokers	4. Consumers	5. Urban buyers	6. Others, specify
1. Who pays the best price for the cassava delivered?						
2. Who has the most reliable weights?						
3. Who pays timely for the cassava delivered than all?						
4. Who is located nearest to your farm?						
5. Who is the strictest cassava quality requirement?						
6. Which marketing outlet do you prefer most?						

7.0 Revenues from sale of crops (*Record for the year 2016 only*)

Table 10: Revenues from sale of crops

Variety (*Use crops codes sheet*)	Quantity sold Kg	Price (Kshs/Kg)	Sales revenues (Kshs)

8.0 Management of improved cassava varieties

Table 11: Farm management

Recommended management practice			
8.1	Fertilizer application		
8.2	Mulching		
8.3	Line planting		
8.4	Spacing		
8.5	Use of healthy planting material		
8.6	Regular weeding		
		Codes 1=yes 0=no	If no, why not? codes 1 = Labour intensive 2 = Lack of money 3 = Not aware 4 = Not beneficial 5=other(specify)

9.0. Since you started growing improved cassava varieties has there been any change in any of the following household livelihood outcomes?

1 = Increased production 1=Yes 0= No 2= Extra income 1=Yes 0= No

3 = More food for the household 1=Yes 0= No

If the answer to question 4.7 is 2 go to question 4.8 otherwise proceed to question 4.9

9.1. Which are the four major household expenses (in order of importance) is the extra income from cassava in your household used for?

1. Education, 2. Food,3. Household items 4. Clothing, 5. Health

6. Investment 7. Saving

10.0 Extension contact

Table 12: Extension services

10.1	Were you ever visited by an agricultural extension agent in 2016? 1= yes 0=no	Response
10.2	If yes, during the 2016 production season how many times did an agricultural agent visit your farm?	
10.3	Have you ever participated in cassava field day or cassava extension programme before? 1= yes 0= no	
10.4	If yes, what kind of extension service (s) did you receive in 2016?	

11.0Group membership

11.1 Is there anyone in the household who is a member of cooperative or farmer groups with economic objective? (Yes) (No)

11.1.1 If yes, which type of farmer group?

1. Cassava cooperative society ☐ 3. Others ☐ specify ……………..
2. Community farmers' group ☐

11.2. What is his or her position in the group? ………………

11.3. Have you ever got information on agronomic practices from the group or the cooperative society? Yes ☐ No ☐

11.3.1. If Yes, explain ……………………………………………………………………..

…………………………………………………………………………………………

…………………………………………………………………………………………..

…………………………………………………………………………………………

12.0. What other benefits have you got from being a member of the group?

12.1. Do take your dry chips to processing facilities (Yes) (No)

12.2. If yes, what is the distance from farm to the facility? ……………………

13.0. Constraints to cassava production

Please indicate with respect to the following your constraint to the production of cassava

Table 13: Constraints in cassava production

Constraint		Yes	No
13.1	Lack of planting materials		
13.2	Low market prices		
13.3	Inadequate market		
13.4	Lack of access to Extension services		
13.5	Cost of production		

14. What can you recommend on promoting perception and adoption of improved cassava varieties?

1. ……………………………………………………………………………………….
2. ……………………………………………………………………………………….
3. ……………………………………………………………………………………….
4. ……………………………………………………………………………………….
5. ………………………………………………………………………………………..
6. ………………………………………………………………………………………..

CROP CODES SHEET

CODES A

Cassava varieties

1. TMS 30572
2. TM 14
3. MH93/OVA
4. Selele
5. Obar Dak
6. Others, specify………………..

Appendix5: Focus group discussion checklist questions

1. For how long have you been growing cassava?
2. Do you practice farming for subsistence, commercial purposes or both?
3. Have you adopted the improved cassava varieties ………………………
4. What are some of the challenges you experienced in cassava farming before adopting new varieties?
5. What is your perception on the new varieties?
6. Do you believe they are:
   I. Disease resistant ☐
   II. Drought resistant ☐
   III. High yielding ☐
7. What are the major challenges you have experienced since you adopted the new varieties?
8. How many times do you access extension agents per season?
9. Is there good market for the farm produce?
10. Is market price sufficient enough to motivate production?
11. Did you participate on plot demonstration?
12. Which benefits have you gained from plot demonstrations?
13. What are the main sources of information on new cassava varieties?
14. Do you access credit services financial terms from financial institutions?
15. Which institutions do provide credit facilities to farmers?
16. Do you prepare food for domestic consumption out cassava?
17. What kind of meals do you prepare out of cassava?…………………………………….
18. Is there presence of other alternative crops ? ………….
19. Please state these alternative crops ……………………………………