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DETERMINANTS OF ADOPTION OF AGRICULTURAL TECHNOLOGY IN KENYA: A CASE OF SMALL SCALE FARMERS IN KIRINYAGA

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DECLARATION

I declare that this work has not been previously submitted and approved for the award of a degree by this or any other University. To the best of my knowledge and belief, the Research Project contains no material previously published or written by another person except where due reference is made in the Research Project itself.

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ABSTRACT

Agricultural technologies are seen as an important route out of poverty in most of the developing countries. However the rate of adoption of these technologies has remained low in most of these countries. This study aim at shedding some light on the potential factors that influence agricultural technology adoption in Kenya by looking at small-scale farmers in Kirinyaga. Kenya. The following study objective guided the study, to identify determinants of adoption of technology in agriculture among small scale farmers in Kirinyaga. A logit and probit model is used to analyze the determinants of technology adoption, using a secondary survey data of 4363 observation. The following were the findings, education level, age, farm size, level of income, belonging to a group and access to credit influence the decision of adoption. Given these results, the paper recommends tailored credit schemes for farmers, dissemination of information via groups, improvement of links between manufacturer of the modern technology and the farmers and subsidizing of the modern agricultural technology.

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CHAPTER 1: INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Technology has been defined in various ways, Loevisohn and Diagne (2012) define technology as the means and methods of producing goods and services, including methods of organization as well as physical technique. According to Lavison (2013) technology is the knowledge/information that permits some tasks to be accomplished more easily, some service to be rendered or the manufacture of a product. Technology itself is aimed at improving a given situation or changing the status quo to a more desirable level. It assists the applicant to do work easier than he would have in the absence of the technology hence it helps save time and labor (Bonabana-Wabbi, 2002). Thus when integrated into Agriculture it leads to more production given the limited resources. Adoption on the other hand is also defined in different ways by various authors. Loevisohn and Diagne (2012)Defines adoption as the integration of a new technology into existing practice and is usually proceeded by a period of 'trying' and some degree of adaptation. Citing the work of Feder, Just and Zilberman (1990), Bonabana-Wabbi defines adoption as a mental process an individual passes from first hearing about an innovation to final utilization of it. Adoption is in two categories; rate of adoption and intensity of adoption. The former is the relative speed with which farmers adopt an innovation, has as one of its pillars, the element of 'time'. On the other hand, intensity of adoption refers to the level of use of a given technology in any time period (Bonabana-Wabbi, 2002).

Consequently one can simply conclude that agricultural technology is therefore the application of techniques to control the growth and harvesting of animal and vegetable products. Adoption of technology in agriculture dates back in the 18th century when agrarian revolution took place. It involved introducing new agricultural methods like crop rotations, Dutch plough, enclosure, development of national markets among others. This increased the output levels of agricultural produce without necessarily increasing force of labour, more time was dedicated to other professions thus work culture of working from 8 to 5 cropped up, and more capital was invested in the available innovations infusing Cobb-Douglas equation $Y = AK^{\alpha} L^{(1-\alpha)}$ for increased product (Cobb Douglas,1928).

Centuries later there are more innovations in the agricultural sector that are being employed to curb the difficulties and ensure more produce given the various limitations like inadequate land space and changing climate. They include drought resistant seeds, crop breeding, green houses and fertilizers just to mention a few. Currently Australian farmers, who have always been very resourceful in developing technologies that cope with the tough environmental conditions, they have come up with no-till farming which is a very specialized and scientific method of extracting the best yields from poor soils and dry conditions. Combined with this, research scientists have produced cereal seeds that best cope with drier conditions and have a shorter growing season (Belloti & Rochecouste , 2014)

Didier, Tebila and Aliou (2013) stated that agriculture remains a major sector in most African countries where it accounts up to 40% to the total GPD and up to 60% to export revenue and remains a major source of income to a significant share of rural households. Despite this importance, the agricultural sector in Africa has consistently faced a crucial problem of low productivity. However, area expansion is getting difficult because of the demographic pressure due to population and urbanization. This threat to agriculture production is worsening with the negative effect of climate change. Thus, raising productivity could be the most sustainable option. Also, agricultural productivity increase is widely accepted as strategic approach to contribute to poverty alleviation in developing countries (Didier , Tebila, & Aliou, 2013).

Narrowing down into the Kenyan context, from table 1 we deduce that indeed agriculture contributes widely to the GDP of the country.

Table 1: Percentage contribution of agriculture to GDP from the year 1960 to 2016

YEAR	AVERAGE % CONTRIBUTION OF AGRICULTURE TO GDP
1960-1970	37.11764042
1971-1980	35.55169227
1981-1990	32.08321307
1991-2000	31.04809596
2001-2010	27.00526619
2011-2016	30.43898764

Source: World Bank Data Base (2017)

From the table we see that agriculture is a major contributor to the economy, by contributing more than a quarter of the total GDP. It is followed by manufacturing industry that contribute 10% and service industry that contributes 6% (KNBS, 2016).

Kenya's exports are heavily reliant on agriculture. According to the Observatory of Economic Complexity in 2015 tea alone constituted 22% of the total exports of $5.25 billion followed by cut flowers at 12%. Thus depicting agriculture to constitute to more than 45% of exports (Simoes, 2015) .

Agriculture is the main source of income for around 2.5 billion people in the developing world (FAO, 2003). Smallholder agriculture is identified as a vital development tool for achieving Sustainable Development Goal one and two of eradicating poverty and hunger. However majority of smallholder farmers rely on traditional methods of production and this has lowered the level of productivity. For instance Over 70% of the maize production in the majority of developing countries is from smallholders who use traditional methods of production (Muzari and Muvhunzi, 2012). These farmers generally obtain very low crop yields because the local varieties used by farmers have low potential yield, most of the maize is grown under rain-fed conditions and irrigation is used only in limited areas, little or no fertilizers are used and pest control is not adequate (Muzari and Muvhunzi, 2012). This has triggered much of discussion on the need to increase productivity and sustainability in agriculture globally but much less information is available on specific means to achieve this aim.
Tapering to Kenya, Small scale farmers locally play a major role in the agricultural sector. Taking tea as an example in 2014, estate production was on 74,385 Ha producing 182,686 tons having a yield (tons/ha) of 2.5 whereas small scale production was 128,621 Ha producing 262,419 tons a yield of 2.0. Small scale farming dominates the banana sub-sector in Kenya with an estimated 390,000 farmers grow bananas with the major production areas are Meru, Tharaka Nithi, Kirinyaga,Embu and Kisii counties (Simiyu & Kamau, 2014).

The reason for higher yields in estate rather than small scale regardless of having almost double the field size is economies of scale and adoption of technology. Instead of manual labour, machines like tractors and tea picking machines are used which are time and cost effective (Central Planning and Project Monitoring Unit, 2015). This begs the question why are small scale farmers not adopting or why the slow diffusion of technology yet it enhances productivity.

Given the vast evolution in technology it is expected that most farmers should at least uptake this innovations. Adopting technology in agriculture benefits all, from the small farmers to the economy at large. Von Braun (1999) stated that increased agricultural productivity, technology adoption rates, and household food security and nutrition can be achieved through improved agricultural practices, expansion of rural financial markets, increased capital and equipment ownership by rural households, and development of research and extension linkages.

Increased technology development and adoption can raise agricultural output, hence improve household food intake. This in turn can also improve the functioning of the human body and the performance of a healthy, normal life which will increase work output (Kennedy & Bouis, 1993). Employing the principle of subsidiary as the technology adoption transforms the smallholder sector it will translate into the nation's economy as well.

This study helps to identify the determinants of adoption of technology in agriculture. The study mainly focuses on small scale farmers as a case study. The study will emphasis on the tools used for preparations whether the modern type, like use of machinery tractors versus the traditional tools which are mainly iron tools.

1.2 PROBLEM STATEMENT

Agricultural sector in Kenya has been identified as one of the six sectors aimed at delivering 10 percent economic growth rate under the Vision 2030. One key policy goal of the sector is to increase agricultural productivity through generation and promotion of technologies and increased resource allocations (Ministry of Agriculture, 2011). Slow technology adoption levels lead to low levels of production especially amongst Small scale farmers who account for 63% of total production of food in the country (Rapsomanikis, 2015).

The current food insecurity problems are attributed to several factors, including the frequent droughts in most parts of the country, high costs of domestic food production due to high costs of inputs especially fertilizer, reduction of cultivating land, high global food prices and low purchasing power for large proportion of the population due to high level of poverty (KARI, 2012). Thus the need for fast adoption of technology in agriculture among small scale farmers, which will provide solutions to these problems and promote economic growth. Over 70% of the maize production in the majority of developing countries is from smallholders who use traditional methods of production thus low yields (Muzari and Muvhunzi, 2012).

The contribution of this paper to literature is largely empirical. It will provide new insight on determinants of technology adoption among small scale farmers. This is by using data collected in 2016 on the small scale farmers in Kirinyaga.

1.3 RESEARCH OBJECTIVES

1. To identify determinants of adoption of technology in agriculture among small scale farmers in Kirinyaga.

1.4 RESEARCH QUESTIONS

1. What are the determinants of adoption of technology in agriculture among small scale farmers in Kirinyaga?

1.5 SIGNIFICANCE OF THE STUDY

The research is noteworthy to the agricultural sector of Kenya. The research will generate new insight that can be used in eradicating the slow adoption of agricultural technology among small scale farmers. This will help the sector boost the produce and achieve the set Vision 2030 and the sustainable development goals.

The study will also interest the investor looking into venture into agriculture. The findings may assist in knowing how to capture an existing niche. Agriculture is a lucrative market in addition it's a growing industry as well.

Lastly the study will aid policy makers and developers of new technology to understand farmers need as well as their ability to adopt technology in order to come up with policies and technology that will suit them. The research will provide findings that will give more insight.

CHAPTER 2: LITERATURE REVIEW

2.1 THEORETICAL REVIEW

The relationship between the inputs of resources and the output of product may be written in an equation known as the production function.

$$y = f(X_1, X_2 \dots\dots\dots\dots\dots . X_n)$$

y = quantity of output

X's – quantities of the various inputs for example modern tools, modern varieties of banana, farm size.

The production function brings out how output is dependable on inputs. The more the inputs the more the output. The increasing productivity is however limited to a certain point where diminishing returns are experienced.

The use of the langragian equation and set constraints enable one to determine the maximum inputs to attain the maximum utility. Assuming that farmers are risk-averse and maximizers of utility due to transitivity. Farmers will prefer more to less, therefore will always choose the utility that satisfies the most. Given the following utilities, $U_k > U_j$ the farmer would choose U_k .

Thus agricultural technology is an input in the agricultural production that can maximize the utility of farmers to a given extent.

2.2 EMPIRICAL LITERATURE REVIEW

Tiamiyu, Akintola, and Rahji, (2003) researched on the use of New Rice for Africa (NERICA) and complementary rice production technology promoted by Nigerian government in order to increase productivity of upland rice farming. This study examines the levels, determinants and effects of complementary technology adoption on productivity of NERICA rice farming. Data collected from sample survey of 227 NERICA were analyzed using Tobit regression model and Cobb-Douglas production function. Results showed that fifty-five percent of the farmers who scored above the mean were categorized as low technology users. Tobit regression estimation shows that farmers' technology score was affected significantly by farmer's level of education, extension visit farming experience, land ownership status, credit use and level of rice commercialization. Cobb-Douglas production estimation showed promotion of complementary technology in NERICA rice production is a worthwhile effort and should continue to be funded.

Uaiene (2009) carried out a research on, determinants of agricultural technology adoption in Mozambique. He used a data from TIA05, from September 2004 to August 2005. An econometric analysis, the probit and logit model was used. The results indicated that, holding other factors constant, households with access to agricultural advisory services, rural credit and members of agricultural associations are more likely to adopt new agricultural technologies. Changes in technology adoption are associated with changes in extension access and changes in credit access as well as initial status of farm household on access to credit and access to extension services.

Langat, Nyangweso and Mutwol (2013) carried out a research on: drivers of technology adoption in a subsistence economy, the case of tissue culture bananas in western Kenya. Household survey data and focus group discussions were used to identify determinants of adoption of tissue culture bananas among smallholder farmers in Western Kenya. Logit and probit analysis showed that gender, off-farm employment, household size, education level, age, land size, off farm income and extension services had significant influence on adoption of tissue culture banana production. More significant is sustainable access to Tissue culture plantlets which is a crucial input. They suggested that successful interventions should target youth, women famers and access to extension information. Policies targeting land consolidation will also help increase technology adoption.

Solomon, Franklin and Messia (2011) examined the driving forces behind farmers' decisions to adopt agricultural technologies and the causal impact of adoption on farmers' integration into output market. They used data obtained from a random cross-section sample of 700 farmers in Ethiopia. They estimated a Double-Hurdle model to analyze determinants of the intensity of technology adoption conditional on overcoming seed access constraints. Their results showed that knowledge of existing varieties, perception about the attributes of improved varieties, household wealth (livestock and land) and availability of active labor force are major determinants for adoption of improved technologies. Their results suggests that the adoption of improved agricultural technologies has a significant positive impact on farmers' integration into output market and the findings are consistent across the three models suggesting the robustness of the results. This confirms the potential direct role of technology adoption on market participation among rural households, as higher productivity from improved technology translates into higher output market integration.

In studying determinants of adopting Imazapyr-Resistant maize (IRM) technology in Western Kenya, Mignouna (2011) stated that, the characteristic of the technology play a critical role in adoption decision process. The study uses data from a multistage, random sample of 600 households of which, 169 were IRM adopters and 431 were non-adopters. Results from the Double-Hurdle model indicates that age of the household head, household size, membership to social group, access to extension services and perception towards IRM for Striga control were found to influence the decision to adopt IRM. And, household size, gap between maize production and consumption per capita, access to extension services and perception towards IRM for Striga control influenced the extent the farmer is willing to adopt. The paper concludes with policy implications aimed at renewing the focus on IRM transfer in western Kenya and other areas with similar conditions.

A study by Adesina and Zinnah ((1993) showed that farmers' perception of characteristic of modern rice variety significantly influenced their decision to adopt it. A similar result was reported by Wandji (2012) when studying perception of farmers towards adoption of Aquaculture technology in Cameroon. Their study indicated that perception of farmers towards fish farming facilitated its uptake. It is therefore important that for any new technology to be introduced to farmers, they should be involved in its evaluation to find its suitability to their circumstances (Karugia , et al., 2004)

Matsumoto, Yamano and Sserunkuuma (2013) researched on the technology adoption and dissemination in agriculture to figure out the empirical puzzle that relates to technology adoption in agriculture. Their study examined technology adoption and dissemination in terms of maize production in Uganda, where the dissemination of technologies relating to intensive farming methods is in its nascent stage. Data was collected from a two part experiment they carried out that included distribution of modern agricultural inputs and a credit sale the use of modern tools using. They noted that the distribution of modern agricultural inputs has a positive effect on the purchases of farmers with little experience in the use of inputs; the intervention had a spillover effect on the neighbors' adoption; and the credit sale option also had a large impact, as it allowed deferred payment of the input cost after the harvest. The impact of the credit sales was largest among recipients of the free trial packages. In addition the findings suggest that farmers learn new agricultural technologies through social networking rather than through geographic peers, and that they will adopt such technologies in cases where they recognize the benefits thereof.

Research has been done far and wide. Data has been collected and from above one would note the main models used are: obit Model, Probit and Logit models and the Double-Hurdle model. Consistency of the results suggest that the determinants of technology transcends place and time. Below are common findings over the past fifteen years by research scoping to fifteen years.

Many authors have analyzed farm size as one of important determinant of technology adoption. Farm size plays a critical role in adoption process of a new technology and in turn be affected by the other factors influencing adoption (Lavison, 2013). Some technologies are termed as scale-dependent because of the great importance of farm size in their adoption (Bonabana-Wabbi, 2002).Many studies have reported a positive relation between farm size and adoption of agricultural technology (Kasenge, 1998;Gabre-Madhin and Haggblade, 2001;Ahmed , 2004;Uaiene, Arndt, and Masters,2009;Mignouna, Manyong, Rusike, Mutambazi, and Senkondo, 2011).Farmers with large farm size are likely to adopt a new technology as they can afford to devote part of their land to try new technology unlike those with less farm size (Uaiene, Arndt, & Masters, 2009) In addition, lumpy technologies such as mechanized equipment or animal traction require economies of size to ensure profitability (Feder, 1990).

Some studies have shown a negative influence of farm size on adoption of new agricultural technology. Small farm size may provide an incentive to adopt a technology especially in the case of an input-intensive innovation such as a labor-intensive or land-saving technology. Farmers with small land may adopt land-saving technologies such as greenhouse technology, zero grazing among others as an alternative to increased agricultural production (Yaron , Dinar , & Voet, 1992); (Harper, Rister, Mjelde, Drees, & Way, 1990).Other studies have reported insignificant or neutral relationship with adoption. For instance a study by (Grieshop , Zalom, and Miyao, 1998), (Ridgely & Brush) , (Waller , Hoy, Henderson, Stinner, and Welty, 1998) (Bonabana-Wabbi, 2002) and (Samiee, Resvanfar, & Faham, 2009) concluded that size of farm did not affect Integrated Pest Management (IPM)adoption implying that IPM dissemination may take place regardless of farmers' scale of operation. Kariyasa and Dewi (2011) also found that extensive of land holdings had no significant effect on the degree of Integrated Crop Management Farmer Field School (ICM-FFS) adoption probability.

Therefore in regard to farm size, technology adoption may best be explained by measuring the proportion of total land area suitable to the new technology (Bonabana-Wabbi, 2002).

Another key determinant of the adoption of a new technology is the net gain to the farmer from adoption, inclusive of all costs of using the new technology (Foster & Rosenzweig, 1995). The cost of adopting agricultural technology has been found to be a constraint to technology adoption. For instance, the elimination of subsidies on prices of seed and fertilizers since the 1990s due to the World Bank-sponsored structural adjustment programs in sub-Saharan Africa has widened this constraint (Muzari, W, & Muvhunzi, 2012). Previous studies on determinants of technology adoption have also reported high cost of technology as a hindrance to adoption.

The study done by Makokha (2001)on determinants of fertilizer and manure use in maize production in Kiambu county, Kenya reported high cost of labor and other inputs, unavailability of demanded packages and untimely delivery as the main constraints to fertilizer adoption. Cost of hired labor was also reported by Ouma, et al (2002) as one among other factors constraining adoption of fertilizer and hybrid seed in Embu county Kenya. Wekesa, Mwangi, Verkuijl, Danda, and De Groote (2003) .When analyzing determinants of adoption of improved maize variety in coastal lowlands of Kenya found high cost and unavailability of seeds as one of factors responsible for low rate of adoption.

Off farm income has been shown to have a positive impact on technology adoption. This is because off-farm income acts as an important strategy for overcoming credit constraints faced by the rural households in many developing countries (Reardon, Stamoulis, & Pingali, 2007). Off-farm income is reported to act as a substitute for borrowed capital in rural economies where credit markets are either missing or dysfunctional (Diiro, 2013).

According to (Diiro, 2013)off- farm income is expected to provide farmers with liquid capital for purchasing productivity enhancing inputs such as improved seed and fertilizers. For instance, her study when analyzing the impact of off-farm earnings on the intensity of adoption of improved maize varieties and the productivity of maize farming in Uganda, Diiro reported a significantly higher adoption intensity and expenditure on purchased inputs among households with off-farm income compared to their counterparts without off- farm income.

However not all technologies has shown positive relationship between off-farm income and their adoption. Some studies on technologies that are labor intensive have shown negative relationship between off-farm income and adoption. According to Goodwin and Mishra (2004) the pursuit of off-farm income by farmers may undermine their adoption of modern technology by reducing the amount of household labor allocated to farming enterprises.

Belonging to a social group enhances social capital allowing trust, idea and information exchange (Mignouna, Manyong, Rusike, Mutambazi, & Senkondo, 2011)Farmers within a social group learn from each other the benefits and usage of a new technology. Uaiene (2009)suggests that social network effects are important for individual decisions, and that, in the particular context of agricultural innovations, farmers share information and learn from each other. Studying the effect of community based organization in adoption of corm-paired banana technology in Uganda, Katungi and Akankwasa (2010) found that farmers who participated more in community-based organizations were likely to engage in social learning about the technology hence raising their likelihood to adopt the technologies.

Although many researchers have reported a positive influence of social group on technology adoption, social groups may also have a negative impact on technology adoption especially where free-riding behavior exists. Foster and Rosenzweig (1995) when studying adoption of Green Revolution technologies in India found that learning externalities within social networks increased the profitability of adoption, but also farmers appeared to be freeriding on their neighbors' costly experimentation with the new technology. Bandiera and Rasul (2002) as cited by Hogset (2005) suggests that, learning externalities generate opposite effects, such that the more other people engage in experimentation with a new technology, the more beneficial it is to join in, but also the more beneficial it is to free-ride on the experimentation of others. As a result of these contradictory effects, Bandiera and Rasul (2002) propose an inverted U-shaped individual adoption curve, implying that network effects are positive at low rates of adoption, but negative at high rates of adoption.

Acquisition of information about a new technology is another factor that determines adoption of technology. It enables farmers to learn the existence as well as the effective use of technology and this facilitates its adoption. Farmers will only adopt the technology they are aware of or have heard about it. Access to information reduces

The uncertainty about a technology's performance hence may change individual's assessment from purely subjective to objective over time (Bonabana-Wabbi, 2002).However access to information about a technology does not necessarily mean it will be adopted by all farmers. This simply implies that farmers may perceive the technology and subjectively evaluate it differently than scientists (Uaiene, Arndt, and Masters, 2009).

Access to information may also result to dis-adoption of the technology. For instance, where experience within the general population about a specific technology is limited, more information induces negative attitudes towards its adoption, probably because more information exposes an even bigger information vacuum hence increasing the risk associated with it (Bonabana-Wabbi, 2002)It is therefore important to ensure the information is reliable, consistent and accurate. Farmers need to know the existence of technology, its beneficial, and its usage for them to adopt it.

Access to extension services has also been found to be a key aspect in technology adoption. Farmers are usually informed about the existence as well as the effective use and benefit of new technology through extension agents. Extension agent acts as a link between the innovators (Researchers) of the technology and users of that technology. This helps to reduce transaction cost incurred when passing the information on the new technology to a large heterogeneous population of farmers (Genius, Koundouri, Nauges, and Tzouvelekas, 2010).

Extension agents usually target specific farmers who are recognized as peers (farmers with whom a particular farmer interacts) exerting a direct or indirect influence on the whole population of farmers in their respective areas (Genius, Koundouri, Nauges, and Tzouvelekas, 2010) Many authors have reported a positive relationship between extension services and technology adoption. A good example include; Adoption of Imazapyr-Resistant Maize Technologies (IRM) by Mignouna (2011)Factors determining technology adoption among Nepalese Karki and Siegfried (2004); (Uaiene, Arndt, and Masters, 2009);Adoption of improved maize and land management in Uganda by Sserunkuuma (2005); adoption of modern agricultural technologies in Ghana Akudugu et al. (2012). This is because exposing farmers to information based upon innovation-diffusion theory is expected to stimulate adoption (Uaiene, Arndt, and Masters, 2009). In fact, the influence of extension agents can counter balance the negative effect of lack of years of formal education in the overall decision to adopt some technologies (Uaiene, Arndt, and Masters, 2009)

Access to credit has been reported to stimulate technology adoption (Mohamed and Temu, 2008). It is believed that access to credit promotes the adoption of risky technologies through relaxation of the liquidity constraint as well as through the boosting of household's-risk bearing ability (Simotwe and Zeller, 2006) This is because with an option of borrowing, a household can do away with risk reducing but inefficient income diversification strategies and concentrate on more risky but efficient investments (Simotwe and Zeller, 2006). However access to credit has been found to be gender biased in some countries where female-headed households are discriminated against by credit institutions, and as such they are unable to finance yield-raising technologies, leading to low adoption rates (Muzari and Muvhunzi, 2012).

There is therefore need for policy makers to improve current smallholder credit systems to ensure that a wider spectrum of smallholders are able to have access to credit, more especially female-

Age is also assumed to be a determinant of adoption of new technology. Older farmers are assumed to have gained knowledge and experience over time and are better able to evaluate technology information than younger farmers (Mignouna et al, 2011; Kariyasa and Dewi 2011). On contrary age has been found to have a negative relationship with adoption of technology. This relationship is explained by Mauceri et al. (2005) and (Adesina and Zinnah, 1993) that as farmers grow older, there is an increase in risk aversion and a decreased interest in long-term investment in the farm. On the other hand younger farmers are typically less risk-averse and are more willing to try new technologies. For instance, Alexander and Van Mellor (2005) found that adoption of genetically modified maize increased with age for younger farmers as they gain experience and increase their stock of human capital but declines with age for those farmers closer to retirement.

Gender issues in agricultural technology adoption have been investigated for a long time and most studies have reported mixed evidence regarding the different roles men and women play in technology adoption (Bonabana-Wabbi, 2002). In analyzing the impact of gender on technology adoption, Morris and Doss (1999) had found no significant association between gender and probability to adopt improved maize in Ghana. They concluded that technology adoption decisions depend primarily on access to resources, rather than on gender and if adoption of improved maize depends on access to land, labor, or other resources, and if in a particular context men tend to have better access to these resources than women, then in that context the technologies will not benefit men and women equally.

On the other hand gender may have a significant influence on some technologies. Gender affects technology adoption since the head of the household is the primary decision maker and men have more access to and control over vital production resources than women due to socio-cultural values and norms (Mignouna, Manyong, Rusike, Mutambazi, & Senkondo, 2011). For instance, a study by Obisesan (2014) on adoption of technology found that, gender had a significant and positive influence on adoption of improved cassava production in Nigeria. His result conquered with that of Lavison (2013) which indicated male farmers were more likely to adopt organic fertilizer unlike their female counterparts. Household size is simply used as a measure of labor availability. It determines adoption process in that, a larger household have the capacity to relax the labor constraints required during introduction of new technology (Bonabana-Wabbi, 2002) (Mignouna, Manyong, Rusike, Mutambazi, & Senkondo, 2011) headed households (Mkandawire and Maltosa, 1993) (Simotwe & Zeller, 2006). This may, in certain cases, necessitate designing credit packages that are tailored to meet the needs of specific target groups (Muzari and Muvhunzi, 2012).For instance in Kenya, the government has started a program that offer free interest loans to youths and women (UWEZO fund). This will help empower women and enable them to adopt agricultural technologies hence enhancing economic growth.

Human capital of the farmer is assumed to have a significant influence on farmers' decision to adopt new technologies. Most adoption studies have attempted to measure human capital through the farmer's Education, age, Gender, and household size (Fernandez-Cornejo, Daberkow, and huang, 1994); (Mignouna, Manyong et al 2011). (keelan et.al ,2014)

Education of the farmer has been assumed to have a positive influence on farmers' decision to adopt new technology. Education level of a farmer increases his ability to obtain; process and use information relevant to adoption of a new technology (Mignouna, Manyong, Rusike, Mutambazi, & Senkondo, 2011); For instance a study by Okunlola (2011) on adoption of new technologies by fish farmers and Ajewole (2010) on adoption of organic fertilizers found that the level of education had a positive and significant influence on adoption of the technology. This is because higher education influences respondents' attitudes and thoughts making them more open, rational and able to analyze the benefits of the new technology (Waller et al., 1998). This eases the introduction of a new innovation which ultimately affects the adoption process (Adebiyi and Okunlola, 2010). Other studies that have reported a positive relationship between education and adoption as cited by Uematsu and Mishra (2010) include; Goodwin and Schroeder (1994) on forward pricing methods, Huffman and Mercier (1991); Putler and Zilberman (1988) on adoption of microcomputers in agriculture, Mishra and Park (2005); Mishra et al. (2009) on use of internet on use of internet, Rahm and Huffman (1984) on reduced tillage, Roberts et al. (2004) on precision farming and Traore, et al. (1998) on on-farm adoption of conservation tillage.

On the other hand, some authors have reported insignificant or negative effect of education on the rate of technology adoption (Grieshop et al., 1988; Khanna, 2001; Banerjee, et al., 2008; Samiee et al., 2009; Ishak and Afrizon, 2011). Studying the effect of education on technology adoption, Uematsu and Mishra (2010) reported a negative influence of formal education towards adopting genetically modified crops. Since the above empirical evidence have shown mixed results on the influence of education and adoption of new technology, more study need to be done in order to come up with a more consistent result.

2.3 SUMMARY OF THE LITERATURE REVIEW

It is evident from the review that research on determinants of adoption of agricultural technology has been done far and wide. The main models used are the Tobit Model, Probit and Logit models and the Double-Hurdle model. Consistency of the results suggest that the determinants of technology transcends place and time.

The determinants observed can be grouped into four major categories; human specific factors, economic factors, technological and institutional factors. From the review, the determinant of agricultural technology adoption does not always have the same effect on adoption rather the effect varies depending on the type of technology being introduced.

Understanding the factors that influence or hinder adoption of agricultural technology is essential. Specifically in planning and executing technology related programs for meeting the challenges of food production in developing countries. Therefore to enhance technology adoption by farmers, it's important for policy makers and developers of new technology to understand farmers need as well as their ability to adopt technology in order to come up with technology that will suit them.

Given that small-scale farmers contribute 63% of the total agricultural produce in Kenya (Rapsomanikis, 2015), its vital modern researchers to seek to investigate the reasons why smallholder farmers do not adopt agricultural technology, and attempt to improve on them. This is a more effective strategy than the prevailing approaches which seek to displace traditional technologies outright on the grounds that they are irrational, unscientific, primitive and backward (Mwangi & Kariuki, 2015). This research seeks to bring new insight and understanding concerning determinants of agricultural technology adoption in the Kenyan context focusing on the small scale banana farmer.

CHAPTER 3: RESEARCH METHODOLOGY

This chapter outlines the process of conducting the research as well as systematic solving of the problem. In this regard the following aspects are research design, model specification, population sample and sampling techniques, data collection methods and tools for data analysis.

3.1 RESEARCH DESIGN

The nature of research is mainly quantitative, it involves determining factors of adoption of agricultural technology using data collected in the year 2016 among Kirinyanga small scale farmer Household survey was used to collect data from smallholder famer in Kirinyaga

3.2 THEORETICAL MODEL

Agricultural technology adoption is based on decision making. According to Feder (1985), decision-making process is characterized by choice of the optimal combinations of the components of a technological package over time. The decision maker is assumed to maximize the utility of asset use over time, subject to various resource constraints, usually assuming a concave utility function. This can be expressed by static models, or by dynamic, sequential models that consider changing knowledge and conditions (Toborn 2011).

Two major underlying assumptions of most farm household technology adoption models are that markets are perfectly competitive and the production and consumption decisions are separable. This is contrary to the economic environment of rural households in developing countries which is often characterized by imperfect or missing markets, resulting in non-separability of the household production and consumption decisions.

Observed outcome variable of adoption of agricultural technology is dichotomous. This requires consideration of models with dummy dependent variables against a mixed set of qualitative and quantitative explanatory variables. Qualitative models have been used extensively in adoption studies although they have been criticized for their inability to account for partial adoption (Feder *et al.*, 1985, Karki and Siegfried 2004).

In this research the Logit and Probit model will be used due to their binary nature. The two models will be used for robustness.

For the Logit model $F(x'\beta)$ is the cumulative distribution function of the logistic distribution

$$F(x'\beta) = \Lambda(x'\beta) = e^{x'\beta}/(1 + e^{x'\beta}) = \exp(x'\beta)/(1 + \exp(x'\beta))$$

In the case of normal distribution function the model to estimate the probability of observing a farmer using an input can be stated as Probit Model

$$P\left(Y = \frac{1}{X}\right) = \varphi(X\beta) = F(Z) = \int_{-\alpha}^{X\beta} \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{Z^2}{2}\right) dz$$

P = probability that the i^{th} farmer uses input and 0 otherwise

X = k by 1 Vector of the explanatory Variables.

Z = Standard Normal Variable (i.e. and $Z \sim N(0, \delta^2)$)

β = k by 1 Vector of the Coefficients estimated.

3.3EMPIRICAL MODEL

The model specification in this analysis can be written as

$$y_i = \beta_0 + \sum_{j=1}^{k} \beta x_i + \mu_i$$

$$y = \begin{cases} 1 & if\ y>0 \\ 0 & otherwise \end{cases} \quad (1.2)$$

1= adoption

0 = no adoption

The dependent variable in the adoption model is a dummy variable taking the values 1 if a household had adopted modern tools and 0 if not

Whereas x is a vector that represents variables includes: education level, age, farm size, level of income, belonging to a group and access to credit

μ_i Represents the error term which is assumed to have standard normal distribution.

3.4 DESCRIPTION OF VARIABLES

The explanatory variables for the regressions were identified in the proceeding section. This section explains the choice of explanatory variables.

The age of household head is incorporated as it is believed that with age, farmers accumulate more personal capital and, thus, show a greater likelihood of investing in innovations (Nkamleu et al., 1998). However, it may also be that younger household heads are more flexible and hence likely to adopt new technologies. The expected sign of the coefficient on age is indeterminate.

Membership to an agricultural association is included because it has been shown that farmers within a group learn from each other how to grow and market produce (Foster and Rosenzweig 1995; Conley and Udry 2000). The expected sign on the coefficient on membership in an agricultural association is positive.

Access to information about a new technology is included as a determinant of adoption of technology. It enables farmers to learn the existence as well as the effective use of technology and this facilitates its adoption. Farmers will only adopt the technology they are aware of or have heard about it. Access to information reduces the uncertainty about a technology's performance hence may change individual's assessment from purely subjective to objective over time (Caswell et al., 2001; Bonabana- Wabbi 2002). Therefore a positive coefficient is expected.

More educated farmers are typically assumed to be better able to process information and search for appropriate technologies to alleviate their production constraints. The belief is that education gives farmers the ability to perceive, interpret and respond to new information much faster than their counterparts without education.

Total income has been shown to have a positive impact on technology adoption. This is because income acts as an important strategy for overcoming credit constraints faced by the rural households in many developing countries (Reardon *et al*., 2007). Thus a positive coefficient is expected

Constrained access to credit figures prominently among the often cited reasons why technology fails to diffuse (Feder, Just and Zilberman, 1985). Differential access to credit or capital is often cited as a factor in differential rates of technology adoption. The expected sign on the coefficient on credit is positive.

Farm size plays a critical role in technology adoption Farm size can affect and in turn be affected by the other factors influencing adoption (Lavison 2013). Many studies have reported a positive relation between farm size and adoption of agricultural technology (Kasenge, 1998; Gabre-Madhin and Haggblade, 2001 Ahmed, 2004; Uaiene *et al*., 2009; Mignouna et al, 2011). Thus the expected coefficient on farm size is positive.

Table 3.1: Description of Variables

Variable	Description
Y	1= modern technology: indicated by the use of tractor, use of chemical. 0= traditional methods: indicated by use of hand tools, slash and burn.
Age	The age of the household head in years
Plot size	Size of the land in acres
Credit access	1 if the household head has access to credit and 0 if not
Education level	The highest level of education of the household head 1- No education 2- Primary level 3- Secondary level 4- Undergraduate
Access to information	1 if the household head has access to related agricultural information and 0 if not
Total income	The accumulated income of the household
Group membership	1 if the household head belongs to a farmers group and 0 if not

CHAPTER 4: RESULTS AND DISCUSSIONS

4.1 DESCRIPTIVE STATISTICS

The data was collected from 4363 households to represent the small scale farmers in Kirinyaga. The following are the average values of the variables

Table 4.1 Showing Average Values of the Variables

VARIABLE	AVERAGE
Education	2.43 (primary)
Total income	Kshs 106,225.3 per annum
Credit Access	0.12 (12% of the sample have access to credit)
Age	32 years
Information	0.316(32% of the sample have access to information)
Size	1.4 acres
Group Membership	0.236 (23% of the sample belong to a farmer's group)

The mean age of sampled smallholder's farmers in the study area is 32 years and this has implications on the availability of family labour and their productivity because age has a direct bearing on the availability of farm labour and the ease with which improved agricultural practices are adopted (Rauf, 2010). Age is a very important factor that can have serious effect on decision making. At times, it could have negative or positive effects. In the rural areas where most people are illiterate, age at times could have negative effect since old people that are already used to a particular way of doing things especially farmers that are already used to old ways may not be interested in improved technologies. It could be hypothesized that younger farmers may be better educated and therefore more aware of the benefits of modern technologies and also older farmers may be more conservative, less flexible and more skeptical about the benefits.

The average education level is primary level (taking up the dummy variable 2). This implies that smallholder's farmers had post primary education. Educated farmers are more aware of the benefits of using modern technology because they are better able to afford to purchase modern technology. In some cases, among the educated individuals, with age, farmers tend to be more enlightened and hence able to understand innovation quickly and consequently adopt it.

The average size of farm is 1.4 acres; this size is favorable for up taking modern technology like use of tractors for land preparation. Modern methods would be efficient for the size. Given the average income is 106,225 shillings per annum and group membership is 32% it explains why the application of modern technology is low due to limited access to credit which is at 12%. This causes a constraint in purchasing and implementing the modern technologies.

4.2 EMPIRICAL RESULTS AND DISCUSSION

Table 2.1 summarizes the results obtained from the two models. One can note the difference in the coefficients values this due to different scale of coefficients for the model. However when analyzing the coefficient the sign is observed rather than the magnitude. Therefore similar signs were obtained from both models. In order to examine the magnitude marginal effects are obtained thus can infer to what extent an independent variable affects the dependable variable. The marginal effects are similar in both models.

Table 4.2: Logit and Probit Results; Determinants of Adoption of Agricultural Technology

VARIABLE	PROBIT MODEL		LOGIT MODEL	
Preparation	Coefficient	Marginal Effect	Coefficient	Marginal Effect
Education	0.2075** (0.5945)	0.0112**	0.5248** (0.1402)	0.0112**
Group Membership	0.0370*** (0.1001)	0.00097***	0.0448*** (0.2389)	0.00097***
Total Income	2.45e-08 (1.32e-07)	5.90e-10	2.76e-08 (2.52e-07)	5.90e-10
Credit Access	0.0816*** (0.1229)	0.0046***	0.2134*** (0.2845)	0.0046***
Age	-0.0006* (0.0003)	-0.0002*	-0.0013* (0.0005)	-0.0002*
Access to Information	0.1087* (0.0912)	0.0065*	0.3039* (0.2143)	0.0065*
Farm Size	0.0760** (0.0139)	0.0031**	0.1443** (0.0306)	0.0031**
_Cons	-2.724607 (0.1627)		-5.5205 (0.3941)	
Pseudo R2	0.535		0.504	

Standard errors are in parentheses below the coefficient estimates.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level

The coefficient for education level has the expected positive sign for the modern technology adoption case. Education increases probability of adopting modern technology by 11.21%.This result supports the hypothesis that human capital plays a positive role in the acquisition and evaluation of new ideas. Moreover programs and materials promoting technological change typically favor literate farmers. This result is consistent with other findings in Africa including (Nkamleu & Adesina 2000; Bacha et al, 2001; Zegeye et al, 2001; Chirwa, 2005; Chianu & Tsiyii, 2004).

In this study, farm size in acres is taken as a proxy for wealth. The coefficient for farm size is positive as expected. A unit increase in farm size increases the probability of modern technology adoption for non- adopters by 3.8%. This finding is consistent with other studies carried out on adoption of agricultural technologies (Zegeye at all, 2001; Knepper, 2002; Isham, 2002; Chirwa, 2005).These results are contrary to what Croppenstedt and Demeke (1996) found on adoption of chemical fertilizer. The findings support the notion that farm size influences modern technology adoption and intensify of use, which is compatible with the notion that access to agricultural inputs and other services is easier for larger producers.

The age of household head is incorporated as it is believed that with age, farmers accumulate more personal capital and, thus, show a greater likelihood of investing in innovations (Nkamleu et al., 1998). However, it may also be that younger household heads are more flexible and hence likely to adopt new technologies. The expected sign of the coefficient on age is indeterminate. In our study we found that age has a negative effect thus reducing the chance of adopting agricultural technology by 0.02%.

Access to credit has a positive association with use of modern technology by smallholder's farmers. This is consistent with expected sign. This finding suggests that farmers use credit to buy the modern tools, which are likely to bring about greater returns than agricultural production with traditional tools and as a result it shows that access to credit is binding constraint to agrochemical input use by smallholder's farmers. The findings is consistent with other studies; (Didier , Tebila, & Aliou, 2013) (Mignouna, Manyong, Rusike, Mutambazi, & Senkondo, 2011).

The effect of participating in a farm group and access to information were found to have a positive effect on the probability of farmers using modern technology. It could be that the group offer advisory services which help make farmers more aware of the potential benefits of using modern farming techniques. In particular, farm groups could provide useful advice on the impact of using modern technology over traditional technologies and the most efficient methods suitable for each farmer.

McFadden's Pseudo-R 2 was calculated, and obtained values indicate that the independent variables included in the Probit and Logit model explain significant proportion of the variations smallholder's farmer's decision to use modern tools for preparation. It was calculated about 0.535 and 0.504.This value represents that variables placed in the model explain high level of the probabilities of decision to use modern inputs by smallholder inputs. Correct prediction rate obtained from Probit and logit model is 90%.This meant that the probit model predicts 90% of the cases correctly.

CHAPTER FIVE: CONCLUSION AND POLICY RECOMMENDATIONS

5.1 CONCLUSION

This study in conclusion describes the determinants involved in adoption of modern technology specifically those that influence the adoption and intensity of use of modern tools and methods for preparation among smallholder's farmers in Kirinyanga. The choice of using either logit or probit is entirely up to one's preference. They both give the same results in terms of signs of coefficients and magnitude of marginal effects. This study concluded that decision to use modern inputs depends on age, farm size, education level, access to information, group membership, access to credit and total income.

5.2 POLICY RECOMMENDATIONS

The following are ways through which ministries and implementing agencies can improve adoption of modern technology among small scale farmers:

Setting up smallholder credit scheme, especially for purchase of farm technologies, could be an important step towards accelerating farm technology adoption. Because the smallholders may not be able to acquire credit from the mainstream financial sector due to the risky nature of their business, the government could step in either as a guarantor or as a direct provider of the funds through microfinance institutions. An alternative approach could be to mobilize the smallholders to form organizations through which to pool resources and obtain additional funding from either the government, or financial institutions.

Subsidize the modern tools and appliances for farming that increases the yield. However it may not be useful to subsidize one of the technologies without due consideration of the famers' capability to fully fund the remaining parts of the cost of adoption. For instance, smallholders may be hesitant to adopt improved plant varieties if they are unable to obtain fertilizer to go with it. Thus, to promote adoption of complementary technologies, it is important to ensure that the technologies are available and affordable to the smallholders.

Larger plots attract adoption of modern preparation methods, it may not be possible to curtail further sub-division of agricultural land as population increases. One option could be to increase access to land through land rental market to enable land-constrained smallholders acquire additional farmland. This is possible through land banks. Another option, though achievable only in the long term, is to expand the industrial sector to absorb more people from the agricultural sector to reduce pressure on agricultural land.

Improved technologies should be availed within easy reach of the farming households. While the government can contribute to this by improving transport infrastructure within the farming villages, the technology producers and marketers have the most important role of setting up distribution outlets closer to the farming communities. Local farmer organizations may also contribute through bulk buying of the improved technologies and directly supplying the same to the members in appropriate quantities

5.3AREAS FOR FURTHER STUDIES

Significant research gaps remain in this area of study which will need to be filled in order to increase the effectiveness of technology adoption in Kirinyaga. These areas are; research on other factors that affect adoption of technology in other sub-counties and influence of the moderating variables like resource adequacy, Government policies and community cooperation on the adoption of technology.

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