ATTITUDES AND PERCEPTIONS OF SMALLHOLDER FARMERS TOWARDS AGRICULTURAL TECHNOLOGIES IN WESTERN KENYA
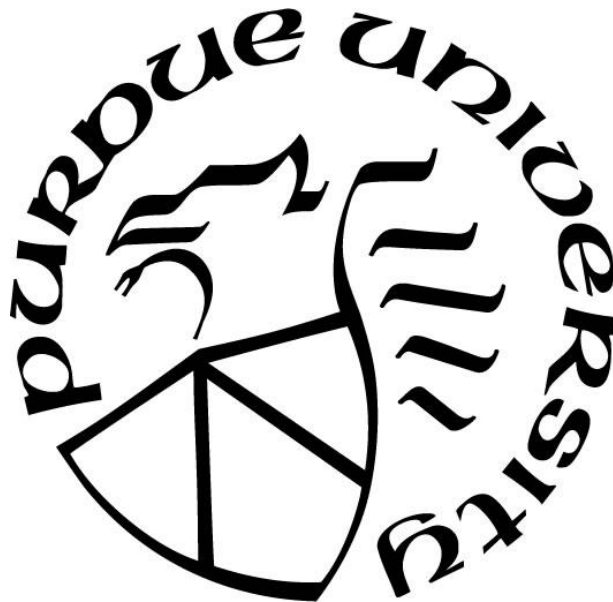
by

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Dedicated to my father, Johnson Nyairo, and mother, Elizabeth Nyairo,who both taught me the meaning of education.

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LIST OF ABBREVIATIONS

AET   Agricultural Education and Training

CA   Conservation Agriculture

CGIAR   Consultative Group for International Agricultural Research

FAO   Food and Agriculture Organization of the United Nations

GOK   Government of Kenya

ICTs   Information Communication Technologies

KALRO   Kenya Agriculture and Livestock Research Organization

LM   Lower Medium Zone

MALF   Ministry of Agriculture, Livestock and Fisheries

PCA   Principal Component Analysis

SSA   Sub-Saharan Africa

UM   Upper Medium Zone

ABSTRACT

This exploratory study assessed attitudes and perceptions of smallholder farmers towards agricultural technologies in Kakamega County, Kenya. Through a mixed-methods sequential design, the study evaluated the key variables predicting farmer adoption of agricultural innovations. While social sciences provide a clear human-driven pattern explaining the process of choices and behaviors regarding technology use, there is still little clarity on the influences of adoption decisions among smallholder farmers in rural Kenya. Using the diffusion of innovations theory, the study explored the attitudes and perceptions of smallholder farmers toward technology adoption in seven sub-counties of Kakamega County (Lurambi, Ikolomani, Shinyalu, Mumias East (Shianda), Malava Butere, and Khwisero). The study design utilized a quantitative survey of 245 smallholder heads of households, followed by focus group discussions to further probe attitudes, values and practices that could influence technology adoption. The survey questionnaire tested two hypotheses: (H1) socio-demographic characteristics are related to agricultural technology adoption; and, (H2) farmer access to extension services was related to agricultural technology adoption. A binary logistic regression model was used to quantitatively estimate socio-demographic variables presumed to influence the adoption of agricultural innovations. Subsequently, four informal focus group discussions of 28 discussants was conducted across representative sub-counties (Lurambi, Shianda, Malava and Ikolomani), to elicit an in-depth understanding of farmers' perspectives on technology adoption. The focus group participants included farmers recruited from among survey participants. The qualitative research instrument sought to answer three questions, (RQ1) what are farmer attitudes and perceptions towards agricultural technologies; (RQ2) what socio-cultural values influence farmers' choice of agricultural technologies; and, (RQ3) what sources do farmers use for obtaining information on agricultural technology? Quantitative results included a principal component analysis (PCA) in which 14 attitudes questions were reduced to five conceptual clusters. These clusters included: challenges in accessing modern agricultural technologies (explained 19.09% of the total variance); effectiveness of agricultural technologies (11.88%); enjoyment of agricultural technologies (10.02%); social influence in use of technology (9.47%); and experience with agricultural technologies (8.13%). A logistic regression model indicated that independently age (.07), education (.10), and off-farm income (.08) were significantly associated with adoption of technology at the 90% confidence level when controlling for all other variables in the model. However, agricultural extension (.42) was not a significant predictor of agricultural technology adoption in this model. Qualitative results provided rich insights which

enhanced findings from the survey data. Key insights in the thematic analysis included: farmers' ambivalence about agricultural technologies; lack of trust in agricultural agents; low levels of agricultural technology knowledge; extension services as the main source of information dissemination to farmers; predominance of gender in determining agricultural technology adoption; and gender inequity in agricultural decision-making. In conclusion, the study results suggested that a mixed-methods approach was valuable in probing the nuances of farmers' perceptions of agricultural extension and technology adoption among smallholder farmers. The results supported the following recommendations: the agricultural extension efforts could be more effectively structured in order to support the dissemination of agricultural information; the issue of gender should be adequately addressed by engaging male and female in collaborative agricultural efforts to help break the barrier of gender inequity; and future research would benefit from disaggregating public and private extension services as a more robust method for determining their individual effects in the promotion of agricultural innovations among smallholder farmers.

CHAPTER 1.　　INTRODUCTION

1.1　Background

Agriculture is the most important sector in the economy of Kenya; sustaining economic growth, improving food security, and reducing poverty. In Kenya, agriculture accounts for 26% of the gross domestic product (GDP) and another 34.5% of GDP directly through linkages with other sectors of the economy (GOK, 2014). The agricultural sector is a source of employment for over 40% of the total workforce, more than 61.1% of those who reside in rural areas (GOK, 2014). Rural-based policies in many Sub-Saharan African (SSA) countries have been instrumental in stimulating growth and reducing the poverty that is prevalent in many rural regions (Mwabu & Thorbecke, 2004).

The promotion of agricultural technologies in Kenya is demonstrated by the integration of agricultural programs into the national strategic plan. The government's emphasis on agricultural technology as a pathway to increasing food production and raising smallholder farmers' incomes is widely promoted throughout the country (GOK, 2014). The country's development plan, National Vision 2030, is an example of a national strategy that provides a holistic development blueprint spanning all sectors of the economy (GOK, 2014). As the main economic pillar of the economy, the agricultural sector relies on innovation as the key engine for its growth and development. The government agencies and other agricultural development stakeholders recommend the use of fertilizer, seeds, and pesticides as the main agricultural innovations for improving agricultural productivity (Sheahan et al., 2013). Both public and private agricultural extension service providers offer crop-specific training to enable farmers to apply improved practices on their farms with the goal of raising yields. Furthermore, agricultural extension providers guide farmers in applying the most current agricultural practices necessary for their success in improving yields.

Sustainable rural agricultural growth and development draws on the appropriate use of information and training that agricultural extension agents deliver to farmers. However, the application of agricultural information and training is presumed essential in enhancing the usage of agricultural technologies by the farmers. The combined application of such practices is necessary in increasing agricultural productivity among smallholder farmers, who provide over

75% of the total agricultural output in most developing countries (Asfaw, Shiferaw, et al., 2012). The majority of these smallholder farmers reside in rural areas and earn lower incomes relative to large-scale farmers. Reliance in their contribution to food security and rural sustenance makes smallholder farmers an essential stakeholder in national development. In Kenya, the adoption rates for agricultural innovations capable of increasing agricultural productivity remain low due to farmers' lack of experience in the use of fertilizer, as well as the lack of education for the household decision makers (Freeman & Omiti, 2003).

Agricultural extension has been one of the key channels for reaching smallholder farmers in remote rural areas. Finding new ways of disseminating agricultural innovations to smallholder farmers is a potential means for improvement in agricultural yields, strengthening food security, and reducing rural poverty. In reaching farmers, agricultural extension agents have capitalized on the growth of information communication technologies (ICTs), particularly cellular phones, as a complement to the historical practice of making household visits or convening farmers together for in-person training. The use of mobile phones has transformed how farmers procure farm inputs, find output markets, and obtain input and output prices, among other benefits (Wyche & Steinfield, 2016). The widespread use of cellular phones facilitates information and knowledge sharing across social networks by intensifying the flow of information across network agents, individuals and institutions (Nakasone et al., 2014). The combination of mobile phones with traditional agricultural extension approaches marks a potential for improvement from the 1950s and 1960s, when information dissemination was much slower.

In Kenya, public and private agricultural extension services are the primary sources of information for supporting farmers in appropriately using technologies to their advantage. These technologies most commonly include fertilizer and hybrid seeds which boost agricultural productivity. Private extension services are obtained at a fee while public ones can sometimes be free or subsidized. Many resource-poor smallholder farmers rely on the public sector and other non-governmental organizations for extension services (Muyanga & Jayne, 2008a). Resource-poor farmers receive limited amounts of inputs from the government through the public extension services by paying a minimal fee. In other times, non-governmental organizations (NGOs) work directly with smallholder farmers in agricultural development by delivering inputs and services at no fee in accordance with existing farmer needs.

Both individual and system-level factors facilitate the adoption of new practices by farmers (Adebiyi & Okunlola, 2013). At the individual level, farmer initiatives determine the potential for adequately applying the most suitable practices and technologies. The education level of the farmer, and their inexperience in agriculture have been purported to lead to the low levels of adoption of new agricultural practices among new farmers in semi-arid areas of Kenya (Freeman & Omiti, 2003). Similarly, farmers' attitudes and values have been found to influence their decision-making (Brunner, Edmund de Schweinitz & Yang, 1949; Willock et al., 2008a). These studies evaluated business and environmental behaviors that lend credence to the role of psychological factors in the decision making of farmers.

In Kenya, at the system-level, public and private extension services promote innovations by imparting agricultural skills to smallholder farmers through farm visits or information sharing. Efforts to promote the use of agricultural technologies, however, is a challenge and agricultural crop yields continue to suffer, leading to pervasive food insecurity and rising poverty (Freeman & Omiti, 2003). The agricultural development literature concludes that resource-poor farmers have limited access to the available varieties of agricultural technologies, a condition that contributes to their failure to adopt those practices (Misiko et al., 2011; Muyanga & Jayne, 2008b).

Taken together, these compounding factors continue to impede the sustainable growth of the agricultural sector, as most commonly evidenced by low farm incomes and widespread food insecurity. Against a rising population, per capita access to food remains challenging for many rural households (Tittonell et al., 2005). Based on current agricultural performance, the adoption of new agricultural technologies is considered critical for increasing agricultural productivity (van Dijl et al., 2015) and addressing these issues.

1.2   Agricultural Extension Services

Kenya's current agricultural extension model involves gathering, developing, and sharing agricultural knowledge with farmers and rural residents. Extension service providers bring to farmers formerly unavailable information and knowledge, such as best principles of pest control, or ways in which manure and compost can be broken down to provide plant nutrients. Thus, extension helps farmers to apply science or new practices that help them navigate the daily challenges of farming. As such, extension services provide a two-way link between rural farmers

and the extension system (Brunner, Edmund de Schweinitz & Yang, 1949) and is a critical part of the success of the diffusion of innovations, particularly adoption of novel agricultural practices.

There are three sources of agricultural extension services for farmers in Kenya. First, there is government (public) extension service, which is provided through the Ministry of Agriculture, Livestock and Fisheries (MALF). The public agricultural extension service is designed to be demand-driven. Second, private agricultural extension services provide information, training, and input loans for farmers who can afford those services. The input loans extended to the farmers are paid in installments with final payments made at the end of the harvest season. The third extension service providers consist of non-governmental organizations (NGOs) working in the agricultural development field. Such organizations tend to be temporary and short-lived in their operations. Farmers also learn from other more experienced farmers, but this is not a structured form of information and training.

However, the use of extension services for adoption of any new practice is a voluntary endeavor influenced by individual farmers' attitudes and values, which result in the decision to adopt new technologies and practices from among those that are available (Brunner, Edmund de Schweinitz & Yang, 1949; Willock et al., 2008a). The structure of farming communities and the regional agricultural technology infrastructure also mediate the effective delivery of extension services. Nevertheless, farmers make the eventual decision to adopt any new practices, often varying according to farm and farming needs. Finally, an effective communication strategy for local agricultural extension agents is integral in implementing education and training programs and for the communication of new practices, inputs, or farming techniques. Information and knowledge dissemination facilitate decision-making and allow farmers to take advantage of the most current advances in technology.

The introduction of new agricultural technologies and practices is presumed to be a critical strategy in the fight against hunger, poverty, and underdevelopment among rural agricultural households. Extension plays an important role in encouraging rural smallholder farmers to use agricultural technologies in their farms. These smallholder farmers are the main beneficiaries of information technologies with the potential to increases production through improved farming efficiency. In Kenya, the national and county governments, as well as other development stakeholders, accelerate and popularize the use of these agricultural practices as a pathway out of poverty and food insecurity for many rural households. Nevertheless, technology uptake remains

a complicated human process thay entails the adoption of new technologies as well as the adaptation of existing practices (Meijer et al., 2015).

Establishing a more comprehensive understanding of the drivers of adoption of agricultural technologies is critical for increasing the use of those agricultural inputs among smallholder farmers. Such agricultural development interventions are necessary to combat food insecurity and poverty among smallholder farmers of western Kenya. Increasing the agricultural outputs of farmers can improve rural livelihoods and enhance economic growth for the regional economy.

In investigating the obstactles to agricultural technology adoption among smallholder farmers in Kakamega, this study sought to identify their perceptions and attitudes towards agricultural technologies. To achieve that objective, the study applied a qualitative and a quantitative design to test two hypotheses and answer three research questions, respectively. For the quantitative approach, hypothesis one (H1) claims that socio-demographic factors are related to agricultural technology adoption; and, hypothesis 2 (H2) claims that farmer access to extension services are related to the adoption of agricultural technology. To more deeply understand both individual and socio-cultural factors that might influence technology adoption, the qualitative phase dealt with three research questions including: (RQ1) What are the farmer attitudes and perceptions towards agricultural technologies? (RQ2) What sociocultural values influence farmer choice of technologies? Finally, to gain a better understanding of the dissemination of new technologies and practices, the final research question (RQ3) asked: What are the sources of accessing agricultural technology information for farmers?

1.3   Statement of the Problem

The adoption of agricultural practices by farmers is a complex human domain that includes how new practices are communicated and the channels of dissemination. Farmers' decisions to adopt agricultural technologies and practices are predicated upon two primary layers of agents: the decision-makers and agricultural extension level support. However, the final adoption or non-adoption decision ultimately relies on a farmer's attitude towards the new innovation. While the social sciences provide a clear human-driven pattern explaining the process of choices and behaviors regarding technology use, there is still less clarity on what really influences the choice of technologies among smallholder communities and what supports or impedes farmers' adoption decisions. The promotion of agricultural innovations by public and private extensions service

providers has not resulted in improved technology adoption among smallholder farmers in western Kenya (Ferroni & Castle, 2011). To better understand the factors that impede progress in this area, this study sought to clearly explain the factors that influence farmers in their decisions to adopt (or not adopt) agricultural innovations.

Specifically, public-private efforts to promote the use of improved agricultural practices have neither yielded sizable adoption rates nor contributed to overall yield changes among agricultural producers in Kenya (Ferroni & Castle, 2011). Empirical research that examines smallholder farmers' attitudes towards these innovations has not received in-depth attention in the literature. For instance, past empirical research has mostly focused on the demographic factors (such as age, gender, education, and income) in determining farmer adoption or non-adoption of agricultural innovations (Asfaw, Kassie, et al., 2012). Since farmers are the intended beneficiaries of the new crop varieties or fertilizers, a broader understanding of their technology adoption behavior might inform agricultural extension intervention to design appropriate dissemination programs.

1.4   The Objective of the Study

The main objective of the study is to assess the perceptions and attitudes of smallholder farmers towards adoption of fertilizer, an essential technology for smallholder farmers in western Kenya. As an agricultural innovation, fertilizer is used as a proxy for agricultural technology and is applied in a variety of crops for yield improvement.

1.4.1   Specific Objectives

1. To establish if socio-demographic characteristics contribute to agricultural technology adoption among smallholder farmers in Western Kenya.

2. To assess the influence of agricultural extension service in farmer adoption of agricultural technologies.

1.4.2   Research Hypotheses

H_0:   Socio-demographic characteristics are unrelated to agricultural technology adoption.

This study seeks to show that this null hypothesis is not supported when examining the population of smallholder farmers in Kakamega County. Thus, the null hypothesis seeks to reject that there is no relationship between the socio-demographic characteristics of the population and the adoption of agricultural technologies.

H_a: Socio-demographic characteristics are related to the adoption of agricultural technologies.

Scientifically, accepting an alternative hypothesis is conditional, because the truth about social relationships can only be assessed indirectly, through the rejection of the false hypothesis. If the research hypothesis is correct, the expectation is to find evidence in the sample that will reject the null hypothesis.

H_0: Farmers' access to extension services are unrelated to agricultural technology adoption.

This study seeks to show that this null hypothesis is not supported when examining the population of smallholder farmers in Kakamega County in relation to access to extension and agricultural technology adoption. Thus, this null hypothesis seeks to prove that there is no relationship between accessing extension services and the adoption of agricultural technologies.

H_1: There is a relationship between farmer access to extension services and agricultural technology adoption.

This conditional hypothesis indicates that if this statement is correct, we should find evidence in the sample that will reject the null hypothesis of no relationship between access to extension services and agricultural technology adoption.

1.4.3 Research Questions

1. What are the farmers' attitudes and perceptions towards adoption of agricultural technologies?

2. What sociocultural factors/values influence farmers' choice of technologies?

3. What are the sources for accessing agricultural technology information for farmers?

1.5 Significance of the Study

An understanding of the underlying causes of the low agricultural technology adoption rates in Kakamega County in Kenya would be key in the design of any agricultural interventions. Any interventions could gain from the understanding of how farmers perceive the adoption of new technologies and agricultural practices.

Findings from this research have the potential to influence the design of county-level agricultural development policies and practices, and to influence the delivery of agricultural information and training to farmers. In addition to that, understanding farmers' attitudes towards agricultural innovations might offer insight into how smallholder farmers make their technology adoption (or non-adoption) decisions.

1.6 Theoretical Framework

The guiding theoretical framework for this study is the adoption of innovations theory, which entails the various elements that Rogers (2003) incorporates as integral in the diffusion of innovations framework. The key constituents of the adoption of innovations are: an innovation; a channel of communication; time; and a social system upon which innovations permeate into society. These elements upon which the theory is founded are equally important in the postulation of the theory. The adoption of innovations framework can be characterized as either a theory of communication and group behavior or a theory of information and individuals' behavior (Edison & Geissler, 2003).

Figure 1.1 below illustrates Rogers'(2003) adoption of innovations theory. The figure provides three types of innovations and captures the four phases that characterize the early adopters, early majority, late majority, and laggards.
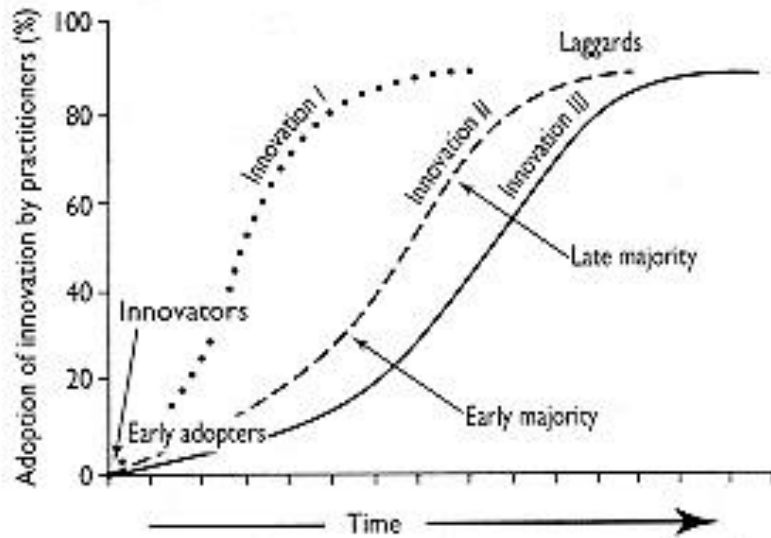
Figure 1.1 Diffusion of Innovations, Speed of Innovation from Rogers (2003).

Rogers' (2003) classic study of the spread and sustainable use of an innovation among farmers in the 1950s showed that once opinion leaders in the community adopt an innovation they influence their colleagues, who rapidly take up the innovation. The S-shaped curve captures the process through which an innovation spreads among users and potential users throughout the social system. Dissemination of an innovation does not guarantee immediate acceptance by the message recipient, implementation strategies that are applied must be sustainable and dynamic and consider variance in an innovation's effectiveness.

The diffusion of innovation paradigm provides a credible foundational premise upon which to investigate socially manifest phenomena exhibited by members of society. In such a scenario, the processes internal to the individuals or society can potentially influence the workings of the entire system. The internal processes, such as the existing channels of communication, transportation, and interaction with others, are integral in driving the social system. Understanding internal processes is necessary for the formulation of well-informed interventions. Individual decisions are not often observable; they may be cognitive, but not homogeneous. Understanding the latter entails a cross-disciplinary review.

1.6.1 Theories of Decision-Making

In the literature, the characteristics of the innovation, particularly the cost of the innovation and its economic benefits, are important attributes to its sustainable diffusion (Fliegel & Kivlin, 1966). Actual perceptions of the cost of the innovations, especially in the context of the potential returns of that innovation is an important attribute that determines how individuals are likely to perceive a particular innovation. In essence, potential users of technology evaluate how they might be better off by applying a particular innovation. Studies have also suggested that differential perceptions of innovations and adoption rates can be a result of innovation attributes, convenience, risk, and uncertainty of the innovation (Kivlin & Fliegel, 1967). Some decision-making theories highlight the role of extrinsic factors such as the characteristics of the technology and the attributes of the external environment. The characteristics of the users of these technologies are an integral part of the technology adoption literature (Kivlin & Fliegel, 1967). A potential consumer's ability to afford a particular technology, depending on its cost attribute, can determine the pace of adoption of an innovation.

However, the recent literature emphasizes the internal decision-making characteristic of users, psychological factors, and their motivational considerations. This process also considers the design of a technology message and how individual farmers or household may perceive it. The key characteristics that are embedded in these studies include knowledge, attitudes, diffusion, policy, and farmer practices (Röling & Jiggins, 1994). In the Röling & Jiggins (1994) study, the authors used an example of Dutch farmers, who by far have the most intensive forms of land use in the adoption of technologies, to illustrate how desirable farming practices use science-based component technologies in the adoption and delivery of innovations.

1.6.2 Conceptual Framework

The conceptual framework in Figure 1.2 is a structural representation of the factors that determine a technology user's eventual adoption decision. A number of direct and indirect factors contribute to the final adoption decision. In the diagram, the external and internal range of factors that constitute the technology adoption decision include individual farmer attributes, the external environment, the nature of the innovation, and an aggregation of policy considerations. These factors interact differently to influence the final decision making outcome.
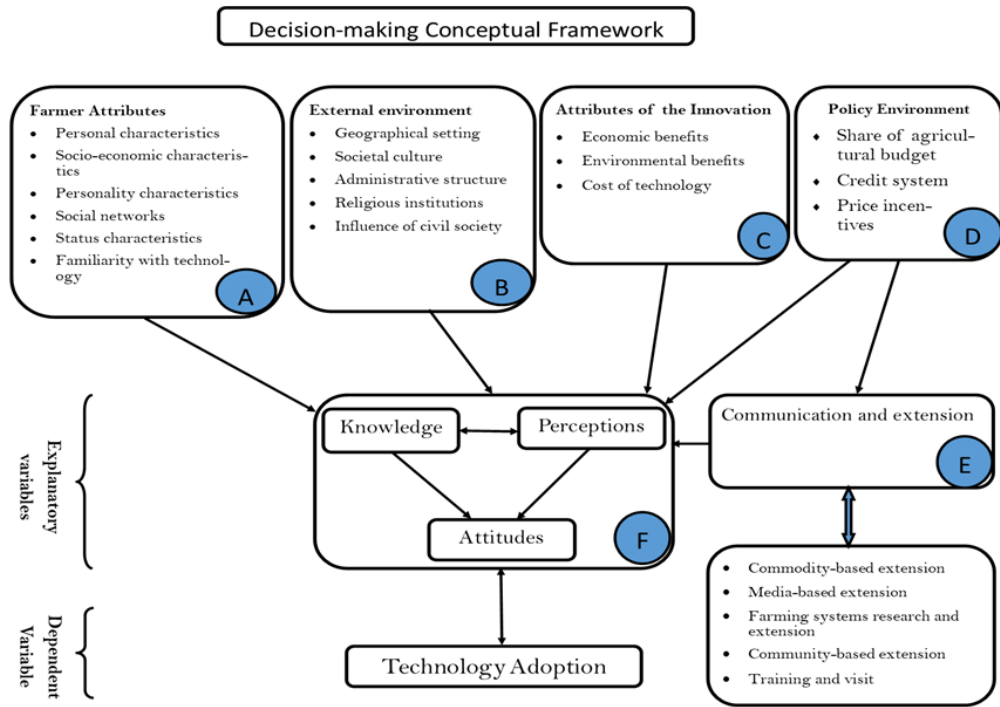
Source: Adapted from Meijer et al., 2015

Figure 1.2 Decision-making Conceptual Framework

Figure 1.2 illustrates the four extrinsic factors that shape decision-making and the intrinsic factors that collectively result in an adoption decision. Farmer perceptions about innovation or new farming practices are related to the knowledge or experience they have about it. Farmer knowledge represents the information and understanding of the technology – based upon what that technology is capable of achieving. On the other hand, perceptions arise from a farmer's views and judgement about a technology and previous experience with that innovation. That knowledge and perception leads to the formation of attitudes towards that practice. Meijer et al. (2015) argue that positive attitudes towards agricultural technology increase the likelihood of adoption, and vice versa. The extrinsic attributes also serve an intrinsic role in relation to the external environment, the attributes of the innovation, and the policy environment.

Figure 1.2 illustrates the conceptual framework that guided the study and it captures the key extrinsic and intrinsic variables of the study. This structural representation illustrates the factors that contribute to decision-making on adoption. It also brings out the social component of

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the diffusion of innovation theory, with emphasis on an innovation, a channel of communication, a social system, and time. The theoretical and conceptual models both capture the socio-demographic variables applied in the study: socio-economic and attitude variables. The latter represent the intrinsic determinants of agricultural technology adoption.

CHAPTER 2.   LITERATURE REVIEW

2.1   Literature Review

A review of the literature explores the overriding factors that influence farmers perceptions of the adoption of agricultural technologies, with a focus on the research in developing countries. The focal points of the literature review include four sections which outline: 1) the attitudes and perceptions of smallholder farmers in the adoption of agricultural technologies; 2) the role of social networks in learning about new innovations in agricultural communities; 3) the major models of agricultural extension, and its role in dissemination of information in developing countries; and 4) the adoption of agricultural technologies and the resulting benefits of technology use. To end the literature review, the section concludes with a summary of the evolving role of agricultural extension as a channel for information sharing among smallholder farmer networks in Western Kenya.

2.1.1   Attitudes and Perceptions of Farmers on Agricultural Technology Adoption

The decision-making process for adoption of technology involves both extrinsic and intrinsic factors that influence acceptance of new technologies and practices. The current literature on the role of knowledge, attitudes, and perceptions in the adoption of agricultural technologies tends to focus on the extrinsic characteristics, such as economic considerations (Meijer et al., 2015). However, intrinsic factors may be equally, if not more important, in their influence over adoption of agricultural and agroforestry innovations in smallholder communities in sub-Saharan Africa. Recent research has shown that a combination of extrinsic and intrinsic characteristics can provide a more holistic understanding of farmers' views of technology adoption (Meijer et al., 2015).

The attitude of farmers towards new technologies may be the foundational construct in understanding farmer's adoption of new agricultural practices. Attitude is a central, intrinsic construct in social psychology that has been widely applied in the understanding of human behavior (Edison & Geissler, 2003; Fishbein & Ajzen, 1975). As a concept, attitudes serve to evaluate whether an object or practice is favorable or unfavorable. In short, it has been defined as an index of the strength of how much a person likes or dislikes an idea, a concept or views towards

others (Ajzen & Fishbein, 1980). Formation of attitudes is shaped by what an individual perceives as true or false (Willock et al., 2008b). Attitudes serve as influences on the behavior of an individual and are informed by behaviors and values. In agriculture, the decision-making process that an individual farmer undergoes allows the evaluation and formation of favorable or unfavorable beliefs about an agricultural practice, including new technologies. According to foundational theories on attitudes, it may not always be possible to measure the process of belief formation, but attitudes can be observed through the choices individuals make (Fishbein & Ajzen, 1975). The configuration of attitude formation may be influenced by any given number of social or physical environmental variables.

In agricultural production, smallholder farmers have been found to act similarly towards an agricultural innovation as to any other technologies in their evaluation of the utility of the technology (Edison & Geissler, 2003). Socio-demographic factors, such as age, gender, income or level of education have been suggested to be leading determinants of the agricultural technology adoption in the literature (Nyanga, 2012a). Specifically with regard to the role of gender in technology adoption among African women, some studies have concluded that gender roles within households cannot be clearly summarized (Doss, 2001). Even if the female labor share in crop production is high, no clear pattern of adoption of agricultural technologies has been established for women comparatively to men (Palacios-Lopez et al., 2017).

In practice, individual smallholder farmers have been found to behave differently based on their production needs or household circumstances. One study exploring attitudes towards using precision agriculture technology found that a confident attitude had a positive effect on technology adoption. Specifically, attitudes of confidence towards using precision agriculture technologies, the perceptions of net benefits, and farm size positively influenced the intention to adopt agricultural precision technologies (Adrian et al., 2005). These studies suggest that economic benefit may not be the primary reason that producers opt to adopt precision agricultural technologies. However, the findings do not conclude that these findings are generalizable across all technologies.

There is a wealth of studies on the perceptions of smallholder farmers towards agricultural innovations (Ntshangase et al., 2018); however, farmer experiences vary across different parts of developing countries. Employing a cross-sectional study design, Ntshangase et al. (2018) explored the factors influencing the adoption of no-till conservation agriculture (CA) and explored farmers'

perceptions of that technology. Findings from that study suggested that farmers' positive perceptions were positively correlated with higher maize yields.

When farmers' uncertainty towards adopting a new technology is due to lack of information or adequate training, access to extension services can influence a change of perceptions for a farmer toward their agricultural practices (Morton et al., 2017). However, this argument is contingent upon the operating socio-cultural environment that shapes the general belief system in a specific social context. In cases where uncertainty is caused by insufficient information, access to more information has not been found sufficient to address claims of uncertainty when socio-cultural norms are a factor in contesting the introduction of new practices. In such a circumstance, Morton et al. (2019) recommended that scientific information linked to local values and trusted agricultural networks would be more locally accepted. To lessen user resistance to new information, the communicated message must embrace local values and customs in its design. A recent study found that extension service was a determinant in the promotion of no-till conservation practices among farmers (Ntshangase, Muriyowa and Sibanda, 2018). So, in effect, the practices employed by regular extension services may be more effective in reaching farmers when they engage social networks by attending to local attitudes and values. Regional studies are critical in understanding local populations, for attitudes and perceptions towards new practices are not constant but vary across socio-cultural contexts and practices.

2.1.2   Learning About New Innovations through Social Networks

The role of social networks and diffusion of technology in the agricultural sector is widely documented in the literature (Bandiera & Rasul, 2006a; Cavanagh et al., 2017a; Ramirez, 2013a; Suvedi et al., 2017a). As one example, a study investigated decision-making on irrigation technology adoption by examining the contribution of professional collaborations (Ramirez, 2013a). Researchers explored farmers' adoption behaviors under water-conserving technology precision leveling over a five-year period. In assessing the social networks in agriculture, the study hypothesized that family relationships are a conduit for transferring farming knowledge from one network point to another. However, that study assumed that the diffusion process relied more on social networks than other socio-economic factors. The results indicated that farmer participation in leadership activities, both organizational and professional, was a common source for learning new technologies. In other studies where farmers had better information about the technology to

be adopted, those farmers were found to be less sensitive to the adoption choices of their peers (Bandiera & Rasul, 2006a). Similarly, a study by Bandiera and Rasul (2006) emphasized the role of farmers' social networks in the technology diffusion process. Various aspects of the social system served as important channels in spreading information about agricultural technologies among farmers. Farmers learned of new technologies if neighboring farmers were in similar circumstances, which reinforced the idea that learning about agricultural practices is contingent on social processes (Bandiera & Rasul, 2006b; Cavanagh et al., 2017a; Conley & Udry, 2001). In other studies, socio-economic factors such poverty acted as a major hindrance in farmer adoption decisions (Cavanagh et al., 2017b).

Social networks are key in strengthening the contribution of social capital in connecting members of a community. In turn, social learning, directly linked to social capital, facilitates the adoption of new technologies among members of the same social network. A study of social networks among smallholder farmers in Northern Mozambique found that the benefit of adopting technology at the current time period was higher when there were many adopters in the network (Bandiera & Rasul, 2006a). The intensity of information sharing implies that technology diffuses quicker and reaches a wider audience within these established network nodes. The strength of networks facilitates the intensity of shared information. In other studies, the family is a key source of social capital formation. However, it can be inferred from the foregoing studies that social connectedness and the strength of network nodes all differ by community type and that the differences among these communities may be modest, depending on the network structure.

Social networks and membership in farmer groups have been widely argued in the literature to strengthen agricultural technology adoption. Evidence from the literature suggests that these networks are essential in influencing agricultural technology adoption among members of similar or related networks (Cavanagh et al., 2017a; Liverpool-Tasie & Winter-Nelson, 2012; Ramirez, 2013a). In the foregoing studies, social networks are found to be essential in strengthening professional and non-professional networks. Findings also reveal that both network types (professional and non-professional) facilitated the likelihood of agricultural technology adoption.

While social networks are important in information sharing, it has been demonstrated that governments can sometimes cause civic disengagement through the expansion of the welfare state, whose growth can crowd out private initiatives (Fukuyama, 1995). These state initiatives can shift dependencies and weaken social capital by dismantling community ties. It is a common feature of

threshold models of collective action that people will engage in collective action based on others in their personal network; making individual adoption of a behavior a function of the behavior of others (Granovetter, 1978). The variability in the individual thresholds will dictate whether an individual will adopt or not adopt a new practice. Most generally, these social networks are strengthened by interdependence, and driven by differences in needs or events controlled by others (Coleman, 1990). This social network approach is clearly relevant to the adoption of innovations paradigm, which identifies the role that the social system plays as a core requirement in the spread of innovation within a social network. Social networks, in agriculture as well as in other social engagements, play a critical contextual role in the spread of new ideas among members of society.

2.1.3   Agricultural Extension Models in Developing Countries

In the literature, agricultural extension plays an important role in the dissemination of information and training among farmers in the adoption of new agricultural practices (Ntshangase et al., 2018). Agricultural extension education is integral in the dissemination of essential information and training capable of transforming the slow agricultural growth in developing countries to a dependable, sustainable the sector (Doss et al., 2003; Suvedi et al., 2017b). In particular, the adoption of new farming techniques and promoting their use by farmers is critical in improving agricultural output and harnessing overall farm efficiency. Channels of communicating agricultural innovations to farmers are a necessary determinant in the spread and adoption of those practices in developing countries, where the adoption of new agricultural practices and technologies remains low (Doss et al., 2003). The literature suggests that the agricultural yields among smallholder farmers have not positively responded to public and private agricultural extension interventions(Ferroni & Castle, 2011).

In order to evaluate the role of agricultural extension in adoption of new technologies, it is important to understand how different models of extension services are structured. Three models remain dominant in the delivery of agricultural extension in developing countries (Ponniah et al., 2008a). The first model captures smallholder farmers, who rely on public extension services. These smallholder farmers grow staple food and minor cash crops according to the size of their land. These farmers also rely on subsidized services, available to smallholder farmers engaged in growing staple foods and minor cash crops across various agro-ecological zones. In this model, farmers receive basic inputs, such as seeds and fertilizer from the public extension services. The

inputs and services under this model are provided at no charge. In a second model of extension service, farmers share the cost of any extension services that they receive either from public or private sources. The effectiveness of this model is measured by farmers' willingness and ability to share the cost of any extension service they receive (Ponniah et al., 2008b). The implementation and delivery of service can run into potential problems if farmers are pressured into investing in technologies that are unproven, and that they may consider to be risky. However, a major benefit of this model is its farmer ownership, often demonstrated by a commitment to bear some of the costs. This model may be difficult to implement because of the broad variability in farmers' needs and availability of resources. Finally, a third model involves fully commercialized agriculture comprised of private sector services, featuring private companies and cooperatives, and quasi-public organizations who work mainly with specific commodities such as tea, coffee, and sugar (GOK, 2014). The latter model is uncommon among smallholder farmers due to the large scale nature of production that is incomparable with small scale farming. Under the latter model, the producer often deals with private sector companies or service providers engaged in the production and distribution of seeds, fertilizers, and pesticides. This model is suitable for large scale producers with varied sources of financing and who can afford various technologies and services, mostly from private service providers (Mwangi & Kariuki, 2015).

Implementing the foregoing models of extension depends on other actors in agricultural extension education who provide complementary roles in disseminating agricultural information. The actors across the three private and public extension models provide services ranging from delivery of inputs, agricultural marketing, insurance, education, and other services. Understanding the variability in farming systems is an integral factor for determining the corresponding services needed in order to develop an effective agricultural extension model. In addition, the various stakeholders may interactively play different, complex, and complementary roles in support of the farmers' needs.

2.1.4 Diffusion of Agricultural Information

The delivery of extension training and education requires a diverse set of networked actors and multiple pathways from which farmers learn about new technologies. These pathways include experiential learning, social learning from face-to-face interaction, and technical learning from outreach materials provided by more formal institutions (Lubell et al., 2011, 2014). Access to

agricultural information includes both formal and informal sources of knowledge that farmers integrate into their farm practices based on individual needs. Among smallholder farmers, farmer-to-farmer interaction is one of the main learning channels through which new and existing agricultural information and knowledge can be shared across social systems. Agricultural extension could leverage these social networks under the right conditions.

To take advantage of the networked infrastructure of knowledge systems, agricultural extension services need to be modified to establish that the novel technology is suitable for local agricultural systems (Lubell et al., 2014). This may require customizing proposed technologies with local farming practices to make them more acceptable and relevant to local farming needs. For example, farmers in eastern Zambia revealed that while they had positive attitudes towards minimum tillage as a conservation technology, local resources did not allow them to continue using minimal tillage, eventually resulting in farmers dropping that practice altogether (Grabowski et al., 2016). These findings support the idea that to sustain the adoption of a particular technology, the new practices must be integrated to local resources. Other studies have demonstrated that if the application of technology involves a series of complicated stages and processes, it can be a barrier to adoption among potential adopters (Ronner et al., 2018). In other studies, failure to involve key stakeholders in agriculture has resulted in the underperformance of the agricultural sector. For instance, a study on gender perceptions and adoption of push-pull technologies in eastern Africa found that 98.6% of women perceive technology to be more important than men (Murage et al., 2015). Yet another study identified that women often failed to access extension resources, even though they represented a crucial resource in agriculture (Murage et al., 2015). These studies demonstrate that extension services could benefit from the exploration of local factors that influence farmer engagement, as well as exploring the underutilized resources for technology adoption.

Several studies have looked into the use of outreach as an avenue of reaching farmers in need of extension services. Findings from those studies concluded that the understanding of local dynamics and customs as essential for effectively sharing information about local farming practices (Bandiera & Rasul, 2006b; Cavanagh et al., 2017b; Ramirez, 2013b; Suvedi et al., 2017b). These studies suggested that adopting effective new agricultural extension approaches may be contingent on extending, not eliminating traditional and regionally specific agricultural knowledge, customs and practices.

2.1.5   Adoption of Agricultural Technologies

Widespread adoption of novel agricultural practices in developing countries has been touted as a viable means of improving agricultural productivity, and in improving economic and social livelihoods (Beyene & Kassie, 2015; Kassie et al., 2014; Suvedi et al., 2017a), and in sustaining farmers' wellbeing (Mukasa, 2018). Overall, the use of these appropriate technologies is integral in reducing the poverty that is prevalent in many rural areas of developing countries (Liverpool-Tasie & Winter-Nelson, 2012). Several studies around smallholder agriculture in developing countries have concluded that adoption of agricultural technology is critical, yet the types of technologies that farmers in developing countries use varies from region to region and it is important to recognize these regional variations.

The push-pull technology is an agricultural practice commonly promoted as a novel technology among farming communities. An example of this practice consists of a new cropping system that was developed for integrated pest, weed, and soil management in cereal-livestock-based systems (Khan et al., 2011). This type of technology is appropriate for smallholder farmers because it is economical and involves the use of locally available perennial input plants and also addresses farmer constraints while fitting in well with traditional mixed cropping systems. Its application allows for customized configurations based on the needs of the farmer, but can be knowledge intensive – requiring in-depth understanding of agrobiodiversity, as well as plant-plant and insect-plant interactions. For instance, in western Kenya, about 24,000 farmers apply this technology and that number has been increasing (Khan et al., 2011). The benefits of a simple push-pull technology provide important incentives for farmer adoption, but questions still remain regarding its sustainability as an application among smallholder farmers who may be mainly resource poor and illiterate.

A popular mechanism of raising crop yields is through the use of agricultural technologies, such as fertilizers, seeds, and cropping techniques (Aker, 2011). That approach must be complemented by applying suitable high-yielding crop varieties, improved seeds and other inputs with the highest potential of enhancing productivity. To successfully implement these technologies, other conditions such as the type of crops and the specific needs of the agricultural audience must be taken into consideration (Lubell et al., 2014). Information and training dissemination of these innovations would depend on how well the outreach efforts are customized to the specific regional environment.

The choice of appropriate agricultural technologies and practices is often a function of a good knowledge of the beliefs and values of the target system, as well as the range of existing technology options. Knowledge of the farming environment requires an adequate collection of the necessary information about that environment from dependable sources. The sustainability of technology use over time might be an indication of how the end users (farmers) evaluate the relevance of these new technologies to their local practices.

In short, the technologies amenable for use in a particular farming environment must adequately reflect both the biophysical and socio-economic environment for optimal yield targets (Mutsaers et al., 1997). The western Kenya region continues to remain a food deficit area, with widespread low-crop yields and poverty. This phenomenon is compounded by food insecurity and an increasing population growth which highlights the need for utilizing every available tool to enhance the agricultural potential of this region.

Summary

This review of the literature explored how a range of socio-cultural factors may influence technology adoption in developing countries. These factors included, the attitudes and perception of farmers, the use of social networks for dissemination of information, as well as the role that agricultural extension models can play in the adoption of novel agricultural technologies. The highlighted research conducted in smallholder farmers suggests that historically, the explanation for the low adoption of agricultural technologies has rested primarily on general socio-economic variables.

The literature reviewed indicated that observable, extrinsic socio-economic factors such as types of social networks, farm income, or age (Asfaw, Kassie, et al., 2012; Nyanga, 2012a) continue to be dominant in explaining the slow adoption of new technologies necessary in agricultural production. However, the decision to adopt a new practice may be a function of both external and internal stimuli. Intrinsic factors such as farmers' attitudes and perceptions of new technologies, and their beliefs and perceptions about technology adoption may be important variables for discovering the unobservable drivers of technology adoption. For example, the introduction of a new seed variety which can be deemed to be universally more productive by scientists may not necessarily be readily embraced by all farmers. Instead, individual internal factors may interact with socio-economic variables to influence technology adoption decisions.

Thus, combining extrinsic and intrinsic factors in the adoption process could provide a more comprehensive and holistic explanation of adoption decisions.

In addition to the prominence of observable, socio-economic variables in the literature, the majority of these studies rely on a single method of analysis rather than a combined methodological approach. An approach that combines economic variables, individual factors (attitudes and beliefs) as well as socio-cultural variables may be more effective for uncovering the range of variables that impact the adoption of technology among smallholder farmers in developing countries. The prevalence of socio-economic variables in the literature is an indication of their importance in agricultural technology adoption. Nevertheless, the emphasis on a single methodological approach in the investigation of the determinants of adoption may be insufficient in getting to the core of what directly influences the adoption of these technologies. To address this deficiency, quantitative data collection could be augmented with qualitative data to allow for a richer understanding of the range of variables that influence technology adoption as well as how these variables may interact.

In summary, for the effective dissemination and sustainable adoption of new agricultural technologies, the attitudes and beliefs of the farmers, socio-economic factors, and the efficacy of extension as a channel of communication for the dissemination of agricultural information may all be integral in the adoption decision-making process. To address the identified gaps in the literature, the inductive mixed methods research explored the range of factors that influenced technology adoption. The study assessed observable and intuitive factors that are presumed to provide a holistic perspect of adoption among smallholder farmers. By collecting and analyzing qualitative and quantitative data separately, the process allowed a critical evaluation of the decision-making process.

CHAPTER 3.   MATERIALS AND METHODS

3.1   Study Area

The study was conducted in Kakamega County, one of the 47 counties of Kenya, located in the western part of Kenya. The area is characterized with mixed small scale agriculture and widespread low agricultural productivity (GOK, 2014). The resulting low incomes contribute to the prevalent poverty and food insecurity among the rural agricultural households. However, the area is endowed with rich soils and ample rainfall due to its location on the Equator. There are two main ecological zones in Kakamega County; the upper-medium (UM) and the lower medium (LM) zones. The two zones possess different soil fertility features and different crop yields (GOK, 2014; Mutua et al., 2010).

The study area covered the upper-medium ecological zone which included the central and southern parts of the county**.** The seven sub-counties covered in the study were: Malava, Shinyalu, Mumias East (Shianda), Ikolomani, Khwisero, Lurambi, and Butere. The selected counties of the study are all located in the Upper Medium zone, where subsistence farming is predominant. Households produce food for themselves and limited surplus for the market. Farm sizes are generally small on average, crop productivity is sub-optimal, and food insecurity is prevalent.

Kakamega County has a land area of about 1,171 mi² and it is located on the Equator with average temperatures ranging between 66.74°F in July and 70.34°F in February (Ali-Olubandwa et al., 2011), and high precipitation typically over 78.74 inches per year. The climatic conditions in the area are favorable for growing a variety of tropical crops. The main crops grown are maize, beans, and horticultural crops. The short rains arrive between November and February, while the long rains are between March and October (GOK, 2014).

Mixed farming is a prevalent agricultural practice in Kakamega County – farmers concurrently raise livestock and grow crops. The amount of livestock per household depends on farmers' ability to manage and adequately feed them. Households raise dairy cows, sheep, and goats as essential sources of milk or meat for household consumption and for sale in local markets. Raising poultry serves as a source of eggs and meat, an important protein source for the household. The classification of farmers into smallholders and largeholders is measured according to the size of their land and the scale of production. The size of a smallholder is less than five acres on average

with limited mechanization. Kakamega County has 3,249 farmers that fell into the smallholder category (GOK, 2014).

Figure 3.1 Kakamega County Map

3.2   Materials and Methods

After obtaining the Institutional Review Board (IRB) (Protocol #:1905022191) approval from Purdue University, data was collected from smallholder farmers in Kenya. In accordance with the sequential mixed methods research design, a quantitative research survey instrument was administered, followed by qualitative focus group discussions. In phase one of the study, survey data was collected and analyzed. Subsequently, research questions for the focus group discussions were developed. The focus group discussants were purposively pre-selected during the administration of the survey based on their presumed expert knowledge and diverse gender representation.

In the administration of the quantitative survey, the researcher read survey questions exactly as they were worded in the survey questionnaire in Kiswahili (the native language). Household heads participating in the survey administration phase were randomly selected from the seven purposively selected sub-counties of Kakamega County. The second qualitative portion of the data collection was also administered in the local vernacular, Kiswahili. In accordance to

the IRB protocol, participants were informed of the confidentiality protections for their information obtained for this study. Any names that were used in the analysis section of focus groups were not the real names of the research participants.

3.3   Methodological Approach

The study utilized an inductive mixed-method design, integrating a quantitative and a qualitative research approach, to identify the practices of smallholder farmers towards agricultural practices in western Kenya. By definition, mixed methods research involves collecting, analyzing, and interpreting quantitative and qualitative data in a single study or through studies investigating the same phenomenon (Leech & Onwuegbuzie, 2009). One distinct characteristic of the mixed methods approach is the integration of quantitative and qualitative research methods without falling into one or the other worldview (Feilzer, 2010). The mixed-methods approach is a relatively new design in its use as a single methodology. This methodological paradigm considers multiple realities and concurrently interconnects the subjective, intersubjective and objective parts of the world into one (Tashakkori & Teddlie, 2010) fusing two distinct approaches into one by recognizing the benefits of balance and compromise. The use of quantitative and qualitative research approaches in a single study provide unique analytical tools in broadening and deepening understanding of a research phenomenon.

However, there are philosophical issues that question the authenticity of the mixed methods approach as a single methodology given the different epistemological and ontological assumptions that underlie stand-alone qualitative and quantitative methods (Bryman, 2006). The underlying argument in that debate contends that the two different approaches combine contrasting and incompatible foundational perspectives. The qualitative component suggests that human thoughts, feelings, experience, and emotions are real and the researcher does not have to manipulate the phenomenon of interest (Golafshani, 2003). The quantitative approach espouses objective realities in seeking to answer pertinent research questions of a study. In terms of its philosophical leaning, the mixed methods research design applies dialectical pragmatism as a philosophical paradigm; it is dialectical since it espouses qualitative and quantitative perspectives in creating workable solutions or in responding to the research questions. As a new approach that still faces questions of validity, the philosophical paradigm of dialectical pragmatism emphasizes dialogue between qualitative and quantitative paradigms (Johnson & Onwuegbuzie, 2004).

The current study combined quantitative and qualitative research approaches that lent a more nuanced understanding of how farmers make decisions. This research design entailed the collection of socio-demographic information during the first phase of the study and collection and analysis of qualitative data; obtained through focus group discussions, in the second stage. The second stage of the design added rigor to the investigation of the social phenomena relevant to farmer adoption decisions. The survey phase also identified the socio-demographic factors important in agricultural technology adoption followed by a broader scope of the farmer views towards emerging issues from the survey results. To answer the question of the role of attitudeds and perceptions of farmers towards adoption, the qualitative and quantitative data were triangulated. The criticism of this approach notwithstanding, this paradigm enriched the current study by allowing the analysis of the subjective and objective realities in the research inquiry. The current design started with the quantitative approach, which provided baseline information for further inquiry in the succeeding phase. By combining the qualitative and quantitative approaches, the study provided deeper insight into the adoption phenomenon and offered validity of the results.

3.3.1   Sequential Mixed Methods Design

The sequential inductive mixed methods research design was deemed suitable for investigating a phenomenon that has received considerable attention in research. The second strand of the research design, an innovative aspect of the research, utilizes findings from the first strand of the design (quantitative phase) to broaden the investigation. Since qualitative or quantitative paradigms originate from different philosophical foundations; hence theoretical and methodological paradigms, questions of validity arise from the different types of data, analytical approaches, and interpretations. As such, some researchers argue that fusing the two methodological approaches is like putting mangoes and oranges together (Tashakkori & Teddlie, 2010).

However, this multimethod approach is consistent with a pragmatic perspective. The framework offers a worldview different from the positivism/post-positivism and constructivism worldviews. The pragmatic approach focuses on the researched problem and the consequences of the research (i.e. for smallholder farmers) (Creswell, 2015). Creswell (2015) presents different perspectives of the mixed methods approach and argues that this methodology presents a distinct design. This perspective identifies mixed methods as a process that entails the collection, analysis

and interpretation of multiple types of qualitative and quantitative data in response to related or separate research questions. Compared to other methodological approaches, the mixed methods approach offers a broader and deeper investigation of an issue. This is a key advantage of combining the two approaches in investigating farmer adoption decision-making process; which entails directly measurable determinants and intrinsic nuances.

The study utilized research instruments suitable for mixed methods design namely: quantitative and qualitative approaches. A survey questionnaire was used to obtain socio-demographic information and other information pertaining the practice of agriculture. This was followed by qualitative data collected through focus group discussions from a purposive sample of respondents. A total of four focus group discussions were selected with discussants from Ikolomani, Malava, Mumias East (Shianda), and Lurambi sub-counties. A total of 28 discussants participated in the four focus groups. The focal discussion questions in the focus groups were the emerging issues arising from the survey data. The qualitative discussions targeted broader and deeper information on the perception of farmers towards current agricultural technologies in the area of study. Socio-cultural variables such as gender in agriculture are least understood and not directly measurable through survey data. These values were investigated further in the focus groups.

Questionnaires are easy to administer and analyze and to capture attitude questions, norms, and knowledge of social variables. They are also an excellent tool for studying overt attitudes or knowledge, but maybe poor predictors of internalized views towards communication effectiveness between agricultural agents disseminating information and training the farmers who require the knowledge in their agricultural fields. To compliment the survey, focus groups provide in-depth perceptual information on individual behavioral attitudes and views regarding the practices that the farmers apply in their practices (Dilman, 1978).

3.3.2   Sampling and Data Collection

The study sample selection followed a two-stage sampling approach. The first stage involved the purposive selection of seven out of twelve sub-counties of Kakamega County based on similarity in the type of agricultural activities performed in the area. A random sample of households were selected within the seven sub-counties. In accordance with the research design, survey questionnaires were used as the primary quantitative tool. In the literature on adoption, the

survey approach is commonly used in obtaining socioeconomic data (Asfaw, Kassie, et al., 2012; Nyanga, 2012b; Suvedi et al., 2017b). The actual survey participants were heads of households they represented a random sample of smallholder farmers from the seven sub-counties.

According to the Kakamega County household baseline survey of 2014, a total of 3,249 smallholder farming households meet the small scale classification ideal for the target sample from the population (GOK, 2014). On average, 2,500 households resided in the seven sub-counties included in the study. With a 95% confidence interval, the researcher selected an 80/20 split, implying less variability in farmer responses to survey questions (Dilman, 1978). Based on Dilman (2007), a minimum sample size of 232 was recommended for the survey phase, but a total of 245 farmers responded to the survey.

Nyanga (2012) has applied a mixed-method research design to investigate adoption of conservation practices in Zambia using focus group discussions as the primary tool for obtaining qualitative data. The current study follows a similar approach by collecting and analyzing qualitative data continuously during and after it was collected. In addition to the obtaining the qualitative data, the research also recorded observations and took notes during the household visits.

3.3.3 Methods of Survey Data Collection

The data for this study was collected through a household survey conducted between June and August 2019. A face-to-face quantitative survey was administered among 245 smallholder farmer household heads or principal decision makers in those households. The survey questionnaire (see Appendix A) was designed to collect socio-demographic information, farmer views on technology, and extension information. Table 3.1 below provides information on the number of participants per sub-county.

A two-stage sampling approach was used in this study. The first stage involved purposive selection of the study area – selection of seven out of the twelve sub-counties of Kakamega County. This was followed by a random selection of households across the seven sub-counties. The researcher could walk into the homestead and ask to speak with a household head available. Upon their consent, he proceeded to administer the survey. This was done continuously on a random basis across each of the sub-counties that were selected for the study.

Table 3.1 *Distribution of respondents by sub-county*

Location of Study	Frequency	%
Mumias East	30	12.2
Khwisero	31	12.7
Malava	41	16.7
Ikolomani	35	14.3
Lurambi	35	14.3
Shinyalu	44	18.0
Butere	29	11.8
Total	245	100

Prior to administering the survey questionnaire, the researcher read the questions out loud to the respondents in the local language, and allowed them respond to those questions. The head of the household or a decisionmaker present during the survey responded to the survey.

3.4 Survey Data Analysis

The researcher directly sought to obtain socio-demographic information, such as age, gender, education level, income, marital status and membership in social groups from the survey. The socio-demographic variables were used as explanatory variables in a binary logistic regression model to determine their influence on agricultural technology adoption. The proposed model investigated the following hypotheses:

H_0: Socio-demographic characteristics are unrelated to the adoption of agricultural technologies

H_a: Socio-demographic characteristics are related to the adoption of agricultural technology.

H_0: The use of agricultural extension services by farmers has no influence on the use of agricultural technologies/practices.

H_a: The use of agricultural extension services by farmers positively influences the use of agricultural technologies/practices.

The emerging issues from the survey analysis and the research questions of the study guided the focus group discussions of the key participants. The qualitative component of the study was expected to offer a deeper and more nuanced understanding of what drives farmer adoption or non-adoption of agricultural technologies.

For reliability and validity, an exhaustive list of possible relevant variables with the measurement items was reviewed in the literature and complemented by field observations during the pilot phase of the research (Asfaw, Shiferaw, et al., 2012; Becerril & Abdulai, 2010). It was established from these studies that the quantitative model variables are widely used in the adoption literature.

3.4.1 The Regression Model

Quantitative data was analyzed through a logistic regression model by estimating agricultural technology adoption as an outcome variable. The predictor variables comprised socio-demographic variables assumed to influence agricultural technology adoption. These socio-demographic variables are widely applied in the adoption of literature (Nyanga, 2012a; Suvedi et al., 2017a). Nyanga (2012) used farm size, conservation agriculture training attended, previous experience, and membership in a local organizations as the scio-economics variables. Suvedi et al. (2017) used age, education, and distance to the extension office to inform technology adoption. A logistic regression model was used in that study. For the current study, the logistic regression is represented as follows:

$$Prob(Y_i = 1) = P_i = F(Z_i) = F(\propto + \sum(\beta_i X_i) = \frac{1}{1+e^{-Z_i}} \tag{1}$$

In the foregoing specification, P_i represents the probability that a farmer participates in adopting a new practice or technology or not; X_i represents explanatory variables (factors contributing to the choice decision). The βs and αs are the parameter estimates.

$$Prob(Y_i = 0) = 1 - Prob(Y_i = 1) = (1 - P_i) = \frac{1}{1+e^{Z_i}} \tag{2}$$

From 1 and 2, we obtain

$$\frac{Prob(P_i=1)}{Prob(P_i=0)} = \frac{P_i}{1-P_i} = e^{Z_i} \tag{3}$$

In equation 3, P_i is the probability that Y_i takes the value 1, and $1 - P_i$ is the probability that Y_i takes the value 0, and e is the exponential constant.

Taking the natural log of both sides of equation 3, we get

$$Z_i = ln\left(\frac{P_i}{1-P_I}\right) = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \cdots + \beta_k X_{ki} + u_i. \qquad (4)$$

The Xs are the factors that influence the adoption of agricultural technology and equation 4 is the estimated model. Suvedi et al. (2017) and Nyanga (2012) use a binary logistic model to estimate factors that influence technology adoption. These predictor variables are presumed to influence farmer adoption decisions.

The adoption and non-adoption decision of an agricultural technology is represented by a dichotomous choice model as exhibited in equation. The outcome variable, which is binary, takes the value 1 if the farmer adopts a technology, zero otherwise. The farmers' adoption choice of an agricultural technology was estimated using variables obtained from survey data collected from the sample data was obtained from seven sub-couinties where mixed agriculture smallholder farming was predominant.

The empirical model is specified as follows:

$$ADOPT = \beta_0 + \beta_1 Age + \beta_2 Gender + \beta_3 Edu + \beta_4 \%OffFarmInc + \beta_5 Ext + \beta_6 Grp + \beta_7 HHSize$$

The predictor variables in the model are: age of farmer (Age), gender (Gender), education level (Edu), percentage share of off-farm income of total income (Off-FarmInc), access to extension (Ext), household size (HHSize), and group membership (GrpMem). Fertilizer, a common input applied in agriculture, is used as a proxy for technology (ADOPT) and it is used as a binary proxy variable that takes takes two outcomes; adoption or no adoption.

The factor loadings of the highly correlated attitude variables from the principal components analysis were included in the regression model to gauge their influence on adoption. The attitude variables were selected from the highly correlated variables from the retained principal components.

Table 3.2 *Definition of Socioeconomic and Demographic Variables in Model*

Variables	Unit of type	Description
ADOPT	Binary	1, if farmer adopts technology; 0, otherwise
Age	Years	Age of farmer in years
Edu	Years	Years farmer spent in formal schooling
Gender	Binary	Male of female
%Off-FarmInc	Number	Percentage share of off-farm income of total income
ExtAcc	Binary	1, access to extension; 0, otherwise
GrpMem	Binary	1, if member of farmer group; 0, otherwise
HHSize	Number	Total number of people in the household

3.4.2 Definition of Regression Model Variables

Fertilizer: Fertilizer use is used as a proxy for agricultural technology adoption because it is a common technology farmers use in the region. Given the homogeneity of the crops that smallholder farmers grow, fertilizer is the most commonly applied technology or input on their farms. Commercial fertilizer is an innovation that improves upon the use of manure that other farmers apply in their farms.

Gender: This variable is measured as the respondent's gender, whether it is male or female. Male and female members of the household play different roles in agriculture. Women in developing countries participate more in agricultural production while most of the men engage in off-farm employment.

Percentage share of off-farm income: Off-farm economic activities, such as working as a laborer or in a business contribute to the income of the household and the household's ability to acquire agricultural inputs. Many farming household technology adoption decisions rely on off-farm income earned by off-farm labor. Off-farm income contributes a substantial share of household income among many smallholder households in sub-Saharan Africa, and it is sometimes higher than on-farm income (Reardon, 1997).

Access to extension service: Access to agricultural extension has been found to improve farm productivity (Danso-Abbeam et al., 2018). Some studies have shown that access to some agricultural extension programs have been found to positively affect farm incomes.

Membership in farmer groups: This variable measures membership in a local farmer group, a source of sharing agricultural information among farmers. Membership in local social groups provides social support and a full range of other resources, such as table banking, a group funding strategy where members save, marketing advantages, and bargaining power in the acquisition of inputs.

Household size: A large household size is a source of agricultural labor due to the reliance on unskilled farm labor. Meeting the basic needs of large households constrains the meager incomes earned from farm output.

Education: Education is measured by the number of formal years of schooling that a farmer received. Education is an important factors that influence a farmer's decision to bear the risks associated with new technologies and agricultural information sources. Educated farmers tend to be earlier adopters of modern technologies and apply modern inputs more efficiently (Feder et al., 1985).

3.5   Qualitative Data

Qualitative data was obtained from the focus group discussions administered in four of the seven sub-counties of Kakamega County. Observation of the homesteads during the data collection revealed the resources available to the households. This informed what farmers reported in the discussions and allowed the researcher to validate the information that farmers provided. Field note taking allowed the researcher to record observed phenomena within the households during the visit. Triangulation of the data was critical in validating the credibility of the data collected from the participants and any conclusions to be drawn thereof.

3.5.1 Focus Group Methodology

The qualitative portion of the current study utilizes focus group methodology, which allowed the sharing of different perspectives and permitted the researcher to interpret the interactions of the participants. In this approach, focus group methodology is used as a source of negotiating meaning through intra- and inter-personal debates among participants. As a methodology, a focus group is an informal discussion among a group of selected individuals about a particular topic and it involves more than one individual per data collection session (Wilkinson, 2004). Focus groups allow the researcher to witness social interaction among participants and allow for interpretive interaction (Liamputtong, 2015).

3.5.2 Selection of Group Discussants

To answer the three research questions in the study, a qualitative questionnaire was developed (refer Appendix 1 Qualitative Instrument) to address the stated research questions. In total, the 28 discussants who participated in four focus groups were purposefully selected from among the larger pool of survey respondents. Respondents represented four of the seven surveyed sub-counties: Malava (7 discussants), Lurambi (9 discussants), Shianda (5 discussants), and Ikolomani (7 discussants). The participant selection aimed at obtaining varying viewpoints, gender representativeness, and farming experience.These discussions sought to investigate the research questions and associated issues that were common from the survey analysis. For consistency, the same research questions were replicated across all of the focus groups.

Table 3.3 *Focus Group Discussant Breakdown*

Sub-county	Number of Discussants	Duration
Malava	7	00:53:49
Mumia East (Shianda)	5	01:02:32
Ikolomani	7	01:15:03
Lurambi	9	01:16:05

Table 3.3 is a list of the sub-counties where the focus groups were conducted and the duration of time for each focus group. The selected farmers were key informants in the community and possessed specialized knowledge on local agricultural issues. The focus group discussions, which lasted approximately an hour in each case, were guided by the research questions. The discussions sought to provide a cross sectional perspective of farmers' experiences with and views of technology use in their farms. Discussing with key informants brought out nuanced views and perspectives that shaped agricultural technology decisions.

The focus group discussants were recruited during the survey administration phase. During the survey data collection, the potential focus group discussion participants participants were informed of a follow-up study and asked if they would be willing to participant. The research participants were selected inorder to capture the diversity of their socio-demographic profile. Their shared engagement in smallholder agriculture was a defining practice for the researcher (Ivanoff & Hultberg, 2006). In conformity with that criteria, the focus group participants were farmers who possessed critical information assumed to provide a generalized perception of small-holder agricultural technology. Participants were also representative of gender, varied age groups, and all had extensive knowledge of agriculture and agricultural technologies applied in the county.

Opinion leaders from the community, as well as other farmers, were selected in order to capture the variability of views towards agricultural technologies. The lead farmers were more informed and trained in agriculture and served as a resource in their communities by encouraging other farmers to attend agricultural trainings. In order to increase diverse opinions and generate a holistic representation of farmer views across the sub-counties, the inclusion of male and female discussants in each of the focus groups was important in being gender sensitive and sampling how technology may be perceived differently among males and females. Consideration of the gender

perspective was integral in understanding its role in the choice of technologies and its potential influence in household decision-making.

3.6   Focus Group Discussions (FGDs)

Focus group discussions elicit people's feelings and views about local opinions in an environment that enables them to delve into ways through which services or products directly affect them (Flachs, 2019). In the current study, the main aim of the FGDs was to obtain the farmer views of the agricultural technologies and agricultural extension services. Group discussions offer crucial group dynamics rather than individual opinions about issues pertaining to agricultural services and other elements that affect their live rural experiences. The FGDs were designed to provide in-depth attitudes and perceptions not readily discernible in survey data.

This data was collected from participants in Malava, Ikolomani, Mumia East (Shianda), and Lurambi sub-counties. They were conducted in different locations according to farmer preferences – in a church (Mumias East), in a large living room of one of the lead farmers (Lurambi), in an open field of a farmer's compound (Malava), and in a farmer's house (Ikolomani). A total of 28 discussants were recruited from four of the seven sub-counties included in the study. Survey participants were informed of a follow up phase of the study to explore further farmer perspectives of adoption. Potential participants were asked about their willingness to participate in that follow-up phase of the study.

3.6.1   Coding and Data Analysis

Once data was collected from all the focus groups, it was transcribed from Swahili to English by the researcher. The exploratory data coding method was selected for coding the data. In the coding process, the transcribed data was read and re-read in order to ensure that the codes were accurate and represented the message they contained (Saldaña, 2013). The framing of the research questions guided the coding process. The study sought to answer epistemological questions based on the deductive approach since they addressed the theories of knowing and sought to understand the phenomena of adoption of technology decisions. The research revealed themes related to the research questions the study sought to answer.

The researcher's code book identified themes derived from a systematic selection of common relevant themes that featured prominently in the focus group discussions. The selection of the most prevalent themes from the focus group data were also directly triangulated with the survey findings for comparison. After analyzing the text, the common themes from the data filled some of the gaps from the quantitative results, and some contradicted the quantitatie survey findings. The goal of comparing qualitative and survey findings was to provide further insight into farmer attitudes and perceptions towards the agricultural technologies.

The data triangulation approach and analysis permitted cross-validation and exploration of issues pertaining to the attitudes and perception of farmers towards agricultural technologies. Qualitative data was collected from focus groups, field notes and participant observations all of which converged to explain farmer perceptions towards technologies. Data triangulation facilitated identification of concerns and experiences of agricultural technology users. Triangulating between qualitative and qualitative phases of the research allowed for comparison of the findings and help enhance the reliability of the findings. The triangulation of datasets is critical in offering clarity to research studies and enhances credibility of study conclusions (Thurmond, 2001).

Positionality and reflexivity are necessary criteria for doing ethical and rigorous research in any field, particularly in the social sciences (Finlay, 1998). Exploring the critical moments of a researcher's positionality can be a complex ethical consideration that cannot be completely ignored as a cause of bias in research and forms a legitimate basis to question the type of knowledge created through research. As a Kenyan scholar conducting research among Kenyan smallholder farmers, the researcher's insider status was undoubtedly evident and likely to influence the data collection process and subsequent analysis of the data. However, the aim of any researcher is to ensure that the conducted research is valid, rigourous, and relevant (Finlay, 1998). The researcher's positionality in the construction of knowledge cannot be avoided. Throughout the research process, particularly focus group data, the researcher attempted to set aside his own attitudes and presuppositions of the research participants in order to obtain "objective" data and to make objective analysis. For the latter, the notes taken during the data collections helped in reducing any bias during the data interpretation phase.

Table 3.4 *The Framework of Mixed-Methods Research Design*

Method	RQs /Hypothesis	Variables	Instrument	Analysis	Measures & tests	Category	Theory
QUAN	H_0: Socio-demographic characteristics are not related to agricultural technology adoption. H_a: Socio-demographic characteristics are related to the adoption of agricultural technologies	Gender of HH DM /gender roles Education level **[Experience in farming]** Other income **Land size** **Access to credit**	Survey	Regression (Binary logistic model)	Descriptive statistics Wald test ML[parameter estimation] Hosmer-Lemeshow test & statistic	Demographic	
QUAN	H_0: Farmer access extension services are unrelated to agricultural technology adoption. H_a: There is a relationship between farmer access to extension services and agricultural technology adoption.	Inputs use [regularity?] Agricultural practices Uptake of technology Access to inputs Crops grown	Survey **FGD**	Regression (Binary regression model)	Frequencies Standard deviation SD Means	**Comm./Ext.**	**Adoption**
QUAL RQ1	What are farmer attitudes and perceptions towards agricultural technologies?	Attitudes, perceptions, knowledge of practices	FGDs	Thematic analysis	SD Means Covariance Chi-square	**Psychological**	**G. Theory**
QUAL RQ2	What cultural values/ factors influence farmer choice of technologies?	Cultural values/customs Time rationing [farming &off-farm], and gender	FGDs	Thematic analysis	Frequencies Standardized covariance	**Socio-cultural**	**G. Theory**
QUAL RQ3	What are the sources of accessing tech. information for farmers?	Info networks networks for tech access [common info channels]	FGDs/ Survey	Thematic analysis	Means Frequencies SDs	**Info. networks**	**Diffusion**

FGDs = Focus Group Discussions; Hyp. = Hypothesis; QUAN= Quantitative; QUAL= Qualitative; RQ= Research Question; SD = Standard Deviation

3.6.2   Framework of Research Design

RQs/Hypothesis	Phase	Procedure	Product
H_0: Socio-demographic characteristics are not related to agricultural technology adoption	**Quantitative Data Collection**	Cross-sectional survey (N=245)	Numeric data from regression Parameters
H_a: Socio-demographic characteristics are related to the adoption of agricultural technologies	**Quantitative Analysis**	Data screening Logistic regression model Frequencies SPSS software	Descriptive statistics
H_0: Farmer access extension services are unrelated to agricultural technology adoption	**Case Selection: Develop Focus Group Guide**	Purposive selection of: Focus group discussants Developed interview questions	Four Focus groups discussions [**Lurambi, Shianda, Malava & Ikolomani sub-counties**]
H_a: There is a relationship between farmer access to extension services and agricultural technology adoption .	**Qualitative Data Collection**	Administered FGDs Field notes Observations	Audio-data (interview transcripts)
RQ1: What are the farmer attitudes and perceptions towards agricultural technologies?	**Qualitative Data Analysis**	Data screening Frequencies SPSS	Code generation Identification and Analysis of themes
RQ2: What cultural values influence farmer choice of technologies? **RQ3**: What are the sources of farmer access agric. information and training? **Adopted from Creswell & Clark (2011)**	**Integration of Quantitative Qualitative Results**	Interpretation and Analysis of the quantitative and qualitative results	Discussion Implications Future research

CHAPTER 4.   RESULTS

4.1   Introduction to the Results Section

The central objective of this study was to explore the perceptions and attitudes of smallholder farmers towards adoption of agricultural technologies, with the long-term goal of identifying ways to improve the communication of agricultural practices and address food insecurity in western Kenya. The current study assessed the factors influencing smallholder farmer adoption of agricultural technologies in seven of the twelve sub-counties of Kakamega County, Kenya. To investigate the overarching objective of the study, a mixed methods research approach was applied. The initial phase of this inductive study was a quantitative survey of 245 smallholder farmers tested two hypotheses concerning the influence of socio-demographic variables and the importance of farmer access to extension services. This study hypothesized that: (H1) Socio-demographic characteristics are related to agricultural technology adoption; and, (H2) Farmers' access to extension services is related to agricultural technology adoption.

Subsequent to the quantitative survey, focus group discussion spanning four of the seven sub-counties included in the study were conducted to explore three specific research questions pertaining to farmers' perceptions and attitudes towards adoption of agricultural technologies. The four sub-counties were purposively selected and discussants were selected for representativeness and assumed knowledge of agriculture in the area. The qualitative segment sought to explore three research questions: (RQ1) What are the farmer attitudes and perceptions towards agricultural technologies; (RQ2) What socio-cultural values influence farmer choice of agricultural technologies; and, (RQ3) What are the sources of obtaining agricultural technology information for farmers?

The presentation of the results is in accordance with the inductive sequential research design – the quantitative survey findings are followed by the findings from the focus group discussions. In the discussion section, findings from both studies elicit a discussion of the implications of the role of extension education in the adoption of agricultural technologies in Western Kenya. The concluding section offers a summary of the findings along with the implications for future research in this area.

4.2 Quantitative Survey Results

The quantitative survey results have been organized into three main sections outlining the descriptive statistics; a principal component analysis; and a logistic model for hypothesis testing. The principal component analysis addresses (RQ1) the farmers' attitudes and perceptions towards agricultural technologies by reducing the 14 attitude and perceptions questions (see Appendix 1 question 22) from the quantitative survey into five principal components. Finally, the logistic regression model is discussed as well as findings from the two hypotheses to explore whether socio-demographic characteristics were related to agricultural technology adoption; and whether access to agricultural extension services positively influenced the adoption of agricultural technologies.

4.2.1 Descriptive Statistics

The descriptive statistics are organized into five sections, all of which capture the socio-demographic characteristics of the study area, namely: 1) the gender profile of survey participants; 2) the average cultivated land size across the seven counties included in the study; 3) the average years of schooling (by gender); 4) description of the average age of the respondents by sub-counties; 5) the on-farm and off-farm annual average household incomes of the participating households; 6) the role of social networks in the diffusion of best management practices; and 7) frequency of social group interactions.

4.2.2 Gender

Table 4.1 below provides a summary of the male and female participants in the study.

Table 4.1 *Gender Profile of the survey Respondents*

Gender	Frequency	%
Female	137	55.9
Male	108	44.1
Total	245	100

Note: Gender profiles include n=245, across seven sub-counties in Kakamega County, Kenya

The number of respondents in Table 4.1 does not presume gender as a determinant in the allocation of agricultural roles. On the contrary, the male and female respondents were randomly selected household heads willing to participate in the survey. However, culturally, in the division of household agricultural labor in Kenya, research has shown that women traditionally work on the farm while their male counterparts engage in wage employment (Lado, 1992). In most cases, women are responsible for tilling the fields, planting, and harvesting, in addition to other household chores while men mostly participate in off-farm activities whose cash earnings are channeled to support the on-farm activities.

The disproportionately large number of female respondents at home during the collection of survey data might have suggested that their presence in the homestead was for the reason of carrying out the household chores, as part of a normal routine, in addition to looking after their families. Culturally, in Kenya, the role of the woman in the home is split between the farm and the home. For instance, in many households, women and girls participate in chores such as looking for firewood and fetching water from nearby streams for cooking. Except in instances when they hold formal employment, women stay and work at home to raise their families.

4.2.3 Land

The average land size in the seven sub-counties of the study is less than three acres, which is typical of smallholder agriculture in many parts of Kakamega County (GOK, 2014). On average Lurambi and Khwisero were the only two sub-counties with an average land size of roughly three acres. The average landholding in other sub-counties was generally lower than three acreas. Land ownership qualified as an important asset capable of being used as collateral. However, the overall small land size was a basis for the county government's promotion of intensive agriculture in order to raise agricultural productivity and to compensate for the increasing population. In 2012, the county government introduced an input subsidy program to encourage and increase farmer use of new agricultural innovations, such as fertilizers and hybrid maize seeds, with the overall aim of improving the declining maize crop yields in the area (GOK, 2014). In spite of its inefficiencies, the Kakamega County Government continued to deliver subsidized fertilizer and hybrid maize seeds to farmers at half the market price.

The small farm sizes and the less intensive farming systems in the region contributed to low agricultural output, leading to low on-farm incomes and widespread household food insecurity.

The low agricultural output forced households to engage in off-farm income-generating activities to supplement their meager on-farm earnings. Off-farm income generating activities included: operating small businesses in nearby shopping centers, participating in formal employment, operating motorbike taxis or selling second-hand clothes in nearby flea markets (GOK, 2014).

4.2.4   Gender and Education

The average number of years of schooling for male and female respondents in the study area were relatively similar. The average education level among male and female residents averaged about 8.3 years of schooling. It has been suggested in the literature that investment in formal education in the rural areas is a central ingredient in the improvement of agricultural productivity (Lockheed et al., 1980). Going by that argument, a farmer with more formal education would be presumed to have better agricultural management skills than one who has less. Consequently, agricultural education and training could play a vital role among rural smallholder farmers, who represent a majority of agricultural producers in sub-Saharan Africa (Spielman et al., 2008). Aligning education with agricultural training systems may be an essential practice to increase knowledge sharing and promote the spread of new ideas and agricultural techniques among farmers.

4.2.5   Average Age

The average age of farmers across all counties was 48.4 years. In Mumias East (Shianda), Khwisero, Lurambi, and Shinyalu sub-counties, the average age is around 50 years. However, for research respondents in Ikolomani and Butere sub-counties, that median age averages around 40 years of age, implying a more youthful farming population. It is not evident from the general descriptive data if there is a direct correlation between the average age of the surveyed farmers and the level of agricultural productivity in their respective sub-counties.

4.2.6   Annual Average Household On-farm and Off-farm Income

The average annual household on-farm income across the seven sub-counties is low, less than 250 dollars per year. Of note, Mumias East (Shianda) and Khwisero had a relatively higher average annual on-farm income of about 500 dollars, potentially because these surveyed farmers

reported engaging in the growing sugarcane, which contributed to trending the average on-farm income upwards. The average annual household off-farm income was nearly 500 dollars annually in Khwisero, Malava, Ikolomani, and Shinyalu. The disparity between on-farm and off-farm income can be explained by the relatively higher incomes obtained from off-farm activities than the on-farm activities.

In summary, the socio-demographic characteristics highlighted in this chapter present a comprehensive overview of the study area. In general, the average marketed on-farm income of households was less than 250 dollars per annum, with slightly higher off-farm income. Compared to the average household sizes, these levels of income are not sufficient to guarantee food security or and improved livelihoods in the region. Additionally, the socio-economic conditions were weakened by the rising population in the region which appeared to drain the available resources.

4.3   Social Learning of Best Management Practices

Table 4.2 *Social Learning of Best Management Practices Among Farmers.*

Descriptive Statistics					
	n	Minimum	Maximum	Mean	Std. Deviation
Theory Training	245	0	9	5.98	3.943
Demo/Direct Training	245	0	9	5.82	4.090
Participatory learning Training	245	0	9	5.82	4.084
Farmer-2-Farmer Training	245	0	9	5.77	4.147
Planting Techniques	245	0	1	.93	.248
Crop rotation	245	0	1	.89	.314
Land preparation	245	0	1	.91	.292
Digging trenches	245	0	1	.88	.324
Simple processing	245	0	1	.18	.381
Agricultural marketing	245	0	1	.22	.413

The survey revealed that social networks were a common avenue of promoting best management practices among the rural farmers. These networks provided a platform for

exchanging best agricultural practices and encouraging social learning. If used effectively, good agricultural management practices have the potential to be the basis for strengthening agricultural production and productivity. However, their contribution to sustainable adoption of agricultural innovations was not immediately evident from the survey. The survey revealed that those farmers who were members of local social groups learned a number of practices. Table 4.2 provides a list of best management practices farmers learned through their networks.

4.4   Membership in Social Groups
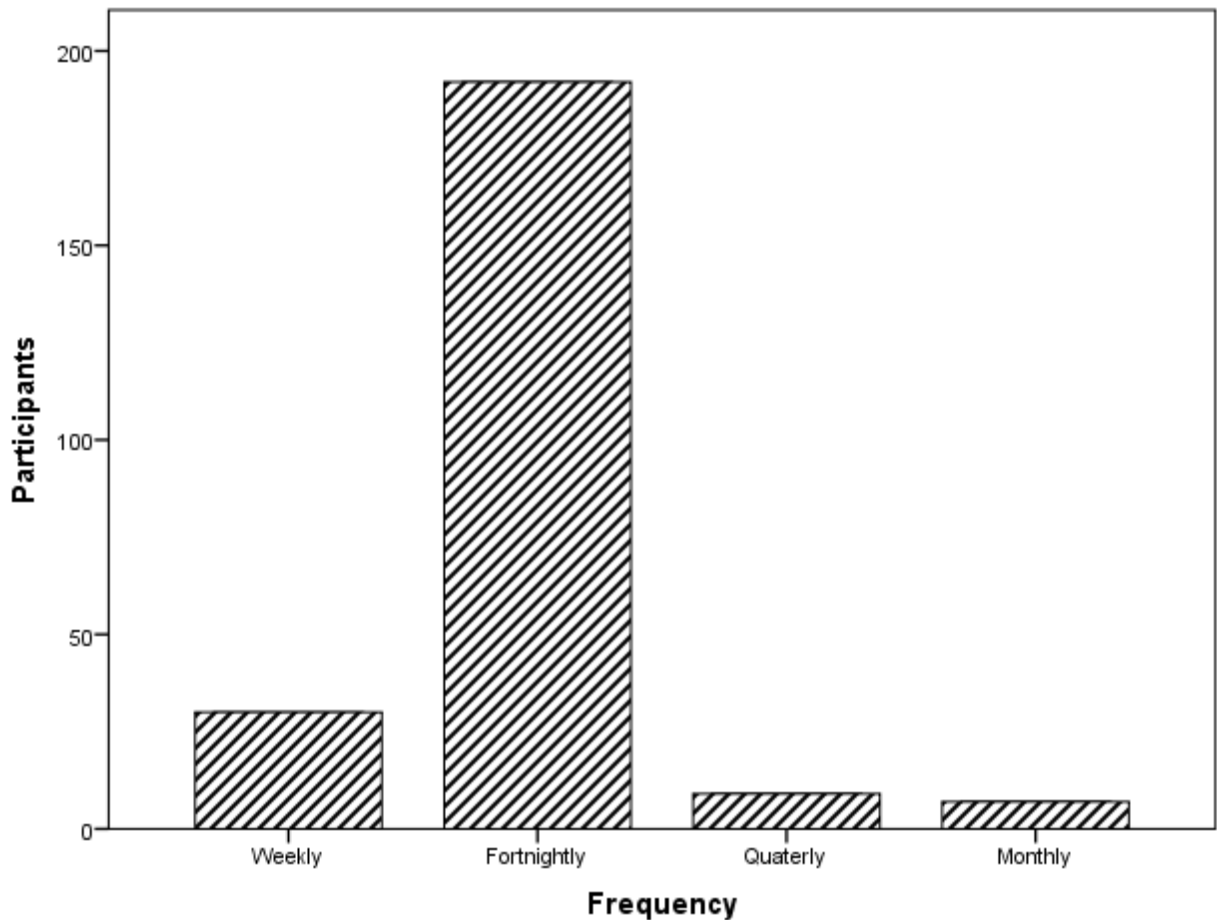
Figure 4.1 Frequence of social group meetings

Social groups were a common feature of social relationships in the surveyed rural farming households of Kakamega County. Farmers used these informal gatherings to regularly meet and

discuss issues related to their communities, particularly agricultural activities. Polled survey participants confirmed that they met quite regularly, forthnightly. The social gatherings of local farmers were not gendered; men and women gathered together to work on commonly agreed projects. Among the most common projects tices that they worked on was providing a support system, such as organizing merry-go-rounds that enabled farmers obtain the necessary inputs for the planting season.

4.5   Principal Component Analysis of Attitude Variables

The first research question (RQ1) explores farmers' attitudes and perceptions towards agricultural technology. To address this question a principal component analysis (PCA) methodology was utilized to reduce the 14 scaled survey questions (see Appendix 1 Question 22). As a data reduction technique, principal component analysis groups together variables that are correlated into principal components and simplifies analysis (Olawale & Garwe, 2010). These fourteen survey questions assessed farmer attitudes and perceptions towards agricultural technologies and evaluated their preferences towards agricultural technologies using a standard scaling approach.

Table 4.3 lists the fourteen survey questions which captured farmers' attitudes and perceptions towards agricultural technologies. The Likert Scale questions had five options ranging from strongly agreed to strongly disagreed. These survey questions sought to obtain a holistic view of people's opinions and their level of agreement with those statements.

Table 4.3 *Reference Table of Attitudes and Perceptions Variables*

	Variable description
ATT1	I experience challenges in accessing agricultural technology whenever I need it
ATT2	The use of technology increases effectiveness in my farm activities
ATT3	The use of technology saves me time in my farming tasks
ATT4	My use of the commercial inputs increases the quantity of output for the same amount of input
ATT5	The use of any new farming practices makes me popular among my peers
ATT6	Modern agricultural inputs are a plausible alternative to traditional agricultural production
ATT7	Modern agricultural practices influence my practice of agriculture
ATT8	I receive personal satisfaction from applying modern agricultural production practices
ATT9	I need the practice of new agricultural production techniques in our small agricultural practice
ATT10	I will continue to use new agricultural innovations even if the price can sometimes be prohibitive
ATT11	The main reason for using agricultural innovations is to increase my agricultural output
ATT12	I enjoy discussing about new agricultural practices currently promoted by the local extension services
ATT13	My farmer friends who use new agricultural innovations influence me to do the same
ATT14	I enjoy reading/listening about the different agricultural practices or technologies currently in use

The attitude questions were ranked in Table 4.3 below according to the mean scores. The statement with the highest mean represents the variable that most participants selected from among all the other attitudes statements.

Table 4.4 *Mean Rating of Attitudes Towards Agricultural Technologies*

	Variable	Mean	Standard Dev.	Skewness	Kurtosis
ATT9	I enjoy applying new agricultural techniques in our small agricultural farm	3.41	1.096	-2.069	3.407
ATT1	Challenges in accessing agricultural technologies	1.78	.932	.637	.474
ATT2	Effect of tech use performance of farm activities	1.64	.647	.408	1.708
ATT10	Influence of high costs to continued use of innovations	1.55	.925	.363	-.089
ATT3	Effect of tech on time as a resource	1.54	.604	-.488	-.235
ATT8	Level of satisfaction for application new practices	1.52	.739	.599	.994
ATT6	Modern agricultural practices versus traditional ones.	1.49	.782	.255	.702
ATT4	Effect of commercial inputs on output for the same inputs	1.48	.591	-.153	-.471
ATT7	Influence of modern inputs on agricultural practices	1.42	.646	-.037	-.239
ATT11	On the use of new agricultural innovations	1.41	.866	.477	.596
ATT13	Main reason for using innovations	1.36	.697	.038	.207
ATT5	Popularity among peers for improved farming practices use	1.30	.783	-.020	-.280
ATT14	Level of enjoyment from listening/reading about different technologies	1.29	.770	.145	-.055
ATT12	I enjoy discussing agricultural practices promoted by extension services	1.27	.836	.551	.686

Table 4.4 provide lists the ranking of the attitudes and perceptions questions based on the mean scores. The attitude/perception statement with the highest mean represents the variable that most research participants selected from among the other participants.

4.5.1   Principal Component Analysis

As a data reduction technique, principal component analysis was utilized to group together variables that were correlated into principal components and simplified analysis (Olawale & Garwe, 2010). The fourteen survey questions assessing farmer attitudes and perceptions towards agricultural technologies were evaluated using a principal component analysis technique (Table 4.5). The applied technique was used varimax rotation to reduce 14 attitudes variables to five clusters. These variables represented the attitudes and perceptions of farmers towards agricultural technologies. Bartlett's Test of Sphericity (BTS) and the Kaiser-Meyer-Olkin (KMO), which measured the sampling adequacy of the data was about 0.6, and was considered low but adequate as illustrated in Table 4.5 below.

Table 4.5 *KMO and Bartlett's Test*

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.574
Bartlett's Test of Sphericity	Approx. Chi-Square	549.151
	df	91
	Sig.	.000

The principal component analysis (Table 4.6) resulted in five clusters with Eigenvalues greater than one. The resulting cluster were analyzed based on the common themes, resulting in five components: modern agricultural technologies; effectiveness of agricultural technologies; enjoyment of agricultural technologies; social influence in use of technology; and experience with agricultural technologies. The factors and the associated loadings provided important insight into the data. The five principal components were:

1) I experience challenges in accessing agricultural technologies whenever in need (19.09% explained variance);

2) The use of technology increasing effectiveness in farm activities (11.88% explained variance);

3) The use of technology saves me time in my farming tasks (10.02% explained variance);

4) Effect of commercial inputs on output for the same input (9.47% explained variance); and

5) The use of new technologies makes me popular among my peers explained 8.13% of the

variance as shown in Table 4.6 below.

Table 4.6 *Principal Component Analysis Table*

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.673	19.093	19.093	2.673	19.093	19.093	1.870	13.355	13.355
2	1.663	11.880	30.972	1.663	11.880	30.972	1.847	13.196	26.551
3	1.403	10.024	40.997	1.403	10.024	40.997	1.761	12.582	39.133
4	1.325	9.466	50.463	1.325	9.466	50.463	1.389	9.925	49.058
5	1.138	8.131	58.595	1.138	8.131	58.595	1.335	9.537	58.595
6	.978	6.987	65.582						
7	.826	5.901	71.483						
8	.823	5.879	77.362						
9	.747	5.332	82.694						
10	.665	4.747	87.441						
11	.600	4.284	91.725						
12	.474	3.388	95.113						
13	.404	2.886	97.999						
14	.280	2.001	100.000						

Note: Extraction Method: Principal Component Analysis.

To justify retention of principal components with Eigen values of more than one, a scree plot is a key metric for visually identifying the components that can be retained based on Table 4.5. An alternative criterion of determining retention of principal components is through a Monte Carlo principal component analysis simulation conducted below.
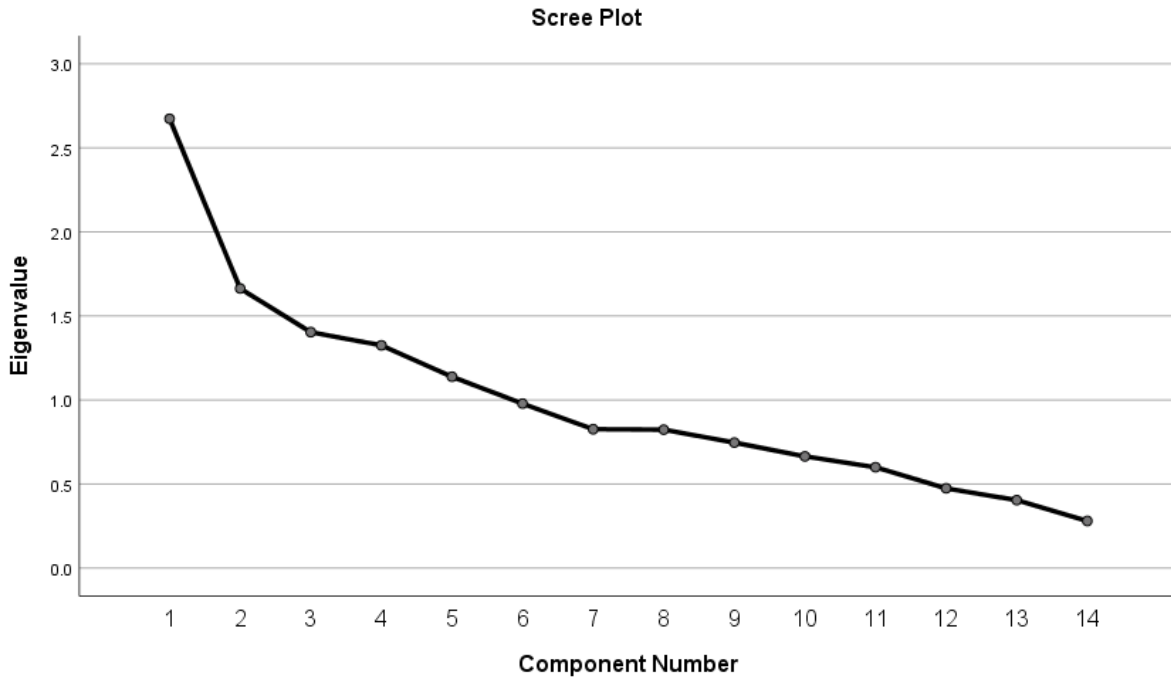
Figure 4.2 Scree Plot of Principal Components

A Monte Carlo principal component analysis simulation determined by comparing eigenvalues was conducted to determine suitability and retention of the components. Parallel analysis suggested that five factors in the scree plot met the computer simulated Monte Carlo test as illustrated in Table 4.7 below. The eignenvalues are the variances of the principal components.

Eigen values and scree plots were conducted on SPSS 24 (IBM Corp. Released, 2017) and the Parallel Test via a separate computer software - Monte Carlo PCA for Parallel analysis, a statistical method used to determine the number of components to retain. Table 4.7 confirms that the five components can be retained since the random eigenvalues for the first five components are less than the Eigen values in Table 4.6.

.

Table 4.7 *Monte Carlo PCA for Random Comparison Eigenvalues*

Number of variables: 14
Number of subjects: 245
Number of replications:1000

Eigenvalue #	Random Eigenvalue	Standard Dev
1	**1.4247**	**.0548**
2	**1.3796**	**.0395**
3	**1.2428**	**.0325**
4	**1.1776**	**.0299**
5	**1.1164**	**.0271**
6	1.0629	.0253
7	0.0112	.0232
8	0.9602	.0243
9	0.9093	.0247
10	0.8609	.0240
11	0.8108	.0258
12	07596	.0279
13	0.7053	.0296
14	0.6387	.0353

Comparable PCA Factors and Eigenvalues:

1. Modern agricultural technologies -   2.673
2. Effectiveness of agricultural technologies - 1.663
3. Enjoyment of agricultural technologies -   1.403
4. Social influence in use of technology -   1.325
5. Experience with agricultural technologies - 1.138

Table 4.8 illustrates the extracted factors and their associated loadings. The factor loadings table contains estimates of the orthogonal rotation using the varimax method – indicating that the extracted factors/components were not correlated.

Table 4.8 *Factor loadings of the Rotated Attitude Component Matrix*

		Components				
	Survey Question	1	2	3	4	5
6	Modern agriculture practices are a plausible alternative to traditional practices	**.743**				
8	I receive personal satisfaction from applying modern agricultural production practices	**.684**				
7	Modern agricultural practices influence my practice of agriculture	**.679**				
3	The use of technology saves me time in my farming tasks		**.786**			
2	The use of technology increases effectiveness in my farm activities		**.612**			.412
4	Effect of commercial inputs on output for the same inputs?		.524			
11	Main reason for using innovations is to increase agricultural output		.501			
14	Level of enjoyment from listening/reading different technologies/practices in use			**.714**		
12	I enjoy discussing new agricultural practices promoted by the local extension services			.559		
9	I need the practice of new agricultural production techniques in our small agricultural practice			.508		-.433
10	I will continue to use agricultural innovations despite high prices				**.733**	
13	Farmer friends influence me to use new agricultural innovations			.536	.541	
1	I experience challenges in accessing agricultural technologies whenever I need it					**.732**
5	The use of new technologies makes me popular among my peers					-.403

Note: Factors loadings in bold are considered reliable

Factors: 1. Modern agricultural technologies; 2) effectiveness of agricultural technologies; 3) enjoyment of agricultural technologies; 4) social influence in use of technology; and 5) experience with agricultural technologies.

Table 4.9 *Reliability Analysis of Attitude Variables*

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	Number of Items
.590	.631	14

The Cronbach's α which is 0.6 may be rated as poor but acceptable for exploratory research. One of the possible reasons for the low statistic could be associated to the number of items in the scale. If there are about 10 items in a scale, the Cronbach's Alpha tend to be lower than 0.7, but greater than >0.5. For exploratory research, the Cronbach Alpha (α) reliability value of 0.60 is acceptable.

4.5.2 Combined Findings from Principal Component Analysis

Table 4.8 illustrates the principal components and the associated factor loadings, representing the items that load together to the five retained clusters. The first component was labelled "preferences of modern technologies over traditional practices" and had a loading of 2.67 and explained 19.1% of the variance in technology adoption. This component consists of three items namely: approval of new technologies over traditional farming techniques (.743); personal satisfaction of innovative agricultural practices (.684); and the influence of agricultural practices on farmers' agricultural experience (.679).

The second component – technical efficiency gains from agricultural technology application - had an Eigen value of 1.67 and explained 11.88% of the variance. The four items defining this category were: The use of technology saves farmers time in their tasks (.786); technology use increases effectiveness in my farm activities (.612); technical efficiency (.524); and role of innovations in increasing agricultural output (.501).

With an Eigen value of 1.40, the third component – enjoyment of agricultural technologies and reliance on social networks in sharing new practices – has three factors on the list namely: level of enjoyment from listening/reading different technologies/practices currently in use (.714); I enjoy discussing new agricultural practices promoted by the local extension services (.559); and I need the practice of new agricultural production techniques in our small farm (.508).

The fourth component – effect of commercial inputs on outputs for the same amount - had

an Eigen value of 1.32 and explained 9.47% of the variance. The two items defining this component are: continual use of agricultural innovations irrespective of the cost (.733) and the influence of farmer friends in the use of new agricultural innovations (.541). This component represents the inspiration that farmers derive from using of agricultural technologies and reflect farmers' attitudes and likelihood to use agricultural technologies in the future and captures potential future attitude towards a particular agricultural technology.

The last component has an Eigen value of 1.14 and a percentage variance of 8.13. There are three items in the component namely: experiencing challenges in accessing agricultural technologies (.732); the use of technology increases effectiveness in farm activities (.412); the use of new technologies makes me popular among peers (-.403); and I need the practice of a new agricultural production technique in our small agricultural practices (-.433). Two of the loading for the fifth component have negative factor loadings, implying a negative correlation.

In summary, a principal component analysis was conducted in order to group together variables that are correlated into principal components and simplify the analysis (Olawale & Garwe, 2010). The five components that were identified in the analysis included: 1) I experience challenges in accessing agricultural technologies whenever in need (explained 19.09% of the total variance); 2) the use of technology increasing effectiveness in farm activities (11.88% explained variance); 3) the use of technology saves me time in my farming tasks (10.02% explained variance); 4) effect of commercial inputs on output for the same input (9.47% explained variance); and 5) the use of new technologies makes me popular among my peers explained 8.13% of the variance. These components were then utilized to inform the hypothesis testing.

4.6 Logistical Regression and Hypothesis Testing

This section reports the plausibility of two claims about agricultural technology adoption among smallholder farmers in Kakamega County, namely:) socio-demographic characteristics are related to agricultural technology adoption (H1) and farmer access to extension services is related to agricultural technology adoption (H2). To investigate these claims, a logistic regression model was estimated consisting of socio-demographic explanatory variables and the highest correlated factor loadings from three first principal components in Table 4.8.

$$ADOPT = \beta_0 + \beta_1 Age + \beta_2 Gender + \beta_3 Edu + \beta_4 \%OffFarmInc + \beta_5 Ext + \beta_6 GrpMem + \beta_7 HHSize +$$
$$Loading1 + Loading2 + Loading3 \qquad (6)$$

The first step includes the estimation of the binary logistic model in equation 6, consisting the variables presumed to influence agricultural technology adoption. To determine the suitability of the regression, the variables are validated by the proportional odds assumption test ($\chi2=10.47$; $p=0.23$). The model summary in Table 4.10 represents the predictive capacity of the regression model.

Table 4.10 *Logistic Model Summary*

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	112.803[a]	.604	.805

The estimated logistic regression model in Table 4.11 indicates that controlling for all other variables in the model, independently age, education, and the percentage share of off-farm income of total income suggest a relationship with the adoption of technology.

Table 4.11 *Logistic Regression of Factors Determining the Adoption of Agricultural Technologies*

Variable	β	S.E.	Wald	df	p-value	Exp (β)
Gender	.406	.576	.498	1	.481	1.501
Age	.028	.016	3.237	1	.072**	1.029
HHSize	-.083	.087	.922	1	.337	.920
Education	.102	.062	2.758	1	.097**	1.108
%OfffarmInc	2.095	1.200	3.049	1	.081**	8.122
Extension	.004	.005	.655	1	.418	1.004
Effect of Tech on time	.009	.407	.000	1	.983	1.009
Modern viz a viz traditional	.079	.331	.057	1	.811	1.082
Enjoyment	.164	.327	.253	1	.615	1.179

** significant at 90% confidence level

The regression model in Table 4.11 provides a summary of the regression output consisting socio-demographic variables and the highly correlated factor loadings obtained from the first three

retained principal components. The latter were presumed to represent farmer intent to adopt a technology.

4.6.1 Hypothesis 1

The logistic regression model in Table 4.11 has three variables at the 90% level of confidence. The model illustrated that controlling for other demographic variables, age (.07), education (.10), and percentage share of off-farm income of total income indicated a relationship with agricultural technology adoption. These results also signified that the percentage share of off-farm income of total income had the highest odds ratio (8.12).

The variable education was statistically significant (.10) at the 90% confidence level. The odds ratio of adopting a technology was 1.11 times higher for a one unit increase in the education of the household head. This finding suggested that acquiring higher education predicted the probability of the household head opting to adopt an agricultural technology. In the literature, formal education has been found to lead to positive agricultural development, such as improved agricultural management practices and better decision-making at the farm-level (Lockheed et al., 1980).

These socio-demographic variables, particularly education, have been found to lead to better management of and informed decisions regarding technology (Nyanga, 2012a). In the current study, however, the influence of age on technology adoption suggested that as a farmer grows older, they were likely to adopt a technology, particularly if the farmers had been practicing agriculture and gained experience.

The percentage share of off-farm income of total income variable was statistically significant (.08) at the 90 % confidence level, suggesting that a one unit increase in the percentage of off-farm income increased by 8.12 times the likelihood of a household falling into the agricultural technology adoption category. The variable had a positive standardized β weight indicating a positive predictive capacity on the binary dependent variable, adoption of technology. This implied that households that had a larger share of their income earned from off-farm activities were more than eight times likely to invest in agricultural technologies; presumably due to access to income that allowed them procure agricultural technology.

The first hypothesis in the study was supported at the 90% confidence level for socio-demographic characteristics of age, education, and percentage share of off-farm income of total

income as key variables that predicted the probability of a household's likelihood to adopt an agricultural technology. Age and education particularly resonated well with other studies in the literature (Asfaw, Kassie, et al., 2012; Asfaw, Shiferaw, et al., 2012; Nyanga, 2012a).

4.6.2 Hypothesis 2

This second hypothesis tested the association between agricultural extension and agricultural technology adoption. The predictive probability of agricultural extension influencing the adoption of an agricultural technology was found to be statistically insignificant (.42). This signified that accessing agricultural extension did not statistically influence the probability of a households falling into the adoption group. This result contradicted other findings in smallholder farmer agricultural literature that conclude that access to extension is often associated with adoption (Pan et al., 2018), a study which suggested that farmers were more likely to adopt technology when they had access to extension. In the current area of study, however, infrastructural challenges may have prevented the smooth delivery of extension services to local farmers.

4.6.3 Role of Attitudes in Technology Adoption

Three attitude variables selected from Table 4.8 were regressed along with the other socio-demographic variables in the binary regression model. The attitude variables were included in the regression to assess their relationship with agricultural technology adoption. However, none of the included attitude variables were found to be statistically significant in their relationship with technology adoption.

In summary, consistent with hypothesis one (H1), the logistic regression found that, controlling for all other variables in the model, the percentage share of off-farm income of total income; education; and age showed a relationship with agricultural technology adoption. However, expressed attitudes towards agricultural technology did not indicate a statistical relationsh with adoption. In testing hypothesis two (H2), if farmer access to extension services is related to agricultural technology adoption, the results suggested that the hypothesis was not supported in the model.

4.7   Qualitative Analysis of Factors Related to Technology Adoption

The main goal of this exploratory study was to assess the attitudes and perceptions of smallholder farmers towards agricultural technologies in Kakamega County, Kenya. The study combined quantitative and qualitative approaches in the research inquiry. In the study, two hypothesis were tested and quantitative results suggest that socio-demographic variables, mainly age, education, and gender; were positively significant in their relationship with agricultural technology adoption. Access to agricultural extension, presumed important in the promotion of information and training, was not supported in the logistic regression model.

The qualitative analysis was conducted after collecting focus group discussion data to provide an indepth analysis of the issues that emerged from the survey instrument. Applying a deductive approach, the qualitative phase of the study sought to focus on three research questions: What are the farmers' attitudes and perceptions towards adoption of agricultural technologies?; what sociocultural factors/values influence farmers choice of technologies?; and what are the sources for accessing agricultural technology information for farmers?

Some of the socio-demographic variables that were measured in the survey were not of greatest concern to the farmers. For instance, gender or education were not issues that farmers considered of significance to them until they were raised during the focus group discussions. Perhaps, access to training on new agricultural trechnologies was of greater importance in their practice of agriculture. Farmers were more concerned about the quality of the services that they received from the agricultural extension providers. Since the focus group discussions were guided by the researcher, other issues of less interest to the farmers became necessary to discuss.

4.7.1   Focus Group Findings

Focus group discussions were conducted across four of the sub-counties surveyed. Three main research questions guided the focus group discussion, (RQ1): What are the farmers' attitudes and perceptions towards agricultural technologies; (RQ2): What socio-cultural values influence farmers choice of technologies; and (RQ3): What are the sources for accessing agricultural technology information by farmers?

4.7.2 Themes

Several themes were identified in the analysis of the focus group data. The selection of the codes was guided by the research questions the study sought to answer. The selected codes were centered around agricultural technologies, experience with common technologies and practices, farmer experiences with agricultural extension agents, and interpersonal relationships among the farmers. The theme identification and selection process was designed to directly respond to the research questions and they were selected from the coded data. Consequently, six main themes were:

1) Farmer ambivalence about agricultural technologies

2) Lack of trust in agricultural agents

3) Predominance of gender in determining agricultural technology adoption

4) Extension continues as the main source of agricultural information and training

5) Level of agricultural technology knowledge

6) Gender inequity in agricultural decision-making

Table 4.12 *Major Themes Indentified in Focus Group Discussion of Technology Adoption*

Themes	Definition	Exemplars
Farmers ambivalence about agricultural technology	Agricultural technology as a source of advantages and disadvantages at the same time	Farmers citing the direct benefits/ risks of technologies and adulterated seeds, pesticides, and fertilizers "Agrovets go on marketing poor farm inputs that fail to perform…" ".. the new maize variety is a good example of the certified seed and its working well in this zone. Most farmers in this zone are really happy with this because it has resulted in an increase in output."
Lack of trust	Absence of trust on technology and the agents who delivered the services	Failure to follow agricultural guidelines provided by extension agents (public and private) Withdrawal from using the marketed technologies "..Another problem with extension officers is that they keep on promising to serve us, but they fail to turn up" "Moreover there are some crop breeds that are being marketed by the extension officers. We have been trying to apply them over a long time, but they have not been productive. Some of us are now tired and we are now trying to avoid them"
Prominent role of gender in technology adoption	Male household head as main decisionmakers due to prominent cultural values	Male/husbands decided the types and amounts of inputs to use during a given season. "…you may want to apply a certain fertilizer on the farm, but the man may reject the idea for fear of loss of soil fertility. So, this forces us to farm without using fertilizer on our farms"
Extension as main source of information and training	Agricultural extension as the main channel of communication information and training among rural household	Primary source of obtaining agricultural information "Extension officers do visit us most of the time for advice and training. These officers rake their time to teach us new farming techniques"
Limited knowledge of agricultural technology and practices	Farmers exhibiting limited knowledge of what they could do with agricultural technology and practices	Unaware of how to use some of the inputs "…..as Malava farmers, one challenge we are facing is a lack of awareness of agricultural information. No one is concerned with the idea of farmers being educated on the new ideas…" "..Farmers have not been educated on the benefits of using certified seeds"
Gender inequity in agricultural decision-making	Cultural norms of male decision-making	"Generally, the man is known to be the key decision-maker at home. Sometimes, as women, we may have certain opinions but men turn them down because they are the owners of the land".

The selected themes from the focus group data were analyzed to address the three qualitative research questions: (RQ1): What are the farmers' attitudes and perceptions towards agricultural technologies; (RQ2): What socio-cultural values influence farmers' choice of technologies.

The third qualitative research question explored the role of extension in information dissemination about technology adoption by addressing, (RQ3): What are the sources for accessing agricultural technology information by farmers? Findings from this analysis are discussed below.

4.8   Research Question 1

The first research question (RQ1) explored the attitudes and perceptions of smallholder farmers towards agricultural technologies. An emerging theme related to this question captured mixed farmer views toward agricultural technologies. Some of the farmers spoke highly of the benefits of using newer fertilizers and hybrid seeds while others entirely doubted the effectiveness of the inputs. About 20% of the discussants expressed their suspicion of the sources of the inputs, particularly the hybrid maize seeds. The participants shared their experiences with adulterated seeds, which they purchased, but never germinated. The general feeling of ambivalence about these agricultural technologies was observed across all four focus groups. Even when these new technologies (seed varieties) were sourced from agricultural extension service providers, the farmers had to confirm if they were still effective, as captured in one the focus groups, " *...alot of seed varieties have been brought to us by extension officers. What we do is try them out first before making them our priority. We've been trying out several varieties but still, opt western seed 614 and 6213...*". Ordinarily, information sourced from agricultural extension providers would be expected to be reliable, but farmers sometimes questioned the inputs, indicating that they never trusted their source.

Overall, the farmers expressed broad economic interest in using agricultural technologies in their farms. To improve the productivity of their crops and to harvest enough output to feed their families and sell any surplus in the market, they expressed openness to using inputs that could lead improved yields. The perpetual importance of agricultural technologies was unequivocally pervasive across the focus groups. In the **Malava** sub-county focus group, one male discussant expressed his overall interest in the use of post-harvest loss prevention technology as an example of the available storage technologies introduced in his village. He also mentioned some of the other technologies commonly promoted in the sub-county by public and private extension agents, such

as maize humidity testers and different fertilizers. He acknowledged, *"So, I think using the PICs[1] bags is a very effective storage means for us and can save us losses".* The enthusiasm expressed by that participant appeared to be an indication of the potential for adoption of this storage technology. Similarly, there was clear unanimity on the benefit of that cereal storage technology from the other members of the group who were using the PICs bags for storage. This prompted the lead farmer, who hosted the focus group in her compound, to bring out the PICs bags she used for storing her grains.

When discussing the current technologies in the market, improved fertilizers and hybrid seeds were regularly mentioned in the focus groups. These two inputs were regularly promoted by the local agricultural extension agents because these technologies were used in growing maize. In the Kakamega area, households mainly planted maize bi-annually as a staple crop for household consumption. Beans were intercropped with maize as a common practice due to the limited land size in the area. In addition to growing the maize cereal and other legumes, farmers planted vegetables during the maize off-season. However, some farmers left their fields fallow as an effective way of minimizing the invasion of weeds.

In addition to the expressed economic benefits of using modern agricultural inputs in their farms, the farmers provided a variety of reasons for enjoying farming as an activity and the additional benefit of agricultural technology to yield improvement. A female farmer from the **Shianda** sub-county expressed her pleasure in agriculture, *"On my side, I enjoy farming a lot. I mostly plant on large scale and vegetables on a small-scale. I have been renting land, mainly to plant maize and this has really worked well."* Farm output contributed to family food needs and growing cereals or horticultural crops was preferred to buying food from the market. Effective use of agricultural inputs in the farms had important positive benefits for the households.

Even with the clear benefits of farmer use of improved inputs in their farms, discussants in **Malava** and **Ikolomani** sub-counties expressed some of the challenges they faced regarding the marketed agricultural inputs. The rising cases of adulterated technologies came up over seven times across the four focus groups. In each of the four focus groups, the complaint of adulterated inputs appeared in 6.4% of the codes pertaining to farmer agricultural challenges. A full-time

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[1] Purdue Improved Crops Storage (PICs) bags are a brand of storage bags that are available for cereal farmers in many parts of the world.

farmer participating in the **Lurambi** sub-county discussion captured one of the reasons why the farmers were not fully satisfied with the new technologies:

> Farmers have realized that there are some seed varieties that are a target of the invasive pests attacking maize. Sometimes, farmers feel that these people who come up with new technology have some of those technologies untested, but still introduce them to farmers. That is why there are challenges even with these technologies. Farmers are even afraid to use those new technologies and would prefer to use farming techniques that they trust.

The foregoing statement suggested that farmers were aware of the technologies that worked for them and those that were ineffective. The experience of this farmer emphasized the need for greater control of the quality of products publicly marketed.

As long as agriculture remains the main source of income, farmers will continue to rely on current and future technologies and practices to increase crop yields. The ease of use of certain practices, and the farmers' familiarity with them were important determinants in their preferences of some practices over others. Some farmers found planting with a rope efficient and useful for keeping plants in a straight line. Others found limited tillage and no-till as a "non-traditional" practice; consequently, they did not accept these practices because they did not conform to their conventional farming practice. The primary reference point for the new practices in general was the apparent familiarity with the most common technologies; those that worked well and the ones that didn't. In the discussion groups, participants identified the variety of hybrid seed types that they planted on their farms, implying that they were well acquainted with them.

Positive views of the new technologies appear to have started to influence other farmers into taking a leadership role to popularize those agricultural practices that were successful in other areas of the county. One lead farmer from the **Ikolomani** sub-county, who appeared very experienced with the agricultural technologies that had been successful in Kakamega County, had begun to promote these new practices in his sub-county by forming an organization to raise awareness of the new farming practices:

> In response to that, colleagues, I have formed an NGO whose aim is to promote the use of farm inputs in this area. This team trains farmers within the sub-county of Malava. We even had the last training yesterday. The team brought in some certified seeds that had failed to germinate earlier on but are now productive. Generally, I think the measures taken by this group are working. Earlier on, I was

not even aware of a variety of farming ideas but with the group, I am now aware. The new maize variety is a good example of the certified seed and its working well in this zone. Most farmers in this zone are really happy with this because it has resulted in an increase in output.

This quote is a clear indication of the inefficiency and failure of the local agricultural extension system to delivery services to the smallholder farmers of Kakamega County. Farmer failure to receive help from the local agricultural extension is demonstrated by the initiatives they were making to find farming practices that were effective to them.

The perception of risk also appeared to influence farmers' attitudes towards new technologies, particularly regarding new and unfamiliar ones. Focus group parcipants were comfortable with using the seeds they saved from the previous planting season or using animal manure instead of commercial fertilizer. The rise in the incidence of adulterated inputs in the market reinforced their perception of risk, and subsequently influenced them to use inputs they were familiar with rather than using new ones, whose effectiveness they didn't know. In **Shianda** and **Lurambi** sub-counties, discussants blamed the Kakamega County government for its failure to curb the spread of adulterated inputs, especially hybrid seeds. In their view, the absence of quality control regulations in the county was contributing to the spread of uncertified inputs, thus costing farmers a lot of money. According to a farmer from **Shianda** sub-county, agricultural risk influenced farmers' attitudes towards new farming practices:

> Currently, it is very difficult to differentiate between real seeds and fake seeds. There are a lot of businessmen out there who only need money and do not care about farmers. They go on selling fake seeds to us. This really costs us and compromises the yield that we received from the farms. This is also a challenge most farmers face. Coming to that I think farmers should buy seeds from the extension officers and not the hawkers.

In spite of the clear benefits of new technologies and the potential to raise yields, farmers reported that they did not receive adequate training to facilitate the application of new agricultural practices. The lack of information and adequate training came up regularly during the discussions. The failure to deliver necessary information and training was seen as a result of an inefficient public extension system. A female discussant from **Lurambi** sub-county had the following thoughts regarding the role of information and training:

> Most of the farmers have not been educated on how to use these herbicides. They are not even aware of most of the types of fertilizers available. So, these companies should actually visit farmers and provide farmers with training and information on

how to use those herbicides. For example, there are these common pests called *kwekwe* … they can be well controlled by the present herbicides. Herbicides have really enabled farmers to save on costs. Previously, farmers have been employing workers to weed their crops to control pests. This has really been costing farmers.

In general, farmers were willing to apply existing technologies in the market, but there were several obstacles preventing access to these technologies. Carefully, evaluating the discussion groups, local farmers were generally interested in technologies that were available to them. One farmer from **Ikolomani** sub-county said, "*Are you aware of PICs bags? They are really good when it comes to storing maize. PICs bags are not easily destroyed by the rats in the store. In my home, we really benefitted when the maize prize shot up. We stored our maize and when the prizes went up, we made a good profit.*" Another farmer from a focus group in **Malava** sub-county echoed the same message, "*So, I think using the PICs bags will be a very effective storage means for us.*" Some farmers were well aware of the differences in yield between those who applied new technologies in their farms and those who did not. For one **Lurambi** sub-county farmer, the benefits of practicing minimum tillage and normal tillage were captured in her views about the practice:

> When you compare the farmers who till their farms and those who do not practice no-till, you notice the difference. You will find that the maize planted using that system of minimal tillage and those who till their farms normally, you will notice a difference. The performance of crops that are planted under no-till conditions do better than those that are planted on normal tillage. Those are the current farming practices that we see in our area.

Overall, in assessing the attitudes and perceptions of smallholder farmers towards agricultural technologies in Kakamega County, Kenya, the positive attitudes expressed by the discussants was an indication their willingness to try some of the new practices in the market. However, this willingness appears to be tempered by lack of trust in those who supply new technologies, and in governments to pass regulations to protect farmers from purchasing adulterated products. In spite of the challenges the farmers faced, there was a strong interest to trying new practices. Several farmers were trying some of the new inputs in their farms in spite of the prevailing challenges.

The lack of informed knowledge of agricultural technologies was a common theme integral in informing farmer attitudes and perceptions towards their adoption. The ratio of agricultural extension educators to the farmers did not make the situation better and may have contributed to

widespread lack of adequate information. In **Ikolomani** sub-county, this situation was expressed by a participant who candidly stated the situation in his area, "I *think farmers lack proper education on the new farming techniques….*". The same farmer complained of the limited number of agents deployed to work with farmers in the sub-county. As the main information diffusion channel, extension services did not reach the most remote parts of Kakamega County. Consequently, the lack of access to information may have contributed to farmers' attitude formation about agricultural technologies.

Overall, the main themes that stood out from the analysis of farmer attitudes and perceptions of agricultural technologies included: farmer ambivalence towards agricultural technologies; lack of adequate knowledge of agricultural technologies; and limited trust of the technologies the farmers were encouraged to use in their farms. The latter theme was embedded in farmers' of lack of trust in the agents who promoted the inputs they marketed to the farmers. Withdrawal from using some of the technologies supported the claim of trust that many farmers expressed in the discussion groups.

The themes identified in this section enlighten the views of farmers and their justification for those views. It allows them to provide examples of lived experiences with agricultural technology in their farms. As a tool of delving deeper into the question of attitudes towards technology, the focus group methodology provided an opportunity to bring out information that filled the gaps that survey analysis was unable to capture. Besides complementing survey analysis, the qualitative approach allowed a convenient way to study abstract variables, such as attitudes and perceptions, whose understanding requires research participant engagement beyond short responses asked in the survey questionnaires.

4.9   Research Question 2

The second research question (RQ2), asked what socio-cultural factors/values influence farmers' choice of technologies were. In answering this question, the only emerging issue that was prevalent and that represented a socio-cultural value was related to the role of gender within agriculture. The long-standing social practices and attitudes towards women was a central feature in influencing the type of technology households could choose to apply on their farm. Women are typically considered to be subordinate to their husbands and must always consult their husbands in decision-making. In some cases, their husbands had the final say in household matters. In the

Mumias East (Shianda) and **Malava** focus groups, male household heads made decisions on the type of technology to use in the farm. Husbands were the main decisionmakers in the household and they needed to be regularly consulted even if they never directly worked in the farm.

In many households in Kenya, men also hold legal ownership of land and cultural practices still prohibit women from inheriting land. Men have used that legal prerogative to decide the type of technology to adopt during a particular season. Even with the recent constitutional reforms that included women as rightful inheritors of land (Republic of Kenya, 2010), it was still a common cultural practice for male household heads to overrule their female counterpart simply because they were not culturally considered the rightful inheritors of land. In **Shianda** sub-county, this cultural tendency was clearly expressed by one of the female discussants who said:

> …in cases where a man is a dominant farmer, he automatically becomes the decision-maker. Generally, the man is known to be the key decision-maker at home. Sometimes, as women, we may have certain opinions, but men turn them down because they are the owners of the land.

It was also evident from the discussions that women traditionally played a less superior role in the decision-making within the household. Many of the women participants indicated, and their men counterparts admitted, that the men owned the land, hence they determined the type of practice to be adopted within that land. The male participants, however, neither denied the practice nor admitted if it was right or wrong. When such topic was raised, the men remained silent or agreed. That role could not be questioned, as one female participant from **Shianda** sub-county expressed her sentiments:

> There is a case where the woman is in charge of agriculture in the household. So, she is the one to make decisions. On the other hand, in cases where a man is a dominant farmer, he automatically becomes the decision-maker. Generally, the man is known to be the key decision-maker at home. Sometimes, as women, we may have certain opinions but men turn them down because they are the owners of the land. Also, men usually have adverse plans on lands and that is why they are the heads of our homes. For example, you may want to apply a certain fertilizer on the farm but the man rejects the idea in the fear of loss of fertility as a result. So, this forces us to farm without using fertilizer on our farms.

The foregoing statement captures a key cultural value influencing technology adoption among smallholder farmers. The role of land ownership was dominant in the adoption decision even if the man did not directly work on the farm. In fact, it was clear that most of the men worked off-farm, but they still wielded their cultural position for dictating what happened on their farms.

The cultural value of male dominance within the household can be interpreted as barrier to agricultural development.

In answering RQ2, the theme of gender featured as a clear hindrance to agricultural technology adoption. Female members of the household played a subordinate role; often relying on their husbands for approval of the technology choices to use the farm. The cultural norms of women in the household not being able to make decisions on farm practices and technologies appeared to be a hindrance to agricultural technology adoption. The role of lived experiences of gender in determining access to education or income is an issue that was not directly investigated in the current study. However, many rural communities have made progress in the "liberation" of women. Women hold positions of responsibility in society and have relatively equal access to education. Most of the women engaged in smallholder agriculture are have limited education, which limits any options open to them.

4.10 Research Question 3

The third research question (RQ3), asked, what are the sources for accessing agricultural technology information by farmers? This question explored how farmers received information and training in farm practices. The qualitative data affirmed that farmers predominantly obtained information through public or private extension services. Radio or television were not the most common information communication channels for obtaining agricultural information. Discussants in all the focus groups concurred that many radio channels aired non-agricultural content making it an uncommon source of information. Rural farmers rarely owned a television, making it a less accessible channel of information on farm practices. Instead, the agricultural extension agent was the most prominent communication channel identified by the research participants for obtaining information about agricultural practices and new technologies. However, most of the farmer participants expressed their reservations about the role of extension service providers. Maria, a middle-aged farmer, expressed her dissatisfaction with extension officers, *"Some of the public extension officers are not very friendly to us"*. Another focus group discussant expressed similar reservations towards private agricultural extension agents:

> …they provide us with farm inputs, but when the harvesting period comes they are already on our necks demanding for their money. When we make losses, we are forced to pay them out and face the consequences. So, most of us try to avoid the

private extension services because of that. I think the government should provide us with its own extension officers who focus on providing services to us. Another problem with the present extension officers is that they keep on promising to serve us but they fail to turn up.

The quote above represents the experiences of farmers in interacting with private agricultural extension, which is considered to be relatively efficient form of extension compare to the public one. The private extension service also extended loans to farmers at the beginning of the planting season, but the manner in which they recovered their loans was not approved of by many farmers, particularly those who had limited financial options.

Except for a few farmers who could afford private extension services, most farmers relied on public extension services for their agricultural information and training. There was a general inclination for farmers to perceive public extension services as being largely ineffective and resented. The public extension officers were deemed slow to act and rarely visited the farms; the farmers identified that the extension educators largely remained in their offices, yet they still drew a salary. Many focus group discussants expressed their lack of trust in these agents due to their poor handling of farmers, and their apparent lack of interest in farmers' agricultural concerns. Wafula, one of the farmers in the **Lurambi** sub-county focus group shared his frustration with agricultural extension personnel, both private and public:

> The problem with the agricultural extension officers is that they have made the offices their own. Yet, they are paid every month to serve the people of this area. Some of them go to the office whenever they feel like it, 11 am or later. Even when farmers visit the extension offices, they cannot find the help they need. Maybe you want to plant and you need advice from the agricultural extension office. On the part of One Acre Fund, the extension officers that they deploy are not enough to service this area. For example, during the planting season, every farmer needs guidance or advice. The deployed officers are not enough to service a large number of farmers. As a result, some farmers choose to plant without seeking advice from agricultural extension personnel.

The foregoing quote captures the lived experiences of farmers with the public extension services. The extension system in Kenya is supposed to be demand-driven – whereby farmers would seek services whenever they needed them. The frustration among farmers, as the quote states, is that the agricultural extension services were not available even when the farmers needed them. As a result, they did not see the need to approach the extension personnel even when they needed their advice.

Undoubtedly, from the group discussions, farmers believed that agricultural extension is an important source of information and training for them. Discussants agreed in various ways that agricultural extension served a crucial role to farmers by providing critical information and inputs. Nevertheless, the discussants complained of the lack of agricultural agent interest in farmer issues as evidenced in agent distancing from the farmers they were supposed to serve.

In summary, in the analysis of the focus group data, five major themes corresponding to the study research questions were selected. Regarding the attitudes and perceptions of smallholder farmers (RQ1), farmer ambivalence about agricultural technologies was a predominant theme associated with prevailing views and opinions among the discussants. While the benefits of agricultural technologies were evident, it was also evident that farmers had issues with technology in general, particularly due to the increase in the marketing of adulterated seeds and fertilizers. In assessing the contribution of socio-cultural values towards agricultural technologies (RQ2), it was evident from the data that men dominated decision-making in the choice of agricultural technologies among households. The issue of gender remains predominant in who made decisions on the choice of technologies. The dominant role of men in the decision-making process prevented women from making any technology choice decisions without consulting their husbands, even when the women were the primary caretakers of the farm.

Regarding the main sources of accessing agricultural information among households (RQ3), agricultural extension featured as the main source through which farmers obtained agricultural information and training. Given the primacy of agricultural extension as the main channel of communicating with farmers, strengthening the nature of services rendered is a critical part of ensuring overall value and impact in agricultural communities. Agricultural information delivery by agents and the implementation of best practices among farmers would need to be improved in order for that information to be acceptable among rural farmers. The larger implication of this finding is that agricultural extension, through agents, will continue to remain an important source of reaching farmers in many rural households before other information communication channels begin to take root in the region.

4.11 Implications and Future Research

The results obtained in this exploratory study contribute to the literature on adoption and reinvigorate a discussion on how to intervene in the adoption of agricultural technologies among

smallholder farmers in western Kenya, and perhaps in other developing nations. The study attempted to understand how communicating with farmers can be improved by incorporating macro-level and farmer-level determinants of adoption – a step towards identifying the hindrances to adoption. In this study, the variables of gender and age are of particular interest in their influence of adoption and how interventions can be designed to enhance sustainable adoption of agricultural technologies.

The survey findings suggest a new way of interpreting the role of age in adoption because the results imply that older farmers who have involved in farming may not necesessarily be against adopting new technologies or practices. Effectively, older farmers can equally embrace agricultural technology in their farms, just as younger ones. In survey analysis, gender is not found to be of significant in contributing to adoption of agricultural technologies. However, focus group analysis provide new insight into ways in which gender inequities impede adoption. Focus group analysis provide profound information that is not captured by survey analysis. Based on the current research design, it may be recommended that to deal with the gender hindrance to adoption it would essential to find suitable context-based ways that would allow both genders to work together in teams. The structure of such initiatives largely depends on the context and the potential ways of overcoming such biases. However, the study results underscore the importance of a multi-method approach in adoption research – a combination of qualitative and quantitative methods complement each other in enlightening an important social phenomenon.

While the findings in this exploratory study are strong and contribute to the literature on adoption, future studies should look at the same phenomenon in other counties in Kenya or in other developing countries before they can be generalized. One potential way of applying future studies would be switching the sequential design – beginning with a qualitative and followed by a quantitative approach.

CHAPTER 5. DISCUSSION

This exploratory study sought to assess the attitudes and perceptions of smallholder farmers towards agricultural technologies. Survey data assessing farmer attidudes and perceptions towards the adoption of agricultural technologies was collected from 245 housholds across seven of the twelve sub-counties of western Kenya. To enhance understanding of factors influencing farmers decisions to adopt technology, focus group discussions were conducted in four sub-counties with a total of 28 discussants comprised of lead farmers and regular farmers.

A mixed methods approach combining both the quantitative and qualitative methods was utilized, presenting meaningful findings on the influence of socio-demographic variables on smallholder farmers' adoption of technology. Both approaches present results that complement each other; giving credence to the assertion that combining quantitative and qualitative approaches can more effectively shed light on working with this population.

The applied quantitative research approach tested two hypothesis: socio-demographic variables are linked to agricultural technology adoption (H1) and agricultural extension is directly linked to adoption (H2). For the first hypothesis, the results supported the association between socio-demographic variables and agricultural technology adoption. Age, and education were found to predict agricultural adoption, consistent with the literature (Nyanga, 2012b). Off-farm income was also found to be a significant predictor of technology adoption. In the literature, age is negatively correlated with adoption, but in the current study age is positively correlated with adoption, potentially challenging the notion that only younger farmers are more likely to adopt technology.

The second tested hypothesis, which pertained to the direct link between agricultural extension and adoption of technology, was not supported. The organization and delivery of agricultural extension is a challenge for farmers in the area of study. The survey questions related to extension were not precise as to whether information sought pertained to public or private extension. Public extension, which most smallholder farmers rely on, is poorly organized and less reliable, at best, according to the focus group discussants. Further, data from the focus groups point out a lack of trust towards agricultural extension, both public and private. The framing of survey questions may not have probed the extension variable elaborately enough to bring out the core issues surrounding this agricultural service. Future studies should discriminate more clearly

between farmers' access to extension services, and farmers' utilization and perceptions of private versus public extension services when adopting new technologies.

A principal component analysis was conducted to explore attitudinal variables and to reduce the variables to the core components that reflect farmers' attitudes towards technology adoption. The results of this analysis identified five principle components, namely: 1) challenges in accessing agricultural technologies; 2) the use of technology in increasing effectiveness in farm activities; 3) the time saving nature of technology; 4) effect of commercial inputs on output; and 5) the use of new technologies as increasing popularity among peers. In the qualitative analysis it was generally evident that people positively regarded agricultural technologies. In addition to corroborating the variables that the PCA identifies, the qualitative analysis indicated that in spite of their favorable attitudes, there were underlying challenges pertaining those technologies. In the qualitative analysis, structural challenges of accessing the agricultural technologies were articulated. In this regard, qualitative analysis complements quantitative findings by broadening the quantitative variables and contextualizing them.

The focus group discussion data identified those factors evident from the survey data, that affected agricultural technology adoption. The prevalent themes in the discussion groups identified that although farmers valued new technologies as a way of increasing productivity and yield, they were often ambivalent about adoption of these technologies due to lack of trust of the sellers of new products, and in the ability of the government to regulate these practices. Additionally, farmers mentioned that they felt they had limited knowledge of new practices, potentially due to the unavailability and lack of trust in the agricultural extension services in general. Consequently, the issue of trust and lack of information and training must be adequately emphasized in order address the low levels of adoption. Regaining the trust of the extension system would take time and require reinvention of the delivery of the services.

Of note, in answering questions about the farmers' attitudes towards the adoption of agricultural technology, gender was identified as playing a dominant role. It was clearly evident that culture influenced the role of women and men in agriculture. Cultural values didn't favor women, as men had to always approve of the decisions that women made regarding agricultural technologies, in spite of the fact that it was primarily the women who managed the farm. Consequently, men at times came out as a hindrance to adoption. In Kenya, male household heads are the primary decision-makers in the household and have the legal right to the land; females play

a subordinate role. These cultural values present indirect implications that undermine technology adoption. These findings suggests that the female farmers do not make their agricultural technology adoption decions independent of the social values governing their household. The survey results do not bring out gender as a significant variable in influencing adoption. However, the qualitative findings provide a strong explanation that links gender with technology adoption decisions. The contrary results in the current research design speak to the robustness of the quantitative research instrument. Perhaps, the quantitative research instrument did not address the gender variable adequately enough to bring out some of the gender nuances that the qualitative instrument was able to bring out.

An interesting finding from the focus group discussions was that smallholder farmers showed a broad interest in using agricultural technologies in their agricultural activities. Those findings reinforced survey results; emphasizing the importance of technology in agricultural production. The focus group discussants stressed the importance of agricultural technologies in production and in preventing post-harvest loss. However, a minority of farmers, about 20%, were dissatisfied with the overall effectiveness of agricultural technologies themselves. The main reasons for this attitude towards agricultural technologies were: the spread of adulterated agricultural inputs by unscrupulous sellers; lack of adequate knowledge and information about agricultural practices; and policy bottlenecks. Those combined reasons were responsible for exacerbating farmer skepticism of agricultural technologies in general; making some farmers to opt for traditional technologies such as recycled seeds from the previous harvest instead of using hybrid seeds.

Most farmers relied on agricultural extension services, both private and public, to obtain their agricultural information. However, there was evident dissatisfaction with the delivery of extension services, particularly public extension services. Overall, discussants expressed a clear lack of trust, that bordered anger, for the entire agricultural extension system and the agricultural extension agents. The value of trust was defined by the lack of inform These sentiments were expressed across all of the focus groups. In the quantitative analysis, extension is found to be statistically insignificant in its prediction of farmers adoption. The weak agricultural extension inftrastructure in western Kenya and the negative attitudes that farmers had towards agricultural extension agents corroborates the quantitative findings. At the same time, discussants indicated that they felt they didn't have enough information, as well as a desire for more education in

agricultural practices. Combined these results point to the potential for extension services to meet these needs, and also indicates that a restructuring of extension practices in western Kenya is indicated to better meet the needs of smallholder farmers.

In summary, this study set out to identify and explain the factors influencing farmers' adoption of agricultural technologies. Motivated by a mixed methods approach, the study uncovered interesting findings with regard to age and gender in influencing agricultural technology adoption. The qualitative results provided important insight into the quantitative findings, highlighting the role of gender and trust in technology adoption, as well as the need for improved models for delivery of agricultural information.

CHAPTER 6.   CONCLUSIONS, RECOMMENDATIONS AND FURTHER RESEARCH

This exploratory study applied a mixed methods design to assess the the attitudes and perceptions of agricultural technology adoption among smallholder farmers in Kakamega County, western Kenya. The selected area of study focuses on smallholder farmers, who dominate agricultural activities in the region of study; a region that is vulnerable to food insecurity. In applying the a mixed methods approache, the study began with the administration of a quantitative survey questionnaire soliciting socio-demographic information from randomly recruited smallholder farmers. Subsequently, a qualitative approach involving the administration of a four focus group discussions, purposively conducted in four of the seven initial participating sub-counties of Kakamega County was conducted. By triangulating between quantitative and qualitative approaches, the study assessed the role of attitudes and perceptions and their contribution in determining agricultural technology adoption.

There are two types of results in this study. Survey results indicated that socio-demographic variables were not all significant in influencing agricultural technology adoption. From these findings, gender, local group membership, and the three selected attitude variables do not predict the probability of farmer adoption, while age, education, and level of off-farm income do. Qualitative results identified gender as an influential variable that determined the agricultural technologies used by households in their farms. Male household heads directly influenced the agricultural technologies to be used on the farms due to their direct ownership of the land according to local customs. Within the households, females had a limited say and no power to overrul the decisions made by their male counterparts. Changing cultural values or customs and getting people to adapt to new roles can be difficult. Finding ways of engaging initiatives that enable male and females to work together was a recommended first step in lessening the stereotyping of females as incapable of making decsions on their own.

The study recommended household capacity building efforts by making available argricultural technology information to farmers. The study results revealed that lack of information and training about existing farming practices served as a hindrance to adoption. The Kakamega County government reformulation of local agricultural extension service delivery would be an important first step to regaining trust with local smallholder farmers. As a start, retraining the

current pool of agricultural extension agents to be more responsive to the needs of the smallhoder farmers in their area might help.

Further and more elaborate research on agricultural technology adoption would require changing the research design. A more effective approach may be to begin with the qualitative approach before embarking on the quantitative phase. The qualitative phase would serve as an important step in developing a robust survey instrument to be applied in the quantitative phase of the study. This conclusion is only a guide for a study whose goal is to better understand human behavior, which often can not be captured entirely by survey instrument derived solely from a literature review.

Based on the findings of this study, there is need for future studies on adoption to be conducted differently. Inclusion of agricultural extension agents as research participants would be an important way to have a balanced view of the phenomenon of technology adoption. In the current study, agricultural extension agents were not interviewed to explain their challenges, perceptions, and concerns regarding the delivery of extension services. Comparing the views of farmers and extension agents would provide a more comprehensive perspective of the challenges they face in the delivery of agricultural training and information. In addition to including other stakeholders in a future study, the qualitative instrument would separate female and male participants for cultural appropriateness.

This exploratory study sought to investigate the factors that determine the adoption of agricultural technology in western Kenya. Motivated by the literature on adoption, the study applied a mixed methods approach in testing two hypothesis and three research questions. The results from the mixed-methods study find important results regarding the relationship between socio-demographic variables (age, gender, and and percentage share of off-farm income of total income). In the quantitative analysis, agricultural extension was not found to have a relationship with adoption. The qualitative analysis elicit the challenges that farmers face in interacting with agricultural extension services. The effectiveness of agricultural extension needs further analysis. The qualitative findings provide an elaborate explanation of the complex lived experiences of gender and the subtle ways in which it is related to agricultural technology adoption.

APPENDIX

SURVEY

Attitudes and Perceptions of Smallholder Farmers Towards Agricultural Technologies in Kakamega County, Kenya

Department of Agricultural Sciences
Education & Communication
Purdue University

Survey Questionnaire

Date: _____/_____/2019

County: **Kakamega** GPS Coordinates: _____

Sub-County: _____ Location: _____

Village: _____

Enumerator: _____ Respondent code: _____

Gender of respondent:

Male	☐
Female	☐

1. [**FA**]What is your age?

    _____

2. [**FA**]Who helps in decisions on the type of technology to use in the farm?

self		spouse		sibling		land owner	
☐	Yes	☐	Yes	☐	Yes	☐	Yes
☐	No	☐	No	☐	No	☐	No

3. [**FA**] How many people are in your household?

    Spouse_____

    Kids _____

    Parents ____

Other_____

4. **[FA]** How many years of schooling do you have?

_____

5. **[FA]** Is farming your main occupation?

yes	no
☐	☐

6. **[FA]** Are you engaged in another occupation besides farming?

If yes, state other occupation_____

7. **[FA]** What size of land do you own?

_____ Acres

8. **[FA]** How many years have you been engaged in farming?

_____

9. **[FA]** What is your HH average annual on-farm income (KSh.)?

_____

10. **[FA]** What is your HH average annual off-farm income (KSh.)?

_____

11. **[FA]** How many acres of the following crops do you grow?

	maize	beans	tea	coffee	sugarcane	Horticul.
2019						

12. **[FA]** How many kilograms the following crops did you harvest last season?

	maize	beans	tea	coffee	sugarcane	other
2019						

13. [**FA**]What are your sources of finance?

	bank loan		sacco loan		own funds		remittances		other	
	☐	Yes	☐	Yes	☐	Yes	☐	Yes	☐	Yes
2019	☐	No	☐	No	☐	No	☐	No	☐	No

14. [**FA**]What are the main sources of credit for farming?

_____

15. [**FA**] Do you raise any livestock?

yes	no
☐	☐

If **yes**, how many of the following do you raise?

Animal			**Number**
dairy cows	☐ ☐	yes no	
sheep	☐ ☐	yes no	
goats	☐ ☐	yes no	
chicken	☐ ☐	yes no	
donkey	☐ ☐	yes no	
ducks	☐ ☐	yes no	

16. [**FA**] What quantity of the following did you sell in 2019?

	Quantity/month
Milk	
Eggs	

17. [**AI**] What is the distance to nearest commercial seed dealer?

_____

18. **[AI]** What equipment(s) do you regularly use in your farm?

Farm equipment		
Hired tractor	☐	Yes
	☐	No
Own tractor	☐	Yes
	☐	No
Jembe/hand hoe	☐	Yes
	☐	No
Rake	☐	Yes
	☐	No
Sheller	☐	Yes
	☐	No
Panga	☐	Yes
	☐	No
Wheel barrow	☐	Yes
	☐	No
Animal-drawn plough	☐	Yes
	☐	No
Planting rope	☐	Yes
	☐	No
Other	☐	

19. [**AI**] What other physical inputs do you apply in the farm?

Input			Length of time
commercial maize seeds	☐	yes	☐
	☐	no	
saved maize seeds from last season	☐	yes	☐
	☐	no	
commercial bean seeds	☐	yes	☐
	☐	no	
saved bean seeds from last season	☐	yes	☐
	☐	no	
commercial fertilizers	☐	yes	☐
	☐	no	
use of animal manure	☐	yes	☐
	☐	no	
pesticides	☐	yes	☐
	☐	no	

20. [**FA**] Which of this best management practices (BMP) do you engage in?

Practice		
Agroforestry	☐	Yes
	☐	No
Crop rotation	☐	Yes
	☐	No
Intercropping	☐	Yes
	☐	No
Cover crops	☐	Yes
	☐	No
Mulching	☐	Yes
	☐	No
Terracing	☐	Yes
	☐	No

21. [**FA**] Which of these practices do you practice in your farm?

Computer _____

Cellphone _____

Soil sampling tests _____

22. Please rank your attitude to the following statements.

Scale: 0=Neutral 1=Strongly agree 2= Agree 3=Disagree 4=Strongly disagree
`

		0	1	2	3	4
ATT1	I experience challenges in accessing agricultural technology whenever I need it					
ATT2	The use of technology increases effectiveness in my farm activities					
ATT3	The use of technology saves me time in my farming tasks					
ATT4	My use of the commercial inputs increases the quantity of output for the same amount of input					
ATT5	The use of any new farming practices makes me popular among my peers					
ATT6	Modern agricultural inputs are a plausible alternative to traditional agricultural production					
ATT7	Modern agricultural practices influence my practice of agriculture					
ATT8	I receive personal satisfaction from applying modern agricultural production practices					
ATT9	I need the practice of new agricultural production techniques in our small agricultural practice					

ATT10	I will continue to use new agricultural innovations even if the price can sometimes be prohibitive					
ATT11	The main reason for using agricultural innovations is to increase my agricultural output					
ATT12	I enjoy discussing about new agricultural practices currently promoted by the local extension services					
ATT13	My farmer friends who use new agricultural innovations influence me to do the same					
ATT14	I enjoy reading/listening about the different agricultural practices or technologies currently in use					

Agricultural Extension Services

23. [**CE**]What is the distance to the nearest extension office?

_____

24. [**CE**]Do you receive local extension services in your area?

Yes	No
☐	☐

If **yes**, state the training service you receive/d _____

If no, why not _____

25. [**CE**]How often do you receive agricultural extension services?

_____

26. **[CE]** What mode of training do agricultural extension service officers use?

Theory	☐	Yes
	☐	No
Demo / direct training	☐	Yes
	☐	No
Participatory learning	☐	Yes
	☐	No
Farmer-2-farmer	☐	Yes
	☐	No
Other	☐	Yes
	☐	No

I do not know	☐

27. **[CE]** Do they charge a fee for these services?

Yes	No
☐	☐

28. **[CE]** For what farming activities do you always receive training from agricultural extension agents?

Training services		
Planting techniques	☐	Yes
	☐	No
Crop rotation	☐	Yes
	☐	No
Land preparation	☐	Yes
	☐	No
Digging trenches	☐	Yes
	☐	No
Simple processing	☐	Yes
	☐	No
Agric. marketing	☐	Yes
	☐	No
Other	☐	Yes
	☐	No

29. **[CE]** Has your farming practice improved since receiving extension services?

	Time saving?	Profitability?	Soil health?
☐ yes	☐ yes	☐ yes	☐ yes
☐ no	☐ no	☐ no	☐ no

If yes, explain

_____

30. **[CE]** How effective are agricultural extension services in helping you achieve your farming objectives?

Very effective	Slightly effective	Not effective	Undecided
☐	☐	☐	☐

Local Community Networks

31. **[FA]** Are you a member of a farmer group in your neighborhood?

Yes	No
☐	☐

32. **[FA]** What local community group do you participate in?

_____

33. **[FA]** For how long have you been a member?

_____

34. **[FA]** How often does your group meet?

_____

35. **[FA]** What information do you share with members of your network during meetings?

_____

_____

36. **[FA]** What activities does your farmer organization arrange for members?

Conservation agriculture	☐ Yes
	☐ No
	☐ Yes
	☐ No
	☐ Yes
	☐ No
	☐ Yes
	☐ No

37. **[FA]** Do you participate in activities organized by your farmer group?

Yes	No
☐	☐

38. **[FA]** Do you see any benefits in holding membership in the farmer group?

Yes	No	Neutral
☐	☐	☐

39. [EE] Do private companies engage with rural farmers?

Attitudes and Perceptions of Smallholder Farmers Towards Agricultural Technologies in Kakamega, County, Kenya

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Department of Agricultural Sciences Education and Communication (ASEC)
Purdue University

Focus Group Discussion Questions (FGDs)

Qualitative Research Questions

1. What makes agriculture an enjoyable activity? What are some of the risks and benefits that you endure as a farmer?

2. Do you trust the source of the physical technologies that are currently marketed/promoted?

3. What are some things benefits of the technologies that by public/private extension services providers currently promote?

4. Have you considered changing the practices that you apply in your farm? If so, why? What factors contributed to your decision to adopt your current practices/technologies?

5. What may influence you to switch between two practices/technologies?

6. How are current agricultural practices/technologies consistent with your socio-cultural environment?

Probes for Discussion:
- Profitability of agricultural practices
- The link between socio-cultural values and agriculture
- Appropriateness of promoted technologies
- Individual perceptions towards the promoted practices
- Cultural sensitivity of technologies currently promote

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