FACTORS AFFECTING ADOPTION OF AGRICULTURAL INNOVATIONS AMONGST SMALL HOLDER FARMERS: A CASE OF NYOTA BEANS TECHNOLOGY IN BUNGOMA COUNTY

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DECLARATION

DECLARATION

This thesis is my original work and has not been presented for an award in any other university.

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This thesis has been submitted for examination with my approval as the University of Nairobi supervisor.

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LIST OF ABBREVIATIONS

CBOs - community-based organizations

CDDC - County Driven Development chair

DAP - Diamonium phosphate

FAO - Food and Agriculture Organization

GOK - Government of Kenya

KALRO - Kenya Agricultural and Livestock Organization

KK15 - Kakamega 15

KNBS - Kenya National Bureau of Statistics

MT - Metric tones

NARIG - National Rural Inclusive Growth Project

OECD - Organisation for Economic Co-operation and Development

PABRA - Pan Africa Bean Research Alliance

SHFs - Small holder farmers

SPSS - Statistical Package for Social Science

SSA - Sub-Saharan Africa

UN - United Nations

WB - World Bank

NASEP- National Agricultural Sector Extension Policy

ABSTRACT

In the developing world, agriculture remains the major source of income for over two billion people. As a result, in majority of emerging nations, improved agricultural technology and other new sustainable agricultural technologies are viewed as crucial steps toward ending poverty. But in the majority of these nations, these technologies have continued to be adopted at a slow rate. The study therefore investigated the adoption of the Nyota bean seed technology amongst small holder farmers and assessed the factors that influenced its adoption or lack of it, the challenges, and opportunities in adoption of the seed variety among small holders in Kimilili Sub County, Bungoma County. In the study we used descriptive research design and a proportionate random sample technique was used to come up with bean farmers in Kimilili Sub County in Bungoma. The study used 121 smallholder farmers as its sample size and an in depth interview that were structured was used to gather primary data. Data was analysed using frequency, percentages and inferential. The findings showed that the respondents' gender distribution was significantly uneven. Majority of the respondents were females who were largely above 50 years with basic education and had farming experience of over 20 years. Majority of the respondents knew about some of the agricultural technologies recently introduced in the area and listed examples such as improved varieties, fertilizer use, use of crop protection products. The Study findings show that government extension officers and County government were the most preferred sources of agricultural information. Majority of the respondents were members of informal or formal cooperatives whose key functions was savings and credit and had access to credit facilities for buying farm equipment, farm inputs, to do soil testing and buying basic utilities. However, others did not obtain loans because they did not like to borrow. The majority had access to extension services and received training on adopting improved varieties, doing soil tests, and practicing soil conservation. Thus, even though they only allotted a small amount of their land, the majority of respondents adopted the

Nyota technology. Respondents that did not adopt the bean variety cited lack of knowledge and high cost of fertilizer and opted to plant other varieties such as wairimu, nyayoo and rosecoco.

The results demonstrated that farmers' age, gender, and educational attainment all significantly influenced their usage of technology. This study evaluated many aspects influencing smallholder farmers in Bungoma County, Kenya. Results showed that a number of factors, including human, social, economic, educational, household size, access to knowledge, and participation in social networks, influence how widely agricultural technology is adopted. Farming experience positively and significantly correlated with age of the respondents while planting improved variety as an example of agricultural technology had negative but significant correlation with age of the farmers. Aspects of bean that pushed farmers to adopt the technology had significant and positive correlation with planting improved varieties. This indicates that positive attributes of improved varieties pushed the farmers to adopt them. In conclusion, developed policies by the agencies should provide technical skills to both farmers and extension agents on improved agricultural technology adoption and also ensure that they support adoption of improved technologies. They should also consider the farmers needs and develop farmer friendly technologies.

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

The agriculture industry is vital to the development and expansion of the economy in many third-world nations. An estimated 18% and 4% of the population in Latin America and in high-income countries, respectively, depend on agriculture, compared to over 60% in sub-Saharan Africa (SSA), Asia, and the Pacific (Worldbank, 2006). Consequently, the sector's significance to promoting economic growth and development, enhancing food security, and eliminating poverty cannot be overstated. This can only be accomplished by raising small-holder output, in which technology advancement plays a crucial role, as has been stressed by world development reports over the years.

Food security and nutrition however remains a global challenge and is predicted to face considerable challenges in the upcoming period particularly in the developing countries due to rapid societal changes, ecological pressures and climate patterns that put considerable pressure on available resources. (ACF, 2014). This calls for integrated and innovative approaches in ensuring sustainable food production and consumption as agriculture plays key role in economic growth of developing countries. This is also a key goal of United Nations (UN) Sustainable goals in attaining food security and nutrition and ending hunger. Given that up to 70% of the food consumed on the continent is produced by smallholder farmers, smallholder agriculture is crucial for boosting employment, promoting food security, and bolstering the economy. However, smallholder agriculture in Africa is characterized by a low level of production due to the limited deployment of technologies. OECD-FAO noted that for there to be increase in agricultural production, there’s need to increase the farm input resource or change the current farming practices and investing in agricultural research and technology.

Agricultural technology can include the hardware like the machineries or scientific processes, ideas and improvements on previous methods. Even though studies have demonstrated that

smallholders in Africa who embrace technologies gain from doing so, many smallholders are still unable to do so for a variety of reasons. (Glover *et al*, 2019; Mwangi & Kariuki, 2015). In wealthy nations like USA and Great Britain, factors like weather, price volatility, and seasonal workforce, among others, affect how quickly small businesses adopt new technologies while in China, training, age, and family size affect adoption (Li et al, 2020). In Africa, various factors affect adoption by smallholder farmers of new technology. Tey et al. (2017) broadly categorized the adoption determinants into 5 categories, including farmer characteristics, technological features, institutional factors, farm characteristics and financing. Farmers are also seen as a major constraint to adoption. They are either innovators or laggards. socioeconomic factors such as farmers' age, education, income family size, land size have all been reported as affecting the extent of adoption. According to Annan (2018), social and economic factors occupy important space in technological adoption amongst farmers. Factors like gender, age family size, farm size, knowledge and education levels of the farmers influence farmer's decisions. Doss et al. (2003) claim that the likelihood of families under the leadership of male head in developing nations to embrace new technologies is high compared to households headed by women because men are more dominant and more included in extension activities than women. Institutional factors such as the link between the farmer and the agriculture officer, membership of farmers in farmer associations, availability of the officer also affect adoption (Kinyangi, 2015) equally affects adoption amongst small holders. Being in associations allow the farmers to access information from agricultural workers and make informed decisions unlike those who are not in associations.

Common bean is a significant staple food in Africa and is acknowledged as the third source of calories and the second most important source of protein for human diets among all agricultural commodities. (Birachi et al, 2011). In Kenya, it is the most important legume, valued for its cheap source of protein particularly in low-income populations and in institutions such as

schools, colleges, hospitals and in food relief agencies (GOK, 2013). It is grown by more than 3 million households' majority who are small scale farmers (Katungi et al., 2019) hence the importance of increasing and sustaining its production. It is for this reason that new seed varieties were produced by KARLO to increase and sustain bean production amongst small holders and improve on nutrition. Angaza, Faida, Nyota, and Metameta are the four new bean varieties that have now been made available thanks to the work of PABRA. It is high yielding, market preferred and drought tolerant dry bean. Reports however indicate that 7.5 million Kenyan farmers have not yet embraced new seed varieties; instead, they choose to use old harvests or neighbouring farms, an age-old practice (Africa Agriculture Status Report 2016). Additionally, it was stated that they do not experiment with new types since they are unaware of their existence and advantages and because they are not interested in doing so.

Bungoma County in Western Kenya is a key bean producing county and is one of the counties the seed variety was piloted. It is highly dependent on subsistence agriculture with Maize, sunflower, sorghum, potatoes, coffee and beans being the main crops. The economy of Bungoma county is heavily dependent on its natural resource base because agriculture is the primary source of revenue, making it very vulnerable to climate change. Even though it is the the key source of income in the county, agriculture is identified as one largest sector most vulnerable to climate change in the county's Integrated Development Plan (2018-2022). The County has a food insecurity rate of 43% and a poverty rate of 52.9%, which is higher than the national rate of 46% despite being a high agriculture potential area (Mary, 2017). According to Ralph et al (2015), cost of inputs, particularly seeds, fertilizers, fuels, and feeds, significantly affects agricultural production in the county. There is below par use of fertilizer and use of uncertified seeds that reduce productivity among small holders in the County (Raph et al., 2015) and access agricultural credits is a challenge to most farmers even with liberalization of agricultural sector

The study analysed the variables influencing the adoption or lack thereof, the difficulties and opportunities in adopting the seed variety among small holders in Bungoma County, and the adoption of the Nyota bean seed technology among small holder farmers. This knowledge generated will inform on how to bridge adoption gaps amongst small holders particularly on new seed technologies.

1.2 Problem Statement

Due to their reliance on conventional agricultural production techniques, smallholder farmers only produce at a minimal level. Majority of smallholder farmers obtain low yield because of the type of varieties planted which are characterized by low yield potential and are entirely dependent on rain fed agriculture (Sennuga et al., 2020). Smallholder farmers' adoption of agricultural innovation has drawn a lot of attention in recent years due to its links to higher wages and nutritional status, decreased levels of poverty and staple food prices, and more farmer employment options (Feder et al., 1985; Akudu et al., 2012; Jerop et al., 2018; Sennuga et al.2020). However, there doesn't seem to be a clear path for how to accomplish this, and the literature is still ambiguous. In addition, despite the efforts of the government and development partners, Kenya's smallholder farmers have accepted new technologies very slowly (Republic of Kenya, 2007; Ogada et al., 2010). Even though many developing countries see adoption as a crucial step toward reducing poverty, many aspects of it remain poorly understood (Bandiera and Rasul, 2002; Simtowe, 2011). The majority of SSA farmers do not use better seeds made through conventional breeding, hybridization, genetic modification, or gene editing and do not as a result gain from improvements in crop stress tolerance, adaptability, and other traits (Tom et al., 2020).

On almost one million hectares, about 1.5 million smallholder farmers in Kenya grow beans, with yields of about 0.6MT/ha (Duku et al., 2020). Kenya ranks seventh globally and is the second-largest producer of beans in East Africa, after Tanzania. The national consumption of

common beans is projected to be about 755,000MT per year, compared to a production of roughly 600,000MT per year (Duku et al., 2020). The yearly consumption per person in the nation is roughly 14 kg, while in western Kenya, it can reach 66 kg (Katungi et al., 2010). Because of this, it has become necessary to increase productivity and sustainability. Nutrient-enriched bean varieties with considerably more iron were launched in Kenya in 2017 to tackle the iron deficiency that affects 21.8% of schoolchildren, 36.1% of pregnant women, and 21.3% of non-pregnant women. However, only 7.5 million Kenyan farmers have adopted new seed varieties, while others prefer to choose from previous harvests or obtain their supplies from neighbors (Africa Agriculture Status Report 2016). It also been reported that farmers lack desire in experimenting with novel kinds as well as understanding of their advantages. Due to their loyalty to things they are familiar with or used to, small holders have not yet been able to appreciate innovation. The Pan Africa Bean Research Alliance (PABRA) in collaboration with KALRO recently introduced four new varieties namely Angaza, Faida, Nyota, and Metameta. In Bungoma County, there is no empirical data that supports the adoption of newly introduced technologies like conservation tillage, integrated pest control, new seed varieties, or sustainable farming methods.

Therefore, the study will look into what factors influence smallholders' adoption of new seed technologies and assess how the factors influence adoption or lack of it, challenges, and opportunities in adopting new technologies in Bungoma County. It will assess the farmer's social economic characteristics, Institutional, and financial factors and how they affect uptake on new technologies amongst small holders. Technology adoption in this respect refers to the degree to which new and improved technologies are embraced, and applied with the aim of enhancing livelihoods and productivity (Annan 2018; Sunding and Zilberman 2001; Feder, Just and Zilberman 1985). This study's objective is to identify the reasons and factors that

encourage small scale farmers to embrace agricultural technologies, the obstacles to and potential improvements in adoption.

1.3 Research questions

1. What social and economic factors affect Bungoma County's small farmers' adoption of agricultural technologies?
2. What institutional factors in Bungoma County affect smallholder farmers' adoption of agricultural technologies?
3. What are the challenges and possibilities for increasing smallholder adoption of agricultural technology in Bungoma County?

1.4 Research Objectives

The main objective of this study is to analyze the social, economic, and institutional aspects that affect adoption of agricultural technologies as well as to evaluate the prospects and obstacles for enhancing technology adoption in the area among small-scale farmers in Bungoma County.

1.4.1 Specific objectives

i. To examine the influence of social economic characteristics of farmers on the adoption of various agricultural technologies
ii. To examine the institutional factors influencing adoption of new agricultural technologies amongst small holder in Bungoma county
iii. To assess the challenges and opportunities in improving agricultural technology adoption amongst small holders in Bungoma county.

1.5 Significance of the study

Even with known advantages of recently introduced bean varieties, such as their higher iron content than standard types, adoption of the invention has been slow in these regions. Common beans are vital in sustainability of livelihoods though provision of food security (Buruchara,

2011). The introduction of Nyota variety, which is high yielding, early maturity, market preferred, drought tolerant dry bean, climate smart, fast cooking and rich in iron and zinc hence of high nutritional value will provide farmers with increased finances, nutritional and food security. However, very little research has been done to determine the exact factors prompting smallholder farmers in Bungoma to adopt the cultivar. The findings will offer practical information that might guide the adoption of varieties and lessons learned will be disseminated among initiatives of a similar nature in Kenya.

1.6 Assumptions of the study

This study was conducted under the notion that all smallholder farmers face difficulties in adopting new technologies, that respondents will cooperate and voluntarily provide accurate information on adoption of agricultural technologies, and that unrelated outside factors won't interfere with the study. All respondents will have enough time to complete the survey and participate in focus group discussions. Additionally, it is presumable that all small holders in the county were given an equal chance to use the new seed variety.

CHAPTER TWO: LITERATURE REVIEW

2.1 Technology adoption

Technology adoption in this respect refers to the degree to which novel, better techniques and technologies are acknowledged, embraced, and applied with the goal of enhancing livelihoods and productivity. (Annan 2018; Sunding and Zilberman 2001; Feder, Just and Zilberman 1985). Technology transfer is a multifaceted process that involves sending and receiving cutting-edge information, concepts, tools, and materials from one end to the other both domestically and internationally (Takahashi et al., 2019). Technology transfer in the development sector may involve the introduction and exchange of novel approaches and information, followed by the expansion and use of novel strategies and tools from the creators to the beneficiaries.

The introduction of innovative agricultural practices is credited with the green revolution's 1940s success. (Dether and Effenberger, 2012). The use of high-yielding breeds, fertilizers, and irrigation methods that expanded food production was accelerated by the green revolution. Food production was enhanced by new, better varieties created for the duration of the revolution as well as fertilizers and irrigation technologies that provided water for cultivation in regions with less rainfall (Briney 2015). However, a new technology's potential benefits can only be realized when farmers properly adopt and utilize it. Many factors, which can be categorized as social, economic, or institutional, have an impact on how people accept new technologies. Annan (2018) asserts that farmers' adoption of novel technologies is significantly influenced by social and economic factors. Many variables, such as a farmer's knowledge and understanding, training, sex, age, and family size, affect their decisions. According to Doss et al. (2003), men-headed households in developing nations are more likely than women-headed households to accept new technologies because men are more dominant and are more included in extension activities. Similar to this, institutional elements allow farmers access to information about new technology and their advantages, such as membership in farmer

associations and cooperatives (Akubuilo 2013). For its members, associations host workshops in which new information and techniques are presented. This greatly aids farmers in gaining crucial knowledge about contemporary technologies and techniques necessary in raising agricultural productivity. Additionally, cooperatives and associations can coordinate resources like trainings for their members by working with other parties like the government, the corporate sector, and NGOs. As a result, the farmers have an advantage over others who are not members in that they can use the latest technologies with knowledge. Government and non-profit organizations' extension services are very important to the adoption procedure. 2011 (Kudi et al., 2011). Farmers have the chance to discuss ideas and ask questions about technologies with extension agents. Finally, credit facilities enable farmers to more quickly adopt new technologies and access credit and loans to support their farming activities. Farmers can easily get agricultural farm inputs thanks to market variables like the accessibility of agro input and other farm inputs.

2.2 Theoretical Framework

Technology adoption is the process of implementing new technology into a current practice while technology is the means or a way of generating goods and services (Loevinsohn et al 2013). Technology adoption is described by Akubilo et al. (2007) as the systematic application of scientific information for useful purposes. It includes all forms of advanced methods that have an affect the rise and development of agricultural output. High yielding seed varieties, chemical fertilizers, insecticides, herbicides, and mechanical use are a few examples of technologies. It often boosts output while lowering the typical cost of production. Adoption is the choice made by an individual or group of individuals to embrace and employ the innovation consistently.

2.2.1 Rogers Theory of Adoption and Diffusion

Rodgers' (1995) diffusion theory is the foundation for this research, which holds that different people have various characteristics that influence whether or not they embrace an innovation. According to Rodgers, there are a number of theoretical stances on diffusion that are relevant to the idea of diffusion as a whole. Despite being distinct terms, the notions of adoption and diffusion are occasionally used interchangeably when talking about challenges of technical transfer and breakthroughs (Rodgers, 2003). According to this hypothesis, innovative and technological concepts permeate throughout a civilization. In this study, we make various assumptions about the elements that determine a farmer's capacity to embrace a technology, including social-economic, institutional, and economic aspects. Degnet and Belay (2001) suggests that adoption or no adoption vary over time. For instance, adoption of the introduced technology will increase if farmers perceive that the variety has advantages such as higher yields than the traditional bean varieties. This can be promoted by educating farmers, training, and sensitizing farmers to inform their decision making and obtain skills necessary for adoption.

2.2.2 The Individual Innovativeness Theory

According to Rodgers (2003), different people or groups adapt to new ideas, technologies, and innovations at different times, hence many time series cover how people in a society adopt and employ new ideas, technologies, and innovations. Farmers in a given community therefore may adapt to new technologies at different time frames. Rodgers (2003) divides technology users into different classes, including the early majority, the late majority, the laggards, and the early adopters. He continues by saying that the concept of innovativeness is used to categorize adoption and that it encompasses the rate at which individuals adopt or use new inventions relative to others in a given culture or social group. Innovators are swift and show desire in taking up new ideas and readily use them (Dearing 2009).

According to Rodgers (2003) early adopters are typically seen as reputable farmers who have leadership positions in the community. They might be influential members of the community, opinion leaders, or cooperative leaders. In comparison to other farmers, they are also more wealthy in terms of land and other productive resources. They act as the point of approval for other farmers. Adoption of technology is therefore passed from the early adopters to other farmers through continuous interchange of information sharing among individuals and groups

Early majority follow the early adopters and according to Rodgers (2003), they are characterised by deliberating first and pondering on the new technology before adapting or rejecting it. Despite not necessarily being leaders, they still have a significant impact on decisions because of the frequent encounters and exchanges they have with other members of the social system. On the other hand, the modern majority considers the economic advantages of the mentioned invention and the requirements connected with it. They are interested in the social and economic ramifications of the novel concept, and they are also seen to change as a result of influence from their close friends. This is primarily a result of lack of assurance, doubts, and pre-existing misconceptions about the subject. It is therefore crucial that agricultural agencies and implementers consider the social cultural norms in relation to the technology when considering adoption of the late majority group. (Sahin, 2006)

The last group in the adoption process as categorized by Rodgers (2003) is the Laggards. This category usually has fewer resources compared to the other categories and therefore are reluctant in taking risks and adopting new technologies. Their interaction within the social structure is also low and therefore their decision to adopt a new technology is made through key consideration on desirability and workability of the new idea. In this case, the farmers employ greater doubt in a new technology and highly desire to see the benefits it brings.

2.3 Empirical Framework

2.3.1 Adoption and rate of agricultural technology adoption

Adoption of new agricultural technologies, such as the usage of advanced irrigation systems, pesticide use, and fertilizer application, motorized tricycles (Aboboya) for transporting farm inputs and harvest to and from the farms, was the subject of a study conducted by Grace E. (2020) at the International Institute of Social Studies. According to the study, a number of institutional and political elements, as well as socioeconomic factors, help farmers make adoption decisions.

Farmers mostly rely on rain-fed agriculture, which results in low yields because they grow regional varieties with low yield potential. Traditional farming practices used by smallholder farmers have not increased output. Traditional technologies are considered backward and are stumbling block to improved productivity and there is a large gap between what farmers obtain and what they can obtain if they adopted the current technologies. Because of this, there has been a need for increased productivity and this has led to creation of various agricultural technologies like improved seeds varieties, fertilizers, equipment among others. The application of agricultural technologies affects agricultural output, as well as how an increase in agricultural output affects poverty levels and environmental deterioration. (Meinz et al., 2002). ICARDA began an initiative in 2005 to educate farmers in Syria and Iraq about conservation agriculture and zero tillage. The proponents of the system urged farmers to conduct demonstration trials by giving out zero tillage seeds for two years to first-time users in addition to providing free technical support and extension services. The choice of whether the farmers will use the technology on their own was left to them (Yigezu et al., 2018). The key drivers of zero tillage, according to empirical evidence, are lower production costs, higher yields, and higher net farm returns.

The acceptance by a group or individual to use a new innovation is known as technology adoption, whereas technology is one of the resources for agricultural production (Sennuga et al., 2020). Therefore, for increased yield output and poverty reduction, innovative agricultural technology that promotes sustainable food production is essential (Mwangi and Kariuki 2015). Adopters of these technologies have noticed increased production, which has resulted in ongoing socioeconomic progress. For instance, the introduction of these technology has boosted employment prospects, improved nutritional status, and higher wages for farmers (Karisya, 2011; Sennuga et al., 2020).

To adopt a new technology or invention, one must go through at least five mental stages, including awareness, interest, evaluation, trial, and adoption. Adoption is not a one-time event (Cheteni et al., 2014; Sennuga et al., 2020). A farmer learns about the technology's concept during the awareness stage but lacks comprehensive knowledge of it. As farmers become active and show an interest in learning more about the technology, there is additional information about it in the second level. The farmers go through a small-scale trial of the innovation or technology at the third mental stage after learning more, and they ask for additional detailed information to help them with some of their questions. Large-scale technology acceptance and ongoing use characterize the last stage of adoption (Cheteni et al., 2014). To introduce a new knowledge at the wrong time, in the wrong place, or by the wrong people might result in adoption being rejected. Sometimes a technology may be rejected, or a choice to accept it may be made later. The decision-making steps taken by an individual or a farmer are shown in Figure 2.1 below. The model explains the variables that influence decision-making. Farmers with varying knowledge levels are convinced in different ways to embrace or outright reject the technology, according to this model's correlation between knowledge levels and technology attributes. The decision is based on either timing of introduction, location and opposition. Depending on the knowledge levels, farmers can rightfully reject/ adopt or adopt later after

reinvention. At this stage we have farmers who adopt from start, or discontinue to adopt (Figure 2.1). This model supported the definition for adopters and non-adopters in this research where farmers who continued planting the nyota bean up to the recent season were considered adopters while those who discontinued were considered non adopters.

The rate of adoption refers to how quickly people in a social system adopt an innovation (Gatheri, 2021). Participants who are able to embrace a particular technology during a specified time period is typically used to calculate the rate of technology adoption. The typical method for doing this is to calculate how long it will take for a specific proportion of the group to accept the notion (Sunding and Zilberman 2001). When enough people have embraced the technology, adoption eventually reaches a critical mass and becomes self-sustaining.

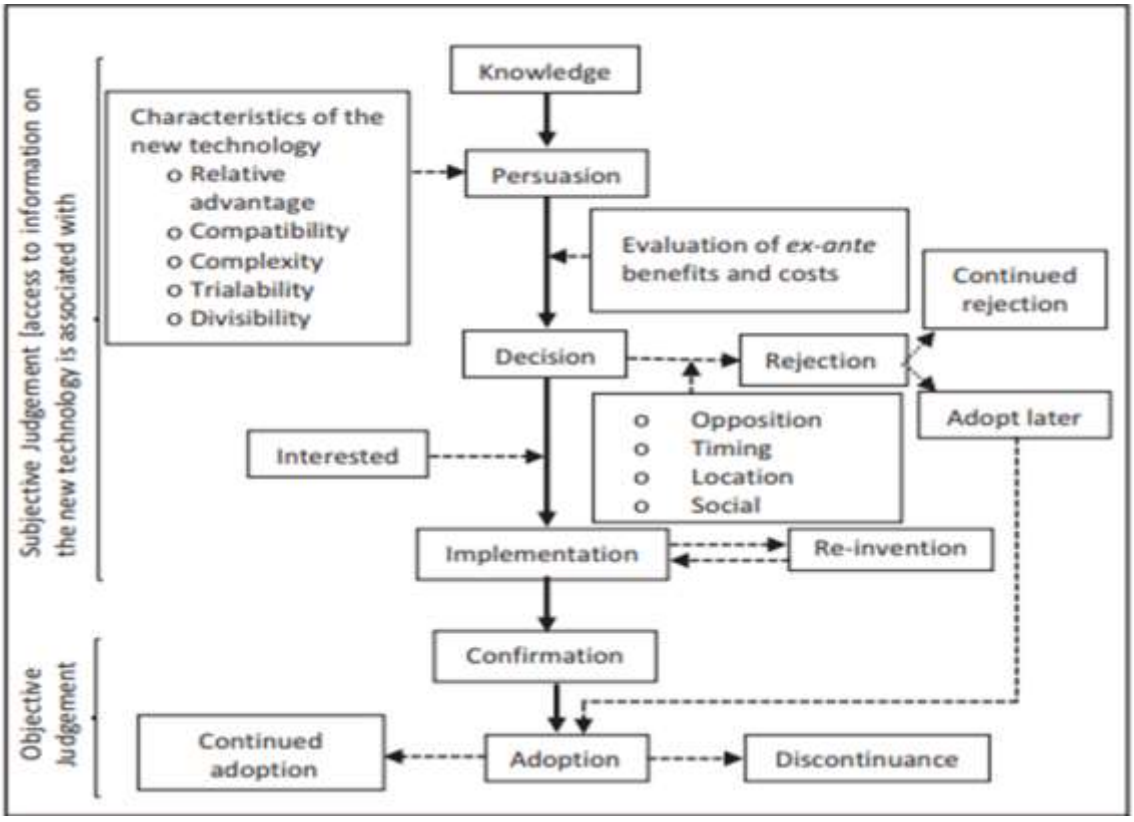


Figure 2.1: A decision-making model for technology adoption. Adapted from Traxler, (2019). Innovation, Technology, and Knowledge Management

2.3.2 Factors affection adoption of agricultural technologies

2.3.2.1 Farmer characteristics

Numerous elements, such as economic, social, cultural, and societal aspects, have an impact on the decision by a farmer to embrace an improved agricultural technology. Furthermore, farmer cooperative participation increased the likelihood of technology adoption by 24% for crop rotation and 11% for organic fertilizers (Manda et al 2020). Farmers' inclination to adopt superior maize seeds was found to be influenced by their level of experience living in a particular area (locality) and their involvement in extracurricular activities.

Smallholder farmers are characterized by small pieces of land, low application of improved agricultural inputs, and low yield, their production is entirely dependent on rainfall. Majority of these farmers therefore lack applicable expertise and skills to apply (Kamara et al., 2019). In most of these areas, family members provide labour and it has been suggested that one element influencing technology adoption is age. Compared to new farmers, older more experienced farmers are less inclined to accept technology. Older farmers, according to Denkyirah et al. (2016), stick to conventional farming practices, are risk averse, and do not view technology investment in the long run. A distinct point of view is held by Donkoh et al. (2019) and Mignouna et al. (2011) whey they contend that elderly farmers are better equipped to evaluate a technology precisely and are more inclined to accept it.

When it comes to adopting new technologies, gender is equally crucial. Due to their limited access to land ownership and obligations as mothers, women are less inclined to adopt new technologies (Addison et al., 2018). Traditions restricting women's access to land and giving them less control over household resource allocation are another advantage for women (Anderson et al., 2014). However, other researchers asserted that gender equality fosters the adoption of technology (Lambrecht et al., 2016; Muriithi et al., 2018). Because education enhances farmers' comprehension and application of the use of new technology, educated

farmers are more inclined to adopt it. Another factor that encourages the adoption of technology is education level (Mignouna et al., 2011). Farmers who have received education are seen to be receptive to novel ideas and might be convinced to embrace one. When both official and informal training is available, improved agricultural technology are more likely to be adopted. However, because of it, smallholder farmers may find it challenging to utilize technology (Carren, 2021).

2.3.2.2 Economic factors

The economic standards of smallholder farmers have an effect on technology adoption. Due to poor road systems and inadequate markets access, many farmers in rural areas cannot sell their agricultural products (Carren et al., 2021). Most farmers in rural areas don't earn enough money from farming, therefore they participate in other businesses to supplement their income. The size of the farm is one of the economic variables influencing the use of technology. Farmers with modest holdings are known as smallholders, whereas those with huge holdings are known as big scale farmers. The latter are more inclined than the former to adopt new technologies (Mignouna et al., 2011; Mutuku et al., 2017). The input costs of a technology also have an effect on technology adoption. For instance, if the sum of all costs needed for adopting a technology is high, chances of its adoption by smallholder farmers are reduced (Foster et al., 2010). Unavailability of inputs coupled with high costs has been cited as the main hindrance to technology adoption by small scale farmers (Kaweesa et al., 2018). According to Minten et al., (2013) high costs of inputs contribute to low acceptance of technology by smallholder farmers in rural areas.

2.3.2.3 Institutional factors

According to Theogene et al., (2018) extension services, the gap between the agricultural office, access to credit facilities, membership to farmer groups, are some of the institutional variable influencing the adoption of technology. The availability and accessibility of extension

officers reduces uncertainties and enables individual farmers to make objective decisions about technology uptakes (Mwangi et al., 2015). The role of an extension officer is very important as they pass information to farmers that help them in solving problems they encounter in the farms (Davis et al., 2012). Easy accessibility to extension services increases the probability of adopting a new technology like irrigation (Theogene et al., 2018). Because many of the innovation technologies require initial investment, access to credit facility becomes a very important factor for adoption. Access to credit facility enhances farmers' ability to afford inputs like fertilizers, agro-chemicals, irrigation equipment to boost production and make long term investments (Lavison, 2013). Access to finance facilities in Nigeria increased the likelihood that rice farmers would use and grow enhanced rice varieties (Awotide et al., 2016). However, lending institutions are underdeveloped in many African nations, and they hardly ever assist farmers. Smallholder farmers are thus deprived of these services and are forced to rely on outdated and conventional technologies. Therefore, governments in Sub-Saharan nations should act to enhance these institutions by giving farmers prospects to access capital subsidies (Haghjou et al., 2014).

2.5 Summary of Literature Review

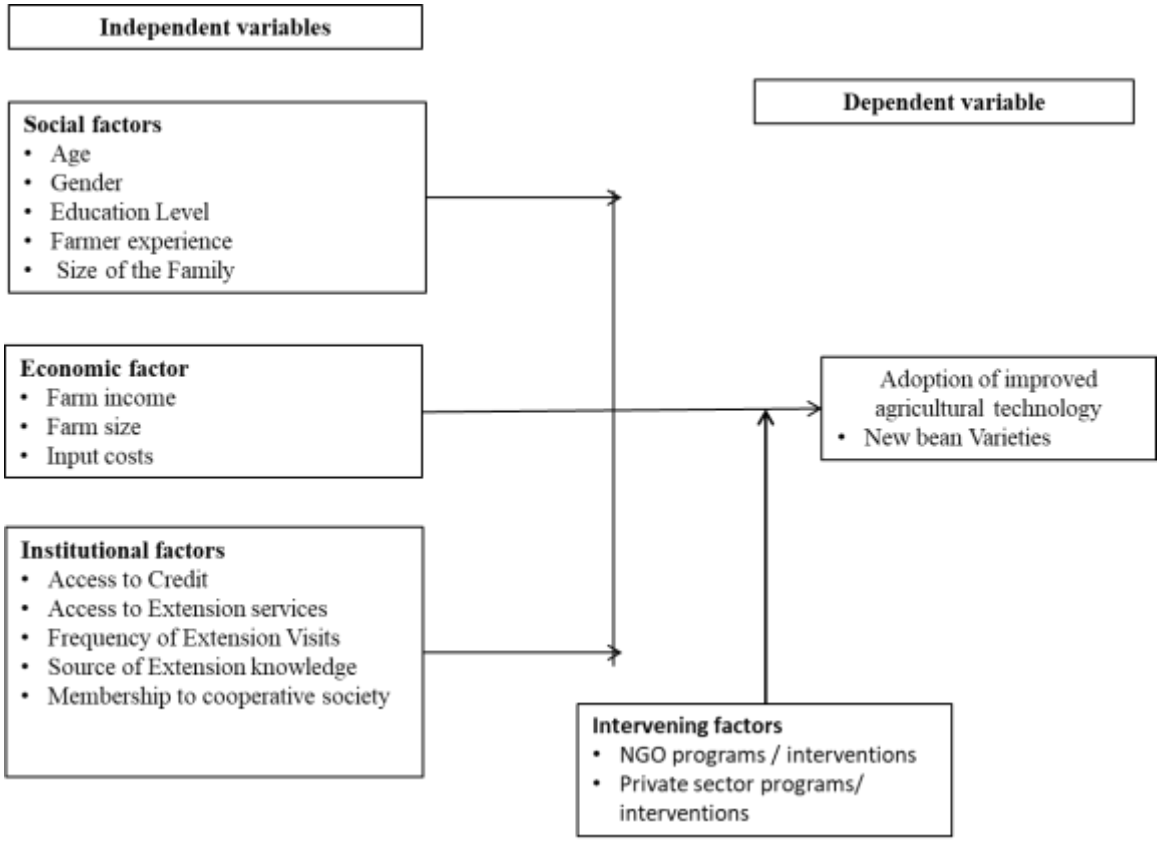
This chapter examined the theoretical and empirical data on social, economic, and institutional aspects influencing small-scale farmers' adoption of technologies. A farmer's choice to embrace a new technology is complex. The variables interact and support one another. Studies have shown and detailed numerous elements that influence the adoption of agricultural technologies. The findings demonstrate that the acceptance or rejection of a technology varies significantly from location to location and also relies on the type of technology being pushed. The impact of social and economic factors, farmer adoption choices, and farmer obstacles on the adoption of diverse agricultural technologies, however, has not been thoroughly explored in many research. The studies that are now available primarily concentrate on technology

adoption and neglect a complementary look at relationships by analyzing technology adoption from the perspective of the smallholder farmer and how consumer resistance affects adoption process. Therefore, this study aims to close the gap by illuminating the reasons for the slow adoption of new technologies as well as the difficulties encountered.

2.5 Conceptual framework

Social factors including age, gender, education, and experience will have an impact on a farmer's choice to embrace a new variety. Adoption will also be influenced by economic factors like income, farm size, and tenure of the land. The institutional elements that influence adoption of a new variety include accessibility to finance and extension services. Figure 2.2 depicts the theoretical framework and how the decision to embrace the technology improved bean varieties relates to the independent variables of social, economic, and institutional aspects. Farmer's age, gender, education level, previous farming experience, and family size are among the variables that have been conceptualized as independent variables. Economic factors like farmer economic status and size of land as well as institutional aspects like credit access, access to and availability of extension services, regularity of extension visits, and source of funding are also independent variables. Extension knowledge, membership to cooperative society and how they influence adoption of bean variety Nyota. The independent variables interplay with moderating variables such as private sector/NGOs programs to enhance effective technology adoption.

Figure 2.2: Conceptual Framework


Independent variables
Dependent variable
Social factors
• Age
• Gender
• Education Level
• Farmer experience
• Size of the Family
Economic factor
• Farm income
• Farm size
• Input costs
Institutional factors
• Access to Credit
• Access to Extension services
• Frequency of Extension Visits
• Source of Extension knowledge
• Membership to cooperative society
Adoption of improved agricultural technology
• New bean Varieties
Intervening factors
• NGO programs / interventions
• Private sector programs/ interventions

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Study area

This study was done in Bungoma County located in Western part of the country with an estimated population of 1.6 million. According to Ralph et al (2015), Bungoma County's main economic activity is subsistence agriculture with Maize, sunflower, sorghum, potatoes, coffee and beans being the main crops. The cost of inputs, particularly seeds, fertilizer, fuel, and feed, is a factor that influences agricultural production in the county. There is low use of fertilizer and use of uncertified seeds that reduce productivity among small holders. According to Ralph (2015), most farmers in the county find it difficult to access agricultural credits even with liberalization of agricultural sector. According to the County's integrated development plan (2018-2022), the county has high, high amount of rainfall distributed evenly throughout the year and high agricultural potential to produce food even for neighbouring countries. The county comprises of a relatively small area but supports 4% of Kenya's 42 million citizens.

The Nyota Bean variety was piloted in Bungoma as one of the high potential counties in bean production. This was under the NARIG project (National Rural Inclusive Growth Project) targeting 2400 farmers in 5 sub counties. The 5 sub counties have 20 wards and each ward had 120 farmers. Kimilili Sub County was specifically chosen for this study. The sub county had high numbers of the farmers who received Nyota seeds and have gone a step further to start the commercialization of the variety using the marketing farmer's groups. The sub county was also recommended through the county for its ease of access. According to a study by Green Revolution (2011), households in Bungoma typically own 1.5 acres of land, which is insufficient to feed a family of 5.7 people who engages in small-scale mixed agriculture and practices land ownership. Sixty-three percent of farmers cultivate a variety of crops, primarily maize and beans. For beans (12.7%) and groundnuts (14.7%), some farmers used the mono-cropping technique, while others intercropped. Farming is basically rain dependent. According

to the literature that is currently available, Bungoma County has a poverty level of 52.9% compared to the country's index of 46%, while poverty is at 43%.KNBS (Mary S. W 2017) despite being a high agriculture potential area.

According to Wakhutu & Hilary (2021), small-holder farmers (SHFs) who cultivate beans on farm holdings between 0.25 and 1.5 acres per household produce the majority of the crop, which is farmed mostly for subsistence (60%) purposes. Small-scale farmers make up 85% of all farmers in Bungoma County, followed by medium-scale farmers who farm between 5 and 15 ha (12%), and large-scale farmers who farm more than 15 ha (3%). Small-scale farmers often keep certain animals, such as cattle, and may also keep fish for domestic consumption with a small surplus for the market. Farming requires a lot of manual labour and uses primitive technology, particularly the hoe. In this area, the entire family engages in farming, particularly the women and children. Farm labour is difficult to come by, and each household typically had between 0.25 and 1.5 acres of land used for the production of beans. Bean varieties are mainly identified by their commercial names and the most common ones in Bungoma County include: Canadian, Rosecoco, Siingwa being common in Bumula, Rosecoco, Mwitemania, Tanzania, Yellow beans, Nyota dominant in Kimilili, Rosecoco, Red Haricot, Nyota, KK8 found in Mt. Elgon and Rosecoco, Chelalang, Nyayo, Grey beans KK15 predominant in Webuye East (Wakhutu & Hilary, 2021)

3.2 Target population and sample size

A population is defined as the total of all objects or people who meet the criteria for a given study. (Gravetter et al., 2020). The study's basis was cross-sectional information gathered from smallholder bean farmers living in Bungoma's Kimilili Sub County. The region had high yields of the Nyota beans and has gone a step further to start the commercialization of the variety thorough the farmers' commercialization groups in the value chain. The sub county was also recommended for the study through the county for its ease of access.

Saunders et al. (2012) states that a sampling edge is a comprehensive inclusion of every instance in the target population from which a sample is taken. Seven key informants and 121 small-holder farmers made up the study's sample size including the Community Based facilitator, County Driven Development chair persons (CDDC) for Maeni and Kamkuywa wards, sub county agricultural officer, cooperatives representative, county crops officer and ward agricultural officer. The sample was obtained using Yamane's formula as applied by Fei and Isa (2010). The project targeted 2400 farmers from the 5 sub counties which have 20 wards. Each ward having 120 farmers. A two-step random sampling process was used; the first stage involved the random selection of farming clusters, and the second stage involved the basic random sample of the farmers inside the clusters. According to Yamane's method for estimating a sample population, the study's sample size was chosen to ensure representation. $n = p \times q[Z/e]^2$

In which,

n- sample size needed

p- percentage within the specified category i.e. technology adopters

q- percentage not within the specified category

z- confidence level (95%=1.96)

e- margin of error

The sample size (n) was assumed that just around 20% of the farmers adopted the technology, z confidence level at 95% and e was 4%

$$n = 50 \times 20[1.96/4]^2$$

$$n = 121$$

For this study, Farmers who have continued to plant the nyota bean variety up to the most recent season was considered as the adopters while those who dropped and no longer plant the bean were considered as non-adopters.

3.4 Research design and data collection

The research used a descriptive research approach to analyze and gather comprehensive data on the factors influencing smallholder farmers' adoption of agricultural innovations and better agricultural technologies. (Yin, 2003). A questionnaire, focus group discussions and structured interviews are the best method of data collection for such design. Quantitative research involving collecting data using a structured questionnaire organized into four sections was employed in this study. Data from the farmers who were specifically identified was gathered using structured questionnaires. The survey concentrated on the socioeconomic traits of smallholder farmers, the amount of beans produced, the types of beans they plant, the introduction of new bean varieties, awareness of better agricultural technologies, and the sources of agricultural information.

3.5 Validity and reliability of research instruments

Validity is defined by Mugenda & Mugenda (2002) as the accuracy of inferences drawn from results, whereas validity is described by White (2005) as the agreement between the researcher's conclusions and reality. The researcher used content validity to evaluate the proposed instruments' dependability. The idea of content validity provides an assurance that the data collected is correct and appropriately reflects a particular perception. The consistency with which a survey instrument produces results or data after several trials during the study is how reliable it is. Through the test-pre-test approach, the consistency of research tools was established. A small number of farmers in Kimilili Sub County, Bungoma County, were given research tools with the exact same information on beans. Therefore, to establish the suitability and consistency of the questions to be used, the survey was pre-tested among a few smallholder farmers in the two Sub-counties, to ensure easier oral understanding and to correct any anomaly that might present before the real survey is conducted. According to Kinyangi (2015), a pilot is a small experiment created to test logistics and collect data prior to a more extensive inquiry so as to improve effectiveness and quality. The researcher used two knowledgeable extension

officers to help with the pilot project. The equipment were modified before actual data collection to meet the performance criterion.

3.6 Data analysis

Kombo and Tromp (2006) defined data analysis as the process of examining the raw data gathered during a research investigation. The Statistical Package for Social Sciences (SPSS) version 20.0 for Windows was used to sort, code, and enter the raw data. Utilizing percentages and descriptive statistics like frequency, the study's data was analyzed. While inferential statistics makes a deduction on the population from which the data originated, descriptive statistics obtains descriptive measurements like percentages, frequencies, and standard deviation (Saunders et al., 2018). The significant association between the respondents' socio-demographic characteristics and the use of agricultural technologies was examined using the Spearman rank influence approach. Testing the degrees of significance and the strength of the relationship between the study variables was done using correlation analysis.

CHAPTER FOUR: RESEARCH FINDINGS, AND DISCUSSIONS

4.1 Influence of social economic characteristics of farmers on the adoption of various agricultural technologies

4.1.1 Socio-Demographic Characteristics of the Respondents

Table 4.1 displays the findings of the respondents' demographic traits. Age, sex, marital status, household size, education level, the main crops grown, household assets, and income level were among the factors examined. Majority of the respondents were female (69.4%) while the rest were males (30.6%) with a SD of 0.46. The findings indicate that the respondents' gender distribution varied significantly (p 0.05). As a result, there was not a gender balance among the respondents that took part in this study. The findings reflect those reported by World Bank (2014) where it estimated that about 42% to 65% of the agricultural labour force was females. This occurrence is attributed to rural to urban migration of men and therefore women's role in agriculture become dominant. However, the results contradict those reported by Olayemi et al., (2020) where majority of the respondents were males and it was mainly due to cultural traditions where females are not allowed to be actively involved in farming. The survey also aimed to determine the respondents' age ranges. According to the findings, just a small percentage of respondents (8.3%) were in the 20–30 age range, while the majority of respondents were over 50. This suggests that the vast majority of survey participants were well-informed and had a range of perspectives about the factors affecting the adoption of technology. It does, however, highlight the fact that most farmers were not in their peak earning years, which could have a detrimental effect on productivity. Older generations have the least impact on farm work since they contribute less to active farm work (Olayemi et al., 2020).

The majority of respondents had completed primary school (52%), closely followed by those who had completed secondary school (32%) with an SD of 0.84. Only 0.8% of people lacked any schooling, whereas the majority had university or tertiary education. This shows that the respondents had a solid education and were more aware of the issues impacting the use of

agricultural technology by smallholder farmers. This outcome is consistent with conclusions from Udimal et al. (2017), who established that the average educational level of a farmer in Ghana's Northern Region was primary four and that some farmers had never attended school. Usually, education degree improves one's capacity to comprehend and use pertinent agriculture technology. However, results here contradict those reported by Uematsu & Mishra, (2010) where formal education had negative influence on towards technology adoption. Farmers are largely informed about latest information about new technology through education (Ongiyo, 2019). Roughly 16.5% of the respondents had practiced farming for over 20 years, with an SD of 1.30, according to the survey. This showed that the majority of respondents possessed the experience, knowledge, and abilities needed to comprehend how different factors influence smallholder farmers' adoption of agricultural technology. In terms of the respondent's source of income, more than half of the respondents (51.3% with SD = 0.50) had other source of income such as businesses, pension. Regarding the household size of the respondents, majority (43.3%) (SD= 0.73) had household size ranging from 8-13. The result is not surprising because large family sizes is seen as sign of wealth and large families provide accessible workforces. Majority (90%) (SD=0.75) of the respondents had land sizes ranging from 0-3 acres indicating that majority of the respondents were small scale farmers. Results mirrors those reported by Ongiyo (2019) where majority were small scale farmers in his study on adoption of new dairy technologies. According to Mwangi and Kariuki (2015), the size of the farm is a key factor in the adoption of a new technology. Studies by Uaiene et al. (2009) and Mignouna et al. (2011), affirms that the size of the farm and the implementation of agricultural technology have a favourable relationship. Farmers with larger farms are more likely to adopt new technologies because they can more easily set aside a piece of their land for experimentation, as opposed to those with smaller farms (Uaiene et al., 2009).

Table 4. 1: Demographic characteristics of respondents

Characteristics	Category	Percentage	Std Deviation
Gender	Male	30.6	0.46
	Female	69.4	
Age (Years)	20-30	8.3	1.00
	31-40	20.7	
	41-50	23.1	
	Above 50	47.9	
Education level	Primary	52.5	0.84
	Secondary	32.5	
	Tertiary	11.7	
	University	2.5	
	Not attended	0.8	
Farming Experience	0-5	15.7	1.30
	6-10	27.3	
	11-15	24.8	
	16-20	16.5	
	Above 20	15.7	
Size of household	0-3	7.5	0.73
	4-7	42.5	
	8-11	43.3	
	Above 12	6.7	
Size of land	0-3	90.8	0.75
	4-7	5.0	
	8-10	1.7	
	Above 10	2.5	
Source of income a part from farming	Yes	51.3	0.50
	No	48.8	
Main source of income	Salary	2.5	0.63
	Business	8.3	
	Farming	82.6	
	Pension	1.7	
	Others	5.0	

Std Deviation – Standard deviation

4.1.2 Use of Agricultural technology

Majority of the respondents (93.3%, SD = 0.65) knew about some of the agricultural technologies recently introduced in the area while only 6.7% did not know (Table 3.2) and mentioned a few such as improved varieties, fertilizer use, use of crop protection products. According to Jain et al., (2020) agricultural technologies include all kinds of improved practices which have positive productivity output. The technologies listed are the same as those

described by Loevinsohn et al. (2013) and include new cultivars, soil fertility management, weed and pest management, irrigation and water management. The respondents also enumerated the benefits of the technologies. Majority 45.6%, SD = 2.24 pointed out high yielding as one of the benefits of the new agricultural technologies. Other benefits reported include early maturity, and high quality seeds. This indicated that most of the respondents had knowledge on various agricultural technologies and also understood their benefits. According to Challa, (2013) new agricultural technologies are likely to raise output and cut the average cost of production which in turn improves farmers' income. Majority of the farmers (48.8%, SD = 1.35) agreed to be planting improved varieties often while about 29.8% reported that they have never planted improved varieties of any crop. Of those that have often planted improved varieties, majority of them (44%, SD = 1.3) were motivated by characteristics such as early maturity, others (38.1%). However, of those farmers that have not embraced improved varieties, their main reason was high cost of production (52.8%, SD = 1.09) followed by lack of finances (41.7%).

Table 4. 2: Knowledge of agricultural technology among the respondents

Parameter	Category	Percentage	Std Deviation
Do you of any AT	Yes	93.3	0.65
	No	6.7	
Example of technology	Improved varieties	32.7	2.24
	Fertilizer use	2.0	
	Use of crop protection products	7.1	
	All three above	9.2	
	Others	49.0	
benefits of the technology	Early maturity	21.5	1.35
	High yielding	45.6	
	High quality seeds	1.3	
	All above	12.7	
	Others	19.0	
How often	Very often	48.8	1.3
	Sometimes	17.4	
	Rarely	4.1	
	Never	29.8	

Motivation	Early maturity	44.0	1.31
	High yields	38.1	
	High nutrient contents	6.0	
	Early maturity and high yields	2.4	
	Early maturity and nutrients	6.0	
	All above	3.6	
Why not plant improved varieties	High cost of production	52.8	1.09
	Lack of finances	41.7	
	Less land sizes	5.6	

AT- Agricultural technology, Std Deviation – Standard deviation

4.1.3 Sources of information on agricultural technologies

Information is a key element that can increase the output and productivity of smallholders. Smallholder farmers' preferred sources of information were investigated, and respondents were asked to list a few sources of agricultural knowledge. Results from figure 4.1 show that smallholder farmers obtained information from various sources. Majority of the respondents (87.6%) preferred to obtain information on agricultural practices from government extension officers followed by County government (28%). Others obtained information from community members with agricultural knowledge. According to the study's findings, county governments and government extension agents were the most frequently used sources of agricultural information. As a result, farmers are better equipped to decide what crops to grow and where to get cheap farm inputs. The acceptance of new technology is determined by the knowledge that is readily available (Mwangi and Kariuki 2015). Access to knowledge eliminates uncertainty regarding a technology's performance, which may eventually shift a person's evaluation from being solely subjective to objective (Mwangi and Kariuki, 2015). Olayemi et al. (2020) assert that agricultural development practitioners and agricultural extension workers must prioritize timely access and dissemination of agricultural information to the farmers. The availability of information on new technology promotes adoption since it makes farmers aware of its presence and how to use it effectively (Udimal et al., 2017). However, it has been noted accessing information can also lead to the technology not being adopted. For example, if

citizens have insufficient experience with a particular technology, more knowledge can lead to unfavorable attitudes about adoption due to an information gap (Bonabana-Wabbi, 2002). Therefore, informationt related to any technology must be reliable, consistent, and accurate. The extensive underinvestment in the extension services and workforce has led to low coverage by the extension farmers. In this study for instance, in as much as farmers prefer to get information from the government services, farmers groups were the highest source of information. NASEP (2012) reports that the public frontline extension worker to farmer ratio is roughly 1: 1,000 as opposed to the advised ratio of 1:400. This was emphasized even more by the key informants as a significant barrier to the county's small holders adopting technology.

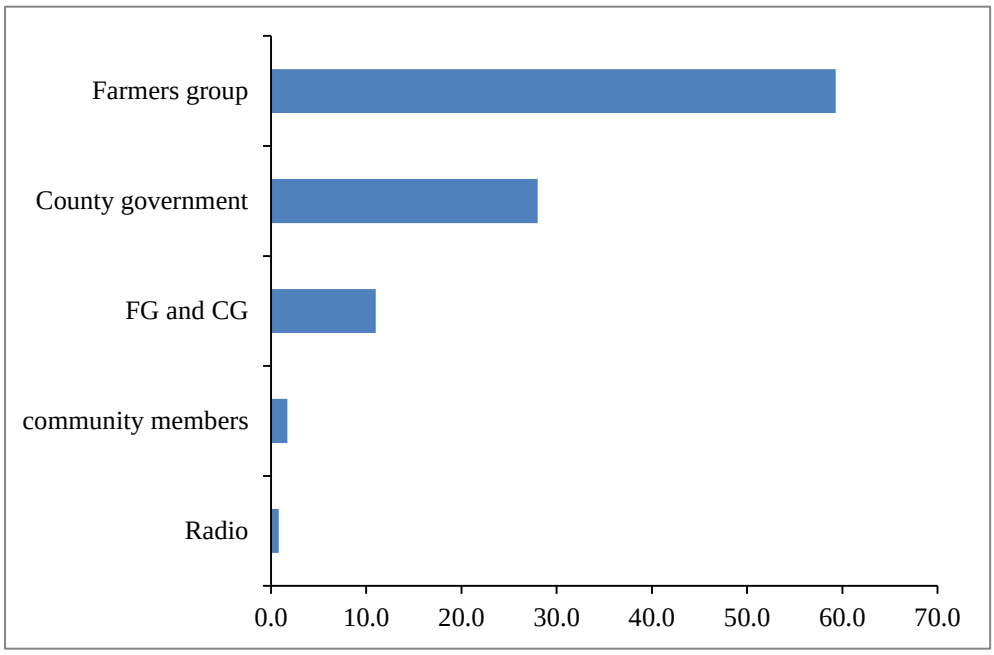


Figure 4. 1: sources of agricultural data on smallholder farmers' use of technology

4.2 Institutional factors influencing adoption of agricultural technologies amongst small holder in Bungoma county

4.2.1 Membership to Formal or Informal institutions

On membership to formal or informal cooperative institutions, a majority were members to various societies. For instance, 53.4%, of the respondents with a SD = 0.49 were members of Women group/Chama, 39.7% were members of Farmer cooperative/association while others

were member of youth association (5.5%), and church organizations (1.4%). Each of the institution had different function. Many (64.4%, SD = 0.86) of the respondents reported savings and credit as the key function of their group, this was followed by training on agricultural production and access to agricultural inputs. Participating in a cooperative society increases social capital and promotes information transmission, (Mignouna et al., 2011). A group of farmers can benefit from one another's knowledge and better adopt new technology since they can better comprehend its uses and benefits. According to Uaiene et al. (2009), cooperative society members' social networking increases the likelihood that they will adopt agricultural advances on an individual basis. According to research by Akankwasa (2010), farmers who usually participate in community-based organizations (CBOs) have a higher probability of participating in group technology learning, boosting their likelihood of embracing the technologies. Social groups may have a negative impact on technology adoption even though it has been stated that they have a beneficial influence, particularly in cases where free-riding behavior occurs (Katungi and Akankwasa, 2010).

Table 4. 3: Membership to Formal or Informal institutions

Parameter	Category	Percentage	Std Deviation
Member of cooperative	Yes	56.7	0.49
	No	43.3	
Cooperative name	Farmer cooperative/association	39.7	0.64
	Women group/Chama	53.4	
	Youth association	5.5	
	Church organization	1.4	
Cooperative functions	Marketing	2.7	0.86
	Improve Input access	4.1	
	Savings and credit	64.4	
	Availing Information on good farming practices	15.1	
	Other	13.7	

Std Deviation – Standard deviation

4.2.2 Access to credit

Majority (53.7%, SD = 0.5) of the respondents had access to credit facilities and obtained loans for various uses (Table 3.4). Most (29.4%, SD = 2.4) of the respondents took loans from various loaning institutions to buy farm equipment, farm inputs, to do soil testing and buy basic utilities. About 26.5% with a SD of 0.49 of the respondent took loans to buy farm equipment. However, 46.3% of respondents who did not have access to lending facilities provided a variety of explanations for why they had chosen not to apply for a loan. Others chose not to borrow, therefore they did not receive loans. Others (6.1%) were not cash-strapped, whereas 2.0% already had a loan. Access to financing has been shown to accelerate adoption of new technologies (Mohamed and Temu, 2008). By linking credit availability to liquidity constraints, hazardous technology adoption is encouraged (Simtoe and Zeller, 2006). This is so that a household can focus on more risky but effective investments by eliminating risk-reducing but ineffective income diversification measures.

Table 4. 4: Access to credit and reasons for taking loans

Parameter	Category	Percentage	Std Deviation
Access to credit	Yes	53.7	0.5
	No	46.3	
Reason for loans	buy farm equipment	26.5	2.4
	buy improved varieties	16.2	
	buy fertilizer	19.1	
	do soil testing	1.5	
	Buy basic needs	7.4	
	All above	29.4	
Why not get loans	I am not cash constrained	6.1	0.49
	I don't like to borrow	87.8	
	I have an existing loan	2.0	
	Others	4.1	

Std Deviation – Standard deviation

4.2.3 Access to extension services

Majority (98.3% and a SD = 0.12) of the respondents had access to extension services and received various extension services (Table 3.5). Most (26.1% and a SD = 2.18) of the

respondents were trained on soil conservation practices, soil testing (7.7%) and on adoption of improved varieties. About 52.9% (SD = 2.19) of the respondents were trained on all the extension aspects. These services were offered by mainly by county government of Bungoma (65.8%), farmer cooperatives NGOs (6.7%), and farmer cooperatives (3.3%) with a SD of 0.97. Some of the respondents, however, had these services offered by two or more of the institutions. Majority of the respondents (44.2%) reported that they received services thrice a year, while others received more than thrice a year (30%). Only 1.7% of the respondents received these extension services once a year. A vital factor in the adoption of agricultural technology is access to extension services. Extension agents educate and train farmers about the new technology's presence and advantages. Extension agents, according to Mwangi and Kariuki (2015), are a bridge between technology inventors and consumers. This lowers the transaction costs linked to dissemination of information about new technology.

Table 4. 5: Access to extension services by the respondents

Parameter	Category	Percentage	Std Deviation
Access to extension services	Yes	98.3	0.12
	No	1.7	
Services received	soil preservation	26.1	2.18
	Use of improved varieties	5.0	
	Usage of fertilizers	4.2	
	herbicides and pesticides use	4.2	
	Soil testing	7.6	
	All	52.9	
Service offered by who	County Government	65.8	2.19
	Farmer cooperatives	3.3	
	Neighbours/ relatives	0.8	
	NGOs	6.7	
	Private companies	0.8	
	CGs and NGOs	18.3	
	CGs, Farmer groups and NGOs	4.2	
Extension service visits	Less than once a year	1.7	0.97
	Once a year	8.3	
	Twice a year	15.8	
	Thrice a year	44.2	
	More than 3 times a year	30.0	

Std Deviation – Standard deviation

4.2.4 Adoption of new bean variety

The respondents learned about nyota bean variety from various sources (Table 3.6). A majority of respondents (59.3%, SD = 1.22) learned about nyota bean variety from farmer groups. Others (28%) learned about this variety from the county government. Other sources include community members (1.7%) and radio (0.8%). Even though many farmers adopted the technology, majority (94.8%, SD = 0.22) only a portion only 0-3 acre of their land to nyota bean variety and planted using DAP fertilizer. Over 58% of the respondents reported aspects such as nutrition, drought resistant, early maturity, marketability and high yields as some of the aspects that made them adopt nyota variety. Over 94% reported that they will plant nyota variety for the next five years and mainly recycled seed. However, 45.6% (SD = 1.71) of the respondents bought news seeds from agro vets. Ali et al., (2022) by adopting farmers improve their living standards while Carleto et al., (2007) suggests that when adoption results in increase of production and profitability there is high chance of technology adoption. Kijima et al. (2011) contend that farmers can forgo the technology if the anticipated advantages are less than the current costs.

Table 4. 6: Information on improved bean variety

Parameter	Category	%	Std Deviation
Information on nyota technology	Radio	0.8	1.22
	Farmers group	59.3	
	County government	28.0	
	community members	1.7	
	Farmer group and CG	11.0	
Land portion of nyota beans	0-3	94.8	0.22
	4-6	5.2	
Planting with fertilizer	Yes	100.0	0.00
	No	0.0	
Which fertilizer do use	DAP	100.0	0.00
	Others	0.0	
Aspects of bean pushed to adopt	Nutrition(Zinc and iron)	11.7	1.71
	Drought resistant	10.0	
	Early Maturity	5.0	
	Market availability	15.5	
	High yielding	15.0	

	All	58.3	
will you plant nyota in 5 years	Yes	94.9	0.22
	No	5.1	
source of seed	Recycled seed	54.4	
	newly bought from supplier	45.6	

Std Deviation – Standard deviation

4.2.5 Non adopters

Majority of the respondents (50.8%, SD = 1.79) cited lack of knowledge and high cost of fertilizer as the main reason for not adopting the technology (Table 3.7). Additional evidence for this came from the key informants, who pointed to the high cost of the technologies and farmers' inadequate knowledge of them as the main deterrents to small holders' adoption. According to Fujisaka, (1994) the reasons why farmers are not able to adopt these technologies are: innovators do not target problems faced by farmers, farmer practices appear to be better than the innovation, lack of extension services, and the innovation does not work and mostly expensive. The respondents were asked if they could adopt the technology when it was packaged in smaller packets, 98.4% (SD = 0.12) agreed while only 1.6% disagreed. This indicates that smaller packets which would not be expensive would be easy to buy. To compensate for not plating the new variety farmers opted for other bean varieties such as wairimu (41.7%), traditional bean races (33.3%), nyayo (6.7%), rosecoco (5.0%) soya (5.0%) with a SD = 1.89. About 5% of the respondents did not plant any bean variety.

Table 4. 7: Reasons for non-adoption of nyota bean variety

Parameter	Category	Percentage	Std Deviation
What made you drop the Nyota bean technology	Expensive	31.1	1.79
	The cost of fertilizer	1.6	
	Lack of knowledge	4.9	
	Postharvest losses	11.5	
	lack of knowledge and high cost	50.8	
Would you plant Nyota bean in new packaged in smaller packets	Yes	98.4	0.12
	No	1.6	
Which bean variety do you grow	Wairimu	41.7	1.89

	Nyayo	6.7
	Rosecoco	5.0
	Traditional varieties	33.3
	red Canadian	1.7
	Soya	6.7
	None	5.0

Std Deviation – Standard deviation

4.3 Challenges and opportunities in improving agricultural technology adoption amongst small holders in Bungoma county

4.3.1 Factors affecting agricultural technology adoption

From the results in Table 3.7, the respondents gave different views on which factors had effect on technology adoption. For instance, 64.5% of farmers believed that the educational attainment of smallholder farmers was a very solid factor determining their use of technology, while just 2.5% disagreed. Studies have found that education lowers the degrees of purported complexity that influence technology, improving the adoption of that technology. The majority of those surveyed (72.7%) believed that the price of technology was a very important factor influencing its uptake by small holders, while 76.9% of farmers thought that the availability of money, tools, and equipment were important variables influencing the use of technology. The majority of respondents (66.9%, SD = 2.5) agreed that the accessibility of financing facilities was also a weighty factor influencing small-holder farmers' use of technology, while just 2.5% disagreed. The majority of respondents (81.8%) believed that exposure to new technologies was a significant influence in small-holder farmers' adoption of new technology, while 71.9% of farmers thought that training in new technologies was a vital aspect. According to Kinyangi (2014) when farmers are trained various technologies, it is easy for them to adopt new technologies. In addition, he makes the case that training has a favorable and considerable impact on how much smallholder farmers adopt new technologies. About 62% of respondents expressly suggested that when extension service agents are trained and they transfer this to farmers, adoption would be successful. When the farmers were asked how creation of awareness would affect adoption, majority (67.5%, SD = 2.5) of the respondents agreed that

creation of awareness to small holder farmers can positively affect adoption on new technologies. The majority of the respondents also listed factors such as age (62%), SD = 3.3, farmers education level (71%, SD = 3.3), in-service farmer trainings (68%, SD = 3.3), market availability (53%, SD = 4.1), as some of the factors which can affect technology adoption. According to Kinyangi (2014), factors such as age, education level, income, family size, tenure status, credit use, value system, and beliefs have a negative impact on small-scale farmers' adoption of technology. Cruz (1987), who contends that a technology's characteristics or attributes, its users or clients, the change agent (a professional extension worker or other individual), and the socioeconomic, biological, and physical environments in which it is used are all factors that affect how a technology is adopted, supports the study's findings. A majority of respondents (69.4%, SD = 1.4) agreed with the assertion that gender has little influence on technology adoption, while 11% strongly disagreed. This finding is supported by those reported by Doss and Morris (1999) and Overfield and Fleming (2001) where there was gender insignificantly affected adoption of improved maize technology in Ghana and coffee production in Papua New Guinea. Additionally, a majority (60%) of respondents agreed with the assertion that older farmers are less likely to accept technology than younger farmers, while 24% strongly agreed and 5.8% strongly disagreed.

Table 4. 8: Factors affecting adoption of new agricultural technology

Factors Affecting adoption	SA	A	U	D	SD
The educational attainment	32.2	64.5	0.8	2.5	0.0
The price of technology	24.8	72.7	0.8	1.7	0.0
The availability of equipment and tools.	21.5	76.9	1.7	0.0	0.0
Money availability	19.0	76.9	1.7	2.5	0.0
Existence of credit options like unsecured loans	18.2	66.9	5.8	6.6	2.5
Experience with technologies	14.0	81.8	3.3	0.8	0.0
Instruction in new technology for farmers	24.8	71.9	3.3	0.0	0.0
Farmers receive training on cultivars with higher yields.	28.9	69.4	1.7	0.0	0.0
Farmers receive training on a range of tools and equipment.	28.1	68.9	1.7	0.8	0.8
Extension personnel receive on-the-job training	33.9	62.0	3.3	0.8	0.0

Information is provided to and awareness is raised among smallholder farmers.	28.3	67.5	0.8	0.8	2.5
Extension agents are constantly available to provide farmers with the most recent technological information.	28.9	60.3	1.7	5.0	4.1
Small-holder farmers receive in-service training.	20.7	68.6	1.7	5.8	3.3
Market availability for the products	31.4	53.7	5.0	5.8	4.1
The main latent factor in adoption decisions is age.	14.0	62.0	5.8	10.7	7.4
Farmers who are older than they are are less receptive to technology.	24.0	60.3	5.0	5.0	5.8
Risk and uncertainty that could lead to limited adoption of new technologies	28.1	62.0	2.5	4.1	3.3
Technology adoption is influenced by farmers' education level	17.4	71.1	3.3	5.0	3.3
The adoption of technology is not significantly influenced by gender.	5.8	69.4	3.3	9.9	11.6
Equal numbers of men and women use technology.	11.6	73.6	7.4	2.5	5.0

Key: SA = strongly agree, A = agree, U = undecided, D = disagree and SD = strongly disagree

4.3.2 Analysis of relationships between demographic characteristics and adoption of agricultural technology using Spearman's correlation coefficient

To ascertain whether or not variables were connected with one another, the Spearman correlation test was performed. Because the Spearman's test employs ranks rather than assuming normality, it can be used to analyze data at both the ordinal level and the continuous level. Using Spearman rank correlation, the factors influencing the adoption of new agricultural technologies and the social demographic traits of farmers were also examined (Table 4.9). The results reveal demographic characteristics had various influence on adoption of agricultural technology. Farming experience positively and significantly correlated with age of the respondents ($P<0.01$; r 0.420). This indicates that the higher the age the more farming experience the respondents had. Planting improved variety as an example of agricultural technology had negative but significant correlation with age of the farmers ($P<0.01$; r-0.260). Aspects of bean that pushed farmers to adopt the technology had significant and positive correlation with planting improved varieties (($P<0.01$; r 0.312). This indicates that positive

attributes of improved varieties pushed the farmers to adopt them. The results in this study concur with those reported by Keelan et al. (2014); Mwangi and Kariuki (2015) who also reported that farmer' socio-economic characteristics influenced adoption of innovative agricultural technologies. However, the present study found that gender did not significantly influence adoption.

Table 4. 9: Spearman's correlation coefficient among demographic characteristics and adoption of agricultural technology

	Sex	Age in years	Level of education	Farming experience	Employment source	Technology Example	Planting improved varieties	Nyota technology	Aspects of the bean	Drop Nyota technology
Sex	1.000									
Age in years	-.156	1.000								
Level of education	-.164	.063	1.000							
Farming experience	-.168	.420**	.071	1.000						
Employment source	-.021	.063	.006	.074	1.000					
Technology Example	-.052	.023	-.068	.022	-.005	1.000				
Planting improved varieties	.152	-.260**	-.075	.058	.101	-.289**	1.000			
Nyota technology	-.106	.169	.135	.175	-.068	.205*	-.192*	1.000		
Aspects of the bean	-.009	.358**	.068	.116	-.097	-.750**	.312*	-.031	1.000	
Drop Nyota technology	-.027	-.085	.072	-.103	-.265*	-.033	.093	-.030		1.000

**** indicates the variables that were significant at 1% and level of significance, * indicates the variables that were significant at 5% and level of significance**

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 summary of findings

Majority of respondents (69.4%) were female, while the remaining respondents (30.6%) were male. Only small percentage (8.3%) of respondents were in the age range of 20 to 30 years, whereas the majority of respondents were over 50. This indicates that many of the respondents were not of an age to be economically engaged. The findings also showed that the majority of respondents (52%) only had primary level education, whereas a small number had completed both postsecondary and university-level education. This shows that a significant portion of respondents had a better awareness of the variables influencing smallholder farmers' adoption of agricultural technology. Additional findings regarding respondents' work experiences show that roughly 27% of them had over 20 years of agricultural experience, and 90.8% of them had properties with a size of 0 to 3 acres. They also said that farming was their primary source of income.

The vast majority of respondents (93.3%) were aware of a number of agricultural technologies, including new varieties and management techniques, soil and soil fertility management, weed and pest management, irrigation and water management, and benefits including early maturity and high-quality seeds. Many farmers received information on farming from government extension officers. Information source on new technology determines adoption of new technology and enables farmers to acquire new knowledge. On membership to cooperative institutions, 53.4% of the respondents were members of Women group/Chama, 39.7% were members of Farmer cooperative/association and each of these institutions had specific functions. For instance, majority reported savings and credit facilitation as key function of the social group. The findings also show that about 53% of the respondents had access to credit facilities and obtained loans for various uses

A vast majority (98%) of farmers could access extension services mostly (65.8%) provided by the county government of Bungoma. Some of the services provided include soil conservation practices, soil testing and on adoption of improved varieties. On adoption of new Nyota variety, majority of the respondents had adopted the variety and they mostly leant about it through farmer groups. Most of these farmers were impressed mostly by the aspect such as nutrition, drought resistant, early maturity, marketability and high yields. Quite a good number of the respondents did not adopt the variety because they lacked knowledge and also cited high cost of fertilizer and this was also cited as main reasons for non-adoption by the key informants. However, they reported that they planted other bean varieties such as wairimu (41.7%), traditional bean races (33.3%), nyayo (6.7%), rosecoco (5.0%). The respondents gave different views on which factors had effect on technology adoption. For instance, the majority of respondents concurred that social factors like age and gender, as well as the level of education, cost of technology, availability of cash and credit facilities, tools and equipment, and exposure to technology, were very strong factors affecting small-holder farmers' adoption of technology.

5.2 Conclusions

This study evaluated the many aspects influencing smallholder farmers in Bungoma County, Kenya to embrace enhanced agricultural technologies (nyota beans). The study emphasized a number of variables influencing smallholder farmers' choices on agricultural technologies. The results primarily indicate that the adoption of agricultural technology depends on a range of elements that may be broadly categorized into human, social, economic, education levels, family size, access to information, and membership in social networks. Age, education, and financial resources all had an impact on smallholder farmers' decisions to accept new technology, according to study results. For instance, it was discovered that elderly farmers resisted technology more than younger farmers did. This meant that older farmers would find it challenging to adopt any technology unless they were taught about its advantages and how

to use it. Results also showed that training and the availability of extension services had a favourable impact on smallholder farmers' adoption of technology. The use of agricultural technology could therefore increase as a result of training provided by extension agents. In conclusion, the agencies should guarantee that they encourage the adoption of improved technologies by developing policies that give farmers and extension agents the technical capabilities they need to use those technologies. The results reveal level Farming experience positively and significantly correlated with age of the respondents (P<0.01; r0.420). This indicates that the higher the age the more farming experience the respondents had. Planting improved variety as an example of agricultural technology had negative but significant correlation with age of the farmers (P<0.01; r-0.260). Aspects of bean that pushed farmers to adopt the technology had significant and positive correlation with planting improved varieties ((P<0.01; r0.312). This indicates that positive attributes of improved varieties pushed the farmers to adopt them.

5.3 Recommendations

The following recommendations were made based on the findings and the conclusions of the study:

Farmers should be trained on various agricultural technologies such as high yielding varieties and other technologies that can positively contribute to high productivity among farmers. Government and local cooperative societies should also create awareness on the availability and usefulness of improved agricultural technologies in the study area.

Policy makers should ensure that broader spectrum of smallholders' farmers given the ability to access credit facilities in order to improve their adoption level of agricultural technology.

Innovators of new agricultural technology should try to understand the farmers needs as well as their ability to adopt technology in order to develop technology that will suit them and equally ensure their availability and affordability.

There is a need for Government to increase farmers' capital and credit facilities and make these services accessible to the farmers.

Friendly credit facilities should be established to enable farmers have access to credit to aid in their agricultural activities

Innovators coming up with new technologies for adoption by farmers should also be involved with on farm demonstrations to create confidence amongst farmers and alley fears that might be associated with the technology

5.3.1 Suggestions for further research

Study recommends further research on how innovators coming up with new technologies for adoption by farmers can involve farmers to ensure the final product is farmer friendly.

The study recommends further comparative research of factors affecting adoption of Nyota beans technology in other sub counties /counties it was introduced to.

Study recommends further studies on how county government policies on resource allocation, inadequate resources and community support influences adoption of agricultural technology

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APPENDIXES

Appendix 1-Questionnaire

Name of Enumerator…….

PART A: Background Information

1. Respondent's Name …….……(Optional) Ward

…….....

2. Respondent's Gender: ( ) Male ( ) Female Phone no. …….....

3. Age: .....

4. Education level……..... (Primary, secondary, Tertiary, university)

4. How many years have you been farming? ……..

5. How many people live in your household, on average? (Include total number of people living in that house) .....

6. What is the estimate size of your land in acres? ……...

7. Apart from farming, do you have any other sources of income? (

…….....

8. What is your main source of employment?

a) Employed (Gets salary)

b) Business net income

c) Farming activities

d)Pension

e)Others(specify)…….

9. Do you know of any recent developments in agricultural technology in the region?

……

……

……

10. What are some of the advantages of the technology you mentioned?

……

……

……

11. When and why do you plant better crop varieties?

……

……

12. Why is it impossible for you to grow enhanced varieties?

……

……

Membership to Formal or Informal institutions

1. Where do you get information on farming advice and support?

Relatives ……. Friends…… Extension officers……

Others

(Specify)…….

2. Are you a member of any cooperative or society?

Farmer cooperative/ Farmers' association……Women associations/group/Chama ……

Youth group/association…… Church organization ……

Others(specify)……

3. What are the responsibilities of your group/ association?

Marketing……..… Improve member's access to input ……

Savings and credit…… Avail information about sustainable agricultural techniques …….

Other

(Specify)……

Obtaining credit

Can you obtain credit or a loan?

Yes …… No …….

If so, why did you decide to take out the loan?

a) To purchase farm machinery

b) To purchase upgraded varieties

c) To purchase fertilizer

d) To purchase herbicides and/or pesticides

e) To do for soil testing

f) Purchase basic needs (food, clothing, school fees)

g) Other: specify …….

If no, why?

a) I am not cash constrained

b) I dislike borrowing because of the risk.

c) I already have a loan.

d) Other: specify ……

Availability of extension services

1. Are there extension services available to you?

Yes……No…….

2. If so, what services did you get from them? (Farmer can choose more than one answer)

a) soil preservation

b) Use of improved varieties

c) Use of Fertilizer

d) Herbicides and pesticides usage

e) Soil testing

f) Other (Specify)…….

3. Who provided the service of an extension?

a) County Government extension service

b) Farmer cooperatives or groups

c) Neighbours/relatives farmers

d) NGOs

e) Private companies

f) Other, specify…….

4. What frequency of visits to the extension service do you observe?

a) Less than once a year

b) Once a year

c) Twice a year

d) Thrice a year

e) More than thrice a year

Project related questions

A. (Questions for both adopters and Non Adopters)

How did you learn about nyota beans technology?

1. Radio
2. Farmers group
3. County government
4. Fellow community members/ cooperative group

B. (Questions for Adopters)

Out of the acres of land you mentioned, how much land do you use for the Nyota bean?.....

Do you plant the bean together with the recommended fertilizer? (yes/no)

If no, why?.....

Which fertilizer do you use for;

1. Planting……
2. Top Dressing?.....

Which aspects of the bean pushed you to adopt it? (Question for adopters)

1. The Nutrition(Zinc and iron)
2. Its Drought resistant?
3. Early Maturity
4. The market availability
5. High Yields
6. Other?.....

Do you think you'll still plant the Nyota bean seed in the next 5 years? (Yes/No)

……

.if No, why?.....

.if yes why……..**.....**

Did you plant Nyota bean from previous harvest or newly bought seed?

1. I used Recycled seed
2. I used newly bought from supplier

C. (Questions for Non Adopters)

What made you drop the Nyota bean technology?

1. The nyota bean seed is expensive. I'm not able to buy
2. The cost of fertilizer

3. Lack of enough knowledge on the bean variety
4. post harvest losses
5. Other reason?.....

ii**) Would you plant the Nyota bean variety if they were packaged in smaller packets?**

1. yes
2. No

iii) **Now that you no longer plant the Nyota bean seed? Which one /What do you plant?**

……..

SECTION B: FACTORS INFLUENCING ADOPTION OF AGRICULTURAL TECHNOLOGY

Select (*) the option that best fits each question in the table below, then enter your score in the bracket. Strongly agree (SA) = 5, Agree (A) = 4, undecided (U) = 3, Disagree (D) =2 and strongly disagree (SD) = 1

Factors Affecting adoption	SA	A	U	D	SD
The educational attainment					
The expense of technology					
The availability of equipment and tools.					
Money availability					
Existence of credit options like unsecured loans					
Experience with technologies					
Instruction in new technology for farmers					
Farmers receive training on cultivars with higher yields.					
Farmers receive training on a range of tools and equipment.					
Extension personnel receive on-the-job training					
Information is provided to and awareness is raised among smallholder farmers.					
Extension agents are constantly available to provide farmers with the most recent technological information.					
Small-holder farmers receive in-service training.					

Market availability for the products					
The main latent factor in adoption decisions is age.					
Farmers who are older than they are are less receptive to technology.					
Risk and uncertainty that could lead to limited adoption of new technologies					
Technology adoption is influenced by farmers' education level					
The adoption of technology is not significantly influenced by gender.					
Equal numbers of men and women use technology.					

SECTION C: INTERVIEW SCHEDULE FOR EXTENSION OFFICERS, COOPERATIVE OFFICIALS

1. What do you think about smallholder farmers' use of technology? (Low, Medium, High)
2. What might be the causes of smallholder farmers' average or low adoption rates?
3. What factors are most important in determining the rates of technology adoption by smallholder farmers?
4. What steps may be taken to encourage smallholder farmers in Bungoma County to utilize technology?

Appendix II- Bungoma County Research Permit

COUNTY GOVERNMENT OF BUNGOMA

OFFICE OF THE COUNTY SECRETARY AND HEAD OF PUBLIC SERVICE

Telephone: 0725 39 39 39
E-mail: countysecretary@bungoma.go.ke

Municipal Building
P.O Box 437- 50200
BUNGOMA

Our Ref: CG/BGM/CS/GEN/VOL. V (106)

Date: 14th June, 2022

PROJECT COORDINATOR (NARIGP)
BUNGOMA

RE: RESEARCH AUTHORIZATION – MILLICENT AKOTH ODONGO (T51/38356/2020)

The above subject matter refers.

We acknowledge the request by Millicent Akoth Odongo and subsequent request from University of Nairobi (UoN) for her to conduct research in Bungoma County on ***"Factors affecting adoption of Agricultural Innovations amongst small holders: Case of Nyota Beans Technology in Bungoma County"***.

This is to inform you that she has been granted approval for three months to carry out research on Nyota Beans under the NARIGP in Bungoma County.

Kindly accord her the necessary assistance required.

Wambati J. W
COUNTY SECRETARY & HEAD OF PUBLIC SERVICE

Copy to: UoN - Department of Economics and Developments Studies.
Millicent Akoth Odongo