A PARTICIPATORY MODEL FOR AN ENHANCED ADOPTION OF ICT INNOVATIONS BY SMALLHOLDER FARMERS

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DECLARATION AND APPROVAL

"This Thesis is my original work and has not been presented for an award of a degree or diploma in any other university or institution".

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DEDICATION

To the Lord Almighty God.

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I give glory to the Almighty God for the good health, strength and knowledge.

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ABSTRACT

Agriculture has been identified as the main source of livelihood for a large population in Africa, with over 80% of farmers being smallholder farmers. However, despite a large group of smallholder farmers being involved in food production, the outcomes show that there is still food-deficit in low-and middle-income countries; which forms greater part of African continent. Nonetheless, sustainable food production in these countries, is only achievable through economic growth and development strategies where agriculture is given a key consideration. One of the notable strategy, is the leveraging of information and communication technology (ICT) innovation in agriculture services to support smallholder farmers in addressing their challenges, increase incomes and production. While ICT has long been acknowledged as a main driving force for sustainable development, the availability of innovations and use remain a challenge for smallholder farmers.

The study, sought to investigate and determine the factors that can accelerate adoption of ICT innovations by small by smallholder farmers. To achieve this, the study set four specific objectives, viz: to identify factors that influence smallholder farmers' decision on ICT innovations adoption in Agriculture; to examine how the factors are perceived by smallholder farmers on adoption of ICT innovations; to determine the core mechanisms/approaches for adoption of innovations by smallholder farmers and hence to develop and a model for an enhanced adoption of ICT innovations in agriculture.

The study used mixed methodology, comprising of qualitative and quantitative approaches to collect data from three counties; Siaya, Uasin Gishu and Kakamega in Kenya. The counties were purposively selected based on geographical locale, and economic endowment. A pilot study was conducted to validate the research instruments. The study applied both descriptive and inferential statistics for quantitative data using SPSS v.25. An exploratory factor analysis was used to extract key factors, which were then confirmed through the use of confirmatory factor analysis using Partial Least Square Structural Equation Model (PLS_SEM); SmartPLS3. Qualitative data were analysed and presented using manual thematic analysis and confirmation of the results made.

Finding indicates that economic factor has the strongest effect on the use of ICT on agriculture and participation (0.412) and (0.361) respectively, followed by social influence (0.199) and Technology factors (0.135). On the model fit, the variable explains about 84% of variance in use of ICT on agricultural, hence adoption of innovations. This was further confirmed by qualitative study.

The research has made theoretical contribution in two dimension; incremental and revelatory; new constructs and development of a new model for ICT innovations adoption that employs participatory approach. Additionally, methodological contributions were also made by using mixed research method to appreciate a multidimensional perspectives. Recommendation to stakeholders: use participatory approach, farmers should works in groups to enhance knowledge uptake.

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CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

According to a study by World Bank (WorldBank, 2018), agricultural development is a powerful tool for raising incomes for deprived people in developing countries. Agriculture provides livelihood for about 2.5 billion people, with about 70% of the people being smallholder farmers and over 80% of the smallholders being from rural areas (FAO, 2015). Food production has increased majorly in developed nations, with developing nation recording unimpressive increment (Hak, 2018). However, the evolution of global food production versus consumption indicates that there is a strong need for increasing yield (FAO, 2017). A report by Department of Economic and Social Affair (UN, 2015), states that over the last century, the global population has increased significantly, currently being estimated at 7.3 billion and this is being projected to reach 9.7 billion by 2050(Nejat et al., 2018). This growth, along with escalating cost of living in most developing countries are driving up global food demand, which is expected to increase between 59% to 98% by 2050 (Schierhorn, 2016). This puts agricultural sector under pressure to meet the expected demands of feeding the growing population without using more land. It is important that farmers get more support on how to improve agriculture by making it knowledge intensive (Rahiel et al., 2018).

The Digitalization of African Agriculture Report (Addom et al., 2019) indicates that emphasizing on the key services such as access to finance, advisory services and market linkages can lead up to a 57% increase in income for farmers, and up to 168% increase in yield. Therefore, providing modalities to support farmers for enabling them access more services such as extension services, trade services or financial services is very important.

Similarly, studies argues that increasing agricultural productivity is critical to meet expected rising demand and, as such, it is instructive to examine performance in cases of modern agricultural technologies(Merga Challa & Tilahun, 2014; Nwigwe, 2019). The adoption of new ICT techniques is key for improving the food productivity and livelihood of smallholder farmers in developing countries and a key ingredient for achieving poverty reduction, food security, rural development and structural transformation(Kuijpers & Swinnen, 2016).

1.1.1. Benefits of ICT in Agriculture

Adoption of ICT in agriculture is important and a major driving force for increasing food productivity. The existing literatures indicate that application of ICT in agriculture, just like in other sectors, is increasingly becoming widespread in Africa; particular in Kenya (Maumbe & Okello, 2013).

The National Agriculture Policy 2017 (NAP, 2017) advocates for a nation-wide ICT systems to support agricultural development by promoting utilization and applications, for increased efficiency in information sharing in the agricultural value chains. While the use of ICT technologies is the most promising way to deliver services, the appropriate modalities for disseminating the content of these services and their rate of adoption by smallholder farmers remains poorly understood (Mwangi & Kariuki, 2015)

The spectrum of ICTs is wide and as dynamic as the field of innovations, its effective dissemination, can improve and upscale agricultural services. According to Okediran & Ganiyu (2019), in industrialized countries, ICTs enable precision agriculture; Farmers harness computer and satellite technologies such as global positioning systems, geographic information systems, yield monitoring devices, soil, plant and pest sensors, remote sensing to cut costs, improve yields and protect the environment(Okediran & Ganiyu, 2019).

According to Chavula (Chavula, 2014), ICT has been used in enhancing information access to farmers through distance education or SMS-based extension service information newsletters. Similarly, technology can facilitate stakeholder brainstorming, exploring alternative production technologies, access to markets and credits, training and demonstration, community learning, searching, selecting and compiling information for individual clients, early warning for disasters and weather forecast, peer to peer sharing and exchange among extension agents(Barakabitze et al., 2017a). Technology transfer in agriculture can be spearheaded by stakeholders. According to study by Santos (Santoso & Delima, 2017) stakeholders play a major role in terms of technology dissemination in agriculture sector. The outcome of technology dissemination is the farmers adopting and further sharing with other people in the community.

1.1.2. Roles of Stakeholders in Agriculture

The stakeholders are persons or organization who have vested interest in the policy, project or program that is being promoted. In agriculture sector there are various actors that are involved direct or indirectly in various activities; financial institutions, government, research institutions, Non-governmental organizations, private sectors among others. The stakeholders in agriculture sector are useful in identification and formulation of projects as well as in the development of strategies with the main aim of improving agricultural production and general rural development. In line with this, timely and effective consultation of relevant stakeholders is important in the sector for the benefits of farmers. This can only be realized through the use of participatory platform that has been promoted as a way to stimulate agriculture growth in developing countries (Adekunle & Fatunbi, 2012).

The participatory approaches in agriculture can empower collective groups of people and put decision-making in the hands of different stakeholders in the farming community(Neef & Neubert, 2011). The farmer-researcher participation and ICT based solution integrations can result into an improved productivity and performance of the agricultural sector. A study by Dalberg argues that 85% of farmers' households will have a mobile phone by 2025, the overall potential of ICT innovation developed would be appropriately disseminated to smallholder farmers, which leads to the wider adoption of services (Dalberg, 2017).

1.1.3. ICT Adoption modes

With the introduction of mobile phones, technology penetration has been growing rapidly even in the remote rural areas. The unprecedented speed of adoption of information technology has raised the general expectations about its potential contributions to spread of innovative farming technology on time with adequate speed (Fua & Akterb, 2012). The question is whether dissemination of innovation through current available technology can speed up the information uptake by smallholder farmers. There is scanty survey data-based evidence on the impact of ICT innovations in agricultural value chain in remote areas probably due to the lack of reliable data on outcome variables as variations across extension and non-extension communities and the study of users and non-users in observable and unobservable factors(Aker, 2011; Deichmann et al., 2016; Miller et al., 2013).

Most agricultural innovations are in material form such as improved high yielding variety seeds, chemical fertilizers and plant protection chemicals, while improved cultural practices are in behavioural forms (Peshin et al., 2019; Peshin et al., 2009). A number of studies have looked at material form and others argue that it equally important to look at

behavioural forms such as software innovations utility by farmers as appropriate ways of dissemination and adoption.

1.1.4. Adoption Concepts in Agriculture

Technology dissemination refers to the general process of moving information and skills from information or knowledge generators such as developers and research institutions to clients such as smallholder farmers (Chi & Yamada, 2012; Kinyangi, 2014). The outcome of new technology dissemination is the farmers' adoption of the technology and bringing it into practice and further diffusion to other individuals in the community. Regarding to adoption, farmers sometimes discover problems in putting recommendation into practice, the extent of adoption, adjustment or rejection depends on farmers' behaviour (J. B valera & Plopino, 1987). Related studies indicate that adoption of an innovation is the process by which a particular farmer is exposed to, considers and finally rejects or practices a particular innovation(Kinyangi, 2014; Mosher, 1987). The innovation decision model by Rogers (1983), shows the process through which an individual (or other decision making unit) passes from first knowledge of an innovation to forming an attitude towards the innovation, to a decision to adopt or reject, to implement of the new idea, and to confirmation of this decision(Rogers, 1983). There are a number of theories that deal with generation of innovations, their dissemination and adoption or non-adoption by the end users. From the first level of development of an innovation upto the level of adoption by farmers- a number of people are required for successful dissemination.

Timely and effective communication by relevant stakeholders is paramount to successful adoption of agriculture systems. According to study by Santoso (Santoso & Delima, 2017), analysing the needs of stakeholders is important and can be used as a mechanism to expose different conflicts that might arise among different stakeholders. The study by Santos,

analyses and group stakeholders into several groups base on their powers and interests. The Stakeholder Interaction Matrix shows that each stakeholder with different role needs different information(Santoso & Delima, 2017). This information comes from interaction between stakeholders. The key issue in adoption is understanding the role of stakeholders and their information need in any approach. Understanding adoption methods is important to support the study with the main aim of enhancing adoption of ICT innovations for agriculture.

1.2 Statement of the problem

Agricultural information is important in enhancing food productivity. Access to knowledge and information are vital for people to respond successfully to the opportunities and challenges of social, economic and technological changes that help to improve agricultural productivity and rural livelihood knowledge. The use of ICT technologies are being recognised as the most promising way to deliver relevant information on crops production, pest and disease control, post-harvest techniques, market, financial services among others. Additionally, Food and Agriculture Organization, maintains that use of ICT on dissemination of information on key services can lead up to a 57% increase in income for farmers, and up to 168% increase in production.

All the same, the use of ICT in agriculture is still a challenge, a study on the ICT innovations and its' implications for Agriculture, indicates that 76.1% of respondents have ICT uptake problems (H.A.C.K Jayathilake et al., 2016). While it is highlighted that the challenges faced by ICT adoption, were more technological related, research indicates that very little studies have been conducted to underpin the approaches of ICT adoption. Therefore, there is a need to establish factors necessary to overcome the challenges and improve adoption of ICT innovations by small holder farmers

1.3 General Objective

The main objective of this study is to develop a participatory model than can enhance adoption of ICT innovations by smallholder farmers. To achieve this, the study examined the following specific objectives:

1.3.1. Specific Objectives

i. To identify factors that influence smallholder farmers' decision on ICT innovations adoption in Agriculture
ii. To examine how the factors are perceived by smallholder farmers on adoption of ICT innovations
iii. To determine the core mechanisms/approach for the adoption of innovations by smallholder farmers
iv. To develop a model for an enhanced adoption of ICT innovations in agriculture.

1.3.2. Research questions

i. What are the factors influencing smallholder farmers decision to adoption ICT Innovations in Agriculture?
ii. What are the factors that are perceived by smallholder farmers on the adoption of the ICT Innovations?
iii. What are the core mechanisms/approaches that enhance adoption of innovations?
iv. How can a participatory models for an enhanced adoption of ICT innovations in agriculture be developed

1.4 Significance of the study

Agriculture is the backbone of most developing countries where at least two-thirds of the population live in rural areas and depend mostly on agriculture. In Kenya, the income from

farming is the source of livelihood for the majority of the farming communities and their families. Kenyan agricultural sector accounts for 26% of the Gross Domestic Product (GDP) while 80% of the population relies directly or indirectly on agriculture (AGRA, 2017a) . Considering the fact that the highest percentage of rural population is employed informally or formally in agriculture, research on agricultural technology adoption is therefore critical. The study provided a model for ICT-in-agriculture adoption towards improving living standards of farmers by upgrading their production capacity and market access. The findings should be helpful to farmers, and other stakeholders towards improving access to agricultural information such as market and prices, farming inputs, credit facilities among others in the rural community. Through this, dissemination and adoption of ICT innovations can increase, hence increase on the agricultural productivity and poverty reduction.

1.5 Scope

The study, sought to better understand the process of ICT innovation adoption through information and interaction processes at the individual, social network, and community levels. For geographical locale consideration, three counties; Siaya, Kakamega and Uasin Gishu in Kenya with variations in economic endowment were included. The study also considered factors and theories which underpins the adoption of ICT agricultural innovations.

1.6 Assumptions of the Study

In this study, the following assumptions were made: Smallholder farmers are faced with challenges of ICT technology adoption. It was further considered that, over and above the challenges, information and communication technologies (ICTs) could benefit smallholder farmers through increased information access and agricultural input use. Additionally,

smallholder farmers have access to digital devices such as phones that can be used to access ICT-in-agriculture innovations. Farmers are willing to form and work in small local groups.

1.7 Definitions of Terms

Adoption: - refers to the decisions that individuals make each time that they consider taking up an innovation or decision of an individual to make use of an innovation as the best course of action available.

Dissemination: Dissemination refers to the general process of moving information and skills from information or knowledge 'generators' such as developers and research institutions to clients such as smallholder farmers

ICTs: Refers to artifacts and practices for recording, organizing, storing, manipulating, and communicating information.

Innovation: software and related tools that help farmers access relevant services along the value chain.

Institutions: include all the services to agricultural development, such as finance, insurance and information dissemination. They also include facilities and mechanisms that enhance farmers' access to productive inputs and product markets. Institutions also include the embedded norms, behaviours and practices in society.

Integration is taken here to mean the incorporation into the management process.

Smallholder farmer: A smallholding or smallholder is a small farm operating under a small-scale agriculture model.

SmartPLS: is a software with graphical user interface for variance-based structural equation modelling (SEM) using the partial least squares (PLS) path modelling method.

Technology: refers to how to cultivate a crop successfully. This success can be obtained by knowing how to apply fertilizer, control pests, and take care of plant for its healthy and good growing.

Utilization: Relates to the use or converting into action the accessed agricultural messages by the farm households to perform the agricultural production activity. The frequency of converting received messages into action is also considered.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter reviews the Empirical literature on ICT for agricultural information and innovations used by smallholder farmers.

The chapter starts by highlighting the concepts of agricultural information to smallholder farmers. Section two, demonstrate that ICT innovation services have been deployed in developing countries, the experiences on production, market access and financial sectors in various countries are reviewed. Section three, represent different ICT channels used in innovation dissemination. Reviewing the challenges and barriers to ICT-in-agriculture innovation adoption is done in Section four. Theoretical approaches to agricultural ICT innovations are discussed in Section five. Section six presents the identified gaps and the chapter finish by drawing the conceptual framework.

2.2 Concepts of Agriculture, ICT innovations and Adoption

This section provides importance of Agriculture to economies and role of smallholder farmers in agriculture. Overview of issues of agriculture and ICT innovation and the utilization of innovations in various production areas are covered.

2.2.1 Role of Agricultural Sector to Smallholder farmers

Agriculture is the backbone of most Sub-Saharan countries' economies and contributes highly to their Gross Domestic Product (GDP)(AGRA, 2017a; Filho & Gomez, 2018). According to Africa agriculture status report (2017), small-scale agriculture is the main source of livelihood for over 70% of the population in Africa (AGRA, 2017b).

In Kenya, agricultural sector accounts for 65% of Kenya's total exports and provides more than 70% of informal employment in the rural areas (Davis, J. R., 2004). A report by Kenya Government states that agricultural sector is not only the driver of Kenya's economy but also the means of livelihood for the majority of Kenyan (AGRA, 2017b; KenyaRep, 2016).

As the agriculture sector is anticipated to continue playing important part in the rural economy, the dynamics of poverty within Kenya are changing and directly influencing the country's agricultural sector. Most smallholder farmers that use rain-fed farming systems, are being pushed into dryer, more marginal areas where they become increasingly vulnerable to drought and the unpredictability of weather patterns resulting from climate change (FAO, 2020b). Given the importance of agriculture in rural areas of Kenya where poverty is prevalent, the sector's importance in poverty alleviation cannot be overstated. Strengthening and improving the performance of the agricultural sector and enabling the engagement of the poorest and most vulnerable in this process is, therefore, a prerequisite and a necessary condition for achieving economic growth in Kenya even after recent years of drought has slowed agricultural development(FAO, 2020b).

Agricultural production especially among rural farmers has been severely curtailed by insufficient agricultural information to farmers that has affected the productivity and livelihood of smallholder farmers, resulting to extreme poverty in most part of Africa (Adeleke Salami et al., 2010). An effective and cost-effective farming cannot be achieved if information is neither available nor accessible to the smallholder farmers. Studies indicate that information is very important and more so, accurate and reliable information is a key element for sustainable development (Angello et al., 2016);(Brodnig & Mayer-Schönberger, 2000). Information has become one of the most important components in the

transformation of the society today, playing a pivotal role in decision making and policy formulation. In the agricultural sector, relevant and timely information empowers farming communities to make the right choices towards sustainable and long-term growth. Use of such information enhances farming as an enterprise that largely depends on productivity and marketing for survival. Thus, availability of information on weather trends, best farming practices, disease control and market distribution provides farmers with the necessary help to pursue value added agriculture as a strategy for growth and development that is sustainable in the long term. Research has shown that lack of access to information is one of the serious obstacles to development, including agricultural development(Rimi & Chudi, 2017).

Information is key to any business; it allows people to make informed decision. For example, investors in the stock exchange market rely on information to determine where to invest their money. Phone companies rely on customer feedback (information) to better their subsequent models (Odera, 2020). Consequently, particular information to farmers can influence productivity; information on soil, seed, fertilizer, planting time among others. The information the farmer gets from the soil test, determine the crops the farmer can grow and the inputs required. Access to market information will assist the farmer decide which crop(s) will bring him the greatest returns(Odera, 2020). Therefore, information is the bedrock of Agriculture and is necessary throughout the value chain.

According to Knickel (2009), information and knowledge driven innovations to increase productivity and competitiveness in agricultural sector is on the rise (Knickel et al., 2009). The ability of farmers to participate and benefit from growth in agriculture sector is linked to their ability to adopt new technologies, to solve problems and be involved in agricultural value additions (Knickel, et al., 2009). The rapid development of internet, mobile phone

and other forms of ICTs in the Kenyan agricultural sector has provided an opportunity for the transfer and access of agricultural information (Aker, 2011). Farmers in most part of Kenya, particularly those with resources and good education, have been known to use ICTs(Simon et al., 2013). Smallholder farmers are now able to identify new market opportunities for their crops and access new input technologies, which was otherwise difficult and expensive to obtain. In Kenya, the National Agricultural Sector Policy (NASEP) presumes that extension service providers and clients will increasingly apply ICT for sharing agricultural information (Simon, et al., 2013). In Uganda, small traders have used mobile phones to carry out transactions with producers in rural areas and buyers in urban markets increasing profits and sales (M. Komunte et al., 2012). However, in many agriculturally based local economies, the low availability of timely and needed information is skewed in favour of more informed individuals or organizations which often force underprivileged smallholder farmers to sell their harvests to them at low price. Poor infrastructure in most of rural areas, lack of access to market, lack of credit facilities, in developing nations, leading to significant differences in the ability to leverage individual and regional strengths (FAO, 2017). Insufficient extension services and poor access to information widen the gap in the adoption of new technologies and normally lead to lower productivity (Takahashi et al., 2019).

Farmers need to interact with multiple sources of information to shape and enrich their knowledge base (FAO, 1995) and make production decisions to maximize output and minimize costs. Therefore, it can be argued that, for maximum production and income, farmers' need to control their environment and resources at their disposal including knowledge and skills. To accelerate the pace at which this information reaches the farmers,

a variety of approaches have been adopted with the assumption that both approaches and technical information packages will be suitable to the farmers.

According to Zhang (2016), when it comes to dissemination of information, the multi-channel service model incorporates both one-way information dissemination (e.g. portal, text message) and two way information interaction (e.g. audio and video communications, online community, and mobile Internet service facilitated two way communications) (Zhang et al., 2016). Hence, the way forward is to explore the best way to carry out agricultural information dissemination by coordinating different service approaches and models, to maximize the service effectiveness and efficiency.

The use of ICT to improve agricultural economies is an area of concern, and full potential has yet to be grasped. A survey by Kenya Competitiveness (Schwab, 2019) indicated that the rate of adoption of agricultural technologies and subsequently food production in the Kenya is low. Most of these studies were carried out in developed economies, though focused on the factors affecting adoption of technologies among farmers. With most innovation limp in the pilot phase, research is necessary for ICT to enhance and improve more productivity innovations, which are often delivered through extension agents in developing countries. Miller (2013), argues that potential issue for extension services is the question of viability, and such services may need to be supported on a regular basis by local governments or downstream players, such as lead buyer firms, which clearly benefit from long-term productivity improvements in farmers' yields. An integrated model that brings together many different stakeholders in agriculture value chain is a necessity. ICT suppliers can facilitate and fast-track operation among farmers, banks, input retailers and buyers and to put in place processes and mechanism that help the parties to complete transactions (FAO, 2020a). Therefore, a study on integrated model should be able to

enhance network and improve cooperation between the value chain players, developing a demand-oriented system of smallholder farmers.

2.2.2 Agricultural ICT Innovations adoption

In understanding the farmers' knowledge of agricultural ICT innovation adoption, it is stated that users acceptance, integration and use of new technology occurs and develops overtime due to the influence of many interrelated issues (Mng'ong'ose & Matern Victor, 2018). These issues can be grouped into constraints, utilization and partnership or teamwork as illustrated in Figure 2.1

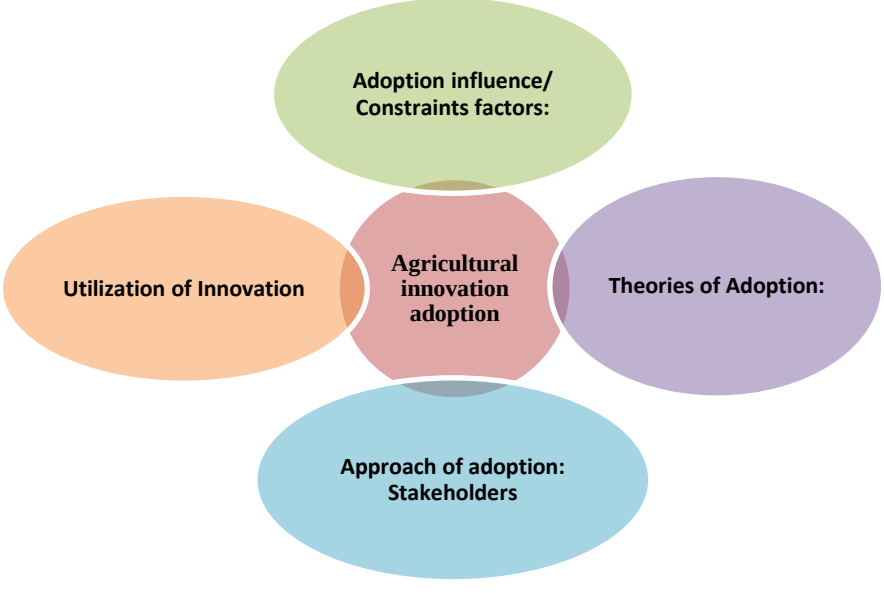

Figure 2.1: Overview of issues of agricultural ICT innovation

2.2.3 Utilization of ICT innovations

Interaction of dynamic ecosystems comprising of government, academia, research institutes and increasingly educated populations are turning developing countries into big market for innovations(Mishra & Tiwary, 2018). Researchers further emphasize that riding on the wave of digital revolution and increasing accessibility, with high number of mobile

subscribers and Internet users and growing, stakeholders are introducing innovative services, products and applications for the mass inclusion of the underserved in various economic sectors (Mishra & Tiwary, 2018).

Similarly, a report by FAO (2020), indicates that ICT innovations are available to help improve the effectiveness and efficiency of agricultural activities, and to demonstrate how ICT stimulate activities in the value chains. Additionally, parties implementing the ICT innovations vary too, such as governments, non-governmental organizations (NGOs) and private companies. The use and value of the different ICT innovations are portrayed from the farmer's or producer group's perspective, with examples from typically larger upstream or downstream players' perspectives, such as banks, cooperatives or processors (FAO, 2013). The main intervention areas in the study are production, market and financial sectors.

i. Use of ICT in Production

ICT innovations has been used in production systems to improve data collection, processing and reporting through simple and affordable means that help smallholder farmers to make decisions that increase their incomes. The information has been beneficiary in helping farmers to improve their crop yields generally, such as, information on plant breeding which takes into account the soil, the right type of fertiliser, seed to be used in a given area at the right price; time of planting; pesticide selection, providing access to weather information among others. In India, the International Institute of Information Technology (IIIT) in Hyderabad, facilitate smallholder farmers to receive advice on planting, monitoring and harvesting crops and on pesticide and fertilizer usage based on digital photos taken by the smallholder farmers themselves (B. V. Ratnam et al., 2006; Saravanan & Bhattacharjee, 2014). Similarly, Sri Lanka through Information and

Communication Technology Agency (ICTA), introduced web and mobile technologies to help dairy smallholder farmers, the system offered a number of "just-in-time" services, including access to artificial insemination agents, to help induce pregnancy(Christine Zhenwei Qiang et al., 2012). The finding is also supported that artificially insemination within the required time frame can increase milk production (Nation, 2018). Hence, on time information can manage crisis hence preventing losses; services such as alert system can enable smallholder farmers to react quickly before an oncoming event reaches them.

In Zambia, Government's Meteorological Department created the Radio and Internet for the Communication of Hydro-Meteorological Information (RANET) project, which helps farmers avoid the disastrous outcomes of weather events (FAO, 2013). With the help of rain gauges farmer are expected to measure rainfall data, which are fed back to RANET's local weather stations via the farmers' mobile phone, frontlines SMS are used to reduce cost of communication. According to Kumar (2014), weather is a key factor to productivity, weather sites can be established to monitor the need for pest (ICRISAT, 2016) control and prevention, and relay information to smallholder farmers via their cell phones. The tracking of temperatures also helps smallholder farmers to prevent losses from frost by monitoring temperatures hourly and sending text messages to the smallholder farmers, who can then take crisis management measures (Kumar & Gautam, 2014).

As far back as 1999, researchers found that livestock mortality in rural areas decreased after extension officers began to provide more timely advice through mobile phones (Sigei, 2010). It is believed that there is likely a correlation between the lack of access to services and communication and the fact that farmers often plants the same crops year after year, despite market prices (Galperin & Mariscal, 2007). According to ICRISAT (ICRISAT, 2016), there is need to have Virtual Academy that trains local women who then, with the

help of remote scientists, who can then provide critical information to smallholder farmers in rural areas. The use of audio and video conferences can help in exchange of key information about droughts, planting practices, pest control, and soil fertility, among others. trained farmers can help local farmers experiment with drought-resistant crops, such as castor, and shares other agricultural practices, market prices and weather information with the help of the remote scientist experts (Paul-Bossuet, 2011).

ii. Use of ICT in Market Access

ICT has been used in market access to support farmers, especially smallholder farmers to access information on the pricing of agricultural products (inputs and outputs), and connections to suppliers, buyers and logistics providers of storage facilities and transport (FAO, 2013). According to Miller (2013), the underlying issue has been having a pricing information component and provide information on or links to at least one of the players: suppliers, buyers or logistics providers, from the smallholder farmers' perspective being buyers. Furthermore, an application like FrontlineSMS has been in use to provide several pricing services to smallholder farmers in Africa, Asia and Latin America (FAO, 2012). In Côte d'Ivoire (Calvin Miller et al., 2013), technology has be used to provide timely pricing information to help small cashew nut producers gain better access to markets through transmitting market information via SMS. Researchers indicated that the situation is not different in Sri Lanka, where FarmerNet system (FarmerNet are electronic market places where buyers and sellers connect over an electronic network) has been used to enable farmers and traders to send information by SMS regarding the availability of/requirement for a particular commodity, including quantity required, price quoted and location for delivery (FAO, 2012). A report by FAO (2013), indicates that in Bangladesh, E-Purjee, an SMS system has been used to issue farmers with permits and billing information for sales

of sugar cane to the 15 State-owned sugar mills, upon which 2.5 million growers across the country obtained fair prices and no longer had to depend on potentially corrupt intermediaries to sell their sugar cane to the mills.

According to report by FAO (2013), on ICT use for inclusive agriculture value chain, Soko Hewani developed by Kenya Agricultural Commodity Exchange Ltd (KACE) is an example of radio programme that help users to sell and buy agricultural commodities. According to KACE, it could facilitate the provision of services for 13 traditional agricultural products, six types of livestock, dairy products such as milk, inputs such as fertilizer and seeds, and even fish and honey. Additionally, the matching involves not only purchasing of these products but also processing, packaging, transport of commodities, storage, grading, quality testing and finance.

There are also some holistic trading systems like DrumNet that essentially can provide pricing information services and VTFs and beyond the simple economics of purchasing and buying agricultural products: weather information, technical information on agricultural practices, and long-term education. DrumNet is a holistic trading model that supports different stakeholders in agricultural value chains – suppliers, buyers, input suppliers and financiers – to facilitate stakeholder relationships and put in place processes and mechanisms that help the parties to complete transactions (FAO, 2008).

The shortcomings to these holistic services are essentially the same as those for VTFs: large capital outlays; and the need for a large network to reach the necessary scale for sustainability, this need is likely to be more pronounced for holistic services than for VTFs (FAO, 2013). Many of the services added on to pricing and trading also require extensive human interaction with the consumers.

iii. Use of ICT in Credit and Financial Services

According to Aryeetey (2005), farmers in the developing world do use financial services extensively, such as savings groups or local money-lenders, even if no formal or semi-formal financial institutions are available. With the help of ICT, formal (banks) and semi-formal institutions (such as NGO microfinance institutions such as JOYWO) can extend their reach if they provide their services in ways that satisfy the primary needs of the rural poor; convenience, security, flexibility, and of course, low cost (Calvin Miller, et al., 2013).

Most financial service providers have always used ICT to extend their reach into remote areas, through eliminating the need for full service branches, which also reduces costs; improving access to financial services, by putting more direct control over how such services are used into the hands of local operators/agents or the customers themselves. The key financial services offered through ICT innovations for value chains are: transfers and payments; credit; savings; insurance and financial derivatives (Aryeetey, 2005).

Kenya has a recognized and successful innovation (M-PESA) in the provision of financial services for offering payments and transfers even to remote area. The most widely known, M-PESA, began as a service enabling people living in cities to send money back home (money transfers) to their families in rural areas in an easy, trustworthy and low-cost way (Mbiti & Weil, 2011). The integration of the mobile phone money transfer in loan repayment plans has increased the access to farm input credit facilities, a step that is reducing poverty among small-holders (Poole, 2017). According to Mbiti (2011), the individuals use their own mobile phone for processing the transfers and visit the local shop for depositing and withdrawing the cash. Similarly, in Philippines there are two main mobile financial service (MFS) providers: SMART Money and GCASH. They have

expanded the services they offer, their main service remains money transfers from family members living abroad (international remittances) and those living in Philippine cities sending money home to rural areas (domestic remittances). SMART Money and GCASH both focus mainly on domestic remittances, airtime purchase and bill payments, although most rural users do not use the bill payment service (BFA, 2010).

The services help improve agricultural value chains not directly but facilitates the provision of supplemental income for when the agricultural cycle does not permit income generation, and therefore, creates a safety net for rural farmers and their families. These types of innovations are often offered by MNOs rather than banks, as the service is a simple cash transfer, similar to that offered by Western Union (FAO, 2013). An online commodity marketing platform Sokopepe, was created to promote local farmers to by-pass intermediaries and sell their maize directly to the highest bidder after registering as a member. Registered buyers then log on via the Internet buyers are often larger and urban-based so have access to what is available the price they should pay (FAO, 2013). Some buyers usually retrieve the maize and pay farmer through M-PESA (Wararu, 2019).

On credit facilities, a number of Cooperative have initiated activities for improving access to agricultural credit in credit management ICT tools to improve credit disbursement and administration for retail input suppliers. The technology used simple off-the-shelf accounting software packages and tools that are customised from other microcredit programmes, including an Excel-based cash flow analysis tool and an Access based loan portfolio management tool (Addom, et al., 2019). The use of technology, improve the funding coordination and communication processes of the larger input distributors providing the financing, while the retailers acted as intermediaries in providing credit directly to farmers and monitoring.

In Kenya, Syngenta Foundation and UAP Insurance piloted Kilimo Salama to provide weather insurance that guarantees at least a partial recapture of the capital investment made if certain weather conditions occur (FAO, 2013). The farmer had the option of being automatically enrolled in the insurance programme when one purchases inputs from one of the Kilimo Salama partners who sell seeds, fertilizer as the stockist scans the barcodes of the products with a simple camera phone (syngentafoundation, 2016) . The farmer must also be registered with one of the programme's solar-powered weather stations. However, with low costs, fast processing and growing trust in the system, farmers are slowly adopting this new type of insurance and distribution mechanism (Ogodo, 2010)

According to FAO (2012), agricultural ICT Innovation is indispensable, not only for developing new products, services, but also for ensuring survival of agriculture sector and providing ample opportunities for growth and profitability. Hence, use of innovation is driven by the ever-changing needs of a society, it is a continuous activity that involves both incremental as well as breakthrough improvements.

Adoption of ICT innovations in agriculture has been associated with: higher earnings and lower poverty; improved nutritional status; lower staple food prices; increased employment opportunities as well as earnings for landless labourers (Kasirye, 2010). Adoption of innovations is believed to be a major factor in the success of the green revolution experienced by Asian countries (Ravallion and Chen, 2004; Kasirye, 2010).On the other hand, non-adopters can hardly maintain their marginal livelihood with socio-economic stagnation leading to deprivation (Jain *et al.*, 2009).

While ICTs facilitate multi-stakeholder brainstorming, exploring alternative production technologies, facilitating access to markets and credits, training and demonstration,

community learning, searching, selecting and compiling information for individual clients, early warning for disasters and weather forecast, peer to peer sharing and exchange among extension (Richardson, 2006). Barakabitze et al. argue that, ICTs when embedded in systems through the use of participatory approaches can bring agriculture development and growth in any developing. It is noted that the use of participatory approach has a great potential in developing and promoting agricultural knowledge to farmers (FAO, 2009). Therefore, there is need to look at how participatory approach facilitate the development of ICT-based agricultural solutions

2.3 Influence of ICT on Adoption of Agricultural Innovations

A number of studies on technology adoption in developing countries reveal that various factors influence technology adoption and they can be categorised based on factors such as characteristics of human, relative performance of the technology and program and institutional factors (Melesse, 2018). This section review factors that have been identified by researchers that influence ICT use and categorises them into various factors.

2.3.1 Human/Demographics Factors

According to Melesse (2018), human characteristics can stimulate the use of technology such as education level, experience with the activity, age, gender, level of wealth, farm size, plot characteristics, labour availability, and resource endowment, among others. The adoption of ICT have been strongly associated with the education level of a farmer and farm size and of age of the farmers (Viraiyan et al., 2017). Researchers argues that there is disparity in adoption between different sizes and types of farm and ICT adoption requires much time and effort (Muriithi et al., 2016). The study by Mwombe, noted that age, gender, income and acreage of bananas planted had an influence on the intensity of use of ICT tools, as a source of agricultural information for smallholder banana farmers in Gatanga

district, Kenya (Mwombe et al., 2014). It can therefore, be argued that human/demographic factors can play a major role in encouraging adoption of innovations.

2.3.2 Economic/Social factors

Economic factors and enabling policies and programs, market linkages, access to institutional support and credit were found to play a positive role in stimulating farmer investment in and adoption of sustainable technologies (Shiferaw & Okello, 2009). Similarly, factors such as availability of credit, the availability and quality of information on the technologies, accessibility of markets for products and inputs factors, the land tenure system, and the availability of adequate infrastructure, extension support among others have also been identified to have important role in ICT update (Melesse, 2018).

A study on the ICT Adoption and its' implications for Agriculture in Sri Lanka, indicates that 76.1% of respondents have ICT uptake problems in agriculture sector, with cost of telecommunication and internet causing higher uptake problems (H.A.C.K Jayathilake et al., 2016). The results suggested that the most important challenge which affects the use of ICT in agriculture is cost of technology. Furthermore, the World Bank report (2008) discovers the challenges that influence rural Women's uptake of ICT as: low economic empowerment, cultural attitudes that discriminate against women's access to technology and technology education.

According to Taragola & Gelg (2015), the challenges like lack of ICT proficiency, lack of ICT benefit awareness, cost of technology, trust level in the ICT system, lack of training, system integration and software availability limit the use of ICT by farmers (Taragola & Gelg, 2015). A study by Pavic (2015), discovered that the adoption of ICT by Small traders is still lower due to lack of knowledge about the potential of ICT, a shortage of resources such financial and expertise and lack of skills. According to Ifinedo (2005) all countries in

Sub-Saharan Africa with the exception of South Africa and its neighbours have a poor e-readiness score. This is evidenced by the fact that, there is a general lack of community awareness about the potential benefits and capabilities of ICT (Ifinedo, 2005). Without a high level of ICT awareness, no community can fully participate in this networked world.

A number of studies showed that Internet access in rural areas are influenced by income and gender for basic users, by the existence of a young member in the family for interactive users, and by the digital divide between rural versus urban location and farmer's competency for the farm oriented users(Tata & McNamara, 2016). Large farming organizations have enough resources to adopt ICT while on the other hand SMEs farming organisations have limited financial and human resources to adopt ICT (Mng'ong'ose & Matern Victor, 2018).

Agricultural extension workers identify the main barriers for technology uptake and agricultural performance as lack of appropriate incentives, low level of recognition, high transportation cost and inadequate budgets, inadequate technology training, lack of affordable system of communication with the farmers, and lack of training in communication skills and social mobilization techniques (Kiptum & Chepken, 2016). A number of studies have looked into a broader perspective of Internet adoption and found that environmental factors such as government intervention, public administration, and external pressure from competitors, play the key role in the adoption and implementation of ICT, especially in e-agriculture (FAO, 2018; Melesse, 2018; Pavic et al., 2015). Kapurubandara et al. (2016), underlines the challenges as internal and external; internal influences for adoption of ICT include user characteristics, communication model, while external barriers include infrastructure, social, cultural, political, legal and regulatory (Kapurubandara & Lawson, 2016). Many studies have also focused on identifying the

determinants that influence ICT adoption and economic/social factors have major role to play.

2.3.3 Infrastructure/Technology factors

According to Boer (2001), factors related to the performance of technology and practices, the perception by individuals on the technology, complexity and performance of the innovation is key. Major issues to consider on technology adoption; availability, complementary inputs, the relative profitability of its adoption compared to substitute technologies, the period of recovery of investment, local adoption patterns of the technology and the susceptibility of the technology to environmental hazards (Boer, 2001).

A comparative study on ICT use in agriculture in Botswana, Ghana, Kenya and Uganda found that low capacity and inadequate infrastructure were major challenges to ICT use in agriculture (Mwombe, et al., 2014). The study further demonstrated that although cellular phones, the Internet, radio, and web-based applications have become increasingly important in sharing and disseminating agricultural information and knowledge, and in marketing goods and services, there is low capacity and usage of ICTs and that inadequate ICT infrastructure in rural areas is a major problem. A study have argued that poor IT skills, lack of familiarity through irregular use, or simply not knowing where to look for information, Internet connections in rural areas are main hindrance of ICT adoption .

In Brazil, ICT diffusion in rural areas has been a concerned, researchers have identified challenges that hinder their access to ICTs as physical access to a telecenter, which are distance from home, unreliable or unstable electrical power grids, equipment maintenance, theft, and limited financial resources (Mng'ong'ose & Matern Victor, 2018). According to a study by Chavula (2014), poor ICT infrastructural development, high cost of broadcast equipment, high charges for radio/television presentations, high cost of

access/interconnectivity and electricity power problems were amongst the constraints affecting ICT utilization by agricultural extension officers in the Niger Delta, Nigeria(Chavula, 2014). According to Lal (2007) investigating adoption of ICT in Nigerian SMEs and farmers, found that one of the major challenges inhibiting ICT diffusion and intensive utilization is poor physical infrastructure. In developing countries some of the ICT adoption challenges include legal and regulatory issues, weak ICT strategies, lack of readiness, excessive reliance on foreign technology and ongoing weaknesses in ICT implementation (Dutta et al., 2003).

The study by Guermazi and Satola (2005 cited by Mng'ong'ose, 2018), emphasised on the need of infrastructure investment for the uptake of ICT far exceeds the resources of most developing countries and is prohibitively expensive or not commercially viable. This can be very true if one considers countries most of the African countries. Wambui (2005) mention of the Sierra Leone's ICT infrastructure that is in great need of reform because of its poor shape. The country lacks communication facilities and the main efficient form of communication remains the radio. Jorge (2002) noted that telecommunications infrastructure is limited in most developing countries and costs are exceedingly high. The limited available infrastructure is mostly found in larger urban areas, thereby neglecting and depriving the rest of the individual farmers and firms in rural areas those in need of a steady flow and ready access to information and wider business networks (Mng'ong'ose & Matern Victor, 2018). This situation is not favorable since the majority of the world's poorest people dwell in the rural and poor areas, where there is little or no ICT infrastructure.

According to Jorge (2002:4), even when infrastructure is available, affordable access is a concern in most developing countries. Personal computers, faxes, printers and some ICT

equipment are expensive and unaffordable to the majority of developing countries inhabitants, even for middle- class families, thereby cutting down the populations who are able to use the technology (Moreno, 2012). The initial costs of ICT and the ongoing expenses of maintaining them are very high and a number of people cannot afford (Galloway & R. Mochrie, 2015)

The use of ICTs for agricultural extension is growing in Asia and Africa especially with the recent expansion in the use of mobile phones, the ICT devices have been used to largely provide agricultural information (Asenso-Okyere & Mekonnen, 2013). Farmers need to understand the importance of improved agricultural practices and farmers' education, agricultural information alone may not necessarily lead to innovations and the desired increased productivity. While use of the ICTs seems relatively easy once in place as opposed to human-based extension service, which requires deployment of large number of extension workers, doing so have some constrains such as, the policy environment, the rural setting, infrastructure and capacity problems and the ability of local communities to use ICTs to access information for their farming activities (Asenso-Okyere & Mekonnen, 2013).

The factors limiting ICT adoption identified provide an indication of remedial priorities and studies have proposed solutions intended to address emerging and existing challenges. There is significant room for ICT to make in road in agricultural sector by considering key factors in developing appropriate framework, areas of consideration can be in agricultural production; access to market information; access to finance and access to information channels. A summary of factors that influence the adoption of ICT innovation as identified in various studies is presented in table 2.1.

Table 2.1: Summary of factor influencing ICT adoption

Areas of context	**Variable considered for ICT adoption**	**Literature Review**
Economic	Education level, farm size	Warren, 2001
Economic, technological and human	ICT proficiency, awareness, complexity, infrastructure, cost of technology, training, availability	Taragola & Gelg, 2015
Economic	Age, gender, income and farm size	Mwombe, et al., 2014
Economics	Awareness, financial, expertise and skills	Pavic et al., 2015
Economic, technological and human	Government intervention, public administration, external pressure from competitors	FAO, 2018
Technological and human	User characteristics, communication model, infrastructure, social, cultural, political, legal and regulatory	Kapurubandara & Lawson, 2016
Economics and technological	Cost access, infrastructure,	Chavula, 2014
Economic and human	Cost of access, gender, competency	Tata & McNamara, 2016
Economic, technological and human	IT skills, familiarity, awareness, reliability, cost of technology	Mng'ong'ose & Matern Victor, 2018
Technological and human	Culture, attitude, education and communication model	World bank report of 2008
Human	Awareness, capabilities	Colle & Roman, 2003:396
Economic, technological and human	Infrastructure, cost of access, training, IT skills, social mobilization	Asenso-Okyere & Mekonnen, 2013

2.4 Theoretical Approaches to ICT Agricultural Innovation Adoption

Technologies play an important role in economic development. Adoption and diffusion of technology are two interrelated concepts describing the decision to use or not use a given technology among economic entities over a period of time. Adoption of innovation is a continuous process and takes time for adoption to be achieved, moreover, adopters may continue or cease to use the new technology. The duration of adoption of a technology vary among economic units, regions and attributes of the technology itself. Therefore, adequate

understanding of the process of technology adoption and its diffusion is necessary for designing effective model for disseminating agricultural innovations.

There are many theories that deal with generation of innovations, their diffusion and adoption or non-adoption by ultimate users. A theory is as a system of statements targeted at describing, explaining and predicting real-world phenomena (Gregor, 2006; S. B. Bacharach, 1989). According to Muller (Mueller & Urbach, 2013), a scientific theory is a system composed of factors and hypotheses.

A number of theories have been proposed for Information Technology (IT) and individual study, the most popular are Diffusion of innovation theory (DOI), Technology Acceptance Theory (TAM), Theory of Reasoned Action (TRA) (Lai, 2017). In area of agricultural information system, DOI and TAM have been applied in developing countries to develop model of ICT adoption by smallholder farmers (Ayim et al., 2020; Kante, 2018). Similarly, Zewge and Dittrich (2017) affirm TAM and DOI as the most used theories in developing countries in explaining and predicting studies on agriculture (Zewge & Dittrich, 2017). Central source of innovation (CSI) model has been used in agricultural information systems to understand the concept of technology transfer, with multi-source innovation (MSI) being improvement of the central source model posits to understand the clients' diverse needs and resources. The DIO, TAM, CSI and MSI can be categorized to belong to a stream of thought that is based on the intention to use, as the dependent variable (Woosley & Ashaia, 2011).

2.4.1 Diffusion of Innovation Theory

The Diffusion of Innovation (DOI) theory by Rogers has dominated the theory and practice of agricultural extension systems all over the world (Rajinder Peshin et al., 2009). The

classical study of 1940s provided the initiative to target innovative farmers to adopt innovations so that other farmers would follow in course of time (Ryan and Gross, 2009). The Diffusion Theory provides an adequate explanation of the relationship between the technological innovations and the social relations. Nevertheless, with its research perspective and deterministic outcomes emphasizing the information exchange, it is an ideal lower level framework for analysing the processes of technology dissemination and the features of an innovation. (Gartshore, 2004)

According to Rogers, diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system (Rogers, 1983; Rogers & Scotts, 1999; Rogers & Shoemakers, 1971). Diffusion is a special type of communication in which the messages are about the new idea and process by which an innovation spreads within a social system (Rogers, 1995). The innovation can only said to have diffused within a social system if it is adopted by individuals or group of individuals. Through diffusion, there should be social change; the process by which alteration occurs in the structure and function of a social system. Consequently, diffusion of agricultural innovations on food production, market information, credit facilities, can lead to improve standard of living among farming community. The diffusion of innovation model focuses on four main elements that influence the spread of a new idea: the innovation, communication channels, time, and a social system (Rogers, 1995).

Diffusion of innovation is only accomplished if a new idea or practice is accepted by an individual or a group of people over a period of time (Greenhalgh et al., 2004). The spread of agriculture innovations from ICT developers, research institutions among other in the case of new systems among a group of farmers is important in this study. The rate of spread

of these innovations depend upon the availability of communication channels and structure of the social system.

An ICT innovation has two or either of the two components, hardware (material form) consisting of physical objects and software (behavioural form) consisting of knowledge base. Some innovations or technologies take less time to spread in a social system while others may take longer time (Peshin, et al., 2019). The innovation decision process is characterized in different stages: knowledge, persuasion, decision, implementation and confirmation (Burgess et al., 2017; Peshin, et al., 2009). In the knowledge stage the individual farmers or groups need to be exposed to the innovation's existence and gain understanding of how it functions and understanding about an innovation. The individuals may need to be persuaded to use it because they do not regard it as relevant to their situation; the outcome of the persuasion stage is either adoption or rejection of the innovation. For the implementation stage, an individual puts an innovation into use and the final stage is confirmation during which the farmers seeks reinforcement for the decision made (Burgess, et al., 2017). The advantage of using the DOI theory is that it provides the contextual sets that drive the acceptance of the technology innovation (Ituma-aleke & Egwu, 2014), such as to the adoption of ICT agricultural innovation by farmers.

i. Attributes of Innovations

Explaining the theory, Rogers (1983), argues that the characteristics which determine the rate of adoption are: Relative Advantage, Compatibility, Complexity, Triability and observability as described in table 2.2.

Table 2.2: Perceived Attributes of Innovation

Attributes	Definition	Application
Relative advantage	The ratio of the expected benefits and the costs of adoption of an innovation.	The innovation that is more beneficial compared to the cost stands more chances of being adopted and used
Compatibility	The degree to which an innovation is consistent with past experiences and needs of the users	Adoption and use are more likely when the innovation is consistent with the economic, human value and philosophical value system of the users and their expectations.
Complexity	The degree to which an innovation is difficult to comprehend and use	Innovations that are perceived as more complex are less likely to be adopted. A system that is perceived to be simple to use would likely be adopted and used.
Trialability	The degree to which an innovation can be experimented with either on limited basis or in instalments	ICT innovation on agriculture that can be tested before adoption are adopted more rapidly.
observability	The degree to which the results of an innovation are visible to others	An ICT that realised benefits are visible to potential users through an interaction with fellow users are more likely to be adopted and used.

Source: Kante 2016; Author 2018

ii. Characteristics of Adopters

Examining the characteristics of the different potential adopters is quite useful in study for shedding light on how they can influence the successful adoption of innovative product and services. The adoption process forms a normal S-shaped curve when plotted over time (Geroski, 2000; Rogers, 1995). According to Rogers (1999) attributes this distribution of adoption to the role of information, which reduces uncertainty in the diffusion process and argue that adopters are classified into five categories: innovators, early adopters, early majority, late majority and laggards.

iii. **Communication Channels**

According to Rogers (1996), diffusion refers to the process by which an innovation is communicated through certain channels over time among the members of a social system. The diffusion of innovations involves both mass media and interpersonal communication channels" Communication is a process by which two or more people share or create information in order to reach a mutual understanding (Peshin, et al., 2019). A communication channel is the means by which message about an innovation or technology is shared among two or more individuals and Information Technology (IT) is highly helpful when it comes to communicating the knowledge. In agriculturally based developing countries like India cannot ignore IT in such transformation. Information technology refers to how we use information, compute and communicate information to the people (Peshin, et al., 2019). Communication channels available for agricultural information can be categorized as Online Web Portal, Voice-Oriented Service. VoIP, SMS/MMS Service, Support Community Formation, Video conferencing (Jodhpur, 2017).

Despite of all communication channels and potentiality provided by ICT, farmers face common challenges and issues like sustainability, scalability, and availability of appropriate content (Glendenning & Ficarelli., 2012). Mobile technology, on the other hand, is increasingly being adopted as the technology of choice for delivery of ICT services and solutions. There has been a steady rise in mobile acquisition by people in the rural areas. As of mid-2012, over 68% of the Kenyan living below poverty line owned a mobile phone (RIA, 2012). Despite the increase of Mobile phone, agriculture sector in developing nations are facing numerous challenges including non-adoption of agricultural technology, due to farmers' lack of access to the latest information (Glendenning & Ficarelli., 2012).

iv. Social system

According to Penish (2019), a social system refers to a set of individuals, informal groups or organizations that are engaged in solving a common problem or in accomplishing a common goal. The members of a social system in this study are stakeholders, they interact by exchanging information, exchanging products, instructions and providing supporting tasks.

Diffusion usually occurs within a social system and diffusion of agricultural innovations at the village level depends upon the structural characteristics of the village or social system, which may be homogenous or heterogeneous (Peshin, et al., 2009). The homogenous village may have population similar in social or demographic characteristics like caste, religion, culture, among others whereas heterogeneous village may have population varied in the characteristics. The innovative ideas may flow smoothly in homogeneous community rather than in heterogeneous community (Peshin, et al., 2019). According to Kart (2015, it is unthinkable to study diffusion without some knowledge of the social structures in which potential adopters are located, just like studying blood circulation without adequate knowledge of the veins and arteries (Katz, 2015).

Another important component of social system is communication structure, which in rural setup, is constituted by informal interpersonal links. The existence of the informal interpersonal linkages results in communication networks that follow a set pattern of information flow (Peshin, et al., 2019). A well-developed communication structures in a social system can facilitate the diffusion of innovations. A community having well integrated social structure is favourably oriented towards change (Rajinder Peshin, et al., 2009), which influences its members who may be farmers to improve their farming situations by adopting innovative practices. In a community, there are few who act as

leaders by influencing opinions of majority of people and they are called opinion leaders. The effective opinion leaders provide orientation to community members towards change and development by persuading them to participate in development activities (Peshin, et al., 2019). Academics complement agricultural researchers who respond to complex realities by planning their activities within the context of an "Innovation System" (Julian Gonsalves et al., 2015). An innovation system is a group of organizations or individuals involved in the generation, diffusion, adaptation, and use of knowledge of socio-economic significance, and the institutional context that governs the way these interactions and processes take place (Hall, 2007), They recognize that the innovation is asocial process involving interactive learning. The social side of innovation requires the process of networking, forming alliances, and partnerships, negotiating priorities and approaches that are central to this study. The social system for popularizing this study will consists of researchers, extension workers, farmers, policy makers and market forces.

The innovation diffusion model has some limitations, main challenge of the model is that it generally assumes that the most important variable is information and the willingness of the individual to change(Hagelaar, 2018). The study further states that individual is characterised according to behaviour without considering factors that influence their behaviour. In reality many other factors are known to influence the adoption of an agricultural innovation (Rajinder Peshin, et al., 2009). These include the farmer's objectives, the level of the resource endowments of the individuals, access to resources, availability of support systems and the characteristics of the innovation. For example, access to resources such as labour and land can limit the adoption of an innovation to a small number of individuals in a society. This could apply to individual access to mobile phones and availability of community grouping. Access to productive resources is also

gendered, with women having less access than men. In such cases an innovative individual may be labelled as a laggard, while late or non-adoption is caused by lack of resources. Information and support services from the different organizations may also limit the spread of innovation by targeting innovators and early adopters while ignoring the others.

2.4.2 Technology Acceptance Model (TAM) Theory

User acceptance is a key factor in determining the success or failure of any information system project (Venkatesh, V. & Davis, 2000). A number of studies on Information Technology (IT), argue that user attitudes and human factors are important aspects affecting the success of an information system (Davis, 1989, Burkhardt, 1994, Rice &Aydin1991). According to Davis (1989) Technology Acceptance Model, information system theory should propagate stages to be followed by information seekers or learners in the acceptance of new technology to achieve information literacy skill (Durodolu, 2016). Durodolu (2016) provides explanation and prediction of Information Technology acceptance and diagnoses problems before users experience the technology, as well as TAM is gaining popularity for understanding the relationship between humans and technology through Perceived Usefulness (PU) and Perceived Ease of Use (PEU) (Durodolu, 2016).

Perceived usefulness is the user's subjective opinion that using a system will increase the user's performance (Davis, F. D et al., 1989). Further explanation states that, it is the extent to which a person believes that utilizing a particular method or technique would enhance his or her routine responsibility (Davis, F. D., 1993). Davis argues that perceived ease of use is the extent to which an individual considers that making use of a specific system would be effortless and hassle free (Davis, F. D, et al., 1989) . A study by Choo (1991) combined the TAM and the information behavioural model to consider relevance of the

information. Similarly, a study by Lee (Lee, D. Y. & Lehto, 2013), combined the TAM with Theory of Planned Behaviour (TPB), perceived risk and perceived benefit to understand the adoption of internet banking.

Technology acceptance model (TAM), has been used by researchers worldwide to understand the acceptance of different types of information systems. A study by Paul (Paul Jen-Hwa Hu et al., 2003), tried to evaluate the acceptance of eLearning systems by teachers by using TAM. Zhou et al (1994), developed a new model based on TAM called online shopping acceptance model (OSAM) to study online shopping behaviour. Additionally a model by Pavlou was developed to predict the acceptance of e-commerce by adding new variables trust and perceived risk (Pavlou, 2003). Furthermore, Tero (Tero Pikkarainen, 2004), developed model to understand the acceptance online banking in Finland, perceived usefulness and information in online banking and its role. Hsu and Chiu suggested a model that specifies that the acceptance pattern and role of internet self-efficacy plays an important role in e-service adoption (Meng-Hsiang Hsu & Chiu, 2014). The model based on TAM and theory of planned behavior (TPB), have been developed to understand mobile service adoption which states that perceived useful is the strongest factor in adoption (Sun et al., 2013). Muller-Seitz (Müller-Seitz et al., 2009) used the Technology Acceptance Model with security concern to understand acceptance of Radio Frequency Identification (RFID). These studies generally have adapted TAM theory because it focused on user's adaption to spiralling performance as easy to use. The study adapted TAM theory to understand usage of agricultural information systems to smallholder farmers. This means if the agricultural innovations are effectively disseminated and accessed by farmers and farm communities, with the aim to improve productivity, economic, social and environmental sustainability. It is important to stress the role of the users (farmers) in the

success of any information dissemination model. The attitude of a farmer towards innovation and source and farmer's ability to use the innovation are important factors for successful use of information disseminated to users.

TAM indicates that two important constructs of the TAM, Perceived usefulness (PU), Perceived Ease of Use (PEOU) and external variables as shown in Figure 2.2. External variables refer to the quality that is outside of an individual, for example, training, system experience and quality of systems. These external factors fundamentally lead to attitudes towards the use of a particular technology and the ultimate usage of the technology.

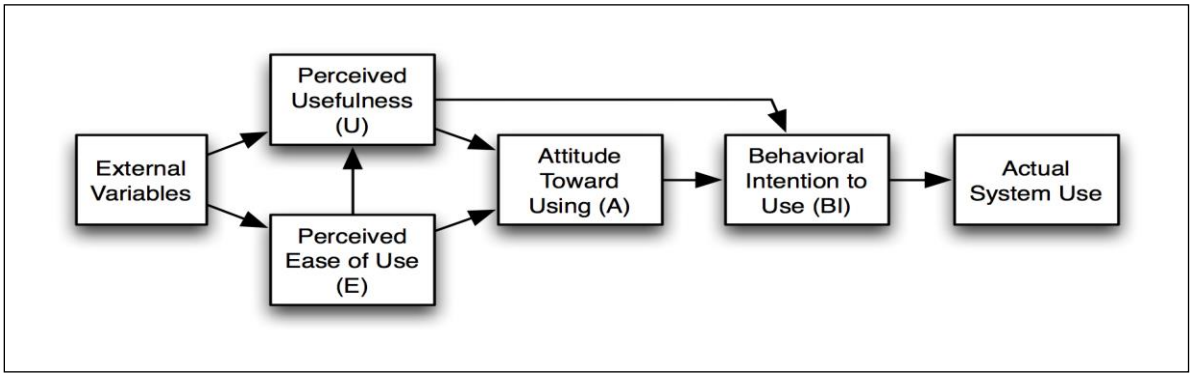

Figure 2.2: Technological Acceptance Model Sources: Davis (1989).

Despite TAM popularity, limitations have been noted on the model. According to study by Lee (Lee, Y.-C. et al., 2010), The model is useful, but should be expanded to include social and human factors. Moreover, TAM lacks method for identifying the determinants of PU and PEOU, as well as the base decision making, addition the neglect of group, social and cultural aspect in decision making (Bagozzi, 2008). The study concludes that though TAM is suitable, but social factors and characteristics of adopters can have an effect on the adoption technology. The human factors allow a study to understand the interaction of people with tasks, equipment/technologies, environment, and evaluate various interactions.

The importance of in cooperating human factors are to optimize user and system efficiency and effectiveness, safety, health, comfort, and quality of life.

2.4.3 Unified Theory of Acceptance and Use of Technology (UTAUT)

The Unified Theory of Acceptance and Use of Technology (UTAUT), perceived that information systems researchers were confronted with a choice among a multitude of models and were bound to choose constructs across models or choose a favoured model, thus ignoring the contribution from alternative ones (Fuksa, 2013; Venkatesh, Viswanath & Zhang, 2010). Researchers argue that, there is a need for a synthesis in order to reach a unified view of users' technology acceptance (Alkharang, 2014). The study by Venkatesh et al. (2003) developed the unified model through reviewing eight models which explain ICT usage, namely TRA, TAM, the motivational model, TPB, a model combining TAM and TPB as indicated in figure 2.3.

Hwang (2011) emphasized that Information Systems (IS) researchers, Information Technology (IT) managers and ecommerce decision makers can benefit from the importance of meta-analysis on UTAUT as a knowledge cumulating tool (Hwang and Schmidt, 2011). Armed with this knowledge innovation developers and other agricultural stakeholders can take more successful steps in attaining increase in technological patronage and usage. Studies have shown that to achieve a top level IT management success, accurate IT prescription is of paramount importance (Benbasat & Zmud, 1999). Furthemore, UTAUT theory has left no stone unturned to explain, conceptualize and hence test user's intentions to use ICT, infrastructure and the subsequent user behavior, this study relates the literature production, marketing and financial sectors in agriculture. The model considers four constructs as direct determinants of user acceptance and usage behavior, such can establish the user behaviour on ICT innovations, namely Performance

Expectancy, Effort Expectancy, Social Influence, and Facilitating Conditions (Venkatesh, Viswanath & Zhang, 2010).

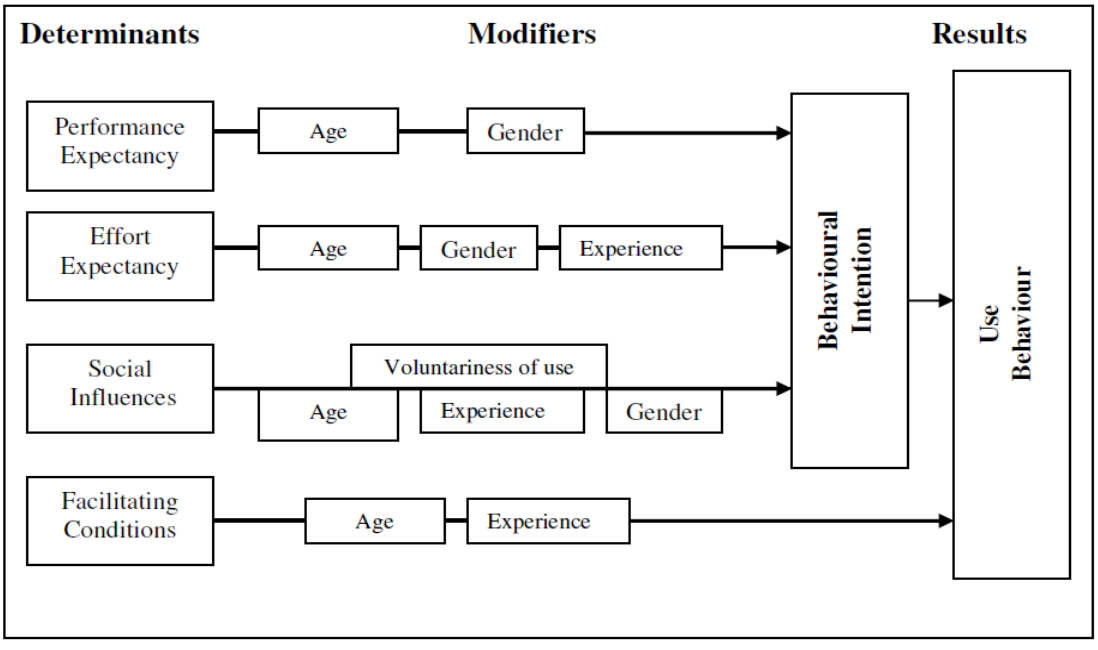

Figure 2.3: UTAUT, (Venkatesh et al. (2003)

When comparing UTAUT with the Theory of Planned Behavior (TPB) and the technology acceptance model (TAM) , results from the comparison of five theory of technology acceptance models, apart from usefulness (performance expectancy), UTAUT addressed the rest of the other important variables: subjective norm (social influence), and compatibility (facilitating condition) (Alwahaishi & Snáse, 2013; Riemenschneider et al., 2003). But according to Chang et al. (2012) their research shows that UTAUT focuses on users who may be less willing to adopt and use new systems, it has served as a baseline model and has been applied to the study of a variety of technologies in both organizational and non-organizational settings. There have been many applications and replications of the entire model or part of the model in organizational settings that have contributed to fortifying its generalizability (Neufeld et al., 2007). The first type of extension/ integration

examined UTAUT in new contexts, such as new technologies (collaborative technology, health information systems (Chang, 2012); new user populations (healthcare professionals, consumers and new cultural settings (Gupta et al., 2008; Im et al., 2011). The second type is the addition of new constructs in order to expand the scope of the endogenous theoretical mechanisms outlined in UTAUT (Chan et al. 2008; Sun et al. 2009).

Criticism of Unified Theory of Acceptance and Use of Technology (UTAUT) according to the study by Van Raaij (2008), use the construct of effort expectancy to capture the concepts of perceived ease of use (TAM/TAM2), complexity, and ease of use, specifically to the information system. Furthermore, the effort expectancy have been defined as the degree of ease associated with the use of the system(Van Raaij & Schepers, 2008). However, many other researchers find no empirical evidence to support the relation between perceived ease of use and perceived usefulness (Van Raaij & Schepers, 2008). The agricultural system is likely to influences the user's intention if only indirectly via the perception of near-term usefulness. This finding concurs with that of the original TAM theory but contradicts the results obtained in many previous studies (Lu, 1994).

A study by Im, I., et.al. (2011), show that the inclusion of exogenous predictors of the UTAUT as variables is extensive replications, applications, and extensions/ integrations of UTAUT have been valuable in expanding our understanding of technology adoption and extending the theoretical boundaries of the theory. However, the review of this study revealed that most studies using UTAUT employed only a subset of the constructs, particularly by dropping the moderators in this case: age, gender and experience (Armida 2008), as shown in figure 2.4. While various studies contribute to understanding of UTAUT in different contexts, there is still the need for systematic investigation and theorizing of the salient factors that would apply to agriculture sector technological use

context. In the case UTAUT which was originally developed to explain users' technology Acceptance and use, has been utilized to combine effort with TAM, DOI critically to examine how dissemination and adoption of innovation can be enhanced among the smallholder farmers.

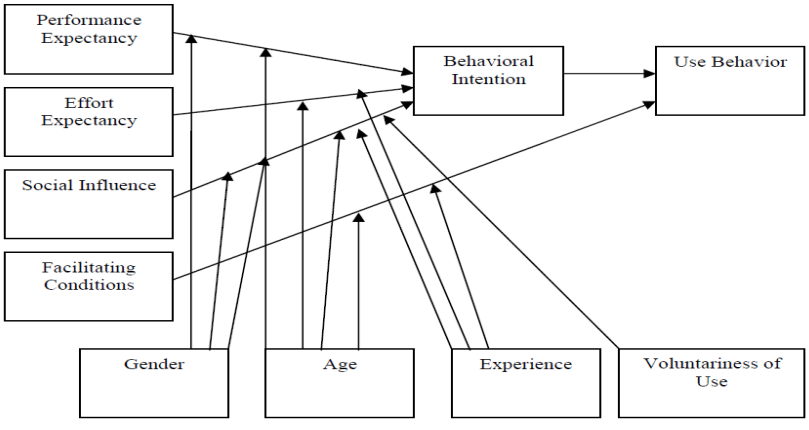

Figure 2.4 UTAUT Moderating variables separated (Im, I., et.al. (2011))

In UTAUT, performance expectancy is taken as the degree to which an individual believes that using the system will help him or her to attain gains in a job (Venkatesh et al., 2003). This factor was derived from the perceived usefulness factor as proposed in TAM. A system that is high in Performance expectancy (perceived usefulness-PU). PU is one that the user believes will reduce his or her task ambiguities and eventually increases work-related performance (Davis, 1989; Venkatesh and Davis, 2000; Amoako-Gyampah, 2007). As evidenced by a research of comparison of five theories later in year 2002, usefulness was still found to be a strong and highly significant determinant of technology usage (Riemenschneider et al., 2002; Lee, 2009; Schaupp et al., 2010). Facilitating conditions are defined as the degree to which individual believes that an organisation and technical infrastructure exists to support the use of the system. Theory has been extended to UTAUT 2, which has the construct price affecting the behavioural intention. This study considers

UTAUT theory as a providing tool for ICT developer and researchers to assess the likelihood of success of technology introductions and to understand the drivers of acceptance in order to design interventions, for agricultural system. Table 3.3, provides a summary of theories and models discussed.

Table 2.3: Summary of the theories/Models

Theories/ Models	Author	Characteristics	Strength	Limitations
Innovation Diffusion Theory (IDT)	Rogers and Shoemaker, 1971; Rogers, 1983, 1993, 2003	• Describe the innovation decision process • Explain the relationship between technological innovation and social relations • Focus on innovation, communication channels, time and social systems	• Provide an account of how technology innovation moves from the stage of invention to widespread use/or not)	• Challenge in managing diverse communication models, ICT solutions, range of stakeholders
Technology Acceptance Model (TAM)	Davis, F. D et al., 1989	• Define the relationship between human and technology; PU and PEU • TAM2 incorporates social influencing processes and cognitive instrumental proves as additional theoretical constructs • Focus on user attitude and human factors	• TAM and TAM2 are effective in predicting system usage based on behavioural intent when adopting new technologies, regardless of the industry	• TAM does not consider social and human factors • Focus on individual users not group usage (participation/collaboration method)
Unified Theory of Acceptance and Use of Technology (UTAUT).	Venkatesh et al. (2003)	• Establish the user behaviour on ICT innovations. • Key determinants and moderators: performance expectancy, effort expectancy, social influence, and facilitating conditions.	• Incorporate the concept of willingness for the use of new technology • Provide a solid vase why users accept or reject technology in a specific perspective	• The model is not measuring acceptance; users have no choice to accept the technology • Difficult to understand how a wide range of items can reflect on single construct

2.4.4 Summary of study theories on Adoption

Several theories do exist that can be applied on this study, however, the study was guided by DOI, TAM and UTAUT. DIO theory seeks to explain how, why, and at what rate

agricultural innovations spread among smallholder farmers. The innovation decision process starts with the knowledge stage during which users learn about the existence of innovation and seeks information about the innovation. The existing literature recognizes that there is a relationship between users' characteristics, innovation characteristics, channel used for dissemination and adoption to innovation without confirming why and how this relationship exists.

TAM is used to design consumer acceptance of technology, it predict users' adoption of technology. Hence, there is need to be considered in the design of the adoption model. External variable: users' characteristics, innovation attributes and channel attributes is proposed to be incorporated into TAM in order to design the proposed model. TAM provides a basis with which one traces how external variables influences intention to use.

A number of studies have compared the influence of TRA, TAM, DIO and UTAU on use of ICT in agriculture, based on different independent variables and moderator, the studies provided different variance. The measure of the proportion of the variance of the dependent by the variables from TAM and UTAUT, define above 50% in the use of ICT on agriculture as shown in table 2.4.

Table 2.4: Summary of key constructs, moderators and variance

Theory/Model	**Constructs (Independent variables)**	**Moderators**	**Explained variance (R2)**
Theory of Reasoned Action (TRA)	1. Attitude toward behaviour 2. Subjective norm	1.Experience 2. Voluntariness	0.36
Technology Acceptance Model - a (TAM2)	1. Perceived usefulness 2. Perceived ease of use 3. Subjective norm	1.Experience 2. Voluntariness	0.53
- b (TAM- including gender)	1. Perceived usefulness 2. Perceived ease of use 3. Subjective norm	1. Gender 2. Experience	0.52
Diffusion of Innovation theory	1. Relative advantage 2. Ease of use 3.Result demonstrability 4.Triability 5. Visibility 6. Image 7. Compatibility 8. Voluntariness of use	1. Experience	0.40
Unified Theory of Acceptance and Use of Technology (UTAUT)	1.Performance expectancy 2. Effort expectancy 3. Social influence 4.Facilitating conditions	1. Gender 2. Age 3. Experience 4.Voluntariness	**0.69**

Source: (Venkatesh*et al.* 2003; Kripanont 2007, Dulle, Minishi-Majanja and Coloete2010).

Considering the explained variance in table 2.4, it is clear that UTAUT and TAM provided a solid base in this study to explain why users accept or reject a technology in a specific perspective and have significant effect on technology adoption.

The cost of ICT product and services is another challenge for farmer in their plight to adopt and use agricultural innovations. The ICT skills and literacy are also challenging farmers in process of adoption and usage of agricultural innovations. A number of constructs are extracted to inform the study as shown in table 2.5

Table 2.5: Summary of the Constructs from Theories

Theory	Attributes	Construct Extracted	Classification
Diffusion of Innovation Theory (DOI)	Relative Advantage	Relative Advantage	Technological factor
	Complexity	Simplicity	Technological factor
Technology Acceptance Model (TAM)	Perceived Ease of Use (PEIU)	Ease of use (Simplicity)	Technological factor
	Perceived usefulness (PU	Usefulness	Technological factor
Unified theory for Acceptance and use of Technology (UTAUT)	Social Influence	Family/friends	Social Influence
		Leaders	Social Influence
	Facilitating conditions	Availability	Use of ICT Technological factor
		Reliability	
Technology Acceptance model	Intention to adoption/ actual dissemination and adoption.	dissemination and adoption of innovation	Innovation Adoption

The need to understand the influence of shared information in this study was important. Collaboration among stakeholders and the influence of each group in community is necessary on enhancing information flow. The collaboration among the stakeholders, observability, and social influence in dissemination and adoption of ICT innovation on agriculture was identified. The study categorised collaboration among stakeholders and social influence by farmers among themselves with respect to adoption and use of ICT innovation.

2.4.5 Participatory Approach on Agriculture

Participatory approach in agriculture has been termed as a method of integrating all actors of agriculture value chain with the interest of solving farmers' problems (Barakabitze et al., 2017b). According to Deloitte (2011), ICTs when embedded in systems through the

use of participatory approaches can escalate agricultural development and growth in most developing countries including Kenya.

As part of understanding opportunities in agriculture, a study on impact of various approaches on agriculture indicates that participatory approaches can make a positive impact because they are not only focused on improving farming techniques but also consider issues of farmers empowerment (Ag4impact, 2018) . The participatory approach recognize the importance of all stakeholders in the generation and dissemination of knowledge, contrary to past approaches where the needs and preferences of the main beneficiaries were often overlooked (Barakabitze, et al., 2017a). Success is measured by the numbers of farmers actively participating and the sustainability of local organizations (Axinn in FAO, 1988.)

In agricultural research, it is indicated that bottom-up participatory approaches based on local farmers' knowledge can increase uptake of improved technologies, and thus can be linked to the knowledge and innovation capacity of farmers to the benefit of all stakeholders (Isgren, 2012). Moreover, it has been argued that harnessing farmers' local knowledge and skills is a prerequisite for the development of sustainable agricultural technology (Altieri 2005). According to Deloitte (deloitte. 2011), transforming agriculture in developing nations, require involvement and participation of all stakeholders. The realisation can be measured by the numbers of farmers actively participating and the sustainability of local organizations (Axinn in FAO, 1988.) Joseph and Andrew (2008), asserts that participatory approaches in agriculture can farmers and decision-making involves all stakeholders in the farming community.

There are a number of participatory approaches in technology development that involve farmers such as Participatory Learning and Action (PLA), Participatory Technology Development (PTD), Farmer Participatory Research (FPR) and Participatory Extension Approach (PEA) (Kaihura, 2012). The application of participatory methods aimed involves analysing community constraints and needs (Participatory Needs Assessment (PNA), or Participatory Situation Analysis (PSA). In this system communities are informers. Joint identification of solutions and actions to overcome constraints, hence, in the process communities take own responsible decisions (Kaihura, 2012). Different participatory approaches are determined on how participation is applied such as passive participation; where communities are mere recipients of messages, assistance and services (Kaihura, 2012). While, in active participation the communities are consulted, they provide information on constraints, needs and even possible solutions.

Participatory development generally seeks to engage local people and communities in development efforts, but defining participatory development more specifically is difficult. Studies suggest that the concept includes three core elements; it is cognitive and aims to create new ways of understanding the issues addressed; it is political in that it aims to be empowering; and it is instrumental, aiming to create new alternatives for its participants (Isgren, 2012). The World Bank simply defines participatory development as a process through which stakeholders, and particularly the poor, influence and share control over development initiatives, and the decisions and resources that affect them" (World Bank, 2011).

Participatory development in practice can be explained as having four key stages. An important point is that participation should play a central role in all stages (Tufte & Mefalopulos, 2000): Research stage where the problem is defined, ideally with all

stakeholders involved in the process, in design stage the activities are designed, with active participation enhancing the relevance of interventions and securing the commitment and ownership of the local communities, Implementation stage, the planned activities are implemented, and participation improves the relevance and sustainability of the interventions. The evaluation stage the performance and impact of the interventions are assessed, and participation ensures that issues are brought to attention and addressed. In order to be meaningful, indicators should be defined in the very beginning of the process through collaboration between all relevant stakeholders (Isgren, 2012).

The range of definitions when carrying out a case study of participatory development are provided and different cases apply to different approaches and motives are always different (Isgren, 2012). The study emphasized on the implementation stage of the farmers' group project and the stages that influence overall perception of farmers.

2.4.6 Review of Participatory Approach Studies

A study by Barakabitze (2017), explored the extent agriculture researchers and extension officers from agricultural research institute collaborate with farmers through different participatory approaches in developing, promoting and adopting ICT-based systems for agriculture. The study provides an insight on the use of various participatory approaches to develop ICTs to the rural farming communities. It further discuss how participatory approaches can help the farming community in adopting ICT-based systems for agriculture thus contributing to solving problems as well as assisting them in identifying their technological and agricultural needs (Barakabitze, et al., 2017a). The study considered farming groups and extension workers without considering other major stakeholder as an important part of participatory group. The approach also does not address the need to integrate information from various stakeholders.

A study indicates that collaboration of multi-stakeholder such as farmers, extension professionals, educators and scientists leads to reducing the time needed to complete research, and improve the efficiency and effectiveness of the research process (Zyl et al., 2014). The study further accentuate that the result of partnership provides integrated information system for agriculture stakeholders that minimizes the duplication of data and ensures consistency, improves integrity of the data, there by addresses wide variety of information needs. The researcher in the study demonstrated significance of cooperation ration, however, the adoption process is not reflected.

The report on e-transform Africa in agriculture sector by Delloite (2012), argues that ICT solutions should support all stages of value chain; pre-cultivation, crop cultivation and harvesting and post-harvest stage. The study further emphasise that, stakeholders need to participate in all stages of ICT farming cycle during the development and promotion of ICT based solutions for agriculture. Transforming agriculture in Africa requires involvement and participation of all stakeholders due to their unique interests and contributions to agriculture (Awuor, et al. 2016), the concept is important in leveraging the capability of the stakeholders with unique interests. The researchers go further to elaborate that these stakeholders can be grouped into business, farmers, government and researchers. Where the government includes relevant sectors such as ministry of agriculture, parastatal entities working under the ministry and other government ministries that directly or indirectly get involved in agriculture. The researcher sector represents all the entities working to train and educate the public on agricultural issues and to carry out research on new farming techniques. The fourth sector is the business that specifically represents the need for market accessibility and using agricultural associations to earn economy of scale and to control the market.

Farmers are normally considered to be the main actor in the agriculture information system, since they are the consumer of financial services, consumer of information from researchers and also work as a team to collaborate with third parties (Smith et al., 2004). Farmers are the main source of data and the utilizers of the processed knowledge. They should, therefore be the natural partners of researchers and their institutions for a mutual exchange and reconciliation of modern and traditional knowledge (Smith, et al., 2004). Farmers and their organizations are the main actors responsible for using and translating formal research results into real life production systems and natural resource management practices. Lack of effective collaboration and understanding of their importance among researchers and farmers can explain the low adoption of technology and minimal research utilization in agricultural production systems.(Smith, et al., 2004)

The study by Deloitte (2011), has highlighted the need to identify and involve all the agricultural stakeholders when considering incorporating ICT-in-agriculture. However, the study has not been exhaustive to illustrate all the agricultural stakeholders therein assuming some key issues like policies that affect adoption and usage of ICT. The Micro finance institutions and the donor agencies that are always keen to invest on viable agriculture have been ignored in the approach. Also, the roles of international community and research centers have not been adequately addressed, while they play key roles in standardization and providing a key platform for comparison. The communication methods have also not been addressed in the approach as timely and effective communication by relevant stakeholders is considered to be paramount to successful adoption of agriculture systems. According to study by Santoso (Santoso & Delima, 2017), analysing the needs of stakeholders is important and can be used as a mechanism to expose different conflicts that might arise among different stakeholders. The study by Santos, analyses and group

stakeholders into several groups base on their powers and interests. The Stakeholder Interaction Matrix proposed in the study, shows that each stakeholder with different role needs different information. This information comes from interaction between stakeholders. Thus, stakeholder interaction and information matrix is set up to identify information needed for every stakeholder.

The study was guided by Dutch diamond model which states that sustainable development requires inclusive coordination (Andeweg et al., 2020). Relevant stakeholders should be involved; the model shows a linkage among farmers and farmers' organizations, financial institutions, government (ministries, policy makers and county assemblies), research institutions, Non-governmental organizations and private sectors. The advantage of the Dutch Diamond approach, is that, is a metaphor for the collaboration between private companies, knowledge institutions, civil society organisations and government bodies. This Dutch Diamond approach can also contribute to transitioning agriculture in emerging economies towards successful, sustainable and inclusive agriculture sectors (Andeweg, et al., 2020). Figure 2.5 illustrates the representation of Dutch model.

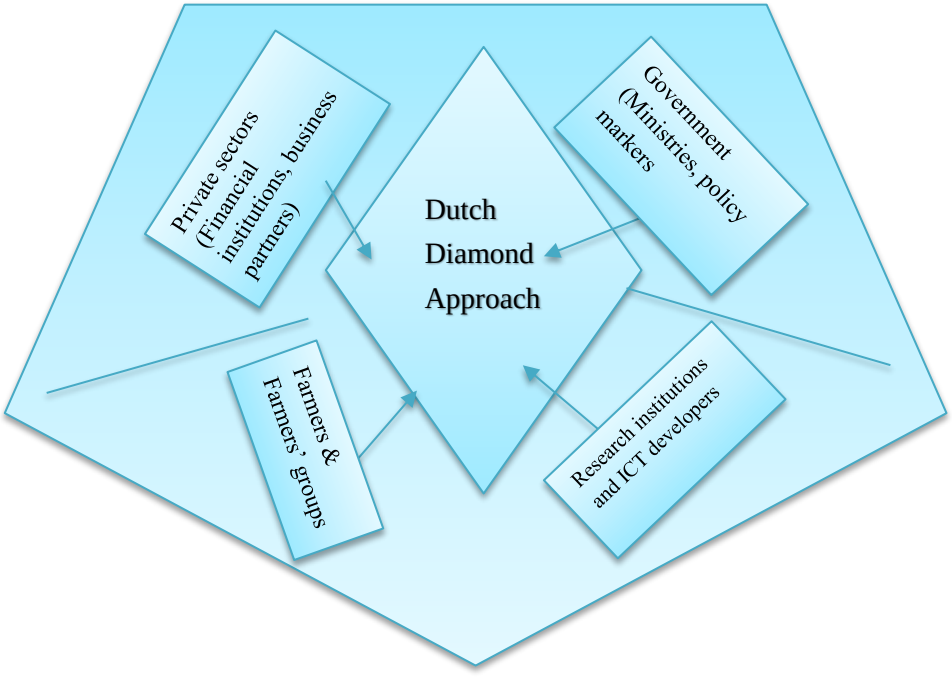

Figure 2.5 : Representation of the Participatory approach (Source - Adapted from Dutch Polder Model Concept)

Farmers and their organizations are the main if not the only producers of the food required by the increasing global population be it in the rural or urban areas. Many farmers and Farmers Organizations in developing countries are diversifying and becoming active in several components of the agri-business chain, not only produce but also process and market commodities (Awuor, Fredrick et al., 2016). Therefore, farmers should constitute the central element and focus of researchers and their institutions whose mandate is to improve this field of the production-to consumption system.

Participatory approach seeks to actively engage local people and communities in development efforts, from problem identification to evaluation. The participation and particularly experiences from farmers and farmers' group discussion helped in guiding the development of these research questions. Hence, the need of different users were taken into consideration, for successful development of the model.

2.5 Related Frameworks and Models

This section highlights some of the related frameworks and models that have been developed to supported use of information technology in agriculture.

2.5.1 Integrated Agriculture Framework

A number of attempts have been made to develop systems which deliver customizable information to farmers to assist in their decision making in terms of crop choices (Awuor, et al., 2016). For instance, the framework proposed by (Armstrong & Diepeveen, 2008), has been presented, which assist farmers in decision making. The framework comprises a series of steps which include data capture, analysis and data processing and which precede the delivery of integrated information to the farmer. Information is collected from disparate sources, collated and validated according to defined rules (Awuor, et al., 2016). The framework emphasised on new technologies being made simple and affordable to farmers, such as the use of the Internet technology can support agriculture management process.

The contribution of Dutch diamond model developed, for instance, by (Omotesho, et al., 2012; Vaghl Y., et al., 2010) provides a mechanism for agricultural scientists and extension specialists to map all aspects of the information flow process accurately and map area to concentrate efforts on to assist in farmer decision making. At a higher industry level, it could be used to improve the likelihood of farmers receiving the most appropriate information to make valued decision. This is similar to a framework developed by (Okello, Al-Hassan, & Okello, 2010) that analyze the link between ICT application in smallholder agriculture, household commercialization, and food security. The framework provides descriptive cases where ICT application in agriculture has benefited smallholder production and improved market performance.

Smart Farm Flagship (2011), proposed an e-Agriculture framework that integrates all ICT applications to farming from an ambitious perspective. This approach, also called smart farm or smart agriculture, connects knowledge management with sensor data and data as a service in desire to create IT enabling farming environment. The framework was built on the premise that farmers are technical engineers and computer scientists and therefore will always know how to access the needed data and mine the required knowledge.

These frameworks have not addressed the role of stakeholders in integrated agriculture adoption that is considered core contributor to success or failure of any ICT initiative. Therefore, the proposed framework may have a sound theoretical bound but it is not practical and applicable. For instance, how the framework would support rolling out of integrated agriculture initiatives has not been clarified from the framework.

Some of the challenges and ambiguity raised from (Smart Farm Flagship, 2011) have been addressed by (Nilsook, 2013) by building specific modules to meet all the information needs of the farmers supported by ICT. However, both the two frameworks have not been able to address the need to integrate information from various stakeholders to give a farmers to provide a unified views. In fact, both (Nilsook, 2013) and (Smart Farm Flagship, 2011) have assumed erroneously that stakeholders are not key components of ICT-in-Agriculture adoption to the extent that they can be neglected.

A number of models were proposed in the literature that attempt to address the need to incorporate ICT-in-agriculture. The integrated agriculture frameworks and models have emphasized involving all stakeholders in building AKS particularly the farmers to make the system farmer centered and not ICT centered. In fact, these models propose that the government formulate policies and regulations for easy access of ICT-in-agriculture by

farmers. However, these researches do not address the need of collaboration among all the involved stakeholders in integrated agriculture framework, and assume that somehow the stakeholders work in unison and collaborate to improve utilization of integrated agriculture for high agricultural production. These models also assume the need to have integrated access framework that incorporates all the ICT-in-agriculture applications. Such assumptions may be disastrous when farmers have so many incompatible and heterogeneous ICT-in-agriculture applications and data to access. Moreover, sustainable agricultural development through ICT-in-agriculture is only realistic when all the stakeholders' interests are considered and addressed.

2.5.2 ICT Adoption Model

An ICT model for use of ICT on agriculture sector, proposed by Kante (2018), was developed for smallholder farmers in developing nation. The model used technology acceptance models and a number of variables were tested; Relative advantage, compatibility, simplicity, observability, cost and information quality. The factors were considered in the study to overcome the challenges in the use of technology by small scale farmers. However, the study was narrowed to the use of ICT services by cereal farmers only (Kante, 2018). Therefore, there was a need to bring all technological development, available information, market sources, government policies and actions, research work, international efforts and other stakeholder to one table and develop the model.

2.5.3 Multiple Source Innovation Model

A multiple source innovation model, posits to understand the clients' diverse needs and resources and views of the users, not only as mere adopters but as active participants in the process of technology development and adoption (Nguthi, 2008). The model emphasizes that agricultural innovations are derived not only from agricultural research

institutions but from multiple sources. These sources can include farmers, ICT developers, innovative research institutions, research-minded administrators, NGOs, private corporations and extension agents(Biggs, 1990; Nguthi, 2008). In the multiple source model, perspectives of the users of technology are seen as important in helping to develop and transfer locally usable innovations (Hardon-Baars 1997). The multiple source of innovation model encompasses the use of participatory approaches that have evolved from efforts to improve technology development and dissemination. Participatory methodologies are often characterized as being flexible and interactive, in contrast with the rigid linear central source model. Experience has shown that innovations for improving agriculture need to address not only the technological but also the socio-cultural, political, economic dimensions such as community structures, gender, collective action and governance. This is especially more so in this era of mobile phone and its projected impacts on agriculture. The model concept had been supported by study, that, there was need to integrate information required by the farmers from the diverse sources (Awuor, F. et al., 2016). Despite the model addressing the need for collaboration among the stakeholders, the model does not address the process and means of innovation adoption by smallholder farmers.

The e-agriculture model (Awour et al) fosters collaboration and cooperation among all the information sources with objective of enriching the data centre to the benefit of the farmers. Without loss of generality, the model illustrate how to integrate various information sources to a single central point such that the farmers can access information from them at a single point. The model integrates services of agriculture extension officers, ministry of agriculture and agricultural support institutions. In the model, farmers are expected to easily access all the information they require to make decision on what crop to grow

depending on the soil type, nutrients contents, market pricing and weather conditions among others, with the main aim that making informed decisions would definitely increase the production output of the selected product. The model has considered stakeholders' interests, however, the model does not consider the dissemination and adoption as a great factor in a way of enhancing the uptake of technology by the farmers. The contribution of this study was to assess the information need of the smallholder farmers and to develop framework for dissemination and adoption with stakeholder in considering the strength and the limitations of various models as shown in table 2.6.

Table 2.6: Related framework/Model on ICT adoption/Gaps

Author	**Strength**	**Limitation**
Developing an information-driven ICT framework for Agriculture (Armstrong & Diepeveen, 2008	Technological factors considered and human factors	stakeholders not highlighted and other adoption factors; economic,
Application of a Data Mining Framework for the Identification of Agricultural Production Areas in WA (Vaghl Y., et al., 2010)	Consider researchers, extension specialists and farmers (some stakeholders)	Stakeholders cooperation approach not defined No emphasis on ICT adoption
Integrated agriculture framework (Al-Hassan, & Okello, 2010)	Emphasize of ICT adoption theories in agriculture	The adoption approach not clarified from the framework
e-Agriculture framework that integrates all ICT applications to farming from an ambitious perspective (Smart Farm Flagship, 2011)	Some adoption factor; usefulness& ease of use investigated	No emphasis on stakeholders
e-agriculture model (Awour et al)	Stakeholder cooperation considered	Key adoption attributes not looked at
An ICT model for increase adoption of Agricultural input information by cereal farmers in Developing countries	Technological, economic and human factors	Stakeholders not addressed

The researchers' consensus that despite abundant experience with ICT Adoption for Agriculture and Rural Development initiatives, the adoption remain a major issue and current critical concern. Adoption of ICT innovation is usually not spontaneous, the technology has to be disseminated, accepted and adopted to existing experiences and integrated into farming. This study explored the challenges that influence adoption of ICT to the livelihoods of smallholder farmers in Kenya and other adoption challenges in other countries.

This study adopted UTAUT in this to conceptualize and relate moderator variables such as: age, gender, experience which also moderate: performance expectancy, effort expectancy, and social influence. The model is paramount to this study since it relates variables that apply user's intentions to use: performance expectancy, effort expectancy, and social influence, which eventually impact the intension to adopt and use agricultural innovations.

The model has been criticised by (Bagozzi 2008) that UTAUT presents a model with numerous variables for predicting intention and independent variables for predicting behaviour and can contribute to technology adoption chaos. Additional, it is difficult to understand how a wide range of items can reflect on single psychometric construct (Van Raij and Scheper, 2008). They further argue that UTUAT is only achieved when moderating the key relationships with up to four variables: age, gender, experience and voluntariness to yield coefficient that are more significant

2.5.4 Gaps from theoretical literature on ICT innovation and models

In Agricultural sector, researchers have emphasised that the perception is positively related to ICT adoption and use. In addition, studies related to agriculture dissemination of innovations report the same relationship between ICT's use and user's perception (**Barakabitze** et.al 2015, Mng'ong'ose & Matern Victor, 2018). The question that remains unanswered, what these perceptions and to what extend do they influence the adoption and use of ICT innovation by the smallholder farmers, was under investigation.

Perceived usefulness attributes (relative advantage, complexity, observability, compatibility and trialability) are necessary for the adoption and use of ICT innovations. A number of researchers have argued that the degree to which the user's subjective probability that using a specific system will enhance his or her productivity can create a relative advantage. However, the extent to which it is affecting ICT adoption by smallholder farmers still remains a question that this study needs to answer. Therefore, the study categorised them as farmers' perception of ICT innovations on agricultural adoption. In terms of the effect, the perception was examined to find how it affected the adoption and the use of agricultural innovation.

In agriculture sector, Adegbidi et al (2012) argues that availability is an issue when it comes to ICT services. Is availability significant in the adoption and use of ICT innovation? Applying this to the context of this study, the availability of innovations being of adopted is very important

Rogers (1995) defines pressure or social norms as the value or behaviours, which are the most, acceptable by the members of the society. Social pressure refers to an individual's belief to be adhered to, therefore it is important to understand how social influence affect the adoption and use of ICT innovation.

The cost of ICT product and services is another challenge for farmer in their plight to adopt and use agricultural innovations. The ICT skills and literacy are also challenging farmers in process of adoption and usage of agricultural innovations.

Farmers decision making framework proposed by (Armstrong & Diepeveen, 2008), the study concentrated on adoption process by farmers for rural development. The research identify technological factors such as simplicity, usefulness and compatibility as key. Furthermore, the reviewed literature in this study reveals that many studies have found these factors to affect the adoption of ICT innovation by farmers in most developing countries. However, the study fails to identify economic and social factors; cost and social influence. Another gap in the study is lack of consideration of the roles of stakeholders in adoption, which has been identified in the literature as a key factor.

The e-agriculture model (Awour et al) systematically recognizes collaboration and cooperation among stakeholders as a way of enhancing technology adoption and enriching the data centre to the benefit of farmers. Nevertheless, the study did not take into consideration adoption factors; technological, economic and social factors, which were identified in the literature review. This is a gap in the model.

E-Agriculture Framework that integrates all ICT applications to farming from an ambitious perspective (Smart Farm Flagship, 2011), the study considered the role played by extension officer and farmers on the adoption of technology. The study was informed by factors such as relevance and simplicity of the system (technological factor), ICT services cost (economics) and social issues and farmers' perception on the ICT services. However, the study did not pay attention to role of stakeholders, hence, a knowledge conflict gap that need to be addressed.

An ICT model for increase adoption of Agricultural input information by cereal farmers in Developing countries proposed by Kante (2018). The study identified technological factors (relative advantage, simplicity, observability), economic and social factors as drivers in the use of ICT by farmers, which have been highlighted in the literature review. However, there study did not consider the role of stakeholders in adoption of agriculture information. Additionally, the study used quantitative method. There is need to explore diverse perspectives using mixed method, this is a gap that needs to be looked at in this study.

2.6 Development of Conceptual framework

The conceptual framework is composed of constructs extracted from theories and models as listed in table 2.5. Based on the review of a number of theories pertinent to technology acceptance and adoption in general and ICT Innovations in particular, the conceptual research model is developed for the research objectives.

The conceptual model strongly influenced by the original TAM. The prevailing models express different views of the relations among the factors we adopted. Following the unified model Venkatesh et al. (2003), social influence is adopted in the conceptual model, assuming that social influence is more important in technology adoption. This is contrary to the original TAM but consistent with most of later model. Moreover, the participatory influence is considered since it plays a major role in influence innovation adoption. Following that assumption, the study tentatively distinguished between external and human factors influencing PU and PEU as shown in figure 2.6.

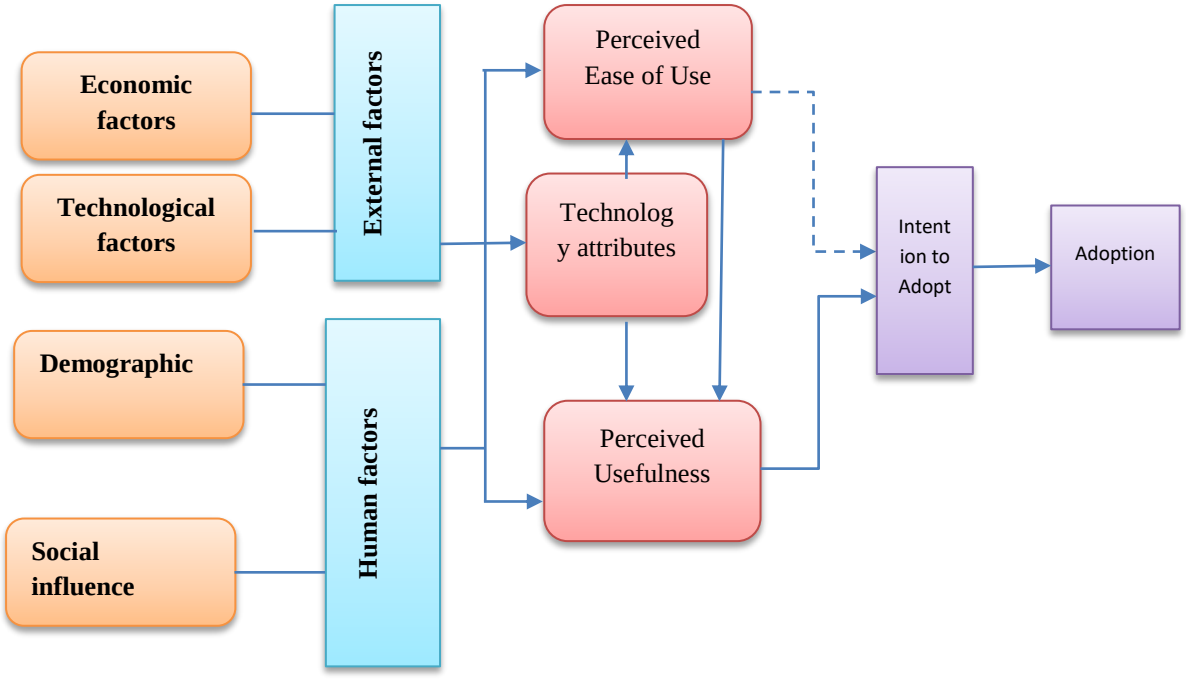

Figure 2.6: Modified UTAUT and TAM models

The factors to be analysed under each of the proposed constructs based on the literature pertinent to the use of ICT innovation are described as follows and summaries in conceptual framework; figure 2.7.

i. **Economic Factors**

According to study (Dhraiefa et al., 2018), regarding economic factors, it emphasize that, it is important determinant of technology adoption. Mwangi (2015) describe economic factor as the support given to the users while interacting with the technologies. The choice of service provider is affected by the economic factors such as land size, credit facility, cost of innovations, house hold size, income among others(Mwangi & Kariuki, 2015).

ii. **Technological factors**

Characteristic of a technology is a precondition of adopting it. Trialability or a degree to which a potential adopter can try something out on a small scale first before adopting it

completely is a major determinant of technology adoption (Mwangi & Kariuki, 2015). According to Islam (Islam & Grönlund, 2017), farmers' perceptions of technology characteristics significantly affect their adoption decisions. Moreover it is also argued that users‟ perceptions about ease of use/simplicity and usefulness are likely to be developed from rational assessments of the characteristics of the technology and the tasks for which it could be used (Amare & Simane, 2017). The characteristics of the innovation identified are usefulness, reliability, simplicity and availability.

iii. **Demographic Factors**

There is a good number of studies describing the importance of the demographic context in use and adoption of new technology. According to those studies, variables that are important in this category are: Age, Gender, Education and household. Age is one of the most discussed demographic factors in the technology adoption literature. Most adoption studies have attempted to measure human capital through the farmer's Education, age, Gender, and household size (Mwangi & Kariuki, 2015). Education of the farmer has been assumed to have a positive influence on farmers' decision to adopt new technology. Education level of a farmer increases his ability to obtain; process and use information relevant to adoption of a new technology (*Mignouna et al*., 2011; Lavison 2013; Namara *et al*., 2013). For instance a study by Okunlola *et al.* (2011) on adoption of new technologies by fish farmers and Ajewole (2010) on adoption of organic fertilizers found that the level of education had a positive and significant influence on adoption of the technology.

Age is also assumed to be a determinant of adoption of new technology. Older farmers are assumed to have gained knowledge and experience over time and are better able to evaluate technology information than younger farmers (Mignouna et al, 2011; Kariyasa and Dewi

2011). However, Alexander and Van Mellor (2005) found that adoption of genetically modified maize increased with age for younger farmers as they gain experience and increase their stock of human capital but declines with age for those farmers closer to retirement.

Gender issues in agricultural technology adoption have been investigated for a long time and most studies have reported mixed evidence regarding the different roles men and women play in technology adoption (Bonabana- Wabbi 2002). In analyzing the impact of gender on technology adoption, Morris and Doss (1999) had found no significant association between gender and probability to adopt improved maize in Ghana.

iv. **Social Influence**

According to the Theory of Reasoned Action (Fishbein and Ajzen 1975), behavioural intention of a person is influenced by subjective norms which in turn are influenced by the significance of referents‟ perception (or normative beliefs) and motivation to comply with those referents. Stiff and Mongeau (2016), find that the influence of social norms on individuals‟ behavioural intentions in some cases is stronger than the influence of attitudes. Sometimes, perception of societal norms may prevent a person's behaviour in accordance to his/her personal attitudes. In a rural context, Jain and Hundal (2007), find that the rural people of India, had been found more influenced by the neighbours ‟ usage and media has been regarded as the negligible impact on the choice of buying a mobile phone". In addition to neighbours, there are some other sources of influence also evident in the literature, such as relatives, friends, and seniors or influential persons in the community (Lee, Y. et al., 2006)

v. **Participatory Approach**

Participatory development generally seeks to engage local people and communities in development efforts, but defining participatory development more specifically is difficult. This study is to uncover and help close the monitoring gap of the farmers' project the role of monitoring and evaluation in participatory development initiatives. Recent decades have seen a growing concern for monitoring and evaluation among donors, NGOs and other actors in research and development in general (Estrella & Gaventa, 2008). Monitoring and evaluation (M&E) are vital for keeping track of the impact of interventions not least in agricultural development, which are often complex in nature as they involve a large number of social as well as biophysical variables (Muller-Praefcke et al., 2010). The participatory paradigm requires a change in attitude, as the farmers move from being passive beneficiaries to active stakeholders (Bessette, 2004).

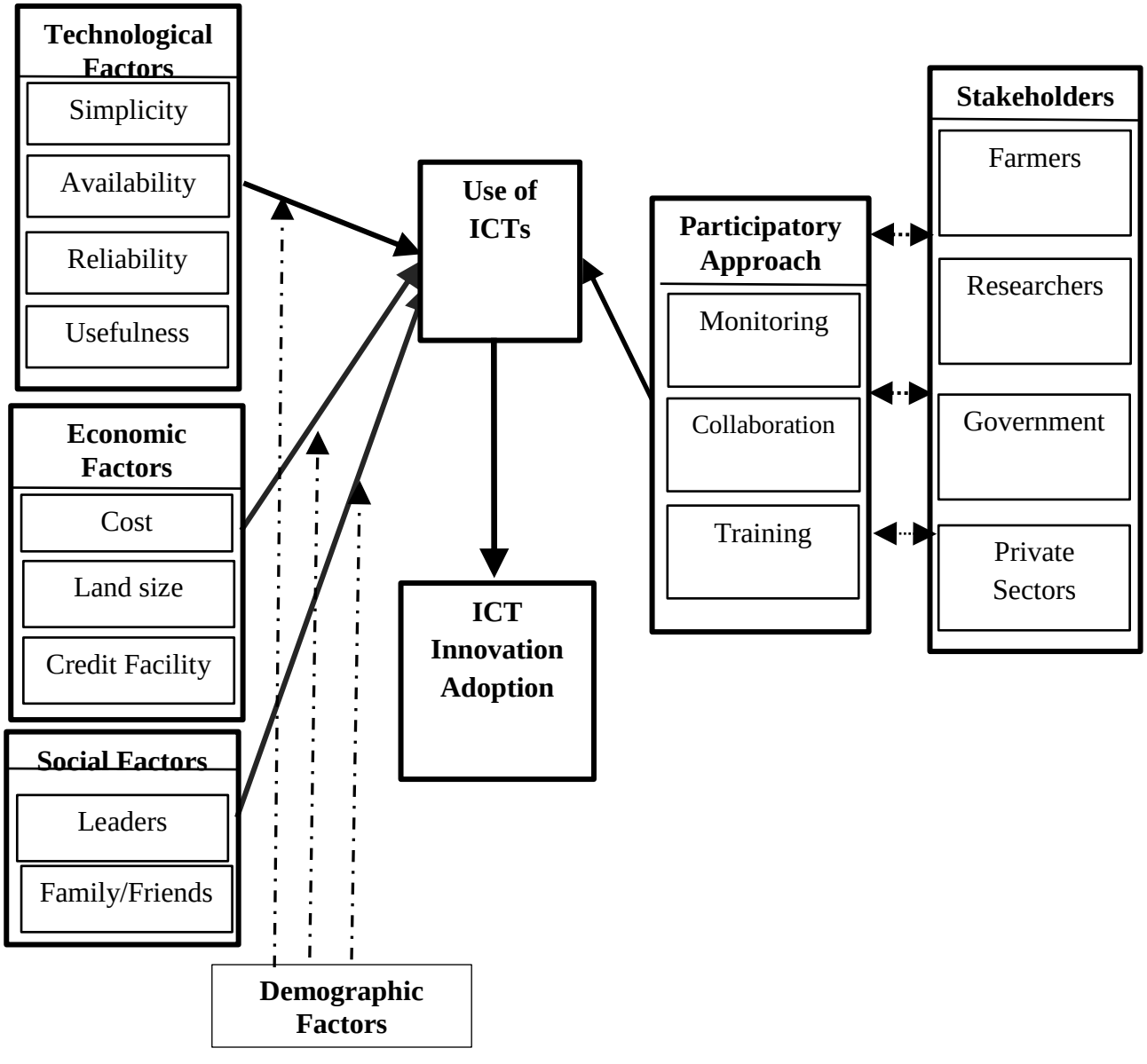

Figure 2.7: Conceptual Framework

This study intended to contribute to the existing literature by establishing how and why the relationships exist by introducing moderating variables. New variables were considered which are cost and availability on the use of innovation into the model. The communication

channels attributes would be analysed to find out how they contribute to the perceived easy and usefulness of the model. Users' characteristics is also a predictors to evaluate the users' behaviour and their intentions to adopt the innovation. This study integrates the users' characteristics, Innovation attributes and communication channel attributes to understand the users intention to adopt innovation in one concept. The inclusion of moderator in this study is to understand the moderating effect on the independent variables to users' adoption of innovation.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

The chapter identifies and discusses research issues which were key and fundamental to the process of data collection and analysis, towards achieving the goals and objectives of the study. The study took a cross-sectional time horizon; the philosophical underpinning (Saunders et al., 2009). The research design encompassed various levels: the approaches, strategies, choices, data collection and analysis. The chapter also discusses factors which the study addressed to enhance reliability and validity of the study.

3.2 Philosophical Underpinning

The study considered this level to reflect important assumptions, opinion and views as the researcher understood the world; in line with scientific enquiry (DeCarlo, 2018) assertion which seeks to account for lived experience. Different authors, however have diverse opinion on this; some broadly classifying the philosophies as positivism and post-positivism (Krauss, 2005; McGuinness, 2011). Another school of thought however classify this layer into different philosophies; the most significant being positivism, realism, interpretivism and pragmatism that influence the way in which the researcher thinks about the research process (Saunders, et al., 2009). This study, adopted a pragmatism philosophical underpinning given that it encompassed a number of thoughts; approaches, strategies, choices and methodologies which were deemed to be complementary and thus fitted the focus. A pragmatic research philosophy was chosen because of the use of mixed research method and inductive/deductive approaches in this study. An illustration of philosophies, approaches and strategies is indicated in table 3.1.

Table 3.1: Research philosophies

Philosophies	Research approach	Research strategy
Positivism	Deductive	Quantitative
Interpretivism	Inductive	Qualitative
Pragmatism	Deductive/Inductive	Qualitative and Quantitative

3.3 Research Design

The research design provides an overall plan for connecting the conceptual research problem to the relevant empirical research (Sileyew, 2019b). Research design provides direction for collecting and analysing data (Churchill, 1979; Sileyew, 2019a). According to Nachmias, research design should derive its importance from its role as a critical thread between the theories and arguments that informs the research and the empirical data collected (Frankfort-Nachmias & Nachmias, 1996). In this study, Figure 3.1, depicts the process followed to arrive at the study conclusion.

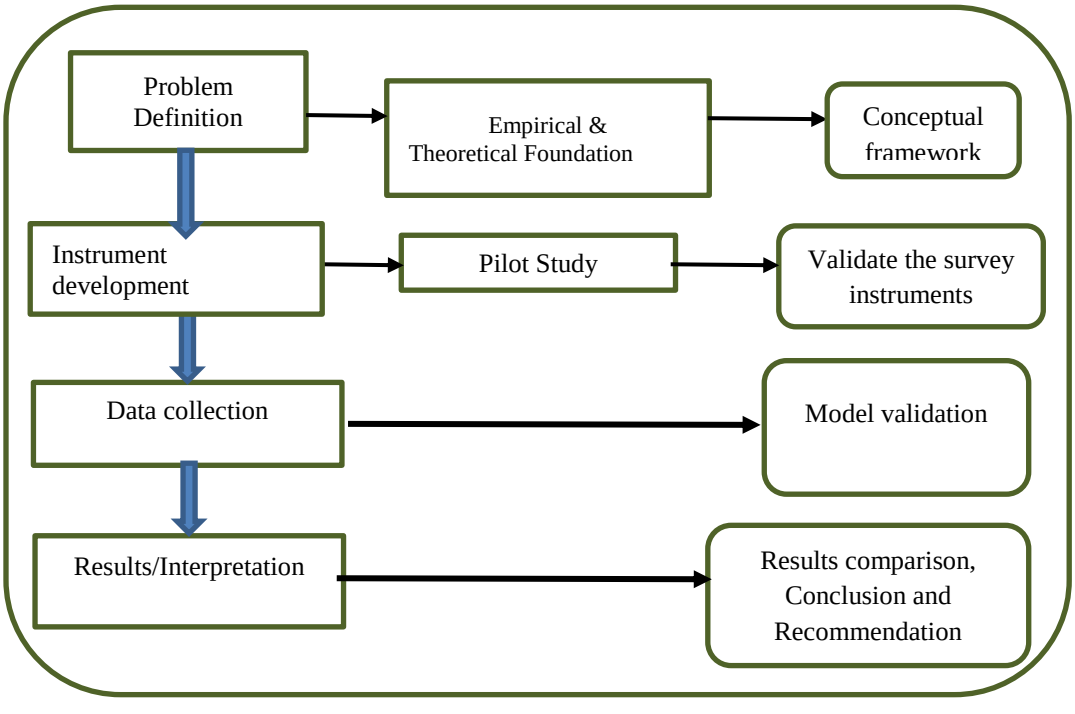

Figure 3.1: Research design Process

3.3.1 Research Approaches

The plans and procedures for research should be evident at the start of the research and thus determine the design of the research project. That is whether the research should use the deductive approach or the inductive approach. According to the authors, deductive approach concentrates on using the literature and observations which aid in problem identification; form patterns there from, formulate questions, from which a theory is developed, an approach which this study adopted. In contrast, the inductive approach involves collecting data based on, or guided by a theory the results of data analysis (Saunders, Lewis, & Thornhill, 2009). This study shows a focus on theory testing, as theory was first adopted as the framework for answering the research questions. However, given the mixed method approach, the study adopted both inductive and deductive approaches. The study focused on the adoption of ICT innovations by smallholder farmers, first through an extensive literature review (secondary data-study) leading to the development of a theoretical framework, which then was triangulated by an empirical study, i.e. collected data guided by the formulated theory. These were then tested and validated. The study was anchored by the search for and development of a conceptual framework to guide the research; creating a framework and methods that was used to answer the research questions.

3.3.2 Research Strategy

Research strategy and time horizons are the third and the fourth layers of Saunders et al (2009) research onion. According to Al Zefeiti and Mohamad, 2015, survey strategy and case study are usually associated with the deductive approach (Al Zefeiti & Mohamad, 2015). The study thus applied this strategy. It is also a popular and common strategy in research and most frequently used to answer who, what, where, how much and how many

(Saunders, et al, 2009). In view of these arguments, the researcher adopted cross-sectional as it is conducted at a particular time and descriptive survey as the most appropriate option for the study.

3.3.3 Research Choices

This study employed a mixed methods research approach that used a sequential exploratory-explanatory approach. The motivation for using a sequential exploratory-explanatory approach was based on the concept that the quantitative data and their subsequent statistical analysis provide a general understanding of the research problem (Creswell & Plano Clark, 2006). The qualitative data and their analysis refine and explain the statistical results by exploring participants' views in more in-depth (Creswell, 2003). The researcher further, view quantitative research design as one in which the researcher decides what to study; asks specific, narrow questions, collects quantifiable data from participants; analyzes these numbers using statistics; and conducts the inquiry in an unbiased, objective manner. Qualitative research is often confirmatory. According to Olds et al (2005) qualitative research is used to collect and test textual data such as surveys, interviews, focus groups, key informants, conversational analysis, and observation.

According to Freeborough (2012) and Dixon (2013) the use of mixed-method research reduce the limitations of purely qualitative or quantitative studies and combine the benefits of qualitative theory building with quantitative-theory testing. Further studies, (Tashakkori, and Teddlie, 2008), have asserted that the purpose of a mixed-method design is to obtain a more comprehensive understanding of a studied model and to complement the weakness of the quantitative approach.

Therefore, this study used mixed method to provide a better understanding of the research problem, rather than using one type of research (qualitative or quantitative), which is not enough to address the research problem or answer the research questions. Additionally, the use of mixed method allows researchers to be more confident of their results, stimulates the creation of inventive methods, new ways of capturing a problem to balance with conventional data collection methods, and also help to find out the unexpected dimension of a phenomenon.

On mixed method design, the researcher used the explanatory sequential design, quantitative data was collected first, followed by qualitative data. To justify, reason for adoption of this approach, the researcher further followed Creswell (2012) response on when to use explanatory sequential design; of which the author cites the following reasons; researcher and research problem are quantitatively oriented; known important variables and instruments are available; participants are available for second data collection; have time to conduct two phases; have limited resources and need to collect and analyze one data type at a time; new questions emerge from quantitative results.

3.3.4 Description of the study area

The study aimed to identify three case study sites contexts with different geographical location/coverage; environmental settings; differing economic orientations or endowments. In view of Kenya broadly in terms of regions, the study was conducted in western part of Kenya and Rift valley; the former Western, Nyanza and part of Rift Valley provinces. The counties within Western Kenya region and Rift valley were purposively selected based on the earlier set criteria to form the study sites. Three counties selected for this study were: Uasin Gishu, Kakamega, and Siaya. In each county, three sub countries were purposively selected (Bukura, Lugari, Lukuyani, Yala, Ugenya, North Gem, Soy,

Turbo and Moi Ben). The target participants from the three sub counties for the research were smallholder farmers and stakeholders that were selected from governmental and non-governmental organizations; researchers, innovation developers, field supervisors and Extension officers.

3.4 Sampling Strategy

Parasuraman, et al (2004); Singleton and Straits (2005), proclaim that sampling is the selection of a subset of cases of the total number of units in order to be able to draw general conclusions about the entire body of units. The choice of an appropriate method of sampling helps generalize results, especially for large population, as is usual for a research study to survey the total population due to time and financial constraints. According to Saunders et al. (2012), sampling techniques can be divided into two: probability or representative sampling and non-probability sampling. In probability samples, the chances of each element being chosen from the population is predetermined and equal in majority of the times for all elements. Therefore, it is possible for both, replying to the research questions, and achieving the related objectives that demands from the researcher to estimate statistically the characteristics of the population based on the selected sample. Thus, probability sampling is usually related to survey and experimental research strategies, (Saunders et al., 2012).In non-probability samples, according to Saunders et al. (2012), the probability of each element being selected from the total population is not predetermined and it is not possible to reply to research questions or to cover objectives that necessitate the researcher to make statistical inferences about the characteristics of the population. Based on the design of this research, it is pragmatic, mixed research, with survey and case strategy and cross-sectional time horizon, accordingly, probability was used in quantitative and non-probability used in qualitative study. To establish the required

sample for a study, the researcher is required to choose the most appropriate sampling technique. There are many approaches of probability sampling such as simple random; systematic; stratified random; cluster; and multi-stage (Saunders et al., 2012). Many other circumstances normally influence the researcher's choice of probability sampling technique such as the need for face-to-face contact with respondents, the geographical area over which the population is spread, the nature of your sampling frame, the structure of the sampling frame and the size of sample needed. Further, if the researcher is using research assistants, the simplicity with which the technique may be explained will also influence the researchers decision (Saunders et al., 2012). The study applied both probability and non-probability sampling. For probability, stratified random sampling strategy was used while for non-probability sampling purposive sampling was used.

The sample frame was a list of smallholder farmers with ideas ICT services in agriculture. A stratified purposive sampling was adopted for the selection of the participants from the sub counties. Kline (2016) argues that about a good sample size for SEM's studies should be around 200 cases. The argument has also been supported by Garson (2016) that 200 cases for PLS-SEM. Data were collected from 120 respondents, which was at least 50% above the required number of 200. Additionally, it is argued that, if the sample size is small then the study using structural Equation modelling is recommended (Kline, 2016) and applying the rule of ten by Hair, Ringle and Sarstedt (2011), the sample size of 120 would still be recommended based of the latent variables (12 latent variables *10 = 120). Thus, given the number of paths (construct) being 12, for the study, a sample size of 120 was then a sufficient estimate.

3.4.1 Questionnaire

According to Saunders et al. (2012), questionnaires tend to be used for descriptive or explanatory research. Explanatory or analytical research allow a researcher to test and explain relationships between variables, in particular cause-and-effect relationships (Saunders et al., 2012).Thus, questionnaire developed based on design, research questions and research objectives were instrument used to collect data in this research. According to Saunders et al. (2012), there are many authors such as Bell (2010), argued that creating a good questionnaire is very hard to achieve and beyond expectation. Further, it is essential for the questionnaire to be an instrument that will collect a precise data to enable the researcher to answer the research questions and achieve the related objectives (Saunders et al., 2012). Questionnaire give the best results with standardized questions that researcher has a confidence that they can only be interpreted in one way by all participants (Robson, 2002). According to Saunders et al. (2012), design of each individual question is driven by the data that is required to be collected for the purpose of fulfillment of the research objectives. The three approaches that followed by the researchers when designing individual question in adopt questions used in other questionnaires; adapt questions used in other questionnaires; or develop their own questions (Bourque & Clark, 1994).The researcher developed the question as illustrated in Appendix II.

Table 3.2: Sample size Distribution

County	Area	Sample
Siaya	North Gem	10
	Ugunja	10
	Alego	10
Kakamega	Bukura	15
	Malava	10
	Lukuyani	15
Uasin Gishu	Turbo	15
	Soy	15
	Moi Ben	20

3.4.2 Focus group discussions

The researcher, carried out the empirical study with focus groups, this was used for exploratory purposes, to discover farmers' thoughts and views and to obtain detailed information about various issues pertaining to ICT innovation and their adoption for use in agricultural services. Data was generated from the interaction with farmer groups. The interaction was useful in generating useful information for identifying key issues such as farmer's needs, expectations, attitudes, perceptions and feelings; and aid in developing interview schedules and survey questionnaire. Three key aspects were considered in conducting the focus group discussions. One was the selection of participants. Participants were purposefully selected with the help of extension officers with whom they had been engaged in a number of activities overtime; on the basis of their experience related to the use of technology and sharing of information in there groups. Two was the size of each group. Several authors recommend a minimum of four to ten participants. This ensures that the discussions and the time for participants to contribute are not too limited (Russell 2002; Ritchie 2003).

Focus group discussions (FGDs) were conducted with a selected number of farmers who had been identified by the extension workers. Table 3.3 below shows the participants in the FGDs.

Table 3.3: Participants in the Focus group discussion

Counties	**Sub-counties/ Areas**	**Groups**	**Number of Female**	**Number of Male**	**Total Number of Participants**
Kakamega	Bukura	FG1	5	3	8
	Lugari	FG2	4	4	8
Siaya	Yala	FG3	7	5	12
	Ugenya	FG4	5	5	10
Uasin Gishu	Soy	FG5	12	8	9
	Moi Ben	FG6	8	3	11
Total			35	23	68

3.4.3 Interviews

In the interview phase, face to face interviews was conducted in order to collect data. Interview is a conversation with a purpose(Bryman, 2006). According to Bernard and Ryan (2010), interviews encompasses researchers and research participants in finding important data. Interviews can be unstructured, semi-structured or structured. While they have a formalized set of questions, semi-structured interviews are flexible. Structured interviews permit new questions to emerge and be asked during the interview according to interviewee responses (Alqahtani, 2013). On the other hand, the unstructured interview is a "casual conversation that allows the qualitative researcher to inquire into something" with no predefined set of questions (Gay et al., 2009). Using interviews was important to provide a deeper understanding of level of adoption of innovations in agriculture by smallholder farmers and key issues in adoption. This involved exploring how adoption issues influence adoption of ICT innovations. The interviews was used to fill in the gaps of information

gathered and to clarify ideas obtained from the focus groups to strengthen findings (Cooper & Schindler, 2006; Hair, Babin, Mony, & Samouel, 2003). Also, interviews in this research assisted in obtaining different insights from lead farmers and supervisors/extension agents working for different organizations. The interview process was recorded with the permission of the interviewees, for later transcription. Other benefits of interviews include providing the opportunity to build trust and connection between interviewer and interviewees, which then improves the quality of the gathered data. Consequently, interviews participants are able to freely discuss feelings and beliefs about the subject of interest and provide more detailed responses (Stokes & Bergin, 2006). Furthermore, interviewees are expected to be comfortable and honest in their opinions and the data gathered is more comprehensive (Hair et al., 2003).

The study used a snowballing sampling technique to identify and recruit the interviewees. Some participants in the focus groups provided the lead to some possible interviewees during the discussion. The suggested people were invited to participate and they were further requested to suggest other potential participants namely non-member (potential farmers who were working individually not a member of any one acre fund group). The purpose of picking non-member was to provide a different view from participants that were attached to groups. The researcher also requested the interviewees to recommend, a person they feel can be interviewed at the end of the session, upon which an invitation was sent to the interviewee.

Background information about the research study was provided in the invitation letter and a request to participate, where participation was clearly stated to be voluntarily. Obtaining participants to participate that meet requirements was challenging. Thirteen participants, including three field offices/extension agents were interviewed independently. The criteria

for the interviewees, was that must have used or been exposed to the use of ICT services or agricultural innovations. The interviewees' details are presented in the following table 3.4.

Table 3.4: Interview Participants Profile

Participants	**Titles**	**County**	**Gender**	**Age**	**Years of Experience**
P1	Lead farmers	Siaya	M	42	20
P2	Lead farmers	Kakamega	M	37	12
P3	Lead farmers	Uasin Gishu	M	46	26
P4	Lead farmers	Uasin Gishu	F	38	13
P5	Farmers	Siaya	F	54	31
P6	Farmers	Kakamega	F	44	19
P7	Farmers	Uasin Gishu	M	58	38
P8	Farmer (non-member)	Siaya	M	42	22
P9	Farmer (non-member)	Kakamega	M	49	19
P10	Farmer (non-member)	Uasin Gishu	M	52	22
P11	Field Supervisor	Siaya	M	34	9
P12	Field Supervisor	Kakamega	M	28	6
P13	Extension officer	Uasin Gishu	M	42	18

The participants were selected from different calibre including group leaders/lead farmers, farmers both participating in groups and independent, field offices/extension officers. Participants were aged between 25 and 60 years. The different age groups of participants' involvement in this research was important in distinguishing between the adoptions patterns in their personal life and within farming activities. The sample of the study matched the research problem of this study and had a good combination of participants.

3.5 Data collection Procedures

According to Maree (2007), data collection is a process that involves applying selected measuring instruments to the selected population for investigation. Similarly, de Vos et al., (2011) contend that quantitative data collection methods often employ measuring instruments such as structured observation schedules; structured interviewing schedules; questionnaires; checklists; indices; and scales. The author attest that it is essential to understand certain concepts and principles that are fundamental to measurement before choosing a specific measuring instrument.

De Vos et al., (2011) also concur with Saunders, Lewis and Thornhill (2009) that there are so many means in which data can be collected and the importance of choosing and understanding the theory and values of measurement should not be underestimated. In addition, the author asserts that the design of the questionnaire affects the response rate, the reliability and validity of the data. In this study, smallholder farmers placed high premium in agriculture since they were sufficiently representative for the purpose of the analysis of the study.

3.6 Research Instruments

3.6.1 Self-administered questionnaires

A self-administered questionnaire was used to collect data on the level of adoption of innovation; the present extent of the success/failure of ICT Innovations; and the strategies to improve ICT agricultural innovations adoption. The questionnaires were further supplemented with interviews with the group leaders and stakeholders. This questionnaire technique was chosen as the most appropriate tool for data collection, as the questionnaires were hand delivered to respondents (Saunders, Lewis and Thornhill, 2009: 362).

As recommended by de Vos et al., (2011:p188), the respondents completed the questionnaire on their own but the researcher was available in case problems were experienced. The study contend that there was need to limit research assistants' contribution to the completion of the questionnaire to absolute minimum. Therefore, the researcher largely remained in the background and could, at most, encourage respondents with few a words to continue with their contribution, or lead them back to the subject (Maree, 2007:P157).

3.6.2 Pre-testing the questionnaire

The questionnaires were pre-tested to ensure that all items were clear and understandable. According to Ngulube (2005), questionnaires should pre-tested before circulation. Similarly, Dawson (2009: 98) purports that a pilot study is a try-out of the questionnaire to see how it works and whether change is necessary before the start of the full-research.

3.6.2.1 Piloting

In this study, Pilot Study for testing the questionnaire was conducted to reveal the weaknesses and to test the instruments the questionnaire was subjected to respondents. Questionnaire used were prepared very carefully so that it proves the effective in collection of the relevant information. Pilot study was done at three different locations; Kimilili and Kabuchai in Bungoma, kwanza in Trans Nzoia. These locations were different from where the actual study was carried.

3.6.3 Reliability and validity of instruments

i. Reliability of Instruments

Reliability refers to the extent of the consistency in result from the repeatability of measurements; high reliability means high consistency, hence checking of the reliability

between different variables is in the same way of checking the survey's internal consistency (Joppe 2000). This study employed three (3) types of reliability: Test-Retest reliability, Cronbach's Alpha (α) and factor analysis (with Communality extraction Factor Loading - (FL).

According to Joppe (2000), reliability is said to be an extent to which results are consistent over time and an accurate representation of the total population under study and if the results of a study can be reproduced under a similar methodology, then the research instrument is considered to be reliable. Kirk and Miller (1986) identify three types of reliability referred to in quantitative research, which relate to: the degree to which a measurement given repeatedly remains the same, the stability of a measurement over time and the similarity of measurements within a given time period. According to Charles (1995) the concepts that consistency with which questionnaire items are answered or individual's scores remain relatively the same can be determined through the test-retest method at two different times. This attribute of the instrument is actually referred to as stability. If a study is dealing with a stable measure, then the results should be similar. A high degree of stability indicates a high degree of reliability, which means the results are repeatable. Joppe, (2000) detects a problem with the test-retest method that makes the instrument, to a certain degree, unreliable. The study explains that test-retest method may sensitize the respondent to the subject matter, and hence influence the responses given.

According to Saunders et al., (2007), reliability means the degree to which the data analysis procedures and data collection techniques yielded consistent results. Reliability is an indicator of consistency, i.e., an indicator of how stable a test score or data is across applications or time. In this study the measure was assessed to produce similar results consistently then since the measures gave the same results.

Similarly, Crocker and Algina (1986) postulate that when a respondent answer a set of test items, the score obtained represents only a limited sample of behaviour. As a result, the scores may change due to some characteristic of the respondent, which may lead to errors of measurement. These kinds of errors will reduce the accuracy and consistency of the instrument and the test scores. Hence, it is the researchers' responsibility to assure high consistency and accuracy of the tests and scores.

Reflective measurement models were tested for indicator reliability, internal consistency reliability, convergent validity, and discriminant validity (Urbach & Ahlemann, 2010). Indicator reliability describes the extent to which an item or set of items is consistent regarding what intends to measure (Urbach & Ahlemann, 2010). Results in Table 3.5 show that indicator reliability is acceptable, with all constructs items loading significant at the .05 level with a loading higher than .7. However, values as low as .5 are acceptable for initial construct development (Chin, 1998). Internal consistency reliability refers to the degree to which a set of items are internally consistent, that is, having the same range and meaning. According to the results in Table 3.5, internal consistency reliability is acceptable, with composite reliability measures exceeding .6 for all constructs (Urbach & Ahlemann, 2010). Moreover, the above is confirmed with Cronbach's Alpha exceeding .6 for all constructs (Cronbach, 1951). Convergent validity involves the degree to which individual items reflecting a construct converge in comparison to items measuring different constructs (Urbach & Ahlemann, 2010). Table 3.5 shows that convergent validity is acceptable, as item factor loadings are significant ($p<.001$) and the Average Variance Extracted (AVE) exceeds the recommended cut-off .5 for all constructs (Fornell & Larcker, 1981).

Table 3.5: Convergent Validity

Construct	Item	Loadings	Indicator Reliability	CA	CR	AVE
Technological	T_1 T_2 T_3 T_4	0.889 0.827 0.943 0.827	0.789 0.845 0.889 0.745	0.736	0.883	0.791
Economic	EC_1 EC_2 EC_3	0.768 0.928 0.897	0.701 0.849 0.805	0.790	0.867	0.626
Social_Influence	SI_1 SI_2	0.856 07687	0.726 0.697	0.920	.984	.726
Participation	P_1 P_2 P_3	0.815 0.904 0.900	0.662 0.863 0.824	0.844	0.906	0.884
Use of ICT	IN_1 IN_2 IN_3	0.813 0.834 0.898	0.796 0.728 0.798	0.832	0.894	0.724

Based on the indicator reliability, Cronbach's Alpha, composite reliability and Average Variance Extracted, the study concluded that the convergent validity of each one of the construct under the study was established

ii. Validity of Instruments

Validity measures the degree to which a study succeeds in measuring intended values and the extent to which differences found reflects true differences among the respondents (Cooper & Schindler, 2008). Cooper & Schindler (2008) went further to place high premium on three types of validity tests: context, construct and criterion-related validity tests. The instrument is validated when the measurement model is established. PLS_SEM algorithm was run and the results such as convergent validity and discriminant validity were reported.

Discriminant validity concerns the degree to which the measures of different constructs differ from one another (Urbach & Ahlemann, 2010). The Fornell-Lacker criterion has been used successfully for achieving discriminant validity if the construct share more variance with its associated indicators. Discriminant validity was assessed by comparing the square root of AVE for each construct to the correlation of that construct with other constructs. The study assessed Fornell-Larcker discriminant validity criterion to ascertain discriminant validity. As shown in table 3.6, the discriminant validity of each on the construct under study was established according to the criterion.

Table 3.6: Fornell-Larcker Discriminant Validity Criterion

	Economics	**ICT Innovations Adoption**	**Use of ICT**	**Participation**	**Social Influence**	**Technological**
Economics	0.829					
ICT Innovations Adoption	0.038	0.803				
Use of ICT	0.024	0.770	0.856			
Participation	0.046	0.847	0.931	0.915		
Social Influence	-0.193	0.058	0.566	0.533	0.901	
Technological	-0.289	0.838	0.621	0.636	0.580	0.880

In PLS-SEM, methods such as AVE of Fornell-Larcker, cross-loading, Heterotrait-Monotrait Ratio (HTMT) are used to assess the discriminant validity (Sarstedt et al., 2017). However, the use of the heterotrait-monotrait (HTMT) is recommended in assessing discriminant validy (Sarstedt et. a. 2014). According to Garson (2016), argues that the HTMT ration should be below 0.9. The constructs of this study passed the heterotrait-monotrait ratio test as shown in Table 3.7.

Table 3.5: Heterotrait-Monotrait Ratio (HTMT)

	Economics	ICT Innovations Adoption	Use of ICT	Participation	Social Influence	Technological
Economics						
ICT Innovations Adoption	**0.274**					
Use of ICT	**0.357**	**0.83**				
Participation	**0.289**	**0.611**	**0.842**			
Social Influence	**0.571**	**0.270**	**0.812**	**0.610**		
Technological	**0.328**	**0.624**	**0.622**	**0.480**	**0.550**	

In conclusion, the discriminant validity of the construct was established in this study. Therefore, the study argue that the construct validity was established for each of the latent variables after establishing the convergent and discriminant validity.

3.7 Qualitative Data Collection

The qualitative data collection techniques involved conducting the focus groups discussions as well as conducting interviews.

3.7.1.1 Focus group

The focus group discussion was used in the study for mitigating and extending the adoption influences notions from the literature. Extension agents and field officers/supervisors (where applicable) were invited and briefed on the research team interest in understanding more on the usage of innovations by smallholder farmers. Facilitators that would be involved in the FGD were introduced to Extension agents and field officers/supervisors. The farmers group to participate in a discussion about ICT innovation adoption was a suitable identified by Extension agents and field officers/supervisors. Participant interaction with the research problem helped the researcher to verify the adoption

influences found from the under-developed literature in the area of ICT innovations adoption. The purposive sampling technique, (non-probabilistic) was adopted in the process of recruiting the respondents under the study to ensure, only relevant groups/respondents who were mostly likely to provide quality, fruitful and meaningful data in the context of examining on how the use of technology and the exchange of agriculture knowledge between farmers, agriculture officers and other stakeholders.

3.7.1.2 Conducting focus group Sessions

The focus groups' sessions were conducted face-to-face and lasted between one to two hours. The room for conduction the sessions were identified by group members. The lead researcher moderated the first focus group and the second sessions were moderated by the key researcher and the facilitators. The interview and discussion guide (Appendix III), was used to facilitate the group interviews smoothly and covered all points. The guide was developed based on the four adoption factors derived from the literature review. After asking a general question to evaluate innovation adoption, the discussion was centered on the attributes under four adoption issues in the guide. The focus groups sessions were audio recorded and all the participants were informed in advance about the researchers' intent to record the session and reminded at the beginning of each session. Ethical clearance was obtained and participants were provided with a project information sheet and consent forms which included the JOOUST ethical approval number for this project (Appendix IV). Participants were encouraged to participate and assured that expression of opinions are encouraged since there was no right or wrong answer.

Focus groups discussion was conducted, the participants were put into groups of six to ten participants in each discussion group depending on the number of members on the group who turned up for the meeting. Farmers' perceptions about the use of innovations in

agriculture, its value and the adoption challenges were discussed. The FGDs were split into three activities without any structure. The first activity sought to look at issues in agricultural innovations from farmers' perspective and how issues influence farmers adoption namely technology, economic, human, participatory influence. The second activity focused on how issues could best be addressed, and through which organizations these solutions could be made possible. Lastly, the third activity focused on ranking of adoption issues based on the benefits, and their preferences of adoption.

The purposive sampling procedure was adopted in order to ensure there is a matching pattern between research questions and the sampling frame under the study (Bryman, 2008). The focus groups' sessions ended by performing the third activity; distributing evaluation forms of the literature findings on innovations adoption influences; (Appendix VI) the focus group protocol as well as the evaluation form. The evaluation form was used in the focus groups to attain all participants' opinions about all the adoption issues and the extent they thought the issues are influential, and secondly, to quantify and measure the importance of the adoption issues based on all participants' views.

3.7.1.3 Interviews

The focus groups, supported the conceptual framework. From which the outcome helped in developing the interview protocol for the second empirical phase, the individual interviews. Furthermore, interviewing farmers individually using semi-structured interviews was essential in order to gain an in-depth understanding of how farmers' adoption of innovations are influenced.

(i) Developing Interview Protocol

Through literature review and conducting the focus groups, factors that can influence farmers' adoption of innovations were identified. The issues with adoption were underlined, and the interview questions extended that data and obtained an in-depth understanding of why and how a particular factor influences a farmers to adopt or reject new innovations. Therefore, the interview questions extended the focus groups' outcomes. The interview protocol was divided into four sections: A) introduction to the interview, B) demographic information, C) main interview questions and D) closure as illustrated in Appendix VII and Appendix VIII.

The adoption of an innovation could be influenced by individuals, social group contexts and the innovation itself (Alqahtani, 2013). Therefore, when investigating the adoption of innovation in agriculture, looking at the context of individuals and groups is significant. The interview started with questions to obtain background information related to individual participants included: job title, age and years of experience; other background information about the group: types, group size and main activities, which was captured in the demographic part. After which, a general view of the current innovation in practice was obtained. This included the type of innovation available in practice, rationale for introducing innovations and farmers' evaluation of the new techniques initiative. The participants was expected to present their group success stories or challenges. The responses to this question helped the researcher in explaining more on the issues of adoption and the participation/group approach on adoption.

According to Alqahtani, F. H. (2013), there are several actions that can be taken by potential adopters including full adoption, partial adoption, experimentation and non-adoption. Here, the interviewer evaluated the actions taken by the interviewees to see if she/he was an adopter, partial adopter, experimenter or non-adopter. Also, the adoption

behaviour needs to be evaluated to see whether the interviewee is a passive or active user of new innovations. Levy (2009) classifies innovations users into passive users, minimal active users and active users. Therefore questions about how often interviewees as an individual or as a group use the innovations (rate of adoption) and how they use it were was essential in the interview. Furthermore, understanding farmers' adoption processes of innovations is important in order to disclose how the adoption elements (individuals, participatory and technology) interact with each other and influence the adoption (Alqahtani, 2013; Jeyaraj & Sabherwal, 2008).

The adoption of ICT technology or innovations in agriculture is an interactive process which assumes that the adoption is a dynamic and continuous phenomenon that changes over time and where various factors impact on each other (Jeyaraj & Sabherwal, 2008; Kautz & Nielsen, 2004). During research interviews, there were questions that helped in exploring the adoption issues, as well as questions that sought to explain how these issues interact and influence farmers' adoption behaviour. This part of the interview protocol used the pre-identified adoption issues and the influence of participatory approach prompted to further discussion.

3.7.1.4 Conducting the interviews

The interviews were conducted face-to-face and lasted from one to two hours, in a venue identified and interviews were audio recorded. All interviewees were informed in advance about the researcher's intent to record the interviews. Ethical clearance was obtained and participants were provided with a project information sheet and consent form which included the JOOUST ethical approval number for this project.

This study adopted the interview process activities as listed in the Figure 3.3. After conducting interviews, they were transcribed and the interview transcripts were checked against the interviews' audio recordings. The participants were provided with the transcripts to review (Appendix VII). The reviewing was to ensure reliable sources are analysed, hence, the research quality. In addition, interview summaries (Appendix VIII) were sent to interviewees in order to share the researcher's understanding with them. Few comments and clarifications were received. In general, all participants agreed on the accuracy of the transcripts and were happy with the summaries. This is a member checking technique used to enhance the creditability of qualitative research; it also involved meeting interviewees at the end of the project to present and discuss the study results.

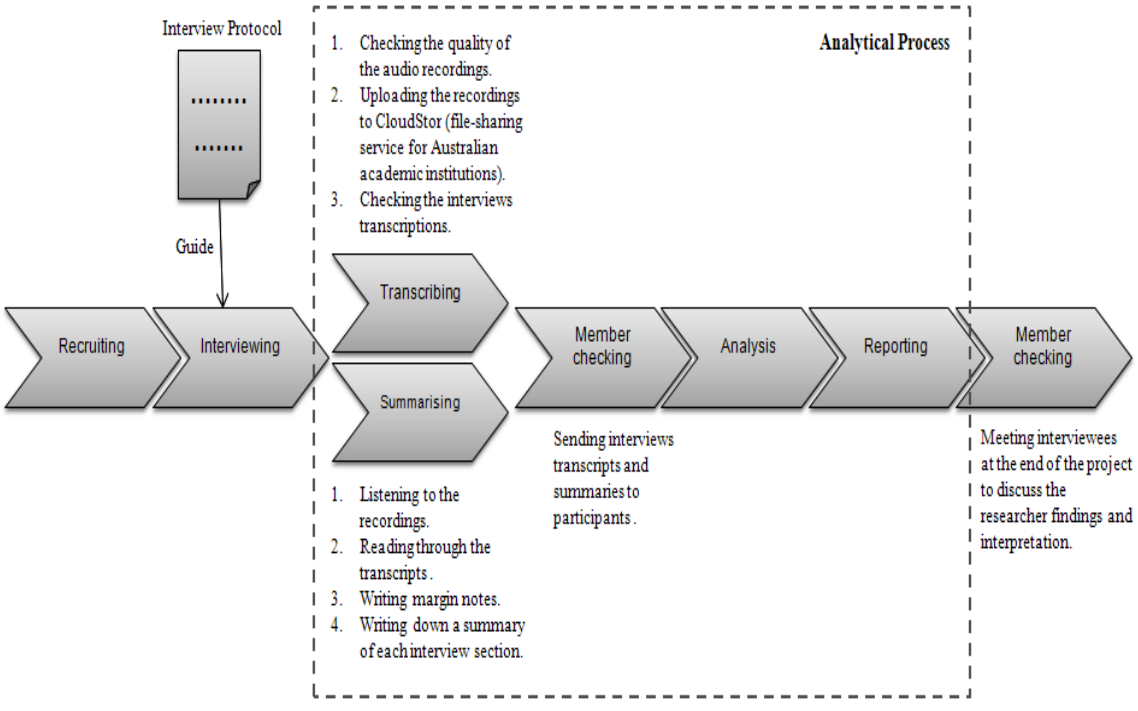

Figure 3.2: Interview Process Activities

3.8 Data Analysis

SPSS V25 was used for descriptive statistics and SMARTPLS 3. 2.7 was used to assess the model, for qualitative study, researcher conducted thematic analysis.

3.8.1 Data Analysis with Quantitative Techniques

According to Nachmias and Nachmias (2008), statistical techniques are a major tool for data analysis. In this study, Statistical Package for Social Sciences (SPSS.25) was used to analyze the collected data and test the constructs. Further, SMARTPLS 3.2.9 was used to assess the model. The Partial Least Square (PLS) Method is a dominant statistical method to test research hypotheses. The method has high efficiency, when the problem is multi-faced and complex, and slight knowledge. The Partial Least Squares Method as a variance-based approach in structural equation modeling that is considered a second-generation method and has overcome on the weaknesses of the first generation of multivariate

techniques (including multiple linear regression, diagnostic analysis, logistic regression, factor analysis and cluster analysis), such as simple look at the linear stage, especially in linear regression, exist the default based on visibility of the studied variables and ignoring measurement error of variables. The Partial Least Squares Method provides possibility of structures factor formation to measurement latent traits by relevant markers and the same time modeling of relationships between independent and dependent latent traits (Haenlein and Kaplan, 2004). New approach of structural equation modeling in Partial Least Squares format generally, is used when the sample size is not sufficient to estimate the significant of parameters and researcher without concern about the number of parameters and their fit with sample size can evaluate the model.

Descriptive Statistics was used to summarize data into Frequencies, Means, Variance, Standard Deviations, Skeweness, Kurtosis, Minimum and Maximum. This allowed for simpler interpretation of the research concepts and also in preparing the data for further analysis using EFA and CFA. According to (Cooper & Schindler, 2010), descriptive statistics display characteristics of the location, spread and shape of an array of data.

In assessing the Model, SEM model contains two models that are linked to each other; the measurement model and the structural model.

3.8.1.1 Model Fit Evaluation

To establish the constructs' validity of the measurement (outer model), the following validly test were carried out: internal consistency reliability, indicator reliability, convergent validity and discriminant validity. According to Urbach & Ahlemann (2010), the criterion for assessing internal consistency reliability is Cronbach's alpha (CA). The values above 0.7 are desirable for exploratory research.

Convergent validity represents the degree to which individual measure correlated with measures or tasks that should tap the same construct. Urbach & Ahlemann (2010) states that an average extracted (AVE) is a commonly used technique for assessing the convergent validity. AVE is a measure of the amount of variance that is captured by a construct in relation to the amount of variance due to measurement error. A value above 0.5 of the measure indicates that an LV is on average able to explain more than half of the variance of its indicators thus indication a sufficient convergent validity (Urbach & Ahlemann, 2010; Garson, 2016).

3.8.1.2 Structural Equation Model

Structural Equation Model (SEM) it structural part of the model that depicts how constructs relate to each other (March & Smith 1995). When a model is proposed, evaluation of it is important. Several techniques permit researchers to evaluate their models such as structural equation modelling (SEM). According to Gefen et al (2000) emphasize on the use of SEM technique to test the extent which information system research suffice standards for high-quality analysis. SEM is used in quantitative research to represent latent constructs, observation and their relationship in a statistical model. The advantage of SEM compared to other statistical tools such as regression, SEM allow researchers to respond to set of interrelated questions by modelling the relationship between multiple independent and dependent constructs simultaneously.

There are two models in SEM: The model that links the latent variables (Structural or inner model) and the measurement model (outer model).

The structural model also has two types of variables: Exogenous and Endogenous. A latent variable is qualified exogenous when there is another latent variable affecting it. In this the

latent variables are use of ICT innovation in agriculture and ICT Innovation Adoption in agriculture.

3.8.1.3 Techniques in Structural Equation Model

There two main techniques in SEM are Partial Least Squares (PLS) and the Covariance Based (CB). According to Gefen et al (2000), the techniques are different in their analyses, objectives, assumptions and fit statistics they produce. With the increasing success of PLS-SEM, the critics lined up. One line of arguments examined the supposed misapplications of PLS-SEM as they relate to the typical arguments in favour of PLS-SEM (small sample sizes, less restrictive distributional assumptions, large model complexity, less restrictive use of formative measurement models) (Sarstedt et al., 2014). The two techniques are compared in table 3.8

Table 3.6: Comparison of PLS-SEM and CB-SEM

Criterion	PLS-SEM	CB-SEM
Objective:	Prediction oriented	Parameter oriented
Approach:	Variance based	Covariance based
Assumptions:	Predictor specification (nonparametric)	Typically multivariate normal distribution and independent observations (parametric)
Parameter estimates:	Consistent as indicators and sample size increase (i.e., consistency at large)	Consistent
Latent variable scores:	Explicitly estimated	Indeterminate
Epistemic relationship between a latent variable and its measures:	Can be modeled in either formative or reflective mode	Typically only with reflective indicators
Implications:	Optimal for prediction accuracy	Optimal for parameter accuracy
Model complexity:	Large complexity (e.g., 100 constructs and 1000 indicators)	Small to moderate complexity (e.g., less than 100 indicators)
Sample size:	Power analysis based on the portion of the model with the largest number of predictors. Recommendations for the minimum number of observations range from 30 to 100 cases.	Ideally based on power analysis of specific model. Recommendations for the minimum number of observations generally range from 200 to 800.

Comparison of PLS-SEM and CB-SEM (Chin and Newsted, 1999)

PLS is widely used in information systems research, strategic management and marketing and many more (Marcoulides and Saunders 2006). Therefore, this study used PLS, PLS path modelling was developed with the main of maintaining interpretability while engaging in predictive modelling since part of this study is exploratory.

3.9 Data Analysis with Qualitative Techniques

There are a number of qualitative data analysis techniques such as content analysis, discourse analysis, grounded theory and thematic analysis (Braun & Clarke, 2006). The studies indicate that thematic analysis is widely used and considered as one of the

predominant techniques for qualitative data analysis (Christofi, Nunes, & Peng, 2009). According to Braun and Clarke (2006), thematic analysis is a method for identifying, analysing and reporting patterns (themes) within data. Thematic analysis is a foundational analysis method for qualitative data, and the first analysis technique that needs to be understood (Holloway & Todres, 2003). The analysis method can be applied across a variety of epistemological and theoretical approaches (Braun & Clarke, 2006) and hence suits the aim of this study.

Guidelines have been developed by researchers for conducting thematic analysis. Braun and Clarke (2006) provided a six-phase guide used in this study as a foundation in conducting thematic analysis as shown in the figure 3.4.

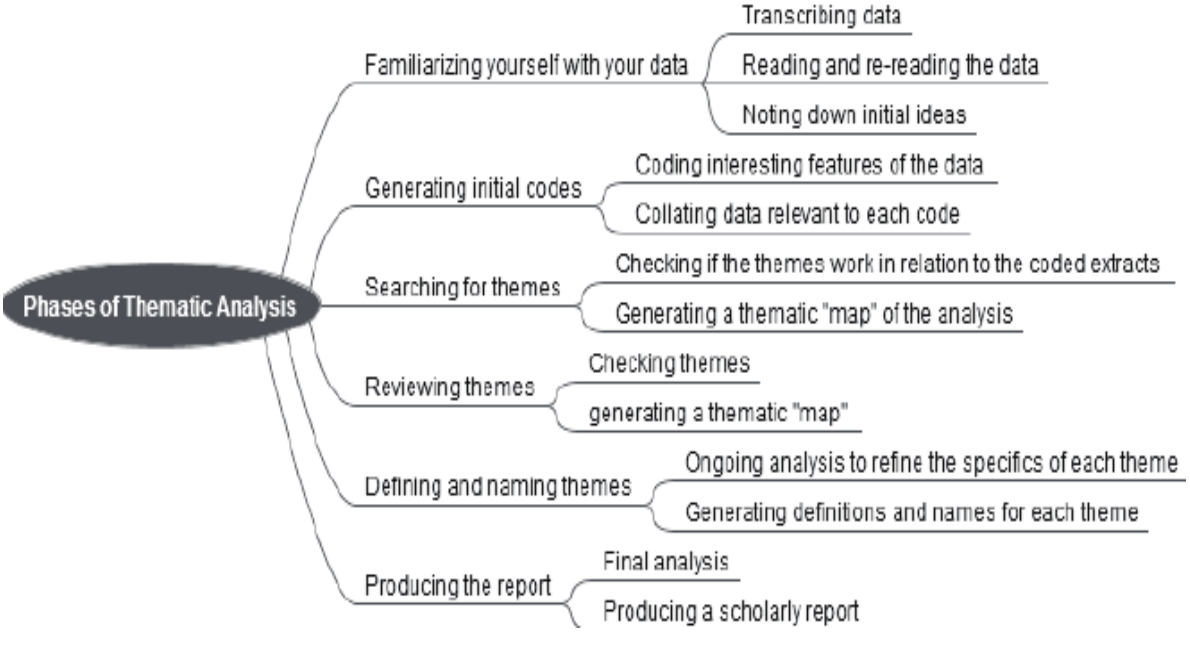

Figure 3.4: Phases-of-Thematic-Analysis (Braun-Clarke-2006-p-87)

The main ways of identifying themes or patterns within qualitative data are inductive and deductive (Braun & Clarke, 2006). In the inductive approach, researchers code their

qualitative data without being informed by a pre-existing coding frame or researchers' analytic pre-conceptions (Frith & Gleeson, 2004; Peng & Nunes, 2010). In contrast, deductive thematic analysis is driven by researchers' pre-conceptions and theoretical interests (Boyatzis, 1998; Guo, Huang, Zhang, & Chen, 2010).

In this study phase an inductive thematic analysis was used, the approach allowed new themes to emerge from the data. The emerging themes could be related to why farmers are adopting/rejecting innovations and how the adoption issues influence farmers. The analysis of the data was performed by thematic analysis technique. As prescribed in figure 3.4, thematic analysis has six steps:

Phase one: "Familiarizing yourself with your data: This focused on reading and re-reading the data, noting down initial ideas". In this phase, the interview was transcribed and read at least twice to begin to identify patterns and meaning, taking notes along. These activities enhanced the researcher's familiarity with the content of every interview.

Phase two: "Generating initial codes: coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code". This phase was focused on reducing the data and the production of initial codes derived from the literature review and focus group. Initial nodes were created using open coding, and applied to all relevant passages in the whole interview data set. Every node was reviewed and described

Phase three: "Searching for themes, collating codes into potential themes, gathering all data relevant to each potential theme". In this phase, Codes were analyzed and sorted to identify themes; merging similar nodes, deleting irrelevant nodes and aggregating nodes with hierarchical relations.

The pre-categorised activity as shown in the last window of Figure 3.4 helped the researcher to see more connections between the initial nodes and hence guided the

remaining categorisation activity. While searching for themes, the researcher considered themes that explained the adoption processes of innovations and the issues that influence its adoption.

Phase four: "Reviewing themes, checking if the themes work in relation to the data, generating a thematic 'map' of the analysis". This phase was focused on refining the draft themes identified in phase three using a two-level analysis of the codes. The first level involved reading through the data for each theme and determining if a coherent pattern has developed. If a coherent pattern was identified, then move on to the second level of analysis, else determine if the theme itself was the issue and information for that specific theme. To complete the second level analysis, the entire data set was read to ensure the themes fit in relation to the data. This gives the opportunity to check if there are any missed additional data that needed.

Phase five: "Defining and naming themes, ongoing analysis to refine the specifics of each theme, and the overall story the analysis tells, generating clear definition and names for each theme". The goal of this phase was to be able to clearly define what the themes are and which ones are not". In realization of this, focus was on defining each theme, identifying the essence of the theme and determining what aspect of the data and research questions the theme fits under.

The activities of naming and defining themes were reviewed by the researcher and the supervisory team in a recursive fashion. At the end of this step, the identified themes could be categorised further, resulting in six innovation adoption themes and a general description of innovation adoption processes, as indicated in table 3.6.

Table 3.7: Agricultural Innovation adoption themes

General Details	
Agricultural Technological innovation adoption characteristics	Agricultural ICT innovation adoption is challenging and has degree of engagement and has process of occurrence
Adoption Themes	**Sub-themes**
Human characteristics	Demographic, family and individual characteristics
Economic characteristics	House hold and financial capability
Technological characteristics	Availability, ease of use, reliability, usefulness, capability
Social Influence	Group norm, influence, support, group activities, awareness
Participatory/Collaboration	External and internal support: Training, relationship, Monitoring
	Leadership, Organization, mobilizing, learning and sharing

Phase six: "Producing the report: the final opportunity for analysis. Selection of vivid, completing extract examples, final analysis of selected extracts, relating back of the analysis to the research questions and literature, producing a scholarly report of the analysis". Themes and their sub-themes were defined and supported by compelling extracts from the interview data. Also, the relations between the adoption themes were identified and discussed leading to key insights about understanding how farmers' adoption of innovations is influenced.

3.10 Ethical Considerations

According to McMillan and Schuhmacher (2006) ethics in terms of conducting research aims to protecting the rights and welfare of the subjects at the same time. This study observed key principles of ethical research. It was undertaken to ensure integrity and quality to the: Stakeholders, Public Universities, farmer groups located in all the targeted

population are maintained. Research groups and subjects were informed fully about the purpose, methods and intended possible uses of the research specifically being an education research, the respondent participation in the research was fully explained. The researcher were insured with an introductory letter, to carry out research from Jaramogi Oginga Odinga University of Science and University (JOOUST), the research Permit was obtained from NACOSTI to enable the study to be officially conducted. Consent was sought from the respondents after clearly explaining to them the purpose of the study. An appointments were booked with respective stakeholders. The confidentiality of information supplied by research subjects and the anonymity of respondents from the target group was respected as such, research participants were called upon to participate in a voluntary way, free from pressure, no harm to research participants what so ever. The independence of research was clear, and any conflicts of interest or partiality was explicit. Everyone involved in this research or process were responsible for maintaining good ethical standards. In good practice, the space for ethical issues will be aired.

CHAPTER FOUR

RESULTS

4.1 Introduction

This chapter presents results from both qualitative and quantitative information alongside each other according to the objectives. The first section of this chapter (Section 4.2) presents the descriptive statistics of the respondent. In section 4.3 discusses the measurement model assessment and section 4.4 presents the structural model. The findings of qualitative are discussed in (Section 4.5 and 4.6). The final section (4.7) concludes this chapter by highlighting the study objectives.

4.2 Descriptive Statistics

The descriptive statistics are reported and discussed as follows.

4.2.1 Response rate

This study specifically conducted research in three counties to understand the adoption of agricultural innovations by smallholder farmers. Figure 4.1 shows a combination of response rates of the target respondents. 120 questionnaires were administered to the respondents (Siaya 30 questionnaires, Kakamega 40 questionnaires and Uasin Gishu 50 questionnaires) out of which 80 were returned for data analysis as indicated in table 4.1. This translates to a total of 66.6 percent return rate of the respondents. According to Fincham J.E (2008), response rates approximating 60% for most research should be the goal of researchers, therefore, the overall return rate is considered acceptable. Since those who did not respond were 40 respondents, this translates to 33.4 percent rate of the respondents, which is basically less than 40% (Table 4.1).

Respondents consists of 23 from Siaya County; 76.7% response rate which translate to 28.7%,out of 27 responses from Kakamega county; 67.5% response rate which translate to (33.8%), 30 from Uasin Gishu county, 60% response rate which translate to (37.5%) The researcher, therefore, obliged to this request.

Table 4.1: Response Rate

Respondent per County					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Siaya	23	28.7	28.7	28.7
	Kakamega	27	33.8	33.8	62.5
	Uasin Gishu	30	37.5	37.5	100.0
	Total	80	100.0	100.0	

4.2.2 Demographic information of the Respondents

The demographic information of respondents with respect to the period of working experience, age groups, gender and ICT adoption is represented. The first output from the analysis is a table of descriptive statistics for all the variables under investigation. Typically, the frequency, percent, cumulative percent and valid percent and number of respondents (N) who participated in the survey are given. Analyzed broadly in terms of male and female respondents, the results from table 4.2 shows that 60% of the respondents were male and the remaining 40% are female. The analysis shows that most of the respondents are male considering the distribution of the gender as shown by the analysis.

Table 4.2: Gender Distribution of the Respondents

Gender					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	48	60.0	60.0	60.0
	Female	32	40.0	40.0	100.0
	Total	80	100.0	100.0	

Further, from table 4.3 it shows that of the total respondents, the age group range of above 50 are the majority with a percentage of 38.8%, which constituted that most of the smallholder farmers are above 50 years, followed by the age range of 40-50 at 30%; followed by the age range of 30-39 at 20%; while the age below 30 at 11.3%.

Table 4. 3: Age of respondents

Age					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Below 30	9	11.3	11.3	11.3
	30-39	16	20.0	20.0	31.3
	40-50	24	30.0	30.0	61.3
	Above 50	31	38.8	38.8	100.0
	Total	80	100.0	100.0	

Considering the education level of the respondents, the majority had secondary education as the highest level at 43%, followed by primary level at 36.3% and Diploma level at 20% as shown in table 4.4.

Table 4. 4: Education level

Education					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Primary	29	36.3	36.3	36.3
	Secondary	35	43.8	43.8	80.0
	Diploma	16	20.0	20.0	100.0
	Total	80	100.0	100.0	

Considering current employment status of the respondents, 77.5% of the respondents of the sample were self-employed, while 22.5% are employed as indicated in table 4.5.

Table 4. 5: Employment Status

Employment Status					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Employed	18	22.5	22.5	22.5
	Self Employed	62	77.5	77.5	100.0
	Total	80	100.0	100.0	

4.2.3 Ownership of ICT devices

The results of table 4.6 summarizes the ICT devices ICT ownership distribution among the respondents. Over 96% of the respondents were using ICT devices.

Table 4.6: Ownership of ICT devices

Age * Gender * Ownership of Technology device							
		Ownership of Technology device					
		Yes		No		Total	
Age		Male	Female	Male	Female	Frequency	Percentage
Below 30	Count	7	2	0	0	9	11.8%
30-39	Count	7	9	0	0	16	21.1%
40-50	Count	13	11	0	0	24	31.6%
Above 50	Count	20	7	1	2	30	35.5%
Total	Count	47	29	1	2	79	100.0%

4.2.4 Awareness of ICT innovations in agriculture

The results of table 4.7 indicates that out of the total respondents; over 80% are aware or rather heard about ICT innovations. This shows that majority of the respondent have awareness of ICT innovations in agriculture

Table 4.7: Awareness of ICT innovations in agriculture

Awareness of ICT innovations in agriculture					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	65	81.3	81.3	81.3
	No	15	18.8	18.8	100.0
	Total	80	100.0	100.0	

On the utilization of ICT devices to access agricultural innovation, the majority of the respondents 65 (81%) being aware of the availability of innovation, majority have access innovations on financial services; access to credit, followed by 12.5% of respondents accessing innovations on input information, 6.3% and 3.8% have used their devices to access information on market and weather respectively.

Table 4. 8: Awareness and Usage of innovations in agriculture

Awareness and Usage innovations in agriculture						
	Cases					
	Frequency			Percent		
Innovation/Technology	Not Aware	Aware and have not used	Have used	Not Aware	Aware and have not used	Have used
Input information on seed, fertilizers and pests	15	55	10	18.7	68.8	12.5
Access to credit e.g. Mkopa,Mkesho, Mshwari	15	3	62	18.7	3.8	77.5
Market prices and places	15	60	5	18.7	75	6.3
Weather information	15	62	3	18.7	77.5	3.8
Transport	15	65	0	18.7	81.3	0

4.2.5 Participation in Farming Groups

Most (86.3%) of the respondents never participated in farming group and don't belong to any farmer group and indicated in table 4.9

Table 4.9: Participation in farming groups

Participation in farmers group					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	11	13.8	13.8	13.8
	No	69	86.3	86.3	100.0
	Total	80	100.0	100.0	

Table 4.10 summarises the farmers' participation in groups and have adopted innovations. Over 90% respondents who are farmers groups were using ICT innovation in agriculture.

Table 4.10: Farmers participating in groups and using innovations

Farmers participating in groups and using innovations					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	10	90.9	90.9	90.9
	No	1	9.1	9.1	100.0
	Total	11	100.0	100.0	

4.3 Measurement Model Evaluation

PLS_SEM assessment comprises of two steps to evaluate the models: measurement models (outer) and structural model (inner). Table 4. 11 present various items and references as used in the model

Table 4.11: Illustration of Variable Vs Items Vs Constructs

Variables	Items	Constructs
Technological	T_1 T_2 T_3 T_4	Reliability Usefulness Availability Simplicity
Economic	EC_1 EC_2 EC_3	Cost of innovation Credit facility Farm Size
Social_Influence	SI_1 SI_2	Friends/Relatives Society Leaders
Participation	P_1 P_2 P_3	Monitoring Knowledge sharing Collaboration

4.3.1 Checking for convergence

While convergence is not often a problem in PLS-SEM, if the solution fails to converge then coefficients in output are unreliable. Therefore it is a good first step to check for convergence after running the PLS algorithm. The stability and consistency is demonstrated when there is convergence after a number of cycles. Convergence was reached in nine (9) iterations illustration in Table 4.12.

Table 4.12: Stop Criterion Changes

	EC_1	EC_2	EC_3	PAM_1	PAM_2	PAM_3	PAM_4	PA_1	PA_2	PA_3	SI_1	SI_2	TF_1	TF_2	TF_3	TF_4
Iteration 0	0.348	0.348	0.348	0.287	0.287	0.287	0.287	0.596	0.596	0.596	0.813	0.813	0.397	0.397	0.397	0.397
Iteration 1	0.333	0.343	0.368	0.319	0.350	0.284	0.175	0.900	0.136	0.357	0.985	0.534	0.114	0.296	0.294	0.753
Iteration 2	0.333	0.341	0.369	0.315	0.351	0.286	0.178	0.916	0.153	0.307	0.902	0.705	0.070	0.220	0.211	0.863
Iteration 3	0.338	0.343	0.362	0.321	0.342	0.286	0.181	0.928	0.109	0.290	0.940	0.640	0.073	0.235	0.223	0.848
Iteration 4	0.338	0.343	0.363	0.320	0.342	0.287	0.180	0.929	0.114	0.286	0.925	0.667	0.067	0.224	0.211	0.862
Iteration 5	0.338	0.343	0.362	0.321	0.341	0.287	0.181	0.930	0.107	0.285	0.934	0.650	0.069	0.229	0.216	0.856
Iteration 6	0.338	0.343	0.362	0.321	0.341	0.287	0.181	0.930	0.108	0.284	0.932	0.656	0.069	0.227	0.214	0.858
Iteration 7	0.338	0.343	0.362	0.321	0.341	0.287	0.181	0.931	0.107	0.285	0.934	0.651	0.069	0.229	0.216	0.856
Iteration 8	0.338	0.343	0.362	0.321	0.341	0.287	0.181	0.931	0.107	0.284	0.933	0.652	0.069	0.228	0.215	0.857
Iteration 9	0.338	0.343	0.362	0.321	0.341	0.287	0.181	0.931	0.107	0.284	0.934	0.651	0.069	0.229	0.216	0.856

4.4 Evaluation of Structural Model (Inner Model)

After satisfying prerequisites of measurement model analysis, the study proceeded to the evaluation of the structural model. In order to evaluate the structural model basically have to follow five steps as assessing a structural model for collinearity issue, assess the path coefficient, assess the level of R^2 ,assess the effect size f^2 ,assess the predictive relevance Q^2. All the threshold values against each and every criterion were clearly represented under the conclusion to have comprehensive understanding about the evaluation of measurement and structural model(Janadari et al., 2018).

4.4.1 Structural Path Coefficients

Structural path coefficients (loadings), illustrated in the path diagram after computation, are the path weights connecting the factors to each other. As data are standardized, path loadings vary from 0 to 1. Weight closet to absolute 1 reflect the strongest paths while weights closest to 0 reflect the weakest path. These loadings should be significant (using bootstrapping). The larger, the stronger that path in the structural (inner) model. A non-significant path may call for specifying the model without that path, or for reasons of theoretical importance and discussion, the researcher may nonetheless wish to retain the path in the model.

On the endogenous latent variables, it was observed that economic factor has the strongest effect on the use of ICT on agriculture and participation (0.412) and (0.361) respectively, followed by social influence (0.199) and Technology factors (0.135). On the last endogenous latent variable, the use of ICT has a very strong effect (0.841) on the adoption of innovations on agriculture. The path coefficient β on the whole model's constructs was greater than 0.1.

Using SMARTPLS 3.2.9, the bootstrapping was ran using the recommended values as stated by Garson (Garson, 2016). Figure 4. 1 shows the bootstrapping setup

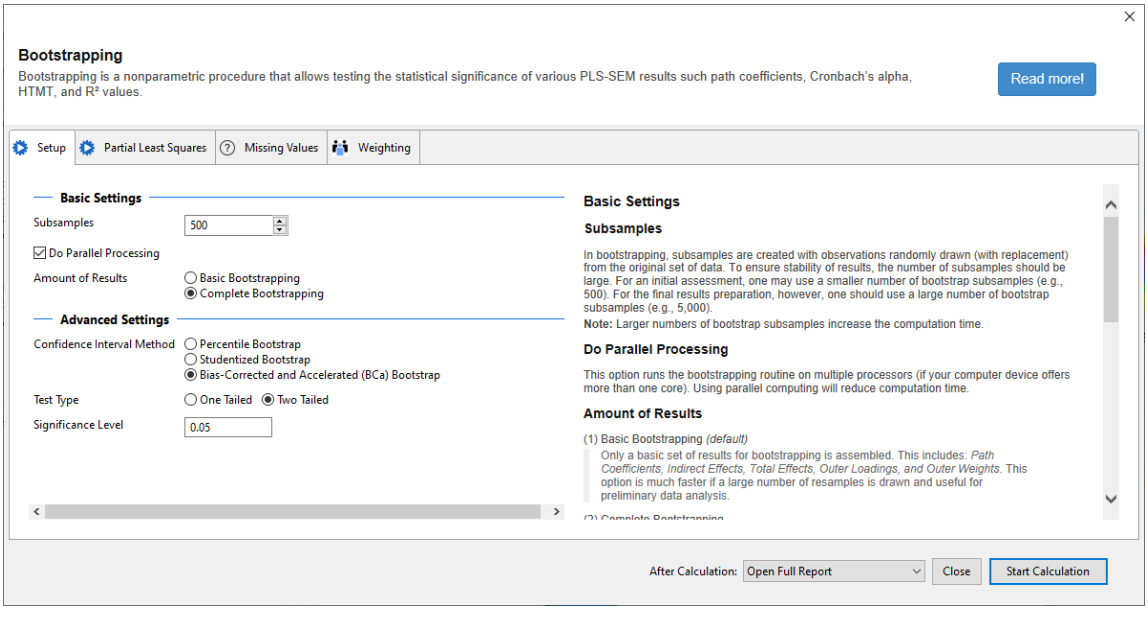

Figure 4.1: the bootstrapping setup

4.4.2 The Coefficient of Determination (R^2)

The Coefficient of determination (R-square) is the overall effect size measure for the structural model. It measures the proportion of the variance of the dependent by the independent variables. R-square is shown for economic, social influence, technological and participatory as these are exogenous latent factors. Chin (1998: 323; see also Höck & Ringle, 2006: 15) describes results for R-square above the cutoffs 0.67, 0.33 and 0.19 to be "substantial", "moderate" and "weak" respectively. In Figure 4.3, the variance for the latent endogenous variable on use of ICT was 0.840. This means that the technological, economic, social influence and participation defined 84% of variance in use of ICT on agricultural. The R^2 of the model when use of ICT is 0.707. This R^2 value of ICT Innovation adoption in Figure 4.3 was higher than the R^2 in figure 4.2 where participation was excluded.

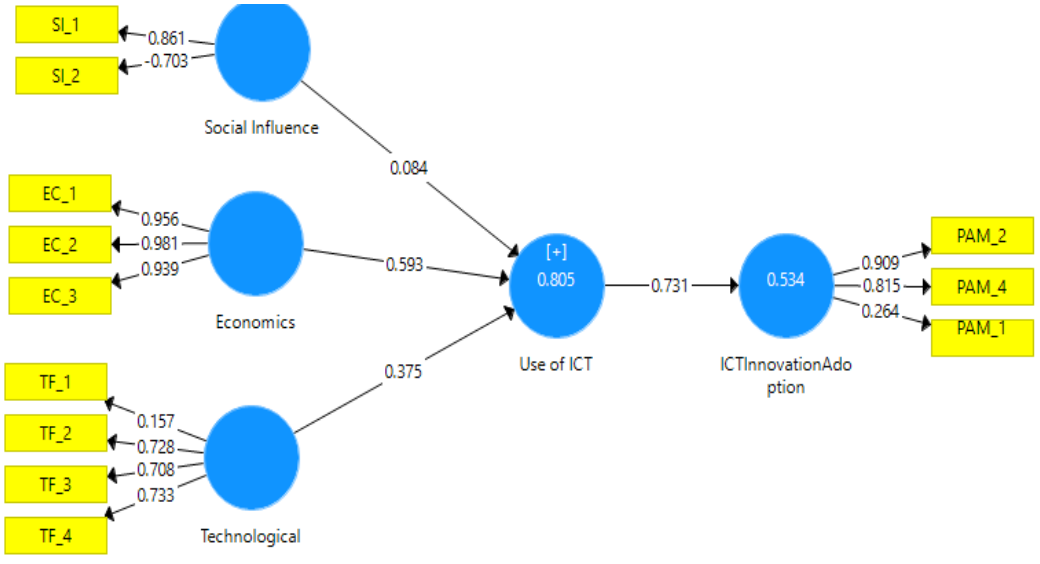

Figure 4.2: Model Results without participation variance

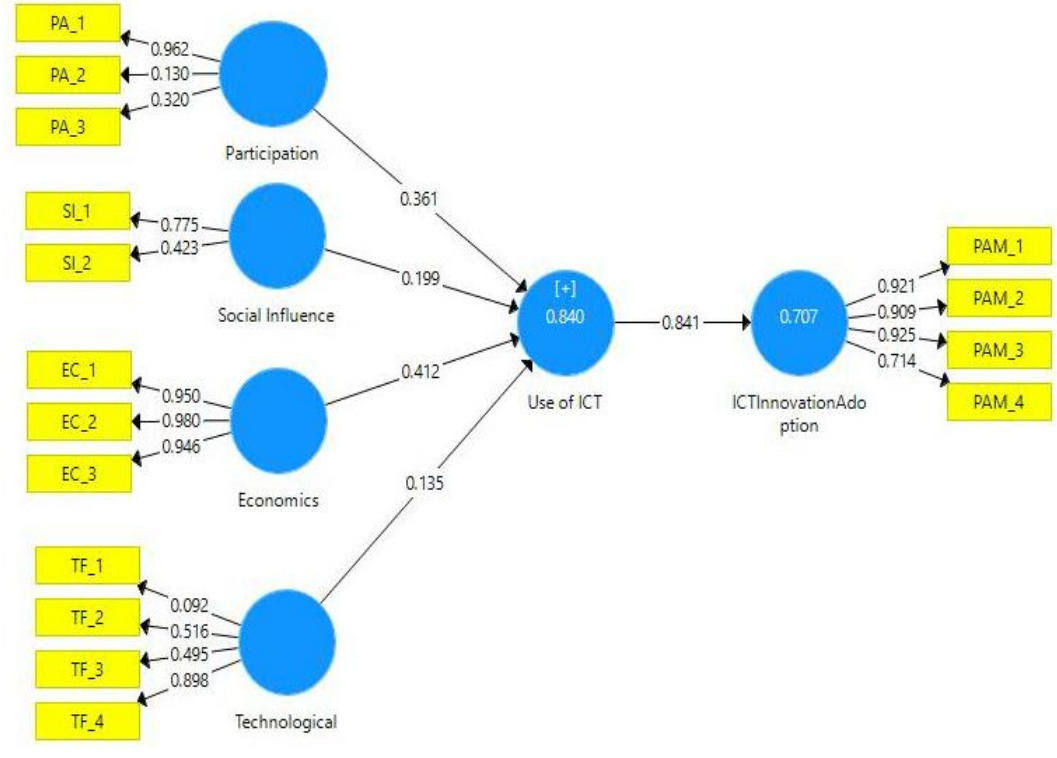

Figure 4.3: Model Results with participation

This demonstrate that the study is recommended and the validated model (variable) of this study explains more clear on the adoption of innovations in agriculture. The R-square here

would be considered to be of moderate strength or effect. As Figure 4.2, model's R^2 was less than .670 that means technological, economic and social factors have effect of the adoption of innovations in agriculture. However, what is "high" is relative to the field: a value of .25 might be considered "high" if the state of the art in the given subject and field had previously led to values even lower.

4.4.3 Effect Size (f2)

The f-square equation expresses how large a proportion of unexplained variance is accounted for by R^2 change (Hair et al., 2014: 177). The effect size measure if an independent latent variable has a substantial impact on a dependent latent variable. Following Cohen (1988), .02 represents a "small" f2 effect size, .15 represents a "medium" effect, and .35 represents a "high" effect size.

4.4.4 Predictive Relevance (Q2)

Another assessment of the structural model involves the model's capability to predict. Table 4.19 shows the results of the predictive relevance done using the Blindfolding function of SMARTPLS 3.2.9. In the structural model, a Q^2 value larger than zero for a certain reflective endogenous latent variable indicate the path model's predictive relevance for this particular construct (Garson, 2016).

The variable technological, economic, social influence and participation are highly predictive with the use of ICT technology on agriculture with a high of Q^2 (0.513) as shown in table 4.19. The use of ICT is also highly predictive of its endogenous latent variable in ICT Innovation adoption with a strong value Q^2 (0.302).

Table 4.13: Predictive Relevance (Q2)

	SSO	SSE	Q^2 (=1- SSE/SSO)
Economics	240.000	240.000	0.000
ICTInnovationAdoption	320.000	155.965	0.513
Participation	240.000	240.000	0.000
Social Influence	160.000	160.000	0.000
Technological	320.000	320.000	0.000
Use of ICT	320.000	223.208	0.302

(i) The standardized root mean square residual (SRMR)

SRMR is a measure of approximate fit of the researcher's model. It measures the difference between the observed correlation matrix and the model-implied correlation matrix. Put another way, the SRMR reflects the average magnitude of such differences, with lower SRMR being better fit. By convention, a model has good fit when SRMR is less than .08 (Hu & BentleUr, 1998). Some use the more lenient cutoff of less than .10. Using SMARTPLS, the function Model fit provided us with the SRMR value of 0.059, indication of study passing the test.

The study answered the research question through validating the outer and inner models by assessing the paths coefficients significance, the direction, the effect size and predictive relevance as shown in table 4.20

Table 4.14: Validation

Objective	Variables	β	T Statistics	Q^2	Effect size (f^2)	Model
To explore factors that influence ICT innovations adoption in Agriculture(barriers and facilitators) and How these factors influence smallholder farmers adoption of ICT innovations	Technological	0.135	1.220*	000	0.098	Supported
	Economical	0.412	1.721***	000	0.189	Supported
	Social Influence	0.199	1.574**	000	0.041	Supported
	Participatory	0.361	1.446*	000	0.159	Supported
Use of ICT model for the increased adoption of ICT innovations	Use of ICT	0.841	26.689***	0.302	2.323	Supported

4.5 Qualitative Findings

This section (4.3) reports the findings of the qualitative phase: the Focus Group Discussion (FGD) and Interview, where smallholder farmer's issues on adoption are discussed.

4.5.1 Findings: The Focus Group Discussion

Despite the acknowledgement of the importance of innovations by the participants, they pointed out that the adoption rate of this technology is low. The innovation adoption of agricultural information is subject to four factors; technology factors, economic factors, human factors and participatory influence.

i. Technological factors

Technology focus on the technical capability of the innovation to meet the users' expectation in the adoption. They also address technical indicators such as user-friendliness, flexibility, reliability, availability, accuracy, efficiency, data quality, scalability and adaptability. Participants perceived that agricultural innovations

technological issues are influential in adoption. The following are some of participants' statements about innovation technological issues.

Focus Group Statements on technological adoption issues was highlighted, after being asked to state how they see new technologies that are given to use in support of information access on agriculture, a group stated that they feel engaged through implementing new practises and sharing experiences with more groups. They statement was alluded by another group that assessing improved crops and practices and sharing the lessons and successes with more farmers in groups is proving to be an effective way to scale up technology adoption. Also noted was that some of the innovations are very useful and have help in increasing productivity and the techniques are ease to use when done as a group. According to other participants, there are so much information they receive from field office but, they still need to be part of the process or wait other group members to implement. On technological adoption, it was noted that some techniques are reliable, however, most of the ideas tested are reinforced and discussed in their groups.

ii. Economic factors

In the context of the sustainability of agriculture system, economic or availability of resources to enhance adoption process is key. Adopting innovation in agriculture requires several resources including land size, Farm income and financial related issues such as availability of funds, affordability of technology or adoption cost, operation cost and farm efficiency or profitability after adoption. The economic factors should aim to improve profits; reduce costs and increase productivity. Participants perceived that agricultural innovations economic issues can influence adoption. The following are some of participants' statements about innovation economic issues. Focus Group Statements supporting economic adoption issues were testified after a question asked about the

facilitation conditions and how participant benefited from group activities. According to one group, anybody with 1 acre qualifies to join the group, so the size of land has not been a limit. Participants also stated that seeds and fertilizers are provided for individual members for later payment so initial cost of input is lowered through the approach, hence a motivation factor to be a member of a farming group. According to another group, using prescribed method has always resulted to better production. However, main challenge, sometimes has been sometimes low rainfall, that affects productivity and farmers have to pay for the inputs. Most of members observed that their status have improved since they joined the group and food security has improved in their families.

iii. Human factors

Human issues affect the way decisions are made in farming; whether to embrace certain techniques in farming or not and the type of operations to carry out. Some of the human factors that were identified in the literature were: household size, age, education and gender. Some of the participants' statements about human issues related to agriculture are were interesting; those with large family have manpower, hence high productivity. Another group stated that the young people are active than some of veteran farmers. According to another group, women in the group are more reliable than men but most of our leaders are men since they command a lot.

iv. Participatory influence

Differences between participatory approaches are often determined on how farmers' participation is applied. The interactive participation was considered in this study because it emphasize on smallholder farmers, jointly working with service providers, in knowledge exchange, solution finding, decision taking, in implementation and monitoring and evaluation. According to one participant, farmers should actively be involved in making

decisions about the implementation of process and programs that affect them. The statement was encored by some farmers who suggested that implementer should listen to their issues before coming up with their products, without proper consultations. A group noted that they have had few interventions from stakeholders and they are invited only during new projected or technology implementation. The group leaders (lead farmers) are influential and help in organizing farmer groups and group activities and some of the practices embraced are due to their leadership. It was also observed that a lot of information is well received in the group meeting and a lot of learning take place during the group meeting where group leaders consult when there are issues.

Most of members learn and support each other when working in their specific grouping, members sharing their knowledge with other farmers has been key to success of most groups. Most groups have adopted table banking practise that help members save and borrow to pay out input costs. Farmers have been organizing to explore marketing opportunities, where, they market their produce as a group and negotiate for prices and sell to a higher binder for example potatoes, maize among other crops.

Despite the acknowledgement of the importance of new techniques introduced in agriculture by partners, the participants pointed out that adoption of the techniques or technologies are based on lead farmers and farmers' group assessment and most cases are promoted by farmers themselves. Field officers/ extension/research staff only introduce the ideas but final decision is made by the group members and their leaders. The farmers' adoption of such technology is subject to the availability of the innovation, the cost of innovation, if the technology is easy to use and if there is a team ready to walk them through the technology among others. Also, several emerging sub factors were identified from the focus groups, including cooperation, group team work, affordability, and training, sharing

skills. The qualitative study suggests that the perceived strength of the adoption factors varies from one participant to another.

The participants evaluated the four adoption issues using a quantitative measure. Figure 4.4 shows participants' evaluation of these issues in a bar chart. In this chart the degree of importance of the adoption factor can be separated into three groups: not important, important and very important. From the figure, it shows that the participants do agree that the adoption issues are important with participation being very important as an adoption influence was much higher than the proportion of participants who believe they are not important.

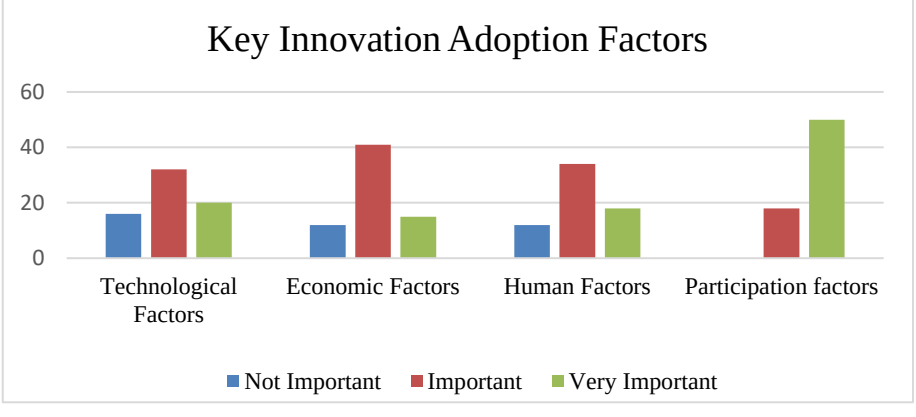

Figure 4.4: Participants' evaluation of adoption issues

However, there are still a number of participants who thought that technology, economic and human factors could not influence farmers' adoption innovations. It is clear from the chart, that participatory approach; where farmers are perceived to be part of the process of implementation is very important influential factor followed, followed closely by other factors in summary, the focus group results showed why users might choose to either use or not use new innovations. These results fulfilled the aim of the focus group phase that is to justify and extend the literature review findings. The results of the focus groups

supported the literature and exhibited that cooperation between partners and farmers is key and can increase adoption. Another new concept that farmers emphasised on, was that working in groups enable them share, have confidence and use new technologies with ease. Another benefit from the focus group research is that it fed into the interview protocol. So those key adoption issues could be further investigated in the semi-structured interviews to understand how they influence adoption.

The group leaders and group members who had high level of understanding of adoption were requested to be invited for interview by the research for further one-on-one discussion. Although the use of focus groups was useful in this phase, the researcher decided to use semi-structured interviews as a research method for the next phase of this study due to drawback of using focus groups; members being hesitant to express their thoughts, especially when their thoughts oppose the views of another participant, the benefits are gained by using semi-structured interview.

4.5.2 Finding from Interview

4.5.2.1 Themes of Influence on ICT Innovations Adoption

The ICT Innovations adoption by farmers in agriculture sector is influenced by a number of issues. The issues are represented in six themes: Human, Economic, and Technological, social influence, participatory, collaboration and knowledge and skills as presented in following table 4.21

Table 4.15: ICT Innovations Adoption: Themes and Sub-themes

Adoption Themes	Descriptions	Sub-themes
Human characteristics	Human characteristics/factors refer to the adoption issues related to individual farmers characteristics; house hold and demographic.	Demographic, house hold and individual characteristics
Economic characteristics	Economic characteristics refers to resources (land, finance) to enhance adoption	Farm size and financial capability, credit facility
Technological characteristics	Technological characteristics refers to technological attributes of the innovation	Availability, ease of use, reliability, usefulness,
Social Influence	Social influence refers to farmers' influence on each other that shapes their attitudes or actions in relation to adopting of ICT Innovations	Friends, leaders, influence, support, society activities,
Participatory/ Collaboration	This theme refers to people involvement in adoption process/ implementation Collaboration refers to interaction with outsiders on adoption , Ways of impacting knowledge and skills	Group activities, internal support, External support: Training, researcher, Monitoring, Leadership, Organization, mobilizing, learning and sharing

The following sub-sections present those themes, showing how they influence farmers' adoption of ICT Innovations

(i) Human characteristics

Human characteristics of the farmer can have a significant influence on farmers' decision to adopt new technologies. In this study, a number of individual traits were found to be important in relation to adoption issues. They can be categorised into two sub-themes:

demographic and household. This section discuss how human characteristics influence adoption.

(a) Demographics

Demographics that influence ICT Innovations adoption in agriculture were identified as farmers' age, gender and Education. Farmers' age is identified by participants to be a determinant in adoption of innovations. From the participants list, it shows that, adopters are relatively younger than non-adopters implying that as the age of the farmer increases, there are chances of developing resistance to the adoption of new technologies. Despite older farmers being assumed to have gained knowledge and experience over time and are better able to evaluate technology information than younger farmers, younger farmers adoption new technology or innovation much faster, as noted: " the young farmers embrace new ideas more frequently" P3.According to P12, "early adopters are usually younger farmers between 20-50 years of age".

Gender issues in agricultural technology adoption have been investigated in regard to different roles men and women play in technology adoption. In analyzing the impact of gender on technology adoption, P4 said, "have not notice the difference between genders in adopting improved farming technique". On contrary, on adoption of technology, P11 noted, "Men influence members on the use of mobile phone in communication than female". This was conquered with that of P4 who indicated "male farmers normally check on weather information and fertilizer unlike their female counterparts."This corresponds well with most researchers' evidences, as there is a feel that women focus more and are active in group projects than men. One researcher complained that young men in particular are difficult to reach out to, as they are driven by fast money making businesses such as

boda-bodas (motorcycle taxis) than farming. While another group said that older men are problematic as they spend a lot of time relaxing. Majority witnessed cases where leadership did not reflect the gender distribution, usually there are more women in farmers groups than men, however, most instances the chair person will always be man" (P13). It was noted that gender have impact on technology adoption, with male being fast in decision making on technology than female.

The education level of farmer can have a positive influence on farmers' decision to adopt new technology and shape the way they interact with devices. Participant stated, "Educated farmer embrace changes and new information and always on the fore front when it comes to implementation of new ideas. They also inquire a lot and always want to see the end results" P12.

(b) Household size

Household size is simply used as a measure of labor availability. It determines adoption process in that, a larger household have the capacity to relax the labor constraints required during introduction of new technology. However, participants agree that it has no major influence on the way they practice their activities.

(ii) Economic characteristics

A number of studies highlighted about cost effect as the factor that determine the acceptance and hence adoption of innovations. In this study, majority of the participants indicated that once they realise that there are some cost tied to the innovation or services, they decide to use their normal routine or explore a different path. Most of participant shared their inability to innovation as a solution to improved productivity due to their families' socioeconomic status. Participants expressed their intention to know or use but

they are discouraged by the costs associated with using innovations. Some participants indicated that they will be willing to use the services if only they can be assured of improved production.

(a) Farm Size

The average farm size in acres for adopters who are in "OnAcrefund" project is 1 acre, while that of non-project member are more than 3 acres, indicating that non-members cultivate a relatively bigger land than project member. This could be interpreted to mean than new technology comes with an extra benefits that group members would want to utilize to enhance their productivity. Farmer P6 states "being a member of the group has enabled him increase productivity compared to before joining the group" These findings are consistent with P4 who observed that "the size of the farm for neighbour (non-member) is larger and harvest more maize". Access to information on farm activities, farming as the main economic activities and availability of mobile phones increase the likelihood of adopting new technology by farmers according to the summary results. Similarly, belonging to farmer's association and also being able to access media, is more likely to induce a household member adopt modern farming technologies.

(b) Credit Facility

Increased project access to agricultural credit is important in promoting information access on inorganic fertilizer and improved maize variety. Improvement of credit improves group members adopting inorganic fertilizer "when I have money, i inquire about the right fertilizer and seed to use". This is consistent with P8 "with enough cash, I prepare my farm on time, I go for the recommended fertilizer, and can use my phone to access the information on the right input". Smallholders may not be able to accumulate sufficient

savings to purchase relatively more expensive technologies like inorganic fertilizer and improved maize variety. On the contrary, increased credit access lowers the probability of adoption of improved maize variety as an individual technology. This implies that access to credit could make smallholders switch to higher value crops.

(iii) Technological characteristics

Agricultural technological factors influence its adoption. The ICT Innovations factors identified are: simplicity, reliability, availability, adaptability, usefulness. Excitingly, the technological factors influence the adoption process in different ways. The clarification of each attribute and their sub-themes associated with ICT Innovations adoption are provided as follows:

(a) Simplicity

While individual factors are acknowledged as a key reason to adopt new agricultural technologies, other attitudes play roles in the adoption of new technology by farmers. The way an individual perceives the new technology is critical to whether they will eventually adopt the innovation. Farmers are oriented towards "easy-to-use" new technology. They are aware of the need to adopt new technologies introduced for improved harvest, however they distrust technologies they perceive too sophisticated to interact with, requiring investments in learning new skills. As the technology applied in the agriculture sector is becoming increasingly complex, the need for a simple and easy way to interact with it is growing among farmers.

There were some reservations on the use of innovation; some farmers stated that while they felt the new technology are good but, they have not been able to use them efficiently due to lack of knowledge. "The innovation requires a lot of knowledge, some recommendations

are hard to adopt. Like using different tools for different things, it's hard to master the concepts. Sometimes the information are sent when it is too late and the disease has already spread. There is need on continuous training regarding maize diseases" (P8).

(b) Reliability

Reliability is an important variable in technology acceptance and use and refers to the correct technical functioning of technology. The reliability issue was not given emphasize with most participant, hence found to have minimum influential on innovation adoption. Only one participants indicated that innovation should be reliable and "some new technology have good quality" (P10). The technology reliability is not a problem according to majority of the participants as they don't detect the errors (P3). However, poor reliability is not acceptable by all means, and lack of performance from technology tools would have a negative impact on adoption. Reliability is key and when lack of it can slow down adoption and frustrating which can portray the whole solution negatively (P4).

(c) Availability

The study looks at the availability of agricultural innovations and ICT devices, and how it has affected adoption of technology among smallholder farmers. Participants indicated that they have access to basic ICT resources, all of them having access mobile phone and almost half of the respondent admitting to have internet connection on their phones at work. However, it is important to note that simply having phone may not translate to ready access to innovation. According to P9 "access to innovation comes with additional cost implications, especially as concerns internet access which was mainly in the form of data bundle". In addition, P10 narrates "sometimes the technologies are not available or not available at the times we need them". The low adoption of innovations was attributed to factors such lack of information and awareness of some of the technologies

(d) Usefulness.

The relevance of innovations was identified in the model as an important adoption factor. Usefulness refers to innovation being beneficial or rather having relative advantage. Participants in this study identified many benefits, such as increasing farmers' awareness, exchanging knowledge and enhancing collaboration, which motivate the adoption of innovation, as noted: Some innovations are very useful and inspiring and very helpful, for example information on market and prices (p10)

This study identified issues relating to the usefulness of innovation that form its influence on the adoption of innovations; long-term usefulness, sometimes innovation usefulness can be discovered after a long time and this hinders its adoption.

(e) Awareness

Some technologies might not be profitable given the complex set of decisions that farmers make about how to allocate their land and labour in their farms. It is noted that low farmer's adoption of technology is mainly due to lack of farmer's awareness of such technology, availability and marketability of the innovations. In Kenya, many farmers are slow to adopt technology innovations (P11). According to P8, "the main reason I do not use some technologies is mainly because am not aware of the benefits of such technologies".

(f) Training

Training includes any formal or informal way of teaching farmers new technologies and the practical skills to use them. In the study, training was mentioned, and considered critical in adoption of innovation, moreover, could be used to persuade some farmers in some cases. Participants from the interview disclosed that the smallholder farmers are inadequately trained on new technologies and that the field offices tend to focus on active

farmers and the well-resourced. According to P7 “field officers like wealthier farmers most less privileged are unattended to” generally most farmers are not adequately trained on most new technologies. “I get most information from our leaders in our groups” states P5. Most participants do need training to use ICT innovation. It is indicated that most require continuous training on use of technologies, as one participant stated: No matter how intuitive and easy to use and all the rest of it, farmers still struggle with new things and need someone to continue holding their hands for successful usage” (P2).

It has been observed that the services of the extension workers are ineffective since the disseminated messages to the majority of the smallholder farmers have become technically redundant and obsolete and it does not keep with modern advancement in technology (Antwi-Agyeia & C.Stringerb, 2021). Therefore, providing training could motivate the adoption of new technologies in situations where innovation is a complex tool to use or when there is a group of older farmers who are not familiar with the technology. Therefore, organisations should consider providing continuous training to farmers.

(iv) Social influence

Social influence is a process where farmers’ influence each other to shape their attitudes or actions in relation to adopting innovations. The studies indicated that this influence can either motivate or hinder innovation adoption. Social influence can be classified under different sub-themes: group norm, relatives, friends and society leaders. For some farmers, working in group is associated with how one relate with other in the community. According to a number of participants, involvement in farming groups have had positive impacts on social life and that they create a network of friends. Some farmers stated that they have been empowered through friends; “I have learnt that if you have good friends, leaders, you can achieve so much” (P6). “I have never been trained how to operate my phone or search

for information, have discovered a lot through group members, relatives and other friends" (P4).

There were also some that felt that learning new farming techniques have improved their personal characteristics and how they are viewed/seen in the community. Through being dedicated to work, trustworthy to the group and being an active member, one can be a role models to others and stabilized the group (P5). Most members who acquire new knowledge go on to share with relatives and friends.

4.5.3 Participatory system influencing the adoption of ICT innovations

The participating farmers were asked to share their feelings on the partners they collaborate with such as 'OneAcreFund". During the interview process for both participants and non-participants, one aspect emerged as particularly common from various respondent; Respondents in various counties complained that for different reasons, the benefits from the partners were not so much. The concerns has often been directed to the field offices who are the point of contact between the project office and farmers. Though farmers are advanced input products (which they pay in instalments with interest), but farmers also expressed that there is a need for the implementers to follow-up to understand production to ensure that those who have low harvest are considered for alternative arrangements. The participants expressed mixed reactions such as "I'm not entirely happy, some seasons have been suppressed and selling all produce to pay for the seeds and fertilizer I was advanced and it is not fair (P2). Others argues, "Some people don't show up to support other once they have been supported. The leadership is poor, it's not balanced, and I don't feel I can air this out to them. The project implementers need to follow up on what happens on the ground" (P6). On support a member indicated that "We need more guidance on how to participant and support each other during planting time. So far the participations have not

been done fairly. Since the project has been introduced the group leaders/field officers have been too quiet about it" (P5).

For non-group farmers, similar concerns were the reasons of not being involved group farming projects. A participant had a strong discontent and felt that members exclude others deliberately. Others shared their concerns as follows; "When organizations are working with communities the implementers select certain people to give support, they are selective on who to give and not to give. The local politics in the villages divide people at the grassroots, if you are not in the same group as the leaders then you are reluctant to join" (P8).

It is important that field officers actively take their role as support partners and not assume leadership. To minimize politics developing within the groups, keeping groups as small as possible can be beneficial. Other things that were pointed out were the need to keep the process open and transparent to reduce factions from forming while others don't seem to benefit, and that the partners can encourage the group teamwork through making people understand that it is more beneficial to work together as a team.

(i) Monitoring

Several farmers pointed out explicitly that it is important for the farmers to understand the role and operations of the supporting organization, and why they should be part of their activities, hence there is need to "sensitize" the farmers. One of the group leader state that "A lot has been invested in OneAcreFund Project, but the response from the farmers has been poor. People have a poor attitude towards cooperative farming, then when they saw the benefits they wanted to join after all, but then the existing members felt late comers should start other grouping. Some people think they won't benefit if they are many" (P2).

Another argument from a farmer “there is need for more time in order to achieve the goals. It is a slow process to sensitize the farmers and it is not easy” (P4).

The need for monitoring or follow-up was also brought up on several occasions. Some farmers felt that the project was probably not going as was planned from the beginning or that the benefits didn't reach as many as they could. As noted “There is need for continuous follow-up on what is being done. The group leaders can easily forget the objectives, so project implementers need to follow up. The field officers and leaders need to be transparent, they need to discuss and update farmers on the new techniques” (P7). Another member emphasized on the need to reach out to farmers “Leaders need to talk to members to reach different groups in local areas. It was also noted that the local farmer leaders need training for proper publicity. Few people in the group have knowledge. Leader will reach out to everyone many farmers in the community” (P9).

The field officer (P12) clarified that following up on certain aspects of the activities; like giving seeds and fertilizers to the groups through talking to leaders and a few participants is part of field offers work, but other than that there is time for continuous strict monitoring.

(ii) Knowledge and Skills sharing

There are groups where sharing becomes a norm; when stakeholders don’t share information with farmers then no progress can be made. On knowledge and skills, farmers were asked to identify where or who they acquired their farming knowledge and skills. Majority of the respondents said that they acquired during group discussions while a few said through extension services. Fellow farmers, however, was the most common sources of farming knowledge among the respondents, followed by knowledge from parents and extension services, while very few identified their own experience. Interestingly, there

were some who were part of the OneAce Fund project yet still stated that they had never interacted with extension staff or researchers personally, the result of field officers coming once is a while.

The participants were requested to share their views on the knowledge of scientists' extension workers in regards to farming practices in their area. The majority responded confirmed that researchers and field officers/extension workers are knowledgeable, and justified this by stating that they have solutions for most teething problems. There were some reservations; some farmers stated that "while they have generally knowledge, there were some issues we have not been able to solve or lacked sufficient knowledge" P8. Others complained that "new techniques are hard to follow and fully implement and the problem is not knowledge but rather they are not involved during the process establishment" (P1). Some farmers were dissatisfied with other group members' interest and commitment to learning and adopting new knowledge and methods.

When participants were asked about their interest in more closely working relationship with external support team (stakeholders) than as it is at the moment, majority of farmers were positive on the issue. Moreover, they understand it as an opportunity to acquire further knowledge. Some expressed that it would be beneficial as it could also influence their work. "We need to work closely with knowledgeable people who can closes monitor our activities, share and be able to correct us instantly"; like when diseases /pests come and we need to use chemicals, we can consult easily; and more so information about how the market works is important for our product and the right time to sell the produce (P8). A member stated, "Recently we learned about accessing weather information and subscribing, these kind of issues we had not thought were very serious before and gain a

lot from being in contact with them; the more the better, we also learn from each other" (P3)

(iii) Collaboration

ICT Innovations adoption is about cooperation; if collaboration is embraced between service providers and farmers, the active adoption of innovation can be accelerated. As much some participants had reservations that it is difficult to interact with outsiders without understanding their interested and objectives clearly. It was almost exclusively noted that participants who had such reservations about collaborating are non-group members. The majority of non-group members prefer an individual approach where the focus was their own farm, rather than a group of farmers. Another respondent indicated that while he won't mind interacting with extension staff or researchers, but due to time, he would prefer just being given capital, while others don't find the need of group since their problem as a farmer is financial related.

The field officers/extension agents who were interviewed confirmed that generally, farmers they interact with are eager to obtain new knowledge and attitudes towards them are generally positive. However, some issues were raised by the agents; Farmers can get "participation fatigue" when the same farmers are asked to participate over and over again they can get tired of it especially on the use of the technique. On the other hand, it is easier to work with farmers who have earlier experience of working with other partners. However, one negative experiences by farmers in the past involving partners/ extension workers can be passed to other new partners. The attitude also depends on technology and techniques/services on focus; instant raising produce/ profitability is of interest to more farmers.

However, the negativity towards outsiders in most cases had exclusively connected to experiences where scientists and/or researchers appear only to give their endorsements. According to some participants “Sometimes they partners and extension have predetermined approaches that do not favor us” (P11). Some argued that “It has become a bit better, but there are still people who just come provide guidance but still no major benefits at all. But with farmer groups, things have been better (P1). According to participant (p10) “I am a bit confused about partners, they come give instructions and disappear, they need to do more” (P10)

There were some indications that participatory approach can have a positive experience compared to the traditional ways of doing things. The farmers who alluded to this, pointed out different aspects as follows; they were able to see concrete action during the adoption of suggested activities rather than just getting instructions (P3). “Before, we only had people come and talk theoretically, now I feel comfortable bringing up issues and people can listen” (P2). “I feel extension workers can have a positive impact on our livelihoods and believe will no longer have to buy food, as before.” (P11). On the contrary they stated that they think that participatory approaches generally are well regarded “It is the most interesting part of the job... being in the office is boring. I think most researchers enjoy being out in the field with the farmers” (p13).

The group participation was considered in this study because it emphasize on smallholder farmers. The study found that group norms have an influence on the early, individual and collaboration adoption of innovations by farmers who become motivated to adopt ICT innovations. The study established that farmers feel social pressure to be part of such a social system and behave accordingly. The social influence of image refers to how one is viewed by others when using a particular technology. Group activities are important benefit

farmers trying to access technology. The current study indicates that information benefits, career enhancement and having somewhere to request help are important positives derived from networking with colleagues. Increasing users' awareness about colleagues and their work and personal updates are other important benefits. This in turn motivates farmers to use ICT to facilitate communication.

External support encourages and facilitates the smooth adoption of innovation. Such support can be provided by different stakeholders in different forms: Monitoring, providing required resources for training, frequent Knowledge sharing on the new ideas with users among others. Training is a form support that can be provided to farmers to introduce technology ideas and the skills on how to use the innovation. While training motivates late adoption, individual and collaboration adoption it can also hinder early adoption.

In conclusion, there are many adoption factors that either stimulate/motivate or inhibit farmers' adoption of ICT innovations in agriculture. These influences fall into various themes. The themes that can be further categorised under four broader categories, namely: human, technology, economic and environment. Adoption influences within every category interact with each other as well as with influences from other categories, such interactions either shape adoption influences to be stimulate or inhibit. Also, farmer's innovation adoption level is influenced. These adoption influences interact with each other continuously during the adoption process, resulting in different modes of adoption: Early/late, individual/group, and collaborative/ non collaborative. The right part of this figure represents the changing nature of adopting innovation, as farmers' adoption mode of innovations keep changing over time, due to the interactions among the human, technology, economic and environment influences.

Table 4.16: Summary of themes influencing of smallholder farmers on adoptions

Adoption influence	**Stimulate**				**Inhibit**		
	Early Adopt	**Late Adopt**	**Individual**	**Group Adopt**	**Early Adopt**	**Individual**	**Group Adopt**
Theme 1: Human Characteristics							
Age	X	X				X	
Gender			X			X	
Education	X		X	X	X		
House hold size			X				
Individual characteristic	X	X		X			X
Theme 2: Social Influence							
Leader	X			X			X
Friend/family	X		X	X			X
Theme 3: Economic attributes							
Cost	X		X			X	
Credit facilitation	X		X				X
Theme 4: Technological attributes							
Simplicity	X		X	X			X
Availability			X	X			
Reliability			X				X
Usefulness	X						
Awareness			X	X			
Theme 6: Participation (involving Stakeholders)							
Monitoring	X		X	X		X	X
Collaboration	X		X	X	X		
Training		X	X	X	X		
Knowledge and Skills sharing				X	X		
Theme 3: Participation (Internal influence)							
Group Activities	X		X	X		X	
Knowledge and Skills sharing	X		X	X		X	

4.6 Summary of Quantitative and Qualitative Findings

This section summarises the quantitative and qualitative findings.

In quantitative analysis, the study looked at descriptive analysis: response rates was approximately 60%, in terms of gender 60% of the respondents were male and the remaining 40% are female. In response to owning ICT devices, Over 96% of the respondents were using ICT devices, with over 80% being aware or rather heard about ICT innovations. Over 86% of respondents also indicated that they not engaged in any farmer groups. Model was also evaluated using PLS_SEM, the assessment comprises of two steps to evaluate the models: measurement models (outer) and structural model (inner).

In qualitative analysis, the study further classifies the six adoption themes (Human, Economic, Technological, Social, participatory and collaboration) found in this study into four categories, namely: Human, Economic, innovation and environment. Therefore, it can be stated that the model of participatory Adoption of innovations, identifies adoption as a process that keeps changing over time, due to the interactions among the Human, Economic, technological and environment influences.

The adoption of ICT innovations by smallholder farmers in agriculture is a complexed issue which is influenced by the interaction of many factors. In this study, the adoption factors are represented in six themes: Human, Economic, Technological, Social, participatory and collaboration

In this study six adoption themes were identified and how they influence adoption are summarized in table. The table also Indicates how the adoption is stimulated or inhibited and modes of adoption; early/late adoption, individual and collaboration.

CHAPTER FIVE

RESULTS DISCUSSION

5.1 INTRODUCTION

The aim of this study was to examine the factors related to adoption of agricultural ICT innovation by smallholder farmer. To understand these factors in the study, quantitative data was collected followed by qualitative data that depicted on explanatory mixed methods research design.

The study examined smallholder farmers' adoption of ICT innovations in agriculture. A number of objectives were identified to understand how adoption factors influence smallholder farmers' adoption and the role of participatory approach in adoption. The discussion of the findings in this chapter is intended to provide approach of stimulating adoption of ICT innovations in agriculture. In Chapter 4, the findings are enumerated; the main goal of the quantitative data analysis was to ascertain the variable identified in the theoretical review. In the qualitative phase, data was collected using semi-structured interviews and participating in focus group discussions from a subset of participants who were participating in OneAcreFund project. The goal of the qualitative data analysis was to get a deeper understanding of the statistical results from the quantitative phase. This chapter is organized as follows (1) a discussion of the findings from both the quantitative and qualitative phases, (2) answering research question three drawing from the qualitative data, (3) conclusions.

5.2 Discussing the Findings of the Study

The findings from quantitative and qualitative survey results confirm that there are factors that are key to the adoption of ICT innovations. The study results from quantitative and

qualitative confirm that the key factors to be considered for successful adoption are related to human, technology, economic and environmental provided for operation. The mode of adoption was also identified to be either individual or group adoption, which can be considered through collaboration support provided to farmers. Adopting ICT innovation by smallholder farmers was found to be a process requiring time and support from agriculture stakeholders. This called for knowledge sharing which can be stimulated through participatory approach. Supporting the finding of the current study, previous research such as Venkatesh and others (2003) indicated that adopting new information systems is often challenging. Interestingly, from the findings, technical issues are less challenging for innovations adoption than previously indicated by a number of studies (Mng'ong'ose & Matern Victor, 2018; Mustafa & Yaakub, 2018). This study explored a number of influences which are potential issues such as human, social, economic, technology, participatory and external collaboration with stakeholders.

The results support that characteristic of a technology is a precondition of adopting it, this has also been stated by Islam (Islam & Grönlund, 2017), that farmers' perceptions of technology characteristics significantly affect their adoption decisions. It is also argued that users perceptions about ease of use and usefulness are likely to be developed from rational assessments of the characteristics of the technology and the tasks for which it could be used (Amare & Simane, 2017).

The result for human factor which is considered under demographic in this study shows that human attributes have major influence in adoption. The finding of this study supports the demographic context in use and adoption of new technology. According to the findings, variables that are important in this category are: Age, Gender and Education (which is directly related to skills). Most adoption studies have attempted to measure human capital

through the farmer's Education, age, Gender, and household size (Fernandez-Cornejo & Daberkow, 1994; Fernandez-Cornejo *et al*., 2007; Mignouna et al, 2011; Keelan *et al.*, 2014). In this study, age is one of the demographic factors that were considered in relation to technology adoption. The results of this study indicate that majority of the younger farmers below 30 year own the ICT devices (phones). The younger also indicated that they have used the devices to access agricultural innovation and are aware of the availability of innovation. The findings also indicated that majority of farmers with phones have access innovations on financial services; access to credit, accessing innovations on input information, have used their devices to access information on market and weather. This study shows that the older adults, as a group, tend to be slower than younger adults to adopt new technologies, this has been supported by a number of studies (Anderson & Perrin, 2017; Berkowsky et al., 2017). Generally, younger peoples' technology usage decision are more strongly influenced by attitude toward using the technology (Morris & Venkatesh, 2000). In contrast, older farmers were more strongly influenced by subjective norm and perceived behavioural control (Francis et al., 2019). Additionally, the adoption of technology for older adults is said to be tied to a number of factors such as perceived benefit of the technology, confidence in uptake and perceived impact on quality of live(Berkowsky, et al., 2017). Therefore, to be able to promote adoption of technology among the older adults, these factors should be considered.

The study has also confirmed that education of the farmer have a positive influence on farmers' decision to adopt new technology. This confirms the literature discussion that education level of a farmer increases his ability to obtain; process and use information relevant to adoption of a new technology (*Mignouna et al*., 2011; Lavison 2013; Namara *et al*., 2013). Supporting results is the study by Okunlola *et al.* (2011) on adoption of new

technologies by fish farmers and Ajewole (2010) on adoption of organic fertilizers found that the level of education had a positive and significant influence on adoption of the technology.

The result on gender influence, mixed findings was discovered. The male and female prefer different mode of adoption. It is evident that majority of men prefer individual adoption while women participate more in farming group activities and can adopt technology more through social influence and participatory method. The results in this study confirms the finding by Bonabana (Bonabana W. 2002), that gender issues in agricultural technology adoption have been investigated for a long time and most studies have reported mixed evidence regarding the different roles men and women play in technology adoption. This can also be explained partly by the cognitions related to gender roles in society where men tend to be more task-oriented (Lynott and McCandless 2000).

Research question 1: The factors influencing smallholder farmers' adoption innovation

The theoretical literature helped in identifying some of the factors that influence smallholder farmers' adoption of innovations. Appropriate studies that are related to technology adoption and more so in the context of agriculture was considered. Table 2.5 (chapter 2) summarises the key constructs in the studies. Reviewing of related studies helped synthesising potential factors that could influence smallholder farmers' decision to adopt agriculture innovations. The key factors that influence ICT adoption were supported by a number of theories: Diffusion of Innovation, TAM, UTAUT and multi-source innovation. A number of constructs were identified from the theories and classified as: Technological factors (availability, simplicity, relative advantage and reliability), social factors (family, friend, leaders), economic factors (land size, credit facility, cost of innovations, house hold size,

income among other) and participatory (stakeholders and farmers groups that held in collaboration, monitoring and training) as shown in Table 2.6. A conceptual model was developed based on UTAUT theory, which provided a solid base in this study to explain why users accept or reject a technology in a specific perspective and had a higher explained variance (Venkatesh, V. & Davis, 2000) as showed in table 2.5.

Research question 2: How the factors influence smallholder farmers' adoption of ICT innovations

Based on the quantitative findings it is revealed that the combination of variables related to technology innovation adoption can be grouped based on the amount of change in the explained variation in the dependent variable as follows: technological variables (availability, simplicity, relative advantage and reliability) with paths coefficients significance of 0.135, Economic variables (cost, credit and farm size) with paths coefficients significance of 0.412, Social influence (Group activities, family/friend influence and leaders) with paths coefficients significance of 0.199 and participatory influence (group participation) with paths coefficients significance of 0.361.

i. Technology factors

The technological factors were supported and were consistent with the literature review. A number of construct (Availability, simplicity, relative advantage and reliability) were tested under technological and found to be the driver in the use of ICT to increase adoption of innovation in agriculture.

According to Islam (Islam & Grönlund, 2017), farmers' perceptions of technology characteristics significantly affect their adoption decisions. Moreover it is also argued that users' perceptions about ease of use and usefulness are likely to be developed from rational

assessments of the characteristics of the technology and the tasks for which it could be used (Amare & Simane, 2017)

This construct was supported and perceived to have influence on adoption of ICT innovations in agriculture. Ventkatesh et al. (2003) studied the construct as effort expectancy and confirmed; Davis(1989) endorsed it perceived Ease of Use and Rogers (1995) called it simplicity for affecting the use or adoption of innovations. Perceived ease of use as one of the important variables to be included in the model for assessment. It explains the extent to which an individual believes that using a system will take less effort (Davis, 1989). The discussion highlighted that the main concern of the smallholder farmers is the complexity or the difficulty in accessing ICT innovations. Therefore the perceived ease of accessing or using the new technology or innovation will influence their acceptance. It was also understood that the ease of use will be determined by the behavioural control on new system; higher control will help in higher ease in using. Perceived ease of use will have a direct impact on both perceived usefulness of the new innovations and attitude towards it. Several studies have been conducted using the variable perceived ease of use ever since the emergence of TAM; this has been used particularly for assessing the acceptance of mobile phone services in the some of the recent studies (Lisa & Judy, 2010; Koenig-Lewis et al., 2010; Akturan&Tezcan, 2012; Amin et al., 2012; Tobbin, 2012; Jeong& Yoon, 2013; Witeepanich et al., 2013).

The perceived beliefs playing important role on simplicity by a number of respondent on the use of innovations are first and foremost the easy to access and find information they are interest in, easy to understand and use.

Relative advantage or Perceived usefulness is defined as "the degree to which an individual believes that using a particular system would enhance his or her productivity" (Davis, 1989). The relative advantage is also labelled as Expectancy in UTAUT (Ventkatesh et al. 2003) and perceived usefulness in TAM and found to have influence on Behavioural Intention (BI) to use in the diffusion of Innovation theory.

Many researchers have used relative advantage construct as a predictor of attitude while assessing the ICT usage and adoption of technology (Lisa & Judy, 2010; Koenig-Lewis et al., 2010; Zhou, 2011; Tobbin, 2012; Akturan&Tezcan, 2012; Amin et al., 2012; Jeong& Yoon, 2013). Relative advantage was found to be a driver in the use of agriculture innovation, education and e-government (carter et al. 2004) and e health innovation (Atkinson, 2007) in developing countries.

Therefore the satisfactory response of farmers' perception towards the existing channel will help increase the perceived usefulness of the innovation. The participants acknowledged the significance of this construct in determining the attitude towards adoption of innovation.

Availability or accessibility of innovation systems was one of the factors considered as an influence in the innovation adoption model. In the refined model, time was recognised as an important factor embedded in a number of adoption influences rather than identified as an influence in its own right. Participants indicated that they have access to basic ICT resources, all of them having access mobile phone and almost half of the respondent admitting to have internet connection on their phones the work. However, it is important to note that simply having phone may not translate to ready access to innovation

The resources, including training and stakeholders support and gratitude/recognition were dimensions of support in the model. Training was identified in the model as a motivator in cases where famers were older or not tech savvy. Stakeholders' role was also a strong motivator when the leaders recognized the importance of innovation and, more importantly, when they were involved and adopted it themselves.

Reliability is an important variable in technology acceptance and use and refers to 'the correct technical functioning of technology. Reliability was found not to be supported. The path coefficient (0.092) was found not greater than the recommended 0.1. Furthermore, the path coefficient significance failed to meet the recommended value of 1.65. Therefore, the construct was removed from the model.

Generally, identified technological attributes could influence farmers' adoption. The study confirms and extends previous innovation adoption studies by indicating that most technology innovation issues are user-friendly because they have intuitive user interfaces, and they are easy to learn and use; these are considered to be important attribute. The quality or reliability of innovation is also an adoption issue where technology is critical for performing everyday work processes.

The availability of technology makes content and visible, easy to find. This motivates users to be more connected with content, updates and participation. In relation to the value of content, users' adoption would be hindered if the content cannot be found easily.

ii. Economic influence

On the endogenous latent variables, it was observed that economic factor has the strongest effect on the use of ICT on agriculture overall being (0.412). According to study (Dhraiefa, et al., 2018), regarding economic factors, it emphasize that, it is important determinant of technology adoption. Mwangi (2015) describe economic factor as the support given to the users while interacting with the technologies. The construct on economic tested were cost with path coefficient of 0.950, access to credit facility 0.980 and farm size 0.946. It was observed that lower cost has positive influence on the use of ICT and adoption of innovations in agriculture. According to Tornatzky and Klein (1982), lower costs are viewed as having a positive influence on the adoption of innovation. The lower the cost the more use of technology is favoured and adopted. Some researchers such as Ali-Hassan and Nevoy (2009), Alqahtani, Watson and Partridge (2010), Onyechi and Abeyssinghe (2009) and (McAfee, 2009a) value technology benefits include enhancing work productivity, boosting return, reducing cost and increasing the rate of innovation. In the field of ICT agriculture, high cost was found to be a barrier to the use of these ICTs innovations. According researchers (Islam & Grönlund, 2017), the cost of subscription for services, bill payment options, user friendliness of the handsets and brand reputations, influences directly both on the PU and PEU of an individual.

A study by Islam et al. (2017) also found that "training, family size, farm size, annual income, farming and living expenditure, innovativeness, communication exposure, organizational participation and, aspiration were positively correlated with their use of information system".In Kenya, land ownership provides a good measure of wealth. However the relationship between farm size and technology adoption is confounded by other factors such as the fixed costs of adoption, human capital, credit constraints, tenure

arrangements and characteristics of the technology (Place and Swallow 2000; Feder et al. 1985). For example, large households with large farms may have more access to credit and thus may adopt a technology that has high costs. It is therefore difficult to determine the effect of land size. Place and Swallow (2000) suggest that farmers are more likely to invest in land which they have transferability rights for example in the form of title deeds. The relationship between land size and technology adoption was represented by a dummy variable indicating ownership/no ownership land size.

The economic factors have a major influence on adoption of ICT innovation. Results shows that availability of resources can enhance adoption process. The results also indicated that farmers' participation in the innovation adoption was mainly due to the economic reward provided by some stakeholders.

This result might be related to the context of the finance industry where users ideas are evaluated for real implementation to gain direct financial benefit; therefore farmers are seen to be motivated by tangible rewards; fertilizers, seeds among others. Therefore, the finding of Paroutis and Al Saleh's (2009) study supports the current research findings. From the finding cost and credit facilities can influence early adoption, individual adoption and to some extend inhibit collaboration.

iii. Social Influence

Social influence is the farmers' influence on each other to shape their attitudes or actions in relation to adopting of agricultural innovations. It was found that this influence can either motivate or hinder the adoption of specific innovations. Social influence includes four sub-themes: group norm or group activities and family/friends/leaders influence. On the literature review on technology acceptance model (Li 2010) reports that found that a

significant study found that social influence predict the use of ICT innovation and hence adoption. Family/friends construct had influence of the adoption of technology posting a path coefficient of 0.861 and leaders influence having a path coefficient of 0.703.

This study also revealed that people in the society are vital part of success of farmers' success. Leaders, friends/family can encourage early adoption which also enable farmers to socially connect, participate and contribute content, resulting in the adoption of ICT innovations. The results show that surrounding people can stimulate early, individual and collaboration adoption, yet it can also inhibit collaboration work. The results supports the finding by Lee that some other sources of influence to adopt technology can be from relatives, friends, and seniors or influential persons in the community (Lee, Y., et al., 2006).

According to Stiff and Mongeau (2003) the influence of social norms on individuals" behavioural intentions in some cases is stronger than the influence of attitudes. Sometimes, perception of societal norms may prevent a person's behaviour in accordance to his/her personal attitudes. In a rural context, Jain and Hundal (2007) stated that "the rural people of India, had been found more influenced by the neighbours and media has been regarded as the negligible impact on the choice of buying a mobile phone". In addition to neighbours, there are some other sources of influence also evident in the literature, such as relatives, friends, and seniors or influential persons in the community (Islam & Grönlund, 2017).

Therefore the social influence construct on the adoption of agriculture innovation has statistically significant influence, because it shows how close people in the society influence each other to shape their attitudes or actions on technology adoption. It was found that such influences can either stimulates or inhibit technology adoption. Social influence includes sub-themes: family, friends, leaders and surrounding activities.

This study revealed that people in the society are vital part of success of farmers' success. Leaders, friends/family can encourage early adoption which also enable farmers to socially connect, participate and contribute content, resulting in the adoption of ICT innovations. The results show that surrounding people can stimulate early, individual and collaboration adoption, yet it can also inhibit collaboration work. Therefore, stakeholders need to pay attention to the surrounding community activities in which farmers share similar practices and where they could collaborate on farming activities.

iv. Human Characteristics

The human characteristics, includes sub-themes: Demographic, house hold size and individual characteristics were found to have key influence on the adoption of ICT innovations. This study found that demographics influence smallholder farmers' adoption level of innovations. The findings show that younger farmers are early adopters of innovations; mobile technology has become part of their daily life and normal way of communication for most people. Results also show that when older famers are in the early stages of using a particular technology, they rely more on community or external support to facilitate their continued use of the technology, in this case, ICT innovation. This suggests that collaboration and group facilitations should be enhance for elderly farmers who are the majority. The stakeholders and researchers should provide facilitation approach for elderly farmers to enhance productivity. For instance, customer help through a call center, instant messaging services, grouping or a lead community can provide support to aged farmers who are new to ICT innovations.

Another demographic influence found in this study is gender. It is evident that majority of men prefer individual operations and adoption and avoid farming groups or collaborations. Majority of women participate more in farming group activities and can adopt technology

more through social influence and participatory method. This is positive but is contrary to past research by ILO (2008) that noted men tend to operate systems and IT related tasks more than women.

Therefore, it can be stated that men tend to rely less on facilitating conditions when considering use of a new technology whereas women tend to place greater emphasis on external supporting factors. This can also be explained partly by the cognitions related to gender roles in society where men tend to be more task-oriented (Lynott and McCandless 2000).

Education level was found in this study to influence adoption. Most of well-educated farmers falls under early adopters, embrace individual adoption and are flexible when it comes to collaboration while less level of education can hinder adoption. Therefore, innovation can be adopted through vigorous training and generally knowledge sharing. Yet over time, and as farmers experience and knowledge about technology increase, they find that using ICT innovation training is less useful. In this study, individual characteristics and house hold size didn't come out as strongly influence to ICT innovation adoption. The results shows that it dependents on different family structures

v. Participation

Participation concept was associated with interaction between stakeholders and farmers. According to findings, farmers' involvement in farming was having positive impacts on their social life. Participation was found to be supported with a path coefficient of 0.361. Group activities constructs a path coefficient of 0.952, external influence/ training influence having a path coefficient of 0.320 and 0.310 being the path coefficient of

monitoring. A further survey was done on participatory in section 4.5 to determine the approach on the ICT adoption.

Research question 3: The core mechanisms/ approaches in the adoption of ICT innovations by smallholder farmers

The question was addressed by assessing farmers' perception of the participatory approach (Empowering collective groups of people through bottom-up approach) compared to the conventional top-bottom approach, where instructions are relayed to farmers and they are expected to follow. The reasons why farmers are adopting or not adopting the technology were investigated. The differences in adoption between the farmers who are member of groups and non-group members were studied. The modes of adoption between the early adoption/late adoption, individual/group and collaboration/non-collaboration and the factors that determine the adoption of innovations were studied.

The findings during focus group and interviews interestingly appear to mirror the notion of culturally constructed participation presented by Roncoli et al. (2011). In the literature on participatory approaches, "taking part" is not necessarily seen as meaningful participation if not accompanied by the voicing of opinions or taking part in decision making, which some of members in the One-Acre-fund project appear to be doing. The results of the quantitative survey, indicated that majority (86.3%) of the respondents never participated in farming group, while 13.7% are in farmer groups. However, over 90% respondents who are farmers groups were using ICT innovation in agriculture. The statement was confirmed during qualitative survey, where the majority of the respondent who are member of One-Acre-fund project, indicated that they have benefited as a group through getting relevant information on planting time, fertilizers, seeds and pesticide to apply on the plants. Furthermore, they stated that, since joining the farming group their

yield are higher and better in quality. Thus, an indication of willingness to adopt to new farming technology and accessing relevant information in time. Surprisingly, despite obvious benefits, the percentage of farmers participating in farmers groups is still low.

The study findings showed that farmers who are non-group members (not participating in group projects) felt that it would be difficult for them interacting with outsiders because of certain conditions that would have to be fulfilled members. It was also noted that non-participants who had such reservations about collaborating, prefer individual approach where they focus on their own farms, rather than thinking as a group. Non-members also felt that they need someone to first explain how he or she could benefit from such activities. Another respondent indicated that while he won't mind interacting with extension staff or researchers, but due to time, he would prefer just being given capital, while others don't find the need of group since they had no problems as a farmer. Remarkably, farmers who are non-group members, mentioned lack of information on various aspects of the technology, the high cost of operation and high requirement inputs as the main factors limiting adoption new techniques.

While members involved in farming groups indicated that their adoption is positively related to group collaboration, non-members indicate that initial adoption is highly related to availability resources for example finance. Financial capital requirement may prevent poor farmers from adopting a technology if they lack cash to make investments which will not yield a return until after the first harvest. The study also showed that young farmers and those engaged in formal employment are more likely to adopt innovation even if they are not members of the groups.

Adoption of ICT innovation has implications for the gender; most of female embracing innovation do it through participating in farming group while most of men are self-motivated to adopt technology. It was also not that regular and open communication between the participants and the implementers is crucial concerns with the group leaders or the group members by the management. It also means that monitoring and evaluation of the project would benefit from being carried out in a participatory manner, since appropriate performance indicators cannot be imposed from the outside.

There is little dispute in the literature regarding the importance of monitoring and evaluation of agricultural development projects (Muller-Praefcke et al., 2010). It is not surprising then that this case study points to the need for implementers to play a more active role in monitoring. Some form of follow-up does occur continuously on specific areas but not on all the groups. Furthermore, the study found that participants want the group leaders to follow up what they have initiated because of problems they do not know how to solve. On several occasions, managers emphasized that the participants must own the process, which is indeed something that is supported by the literature (Opondo et al., 2006; Ugen, 1995). However, promoting ownership of the process is not incompatible with monitoring and providing continuous facilitation.

Negative attitudes based on the past experiences emerged also one issue behind the decision of some not to join the groups. Respondents cited cases where they felt they had been deceived or excluded, either by implementers or by local leader of the groups, or complained that project managers and supporting organizations just push their agenda. The responsibility that is involved in carrying out development projects cannot be stressed enough; the failure of a project can negatively affect a person's whole perception of development efforts and even collaborative work in general.

To a large degree the findings support that participatory influence have a major role to play on the ICT adoption. Participatory approaches evolved as an alternative to top-down approaches, and this should guide the design of process as well as the attitudes and behaviour of practitioners at an individual level. Farmers are generally interested in learning from other stakeholders, but not necessarily in being ordered.

Significant constraints for adoption experience by the farmers were noted. There is a general feeling that the adoption of ICT innovation is challenging and not successful, when asked the main challenges with ICT innovations, a participant stated that few members contribute in the discussion during the meeting and discussion and are always willing to test and begin using the new technique introduced. Majority of members are considered late adopters, wait to see the results from the early adopters. A team leader in stated that most group members fear technology and are always anxiety and feel incapable in during the demonstration using devices or techniques, this leads to increase in avoiding new technology. A number of constraints and limitations of adoption of ICT Innovations in the agricultural were also noted. Farmers use ICT Innovations for production systems to improve data collection, processing and reporting through simple and affordable means.

During the group discussion, member of group narrated that access to information on fertilizer during planting time, SMS on planting time and market prices has become common with majority of farmers. It was noted that as a group they share so much on information received on input to our farms and many farming information. On the promoting innovation, most of promotions of innovation technologies are on support value chain, some members use to influence and train others on the importance as stated once have learnt something we always want to share a lot with friends and relative.

On partnership and Engagement in agriculture sector; participation in creating ICT Innovations that satisfy farmers' needs and fit farmers' conditions is definitely a prerequisite for a higher likelihood of innovations' success and acceptance. Furthermore, collaborating with innovations' designers and providers (stakeholders) could increase farmers' trust and confidence, and their positive attitude towards new technologies. On the other hand, the real engagement occurs when ICT Innovations are adopted frequently, actively and collaboratively (Alqahtani, 2013).

In understanding active use of innovations by farmers, a group stated that as a group they share, contribute ideas and actively involved in experimentation or the learning process. Other farmers too use agriculture ICT Innovations passively, some participant prefer following the discussions on technology quietly, but do implement the ideas. Frequency of use of ICT Innovations is the second way of engagement that was identified. The frequency of using innovations varies among farmers. For example some farmers check and get weather update regularly or check market prices all the time, when they want to sell my produce.

In addition, collaborative/non collaborative way was found to be another engagement approach. Participants identified ways of collaboration; Consultative, Interactive and Self-mobilization. As noted by a few participants who eluded that they consult and asked questions to field officers on the new ideas that have been introduced. In interactive participation is viewed as a right, and people are have influence in planning, analysis and resource use, and a member indicates that as a group they discuss and agree on the way forward. Some farmers take own initiatives, independent of external actors. They may contact research institutions for resources and advice, but control their own resources. A

participant stated that they have been planning on my own and carry their activities and only consult when necessary.

5.3 Conclusion

This chapter discussed the data analysis and findings using the appropriate tools in order to establish the objectives of the study. This study assessed the role of participatory approach on adoption of ICT innovations in agriculture by smallholder farmers. This was done in order to understand the alternative approach that can enhance ICT innovations access by smallholder farmers.

The analysis pertaining to the first objective a number of attributes were identified that influence the adoption of innovations. These attributes were categorized broadly into four factors; technological, economic social influence and participatory. The descriptive analysis of data for establishing how specific factor influence the adoption in the second objective highlighted that smallholder farmers' share an unfavourable response on the existing ICT innovations. On the utilization of ICT devices to access agricultural innovation, the majority of the respondents being aware of the availability of innovation, majority have access innovations on financial services; access to credit, however very few have accessed innovations on input information neither have they used their devices to access information on information such as market or weather. The farmers who have used the innovation stated that expected and experienced an increase access of timely and relevant information on agriculture. The services met their expectations (Relative advantage), reliability, availability and usefulness. This concurred with Rogers's theory (1983), where categorization of technology adoption was unique to the diffusion of innovation theory. Hence relative advantage is valid of the adoption of innovations.

For the qualitative phase, addressing objective three, data was analysed. The following themes emerged from the data: human characteristics, technology; ease of use, usefulness and availability of Innovation, perceived economic benefits, social influence, collaboration and monitoring. These themes helped to explain the variables in the study. Both early and late adopters of technology considered technology training as a priority area of need for them. They indicated that they lacked technology training resources and the trainers were not technically available to train them. They also indicated that technology in general important at group. Participatory approaches evolved as an alternative to top-down approaches, and this should guide the design of process as well as the attitudes and behaviour of practitioners at an individual level.

The fourth objective looked at development of a model to enhance the adoption of ICT innovations. The model for an enhanced adoption of ICT innovations by smallholder farmers through this study by combining UTAUT and TAM. This model comprises constructs from the extant literature as well as those identified from the focus group interviews. Since the respondent segment involves stallholder farmers mostly from rural areas, constructs from the literature were presented for a focus group discussion for selection to ensure validity.

The critical factors in the conceptual model were tested through different constructs. The partial least square structural equation modelling (PLS-SEM) was done with the help of SmartPLS application. The critical variables and their constructs measured using bootstrapping exhibits and thereby, the strength and significance were also established. Reliability and validity of the model was established through the criterion values of the constructs generated through PLS-SEM.

The analysis on the final objective highlighted that over 84 % of the farmers agree that use of ICT can boost ICT innovations. Four different constructs were examined and analyses to find the most influencing factor for innovation adoption. It also showed the existence of significant difference in age and education on the use of technology.

CHAPTER SIX

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This chapter presents the summary of the study, discussions, conclusions and recommendations from the study and for future research. These are divided into three sections; section 6.2 presents the summary of the research with a focus on the findings based on the objectives, section 6.3 presents the contribution and implications of the study, 6.4 presents conclusions of the study and section 6.5 presents recommendations of the study and suggestions for further research.

6.2 Summary of the Findings

The main aim of the study was to establish a participatory model to enhance adoption of agricultural ICT innovations by smallholder farmers. To achieve that, four objectives were identified. Research objective one sought to establish through literature review, the factors influencing smallholder farmers' decision to adoption ICT Innovations in Agriculture. Research objective two sought to establish how the factors identified in objective one are perceived smallholder farmers adoption of the ICT Innovations, while the third objective was to determine the approaches that can be used on ICT innovations adoption. The fourth objective was to develop a model to enhanced adoption of ICT innovations in agriculture.

The study employed a survey and case study research design; applying mixed methodology research approaches to gather primary data. Participants was drawn from three (3) counties with diverse and maximum variation of activities in terms of geographical locale, size, age and economic environment. Certain factors like stakeholders supporting farming activities and grouping were deemed to be the same across the study sites to ensure that patterns

were consistent resulting in confidence in the findings. The following is a summary of the findings based on the research questions.

Research Question 1: What are the factors influencing smallholder farmers decision to adoption ICT Innovations in Agriculture?

The factors Human, economic, technological, social and participatory as the factors influencing adoption of ICT innovations in agriculture. The constructs of the factors were supported in study as shown in the model results in figure 4.3. The factors were further confirmed through qualitative survey as indicated in table 4.22. The validity of the constructs validity was established in chapter 4 (table 13, 4.14 and 4.15).

Research Question 2: How do the determinants influence smallholder farmers' adoption of the ICT Innovations?

This research question was addressed by methods. Using quantitative method, measuring the endogenous latent variables, it was observed that economic factor has the strongest effect on the use of ICT on agriculture and participation (0.412) and (0.361) respectively, followed by social influence (0.199) and Technology factors (0.135). On the last endogenous latent variable, the use of ICT has a very strong effect (0.841) on the adoption of innovations on agriculture. The path coefficient β on the whole model's constructs was greater than 0.1. The validation of the result are illustrated in table 4.15. The qualitative method looked at the influence of each adoption issue in terms of stimulation and hindrance to early adopt/late adoption, individual or collaboration adoption as indicated in table 4.22.

Research Question 3: Which approaches are influencing the adoption of ICT innovations by smallholder farmers?

While comparing figure 4.2 and 4.3, the study confirmed that regular and open communication between the participants and other stakeholders is very crucial. The study further acknowledged that in participation, the approach should be bottom up, for farmers to be part of decision making of the system. The study also revealed that, group participating in different project can benefit through monitoring and evaluation of the project being carried out in a participatory manner, hence, a major influence in adoption of innovation.

The study found that group norms have an influence on the early, individual and collaboration adoption of innovations by farmers who become motivated to adopt ICT innovations. External support encourages and facilitates the smooth adoption of innovation. Such support can be provided by different stakeholders in different forms: Monitoring, providing required resources for training, frequent Knowledge sharing on the new ideas with users among others.

Research Question 4: How can a participatory model for adoption of agricultural ICT Innovations be developed?

The development of the study's model was achieved through the establishment of the participatory model. In Figure 4.3, the variance for the latent endogenous variables (technological, economic, social influence and participation) on use of ICT was 0.840. This means that the technological, economic, social influence and participation defined 84% of variance in use of ICT on agricultural, with the Coefficient of determination of the model being 70%. This R^2 value of ICT Innovation adoption in Figure 4.3 was higher than the Coefficient of determination in figure 4.2 where participation was excluded. Using

qualitative approach to confirm results, there was evidence that participatory approach influence have a major role to play on the ICT innovations adoption as shown in table 4.22 Participatory technique can facilitate knowledge generation and enhance the ability of agricultural stakeholders in understanding the needs of smallholder farmers.

6.3 Contribution of the Study

This study makes theoretical contribution in two dimension; incremental and revelatory. In the incremental dimension, the study has additional variables added to the existing theory to the adoption model; the economic and the participatory and human factors. The participatory approach bridging the gap between participatory adoption research and the technology agnostic information in the literature. The study also demonstrated results by testing moderating variables operationalised on independent variables and external variables which is a unique contribution. In the revelatory dimension, use of participatory approach, where farmers are part of the decision making and more so if farmers are approach as a group rather than individual farmers.

More Contributions by this study is by adopting mixed research method. Despite the dominance of quantitative approach in IT/IS adoption research, mixed approach can provide enhanced understanding of information technology (IT) in use. Employing mixed approach in the current study had a number of advantages; quantitative results were confirmed using qualitative findings. Therefore this study explored and provided in-depth explanations of the multidimensional process of innovations adoption.

The contribution of this study to research includes: identifying ICT adoption characteristics in agriculture sector, and more so, the proposed constructs such as credit facility and cost under economic factors and inclusion of participatory factor. The constructs have been

established as positively influencing adoption of ICT innovations. In the study we did not come across any model that has studies credit facility, cost and participatory factors for ICT adoption in agriculture. This filled the research gaps knowledge and evaluation void.

The study addressed the knowledge void gap successfully in the context of enhancing adoption of ICT innovations in agriculture, and further highlighting the evaluation void gap in the literation review section. The study confirms the results of highlighted studies in the section and goes further to present significance of credit facility, cost and participatory factor on the adoption of ICT innovations. In addition, the moderator factors are identified were more than demographic factors hence renamed human factors; age, gender, education, house hold size and individual characteristic. While reliability was weakly supported in the model, the construct proved otherwise during qualitative survey. Furthermore, farm size was not supported much during the qualitative survey but the model results showed contrary. So the farm size was dropped due to lack of confirmation by farmers during qualitative survey. The research suggests that community leader, family and friend have positive influence when it comes to adoption of innovation. This confirms the results of social influence as a factors to consider in ICT adoption.

The next contribution of the proposed model in this study, is the need to promote team work participation among the stakeholders. Specifically, this study proposes need to form encourage farmers to form groups and harmonize their interests and be able to benefit from stakeholders therein ensuring that the farmers access a synchronized information that reflects the interests of farmers without need to empower individual farmers separately. The revised model is illustrated in figure 6.1.

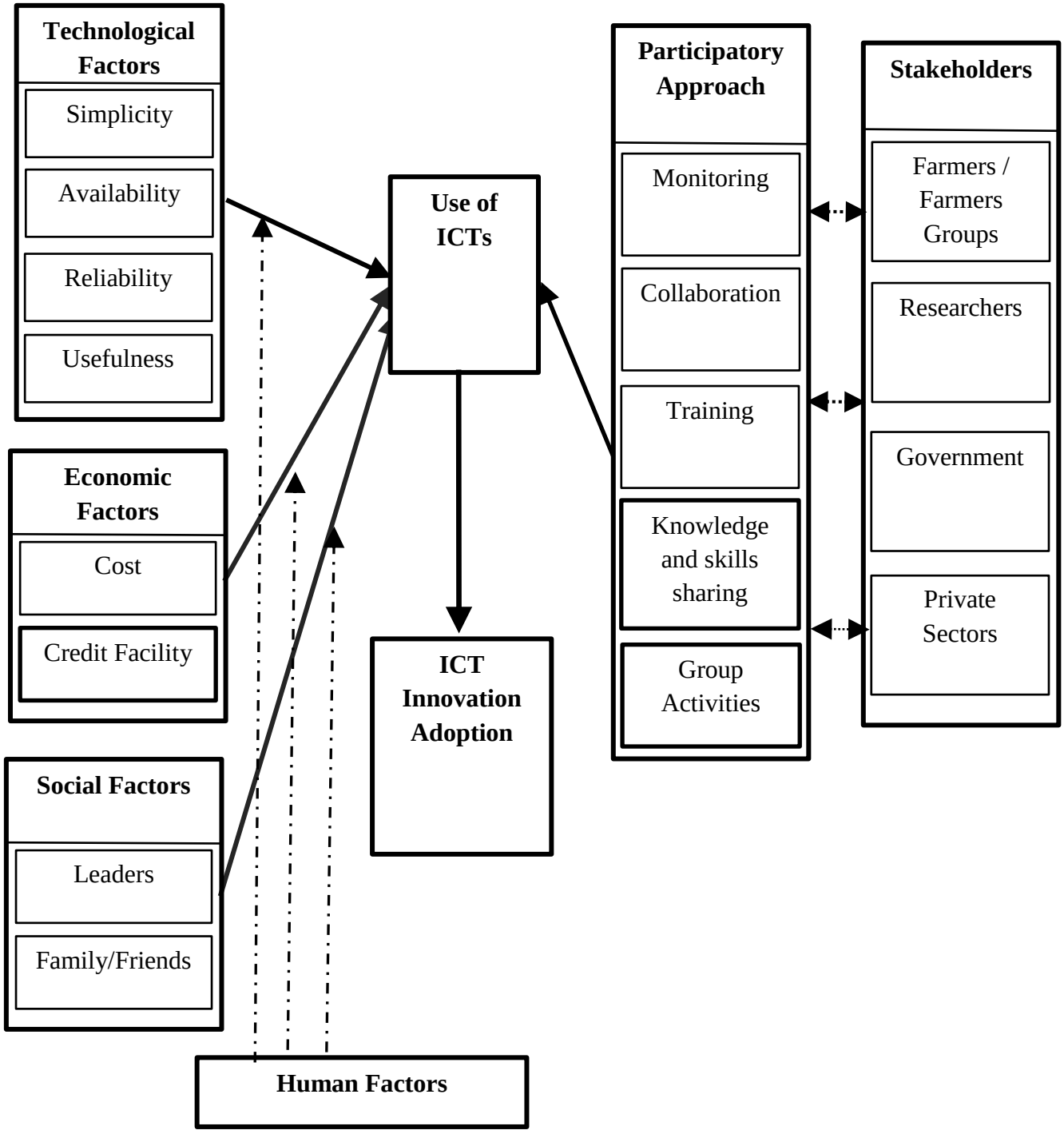

Figure 6.1: The Proposed model for an enhanced adoption of ICT innovations in agriculture

6.4 Conclusion

The broad objective of this study was to develop a participatory model than can enhanced adoption of ICT innovations by smallholder farmers. To conclude each of the objectives of the study, objective one; issues that influence farmers' decision on ICT innovations adoption are economic, technological, social and participatory approach. On how the factors are perceived by farmers, it was noted that economic issues such as cost of innovation and credit facilitation were the most perceived factors affecting the adoption of ICT innovation. The next factor was participation; monitoring, knowledge sharing and collaboration being considered are key, followed by social influence that done through leader and family/friends and finally technological factor with constructs such as simplicity, availability, usefulness and reliability. Education and age moderated the positive effect of simplicity on the adoption of ICT innovation. Early adoption of ICT innovation was experienced young and educated farmers, this was also based on an individual characteristics. Education also moderated cost and credit facilitation on adoption of innovation. Gender moderated credit facilitation and social influence. Gender, individual characteristic and social influence moderated the positive influence of participation on the adoption of ICT innovations. Female are influenced more by friends and leaders and they appreciate group activities and knowledge sharing than men. This was showed in the survey findings, that most of female embracing innovation, do it through participating in farming group while most of men are self-motivated to adopt technology

On the approach, a participatory approach was recommended where farmers are part of decision making in all the activities such as monitoring, collaboration ideas, training and knowledge sharing. Group participation was also one of most preferred participation idea by the farmers.

A participatory model for enhanced adoption of ICT innovations was developed to the knowledge of the researcher. The aspects of prediction using PLS were reported and achieved, where the latent variables predict relevance on use of ICT, and use of ICT predicts the increased adoption by 51.3%. And the latent variable define 84%of variance in the use of ICT on agriculture and increased adoption by 70%.

6.5 Recommendations and Further Research

The study has developed a participatory model to enhance adoption of ICT innovations by smallholder farmers in agriculture, however, some matters need further investigation. The model can be applied by smallholder farmers in local areas. However, further research should other farmers, incorporating different farming groups, organizations or different technologies. This might provide the additional experimental power and data stability to investigate more variables, as well as the additional values in the collaboration and monitoring aspects to determine their influence on adoption. Similarly, it is important to develop a more complex model, with constructs for facilitating conditions, with the more sample of data. Additional data would add to the strength of the findings and the explanatory power of the model.

Examining a large number of stakeholders also will be a better approach to the future. In addition, although the findings of this study present rich insights with regards to the adoption of ICT innovations have been generalized into theoretical, design, conceptualizations, the methodological limitation of using two theories: UTAUT and Dutch model approach, can be overcome in future research by using more than two theories.

This study used the cross-sectional as time horizon to explain how factors are related. The study further suggests an orientation that might apply another time horizon such as longitudinal. The choice of longitudinal could expose a series of snap shots in a longer time period.

The study recommended a participatory approach, where farmers are involve in decision making, however, a further research on partnership and engagement in agriculture sector; participation in creating ICT Innovations that satisfy farmers' needs and fit farmers' conditions should be looked at further for a higher likelihood of innovations' success and acceptance.

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APENDICES

RESEARCH INSTRUMENTATION AND ADMINISTRATION

Appendix I: Letter of Introduction

Dear respondent,

RE: DOCTOR OF PHILOSOPHY IN BUSINESS INFORMATION SYSTEMS RESEARCH QUESTIONNARIE

I am a student pursuing Doctor of Philosophy degree course in Business information systems at Jaramogi Oginga Odinga University of science and technology. My research topic is "**A PARTICIPATORY MODEL FOR AN ENHNANCED ADOPTION OF ICT INNOVATIONS BY SMALLHOLDER FARMERS"**.

The purpose of this letter is to kindly request you to fill the attached questionnaire to the best of your knowledge to help me complete my academic endeavour. The information you will provide will be treated with utmost confidentiality and shall be used for academic purposes only. I'll collect the completed questionnaire or can be sent online to darambim8@gmail.com

Your assistance is highly appreciated,

Yours sincerely,

Dorothy Rambim
Department of Computer Information Systems
Jaramogi Oginga Odinga University of science and technology

Appendix II: Questionnaire for smallholder farmers

The questionnaire is meant to understand the factors influencing dissemination of innovations among smallholder farmers and how innovation has transformed their livelihood. Your responses will be treated in strict confidence.

For each question, please mark your response with a tick (√), unless otherwise indicated. For 'Other' responses, provide a brief response.

SECTION A: DEMOGRAPHIC DATA

1. County of residence……
2. Gender Male [ ] Female [ ]
3. Select your age bracket.(Tick as one option as appropriate)

   Below 30 years [ ]

   30-39 years [ ]

   40- 49years [ ]

   Above 50 years [ ]

4. Highest level of education you have attained? (Tick as appropriate)

   Primary [ ]
   Secondary [ ]
   Diploma [ ]
   Graduate level [ ]
   Post Graduate level [ ]
   Any other specify)……...

5. What is your current employment status? (Tick as appropriate)

   Employed [ ]
   Self-employed [ ]
   others [ ]

Section B: ICT Technology awareness/Availability/ Usage in Agriculture

Availability of technology resource

6. **Ownership of a technology device:** Indicate (Yes) if you own any of the listed technology devices (Mobile phone, computer, tablet among others)

Awareness and availability of technology Innovative products

7. Are you aware/ heard of support being offered by technology in agriculture

   Yes [ ] No [ ]

8. If yes (7), which application/area do you know/ have used in the stated categories (tick (√) where appropriate)

Information supporting Areas	Innovations	Aware and Not used	Have used
Input management information	Crop selection e.g seed for planting		
	Land selection, Land preparation and sowing		
	Calendar reminder e.g planting time, land preparation		
	Fertilizer and pest management		
Financial services	Access to credit/Financial services e.g Mkopa, mkesho, mshwari among others		
Market	Market price		
	Market access		
Weather	Weather information		
Transport	Transport		
	Packaging		
	Processing		

9. **To examine factors influencing ICT innovation adoption by Smallholder farmers in Kenya:**

   Please Use the following scale of 1 to 5 where 1 = Strongly Agree,2 = Agree, 3 = Neutral, 4= Disagree,5= Strongly Disagree:(Tick (√) one of he space below to show your answer

A. Technological factors

NO	**Relative Advantage/Usefulness**	1	2	3	4	5
A1	ICT innovations is more efficient in accessing information that extension officers					
A2	ICT innovation provide more clear information					
A3	Access to ICT innovation has made better contribution to use and access of Agricultural information.					
A4	The innovations are relevant to farmers					

NO	**Availability**	1	2	3	4	5
A5	ICT innovation can be accessed easily					
A6	Information received on innovation was complete					
A7	The information provided on innovations are relevant					
A8	Received better price because of market information					
Others						

NO	**Complexity**	1	2	3	4	5
A9	The technology are familiar					
A10	The instruction while using the innovations clear					
A11	The innovations require skill and knowledge to use it					
A12	Training is necessary to use the innovations					

NO	**Simplicity/ Ease of Use**	1	2	3	4	5
A13	Using ICT technology to access innovation is the easy way of accessing information					
A14	It was easy to get around the innovation					
A15	Innovations are easy to use					
A16	Instruction on innovation usage are easy to implement.					
A17	Adopting ICT innovations can promote ones status					
NO	**Availability**	1	2	3	4	5
A18	The innovations are available					
A19	The support staff are available					
A20	Support documents are available					

B. Economic Influence

NO		1	2	3	4	5
B1	ICT innovations transaction cost are affordable					
B2	The size of land can determines the use innovation					
B3	Access financial credit facilities can promote the adoption of innovation					
B4	Financial status of a farmer can influence the adoption of innovation					

C. Social Influence

C1	Use innovations because my friends are using it					
C2	Leaders are encouraging farmers to use innovations, thus why I use					
C3	Use innovations because family member and neighbours are using innovation					
C4	Using innovation make one be recognised than those who do not					

D1. Participatory Influence (*Stakeholders: Financial institutions, Research institutions, NGOs, Private sectors among others***)**

D1	Collaborating with other farmers can influence members to use innovations					
D2	Collaboration with stakeholders can influence adoption (Participating in development process)					
D3	Training/Knowledge sharing of farmers can influence usage of innovations					
D4	Monitoring/Consultation between stakeholders and farmers can influence use of innovations					

Appendix III: Participant information for Research Project

Agricultural Innovations use and Adoption: Smallholder farmers Perspective

This project is being undertaken as part of a PhD study for Dorothy Apondi Rambim

This research is about the use of participatory approach to enhance adoption of innovations in agriculture by smallholder farmers. The purpose of the focus group is to identify the factors that influence the use and adoption of innovations. The findings and outcomes from the focus group will be useful in proposing and recommending the approaches for enhancing innovations adoption by smallholder farmers to stakeholders in agriculture sector.

The research team requests your assistance as one of the stakeholder in agriculture sector. Your participation will provide real life experience from farmer's perspective towards using innovations in Agriculture

Appendix IV: Consent Form for Research Project

CONCISE INFORMED CONSENT STATEMENT FOR

INVESTIGATION OF FACTORS THAT INFLUENCE ADOPTION OF ICT INNOVATIONS IN AGRICULTURE

You are being asked to take part in this research study because you are a major stakeholder (Farmer, field officer, researcher, private partner or government partner) in agriculture and we feel that you are in a position to help the investigators to determine what may have caused the low uptake of ICT innovations in agriculture. Your participation will provide a real life experience about smallholder farmers' perception towards the use of agricultural ICT innovations.

The study is being conducted by: Dorothy Rambim – PhD Student, Prof. Solomon Ogara – Principle Supervisor and Dr. Samuel Liyala – Associate Supervisor

STUDY PURPOSE

The study is being undertaken as part of a PhD project for Dorothy Rambim under supervision of Prof. Solomon Ogara and Dr. Samuel Liyala.

The research is basically to understand the use of ICT innovations by smallholder farmers in agriculture. The focus is to identify factors that motivate farmers to access ICT technologies or innovations. The findings and outcome will be beneficial in formulation of main acceptance factors that will help in propose recommendations for agricultural stakeholders about how to drive the adoption of ICT innovations and manage smallholder farmers' issues.

.RISKS OF TAKING PART IN THE STUDY:

The risks of taking part in this study include:

1. Emotional distress while answering the questions
2. Some information discovered may be upsetting to you. However, you have a choice to have that information relayed to you or not.
3. Possible unwillingness by concerned persons to shed more light on the low adoption
4. Possibility of dishonest response from other service providers

BENEFITS OF TAKING PART IN THE STUDY:

There are no immediate direct benefits to you as an individual for participating in the study. However, your consent for the study will contribute to knowledge, which will contribute to enhancing uptake of ICT innovations hence improve food production.

ALTERNATIVES TO TAKING PART IN THE STUDY:

The only alternative to participating in this study is to choose not to participate.

CONFIDENTIALITY

All efforts will be made to keep personal information confidential. However, we cannot guarantee absolute confidentiality. Your personal information may be disclosed if required by law. Your identity will be held in confidence in reports in which the study may be published and databases in which results may be stored.

COSTS `

Taking part in this study will not lead to added costs to you.

PAYMENT

You will not receive any payment, gifts or inducements for participating in this study.

Risks

There are no anticipated risks that could arise from participating in this study.

Consent to Participate

I am participating in this research voluntarily; I was not coerced or bribed whatsoever. I also fully understand that I can withdraw from this study anytime without fear of any consequence.

Participant
signature……

Contacts…….

Thumb print (*If he or she cannot sign*)……Signature……

Date…… Time……

Appendix V: Focus Group Discussion Guide

Team Members:

Introduction:

This discussion will include brief questions about the group, their activities and working as a team. The experience of team members in using the techniques being introduced to them in their daily farming activities.

General Questions

1. What is the main aim and activities of this group?
2. What are some of the agricultural innovation have you used in your farming activities
3. What your group trying to achieve by promoting the use of innovations

Main questions

1. What is your opinion on the level of adoption of innovations in farming
2. From your point of view what are the key issues that motivates or hinders the farmers' use of agriculture innovation in your group
3. What is your take on the following?
    a. The influence of the technological issues (Availability, ease of use, usefulness, compatibility, awareness) of innovations on farmers' adoption of agricultural services.
    b. The influence of economic issues (land size, access to credit, income/savings) on farmers adoption of agricultural innovations.
    c. The influence of human factors (Age, education, gender, size of house hold, training) on farmers adoption of agricultural innovations.
    d. The Influence of participating in group (being a member of group) on farmers' adoption of agricultural innovations.

Closure:

1. Ask them to identify one team leader and one potential farmer who could be potential participants in the interview phase for this study

2. Thanking participant

Appendix VI: Focus Group Protocol and Evaluation Form

Rank the following factors according to their importance in influencing farmers to adopt and use innovation. Explain why and how.

Ranks are: 1: not important, 2: important, 3: very important

General Factors	Ranking		
	1	**2**	**3**
Technological issues			
Economic issues			
Human issues			
Participatory approach			

Appendix VII: Interview Guide for farmers

Aim:

The aim of this interview is to get insights from participants about the adoption in agriculture. An in-depth understanding of why and how farmers are influenced to use/adopt or reject ICT innovations needs to be obtained through this interview.

Estimated time:
1 hour for the entire duration of the interview session

The interview session consists of four parts (A, B, C and D):

A. Introduction to the interview (4 mins)
Greeting
Introduction to the research project
Purpose of the interview
Confidentiality
Consent process
Individual opinion or experience (no right or wrong)
Audio recording

B. Demographics information (3mins)
Name: Age: Gender: Education and house hold size

C. Main interview questions (50 mins)
First let us talk about (you in) the use of agricultural innovations in farming

1. Could please list technology devices you have
2. For the devices you know, could you explain how:
    i. How you are using it to access agricultural services/information
    ii. How your group is helping use it to access agriculture information/services (innovations)/how it has been utilized in your group
    iii. How successful is it to access services as a group? why?
3. Which agricultural applications/ services/innovations do you know? (awareness)
4. Which agricultural applications/ services/innovations have you used? for what? how long have you used? who did you start/learnt about it? what's you opinion on the use?
5. What/who influenced you to adopt the innovation(s),

    Prompt:

    - Tell me more about the influences
    - What your take on innovation technological aspect, does it have any influence on your use? Why?
    - How about economic issues, does it influence the adoption in any way
    - What your opinion of does human factors influence the use of innovation in anyway?
    - How about being a group member, does it influence the adoption of new practices/innovations?
    - Are you motivated or hindered by the adoption issues? Why?
    -

6. Participatory Influence (*your group (s))*
    a) Years of being group member/ farmer/working with farmers
    b) Number of farmers in the group (s) you are working with
    c) What does it mean to be a member of farming group; benefits, contribution and influence
    d) For the devices you know, could you explain how:
        i. How your group is helping use it to access agriculture information/services (innovations)/how it has been utilized in your group
        ii. How successful is it to access services as a group? why?
        iii. What are the members attitudes towards the progress, issue of importance to adoption of innovations
    e) What/who influenced you to adopt the innovation(s),
        Prompt:
            - How about being a group member, does it influence the adoption of new practices/innovations?

    f) What are the relationship between farmers and stakeholders? (Monitoring,

7. Individual farmers (Non group members)
    a) How do you find working on your own
    b) What prevent you from wanting to or being able to join farming groups
    c) What are the relationship between you and stakeholders?

8. **D. Conclusion** (3 mins)
    State what will happen next in this research project:
    Transcribing
    Member checking
    Starting analysing the interview data
9. Ask participants to identify another farmer (non-participant/ independent) who could be potential participants for this research study

APPENDIX VIII: Interview guide for Extension Agents/Field offices

Aim:

The aim of this interview is to get insights from participants about the adoption in agriculture. An in-depth understanding of why and how farmers are influenced to use/adopt or reject ICT innovations needs to be obtained through this interview.

Estimated time:

1 hour for the entire duration of the interview session

The interview session consists of four parts (A, B, C and D):

A. Introduction to the interview (4 mins)

Greeting

Introduction to the research project

Purpose of the interview

Confidentiality

Consent process

Individual opinion or experience (no right or wrong)

Audio recording

B. Demographics information (3mins)

Name: Age: Gender:

Name of your organization: Years of /working with farmers

Number of farmers in the group (s) you are working with

C. Main interview questions (50 mins)

First let us talk about your organisation and the use of agricultural innovations in supporting farmers in various groups or individually

1. Tell me the role of your organisation
2. What your opinion on the level of support provided to farmers
3. How will you rate the level of adoption/usage of technology in agriculture
4. Which areas are farmers embracing technology
5. Which factors are influencing adoption of ICT innovation? Why?

6. How are farmers' group influencing adoption?
7. What is your take on the performance of participants (farmers in groups) and non-participant farmers

D. Conclusion (3 mins)

State what will happen next in this research project:

Transcribing

Member checking

Starting analysing the interview data

Ask participants to identify another farmer (non-participant/ independent) who could be potential participants for this research study

APPENDIX IX: ADDITIONAL FINDINGS

Anti-Image Correlation and Covariance

Anti-image Matrices

		Technological_Factors	Economic_Factors	Social_Influence	Participation
Anti-image Covariance	Technological_Factors	.713	-.343	.148	-.020
	Economic_Factors	-.343	.641	-.107	-.077
	Social_Influence	.148	-.107	.409	-.291
	Participation	-.020	-.077	-.291	.429
Anti-image Correlation	Technological_Factors	.391[a]	-.507	.273	-.036
	Economic_Factors	-.507	.568[a]	-.209	-.147
	Social_Influence	.273	-.209	.532[a]	-.694
	Participation	-.036	-.147	-.694	.576[a]

a**. Measures of Sampling Adequacy(MSA)**

Factor Rotation

Rotated Component Matrix[a]

	Component	
	1	2
Technological_Factors	0.198	.899
Economic_Factors	.416	.778
Social_Influence	.932	0.026
Participation	.911	.100

Extraction Method: Principal Component Analysis.

Influence Adoption	PARTICIPANTS' STATEMENTS ABOUT INNOVATION
Technological / Social	*"we feel we are engaged implementing new practises and sharing our experiences with more groups"*
	"in assessing improved crops and practices and sharing this lessons and successes with more farmer…….groups is proving to be an effective way to scale up technology adoption"
	"some of the innovations are very useful since increase our productivity"
	"the techniques are ease when we do as a group at first".
	"the are so much we acquire from field officer……but, I use what I see others using ……….want I see our group leader using".
	"some techniques are reliable ……most of the ideas we try we have to discuss within our group first".
Economics	"anybody with 1 acre qualifies to join our group……."
	"Seed and fertilizer are provided for individual members for later payment so initial cost of input is lowered…….. hence a motivation factor to be a member of the group"
	"using prescribed method has always resulted to better production……..main challenge is when there is low rainfall, and the productivity reduce and we have to pay for the inputs"
	" status have improved since I joined the group……. Have food to feed my family"
Human factors	"Those with large family have manpower, hence high productivity"
	"These young people are active than some of us…….
	Each group member must at least have I acre…….
	"women in the group are more reliable than men…….most of our leaders are men, they command a lot".
Participation	the adoption of the technology is based on lead farmers and farmers group assessment and most cases are promoted by farmers themselves.
	Field officers/ extension/research staff only introduce the ideas but final decision is made by the group members and their leaders.

Normality of data

The dataset was entered into SPSS V25 for checking multivariate normality and multicollinearity.

Test of data normality was carried out and results of different variance as shown in table 3.5.

Test of Homogeneity of Variances

Test of Homogeneity of Variances				
	Levene Statistic	df1	df2	Sig.
Participatory_Influence	4.357[a]	5	49	.002
Social_Influence	.479[b]	5	49	.790
Economic_Factors	2.204[c]	5	47	.070
Technological_Factors	3.713[d]	5	46	.007

Test of Homogeneity of Variances

i. Groups with only one case are ignored in computing the test of homogeneity of variance for Participatory_Influence.

ii. Groups with only one case are ignored in computing the test of homogeneity of variance for Social_Influence.

iii. Groups with only one case are ignored in computing the test of homogeneity of variance for Economic_Factors.

iv. Groups with only one case are ignored in computing the test of homogeneity of variance for Technological_Factors.

ANOVA ANALYSIS					
	Sum of Squares	df	Mean Square	F	Sig.

Participatory_Influence	Between Groups	.606	6	.101	1.987	.086
	Within Groups	2.491	49	.051		
	Total	3.097	55			
Social_Influence	Between Groups	.449	6	.075	1.298	.276
	Within Groups	2.825	49	.058		
	Total	3.274	55			
Economic_Factors	Between Groups	1.426	6	.238	1.576	.175
	Within Groups	7.091	47	.151		
	Total	8.517	53			
Technological_Factors	Between Groups	5.037	6	.840	5.760	.000
	Within Groups	6.705	46	.146		
	Total	11.742	52			

Mean, STDEV, T-Values, P-Values

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
Economics -> Use of ICT	0.412	0.424	0.240	1.721	**0.086**
Social Influence -> Use of ICT	0.199	0.191	0.127	1.574	**0.116**
Technological -> Use of ICT	0.135	0.152	0.110	1.225	**0.221**
Use of ICT -> ICTInnovationAdoption	0.841	0.844	0.032	26.689	**0.000**

Confidence Intervals

	Original Sample (O)	Sample Mean (M)	2.5%	97.5%
Economics -> ICTInnovationsAdoption	0.120	0.127	-0.409	0.653
Participation -> ICTInnovationsAdoption	0.552	0.580	-0.063	1.200
Social Influence -> ICTInnovationsAdoption	0.210	0.159	-0.230	0.538
Technological -> ICTInnovationsAdoption	0.234	0.204	-0.011	0.418

Confidence Intervals Bias Corrected

	Original Sample (O)	Sample Mean (M)	Bias	2.5%	97.5%
Economics -> ICTInnovationsAdoption	0.120	0.127	0.008	-0.422	0.644
Participation -> ICTInnovationsAdoption	0.552	0.580	0.028	-0.151	1.169
Social Influence -> ICTInnovationsAdoption	0.210	0.159	-0.051	-0.095	0.693
Technological -> ICTInnovationsAdoption	0.234	0.204	-0.030	0.042	0.456

APPENDIX X: LETTER OF IDENTIFICATION FROM JOOUST

JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE & TECHNOLOGY

BOARD OF POSTGRADUATE STUDIES
Office of the Director

Tel. 057-2501804
Email: bps@jooust.ac.ke

P.O. BOX 210 - 40601
BONDO

Our Ref: I361/4072/2012

Date: 27th August 2020

TO WHOM IT MAY CONCERN

RE: DOROTHY APONDI RAMBIM – I361/4072/2012

The above person is a bonafide postgraduate student of Jaramogi Oginga Odinga University of Science and Technology in the School of Informatics & Innovative Systems pursuing a PhD in Business Information Systems. She has been authorized by the University to undertake research on the topic: "***A Participatory System Model for Dissemination and adoption of Agricultural ICT Innovation.***"

Any assistance accorded her shall be appreciated.

Thank you.

JARAMOGI OGINGA ODINGA
DIRECTOR BOARD OF
POST GRADUATE STUDIES
DATE
P.O. BOX 210 - 40601
UNIVERSITY OF SCIENCE & TECHNOLOGY

Prof. Dennis Ochuodho
DIRECTOR, BOARD OF POSTGRADUATE STUDIES