AGRICULTURAL INNOVATION CHARACTERISTICS AND THEIR UTILISATION: A CASE OF NATIONAL AGRICULTURAL RESEARCH ORGANISATION

BY

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DECLARATION

I, Barekye Alex declare that the information in this dissertation, except where due reference has been made, is my original work and has not been submitted to any other University for any academic award.

Signature ……………………………………… Date ………………………………

BAREKYE Alex

APPROVAL

This dissertation was carried out under my supervision and was submitted for examination with my approval as the University Supervisor.

Signature………………………………… Date …………………………………

Associate Professor Caleb Tamwesigire

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LIST OF ACRONYMS

CAADP	Comprehensive Africa Agriculture Development Programme
CBSD	Cassava Brown Streak Disease
CMD	Cassava Mosaic Disease
FAO	Food and Agriculture Organisation of United Nations
GDP	Gross Domestic Product
GTI	General Theory of Innovation
IPM	Integrated Pest Management
MAAIF	Ministry of Agriculture Animal Industry and Fisheries
NARO	National Agricultural Research Organisation
PARIs	Public Agricultural Research Institutes
UGX	Uganda Shillings
USD	United States Dollars
ZARDIs	Zonal Agricultural Research and Development Institutes

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ABSTRACT

Although innovations exist in the agricultural sector in Uganda, there is inadequate adoption/utilization of agricultural innovations by end-users. The research was carried out to assess the utilization of agricultural innovations in Uganda using a case of the National Agricultural Research Organisation with the following objectives: to establish the factors that influence development of agricultural innovations, to determine the relationship between agricultural innovation characteristics and utilization of innovations at farm level, and to examine the effect of market attributes on utilization of innovations in agriculture. The study was guided by a conceptual framework which considered agricultural innovation characteristics and market attributes as independent variables and utilization as a dependent variable. Using a cross sectional survey research design, a survey mainly using structured questionnaires was carried out among the National Agricultural Research Organisation (NARO) staff to establish the factors that influence development of agricultural innovations. In order to establish how the innovation characteristics and market attributes affect utilization of innovations, a total of 91 households involved in cassava, maize and rice production were interviewed in Kihiihi sub-county, one of the sub-counties in Kanungu district where the NARO innovations on cassava, maize and rice have been promoted. The data was collected, coded, cleaned and analysed using SPSS to generate frequency tables and STATA to generate an ordered logistic regression of innovation characteristics and market attributes on utilization of agricultural innovations. The respondents agreed that it is important to consider the cost, relevance, and end-user opinion of agricultural innovations as important determinants of developing agricultural innovations. Also respondents agreed that in order to sustain innovations, agricultural research innovators need a clear plan on how innovations should be done (88% of respondents agreed), 91% of respondents agreed that regular information sharing among stakeholders and 94% agreed that the cost of the innovation process, are important factors in sustaining agricultural research innovations. Of the three commodities considered in this study, generation of new varieties emerged as the most important agricultural innovation in the community with 56%, 48% and 54% of the innovation on cassava, maize and rice respectively. The results also indicated that that there was a positive significant relationship between the attribute/characteristics of the varieties and the extent of utilization of varieties. In addition, regression results indicated that innovation characteristics such as relative

advantage, compatibility, triability and, other variables such as gender, age, education had a significant effect ($p<0.05$) on innovation utilization by farming communities. However, complexity had a negative significant effect. The age of respondents has a negative significant effect on the utilization of the innovations while education had a positive significant effect on utilization of innovation.

CHAPTER ONE

INTRODUCTION

1.1 Introduction

In agriculture, innovations can be generated through research, and once adopted innovations could be one way to sustain agricultural development in Uganda. The National Agricultural Research Organization (NARO), which is an agency of the ministry of Agriculture Animal Industry and Fisheries (MAAIF), was established as a body corporate by the National Agricultural Research Act of 2005 with the mandate to coordinate and oversee all aspects of agricultural research in Uganda hence the subject of this study. This chapter examines the background to the study, statement of the research problem, objectives of the study, research questions, the scope of the study, significance of the study, definition of terms, and conceptual framework.

1.2 Background to the study

In business and economics, innovations have been a catalyst for growth. Entrepreneurs continuously look for better ways to satisfy consumers with improved quality, durability, service and price. The innovations in agriculture date back to the domestication of animals and plants to the developments and techniques for raising the productivity. The green revolution which was a series of research, development, and technology transfer increased agriculture production around the world (Hazell, 2009).

Agricultural development during the last 50 years has been shaped by three persistent forces of change: globalization, technology and people. Globalization is the force that is increasingly shifting the focus from domestic to international opportunities, as World markets become more accessible. Improved technologies represent forces that are improving the ability to produce and deliver what consumers want and people are exerting their influence, either directly as consumers, or indirectly as custodians of the environment in which food and fibre products are produced (Keulen, 2007).

In Africa agricultural research was introduced in the late 19th century and early 20th century with the creation of botanical gardens which were mainly used for screening of exotic raw materials to support industries for the colonial powers (FAO, 2002). After the First World War colonial powers needed more raw materials and more formalized research structures were created to conduct basic research on commodities. From 1960 to 1970 almost all sub-Saharan African countries, gained independence. After independence, the responsibility for agricultural research was transferred to each country. The evolution of the system was formed by political decisions made by the new national governments.

In Uganda, according to Beintema and Tizikara (2002) after independence in 1962, all the national agricultural research agencies were transferred to the government. The regional research organizations which focused on export commodities such as cotton, tea and coffee remained under the East African Community until its collapse in 1977 when the Ugandan government started focusing her research on export crops.

Due to political uncertainties towards agricultural research financing of 1970s and 1980s the existing research infrastructure was severely damaged. Later, a national taskforce on agricultural research recommended the establishment of a semi-autonomous agricultural research agency with a mandate covering crops, livestock, forestry, and fisheries, leading to the establishment of NARO in 1993 by the National Agricultural Research Statute of 1992. During the period 2001-2005, the National Agricultural Research system underwent a structural reform that resulted in the enactment of the National Agricultural Research Act of 2005 which repealed the NARO statute of 1992. Therefore, the National Agricultural Research Organization (NARO), as an agency of MAAIF, was established as a body corporate by the National Agricultural Research Act of 2005 with the mandate to coordinate and oversee all aspects of agricultural research in Uganda. The overall goal of NARO is to enhance the contribution of agricultural research to agricultural productivity, sustained competitiveness, economic growth, food and nutrition security and poverty eradication. The focus is on development and dissemination of technologies/agricultural innovations that are client-oriented with high impact for sustainable agricultural development.

Besides NARO being involved in development and dissemination of agricultural innovations, and using all possible pathways to ensure their clients utilize research innovations, there are several theories about innovations, their acceptance and adoption which have an influence on the operations of the organisation. Hayami and Ruttan (1985) highlighted the theory of induced innovations which links the emergence of innovations with economic conditions. They argued that the search for new innovations is an economic activity that is significantly affected by economic conditions. New innovations are more likely to emerge in response to scarcity and economic opportunities. Farmers press the public research institutions to develop new technologies and, also, demand that agricultural firms supply modern technical inputs which substitute for the more scarce factors. For example, labor shortages will induce labor-saving technologies. However, Olmstead and Rhode (1993) argue that other factors also such as availability of scientific knowledge, presence of inputs especially from the manufacturing industry, and the interaction between farmers and input producers among others affect the emergence of innovations.

Yezersky (2007) General Theory of Innovation (GTI) recognises that knowledge is essential in innovations because it allows any organisation to forecast the system (products, processes, service among others) future with great precision. GTI points out that every innovation improves the system. The same theory also proposes that innovations involve cost reduction, quality, reliability, performance and productivity improvement and failure prevention. The GTI points out that innovations aim at identifying a change required for repositioning an organisation with the purpose of obtaining competitive advantage.

Davis (1989) came up with technology acceptance model which specifies two major parameters: perceived usefulness which is the potential users' subjective likelihood that the use of a certain system will improve his/her action; and perceived ease of use which is the degree to which the potential user expects the target system to be effortless. The belief of a person towards a system may be influenced by other factors referred to as external variables. Later Venkatesh and Davis (1996) modified the technology acceptance model and asserted that both perceived usefulness and perceived ease have a direct influence on behaviour intention. This model was further modified and other factors such as job relevance, output quality, result demonstrability, performance expectancy, social influence and facilitating conditions all influence perceived usefulness.

Rogers (2003) described the innovation-diffusion theory (the process by which an innovation is communicated through certain channels over time among the members of social system) that involves five stages in the innovation-decision-making process. The first stage, the knowledge stage, occurs when an individual becomes aware of an innovation and begins to gain some information. The persuasion stage occurs when an individual forms an attitude towards the innovation, either favorable or unfavorable. The decision stage occurs when an individual either accepts or rejects the innovation. The implementation stage takes place when an individual puts the innovations to use. It is also important to note that as an innovation diffuses, it may go through re-invention, that is, it may be changed or modified during the course of its adoption and implementation. The final stage, the confirmation stage, occurs when individuals validate their innovation-decision. The innovation-decision process is basically an information-seeking and information-processing activity in which an individual assesses the characteristic of an innovation and decides whether to adopt or utilize the innovation. Rogers (2003) notes five qualities or characteristics of innovations that account for their rate of adoption which include: relative advantage, compatibility, complexity, trialability, and observability. Rogers (2003) also pointed out that communication is essential in utilization of technologies and classified adopters in different categories as early adopters, early majority, late majority and laggards.

The adoption of agricultural innovations increases agricultural productivity which results in socio-economic development (Kariyasa and Dewi, 2013). In agriculture the most common areas of innovations are new crop varieties, management regimes, soil and soil fertility management, pest management, irrigation and water management (Loeverinsohn *et al*., 2013). Recently production of agro-machinery for value addition, post harvest handling and labour reductions are some of the additional innovations that improve agriculture productivity.

Rogers (1995) defined adoption as a decision to make full use of an innovation as the best course of action available to satisfy a specific need of a customer or end-user. In agricultural research adoption can be measured by estimating proportion of farmers using an innovation or considering the areas under the innovation (CIMMYT, 1993). According to CIMMYT (1993) it is important to study adoption in order to understand the challenges of accepting a new innovation, assessing the impact of agricultural research and its returns on investment and apportioning benefits to the farmer and particular regions where innovations were promoted. The adoption of innovations in agricultural systems is influenced by a number of factors such as farmer resource and farmer characteristics, farming system, market, information (Guerin and Guerin, 1994; Hall and Khan, 2003; Ndjeunga *et al*., 2008).

In Uganda, for the last 10 years supported by an average annual budget of UGX 103 billion, the National Agricultural Research Organisation (NARO) conducted research and development initiatives and generated 801 technologies and innovations (NARO, 2018). However, the uptake and utilization of NARO innovations has been low. For example, it was reported that in Uganda, only 10% of households planted improved seed (UBOS, 2011). In fact, it is commonly said that there are a lot of NARO innovations on shelf implying end-users are not applying the innovations.

Although a number of factors that limit adoption of agricultural innovations have been reported, from research carried out in Uganda, there is inadequate information on how innovation characteristics affect adoption/utilization of innovations. According to Jones (1989) and Rogers (2003) perceptions of innovation characteristics affects their utilization. There is also limited information on how the market forces affect utilization of innovations generated by NARO. Therefore, it is important to carry out an investigation on how the customers perception of product/innovation and market attributes affect the adoption and utilization of innovations in order to guide agricultural research in Uganda.

1.3 Statement of the research problem

In Uganda, the inadequate adoption/utilization of agricultural innovations by end-users has caused the low rate of growth of agricultural sector (averaged at about 3% in the last five years) (UBOS, 2007;2011). For example, Mugisha *et al*. (2004) while studying the performance of farmer-led extension in agricultural technology adoption reported that the adoption rate of rice innovations in Uganda was low at 35%. In another study by Towo and Mugisha (2013) the level of adoption of sunflower innovations in Northern Uganda was reported at 21%. Similarly, Mwanja *et al*. (2016) established a low adoption of improved Irish potato seed production innovations in south western Uganda. There are several factors that have been reported to affect adoption of agricultural innovations. For instance, in a study by Natukunda (2011) on adoption of a vanilla a high value crop in central Uganda, it was reported that education level of farmer, availability of income to hire extra labour, price and availability of market affected adoption of vanilla growing. Kasirye (2013) in a study of constraints to agricultural technology adoption in Uganda reported education level, land holding and peer effects as major factors affecting adoption of technologies. Serunkuma (2005) attributed lack of participation in extension programmes as one of the reasons for low adoption of maize varieties in Uganda.

From most studies available on adoption or utilization of technologies, it is important to note that most studies were done on farmer characteristics with little information on innovation characteristics and market attributes. One of the causes of low adoption of banana hybrids was that end-users prioritised consumer attributes such as quality of cooked food (Akankwasa *et al*., 2016). The available literature on how agricultural innovation characteristics and market attributes of the innovations influence the utilisation of innovations in Uganda is inadequate. Availability of this information will assist the developers of agricultural innovations to generate innovations that would be easily adopted hence increasing productivity and thus enhancing agricultural growth.

1.4 General Objective

The general objective is to assess how agricultural innovation characteristics influence adoption/utilisation of the innovations in Uganda using a case of National Agricultural Research Organisation.

1.5 Specific Objectives

a) To establish the factors that influence development of agricultural innovations.

b) To determine the relationship between agricultural innovation characteristics and utilization of innovations at farm level.

c) To examine the effect of market attributes on utilization of innovations in agriculture.

1.6 Research questions

This study will answer the following questions:

a) What are the factors that determine the development of agricultural innovations in Uganda?

b) What is the relationship between agricultural innovation characteristics and their utilization at farm level?

c) What is the effect of market attributes on utilization of innovations in Agriculture?

1.7 Scope of the study

1.7.1 Geographical scope

Kihihi sub-county is one of the 13 sub-counties that make up Kanungu district. Kihihi sub-county has three parishes; Kabuga, Kibimbiri and Rushoroza parishes with about 3974 households. Forty five percent of the population is involved in agriculture. Of these 69% grow maize while only 11% grow cassava. Rice has been recently introduced and there was no reliable information about the population involved in rice growing. The information available from the DPMO, Kanungu district, (Pers. Communication) indicated that all the three crops of interest (maize, rice and cassava) are grown by farmers in Kihiihi sub-county. The researcher considered utilization of agricultural innovations on cassava, rice and maize.

The National Agricultural Research Organisation has 16 Public Agricultural Research Institutes (PARIs). Seven of these are National Agricultural Research Institutes (NARIs) whose mandate is to conduct basic research to generate the technologies/innovations. The 9 Zonal Agricultural Research and development institutes (ZARDIs) have the mandate of conducting applied and adaptive research and to facilitate dissemination of appropriate technologies to uptake pathways. Two of the NARIs (Namulonge and Kawanda) are involved in generating innovations on maize, cassava and rice. The researcher identified factors considered in the development of agricultural innovations by interviewing staff from the two institutes.

1.7.2 Content Scope

Since NARO was formed a number of innovations in crops, animals, forestry, fisheries, land management, soils, agro-machinery and value addition have been generated (NARO, 2018). For example, cassava research released nine (9) disease resistant and superior varieties which reduced national incidence of cassava brown streak disease (CBSD) from 27.3% in 2011 to 20.4% in 2017 and kept cassava mosaic disease (CMD) occurrence below 20% (NARO, 2018). Maize, cassava and rice are major food security crops which can be easily commercialized to achieve the Uganda government vision of converting subsistence farmers into commercial farmers. To achieve this vision, the agricultural innovations generated have to be utilized by farmers to improve crop productivity. Therefore, the study considered the characteristics of the technologies/innovations developed on maize, cassava and rice that influence the adoption of the innovations.

1.7.3 Time scope

The study covered a period coinciding with the NARO strategic plan 2008-2017, which had been concluded by the time of this investigation. This was appropriate to follow the technologies generated and how they have been disseminated.

1.8 Significance of the study

The findings of the study will make the following contribution:

1. The factors that influence development of agricultural innovations in Uganda have been identified. These will help innovation developers to generate agricultural innovations that will respond to the end-user needs which will enhance adoption of innovations in agriculture and will lead to overall improved productivity.
2. The gaps that will sustain agricultural innovations within the agriculture research have been identified and recommendations made for policy makers. Once these are implemented they will increase staff motivation, more innovations will be generated and resources to support agricultural research will be accessed.
3. The study findings got are expected to add on the existing knowledge on innovations in agricultural research and close the knowledge gap that exists in the development of innovations in agricultural research in Uganda.
4. The results from this study will act as a basis for further research for academicians who will be interested in innovations in agriculture research.

1.9 Definition of terms

Adoption is a decision to make full use of an innovation as the best course of action available (Rogers, 1995). Adoption is also defined as the use and uptake of research outputs by the end users. Adoption can also be defined as repeated application of acquired knowledge. Adoption is a necessary condition to achieving impact. If research and dissemination efforts for a given innovation lead to high level of adoption, the overall impact is expected to be high and the reverse is true.

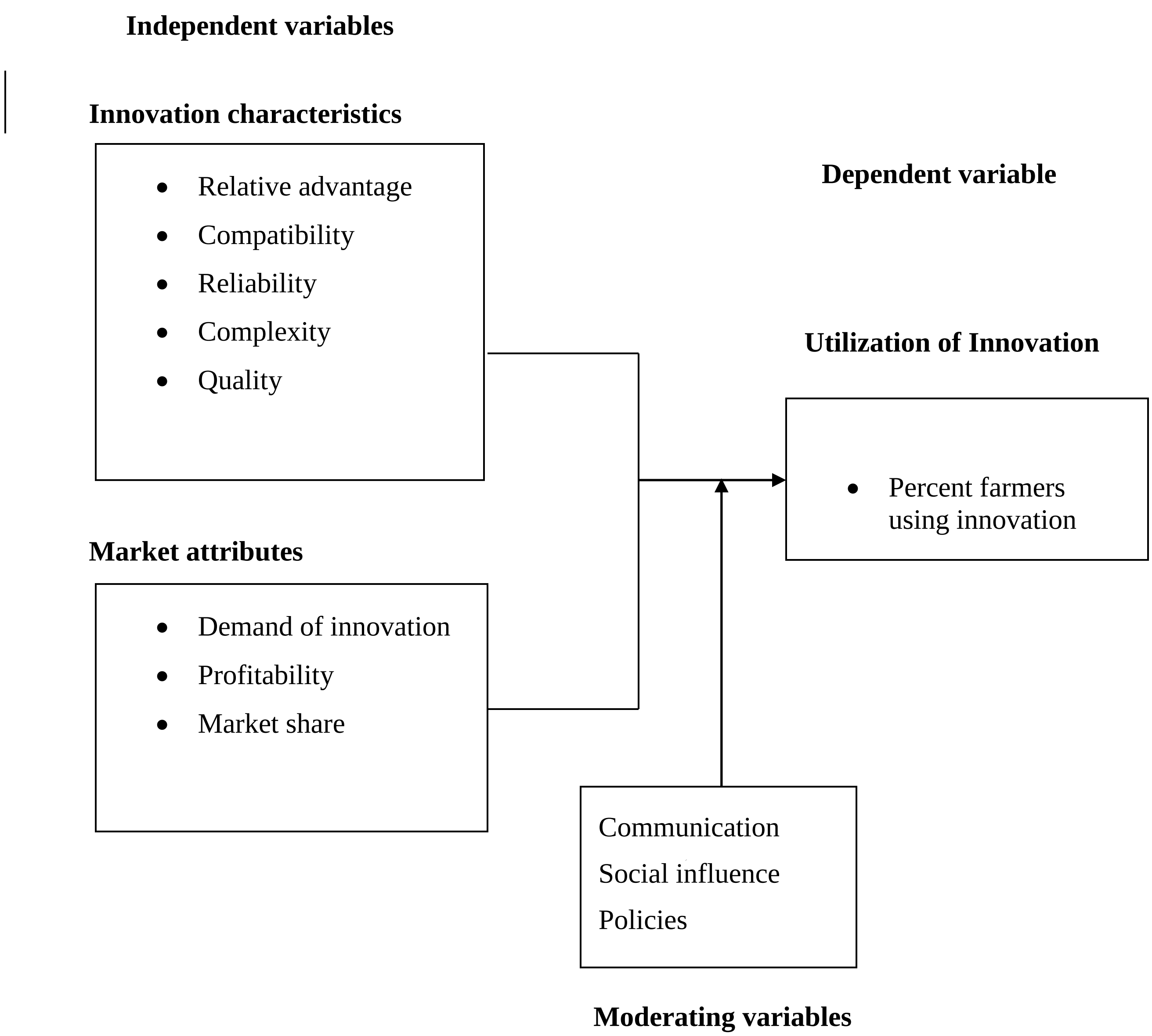
Innovations are actions required to create new ideas processes or products which when implemented lead to positive effective change. Innovations involve new products, new methods of production, new sources of supply, the exploration of new markets and new ways of organizing business to remain competitive (Schumpeter, 1934). An agricultural innovation is the process whereby individuals or organizations bring new technologies, practices or products into use to increase effectiveness, competitiveness, resilience to shocks or environmental sustainability that will bring increased income and satisfaction to the end-user such as a farmer, processor, or a consumer.

Technology is the theoretical and practical knowledge, skills, and artifacts that can be used to develop products and services as well as their production and delivery systems (Burgelman *et al*., 1996).

Utilization is the action of making practical and effective use of something.

1.10 Conceptual framework

The conceptual framework draws upon works of several authors such as Hall and Khan (2003) and Rogers (2003). Their work has been adapted to the agricultural innovations environment in agriculture research in Uganda. The following conceptual framework was used to guide the study.



Adapted from: Hall and Khan, (2003) and Rogers (2003)

Description of the Conceptual Framework

According to Hall and Khan, (2003) and Rogers (2003) there are a number of determinants of innovations and their adoption/utilization. In the context of this study, innovation characteristics (relative advantage, compatibility, trialability, complexity, quality) and market factors (demand of innovation, market share and profitability) were considered as independent variables while utilization of innovations (percentage use, and percent coverage) were taken as a dependent variable. On the other hand, Communication, Social influence and policies are the moderating variables.

CHAPTER TWO

REVIEW OF LITERATURE

2.1 Introduction

This chapter reviews the existing literature on adoption of innovations in agricultural research in Uganda. The literature examined agricultural innovations, adoption/utilization of agricultural innovations, determinants of adoption of agricultural innovations, estimating adoption of agricultural innovations, effects of innovation characteristics on utilization of innovations at farm level, effect of demand on utilization of innovations in agriculture and the effect of policies. The source of literature included: scholarly articles on adoption of innovations, published books and from the internet. The review was conducted in line with study objectives and research questions.

2.2 Agricultural innovations

Innovations are very important in the social and economic development since they enhance production and efficient use of resources. Increasing productivity in agriculture, boosting the income of farmers and reducing poverty are some of the benefits of application of appropriate innovations.

Agriculture is the backbone of Uganda's economy employing 73% of the country's labour force and contributing 27% of GDP (Kasirye, 2013). The annual agricultural growth in Uganda has been low at 3% compared to 6% growth target set by the African governments under the Comprehensive Africa Agriculture Development Programme (CAADP). One of the factors that can enhance agricultural growth is the adoption/utilization of agricultural innovations. Despite the existence of agricultural innovations agricultural growth has remained low. It will be important to understand why the innovations are not utilized. It is also worthy to note that there are unique challenges along the commodity value chains that may limit uptake of the innovations. These include poor infrastructure, weak institutions, coordination failures, weak capital to invest, and unfavourable social and political conditions. Nevertheless government programmes and policies exist to address the infrastructural and economic challenges. The factors limiting innovation uptake could be in the innovations themselves or the perception of end users.

2.3 Adoption/utilization of agricultural innovations

Adoption is a decision of implementing innovations based on knowledge, persuasion of individuals within a given system (Rogers, 1995). There are stages involved in the adoption of innovations. One of them is the knowledge stage where the individual or household is exposed to the innovation and understands how the innovation works. The second stage involves persuading the individuals to use it because they may not regard it as relevant to their situation. The persuasion may lead to either adoption or rejection of the innovation. The fourth stage is the implementation stage where an individual puts an innovation into use. The final stage is confirmation during which the individual seeks reinforcement for the decision made.

There are different theoretical approaches that can explain the development and adoption of agricultural innovation. One of the theories is the economic constraint model. This theory perceives farm households as decision makers whose concern is how much to devote to the cultivation of each crop, whether or not to use purchased inputs, which crops to grow on which fields, among others. Therefore the decision made by the farmer depends on their goals or objectives and the resource constraints of the individual farming household. The economic constraint model makes various assumptions. The model assumes that the household acts as a unified unit of production and consumption that aims to maximise utility subject to its production function, income and total time constraint. Another feature of the model is the use of a single decision maker and the assumption that no conflict exists within the household and that all members have the same utility function so that maximising the household utility would yield similar results as maximising individual functions. This proposition is based on the assumption that household members will sacrifice their individual preferences for the common good of the household. In return, the altruistic head will make decisions based on what is best for the household as a whole.

There is also the influence of custom and culture that are important in household decision making (Pennartz and Niehof 1999). Research has also challenged the conventional notion that ascribes household headship automatically to men. Women are now increasingly recognised as legitimate household heads in their own right (Mencher and Okongwu 1993).

Another model used to explain agricultural research and technology diffusion is the central source of innovation model. In this model, also known as the transfer of technology (TOT) approach, innovations are seen to move progressively from the international agricultural research institutions, national agricultural systems such as NARO, to national extension systems and finally to farmers (Biggs, 1990). The major emphasis in this model is on the transfer of knowledge and technology from research institutions to farmers. The key features of the model include assignment of clear-cut roles to specific institutions and groups of people. Research institutions have either an international or national mandate to conduct research, extension agents are only supposed to pass on the results, whereas farmers are seen as technology adopters or people who have problems that are fed back to extension advisers and researchers. The process of technology generation and transfer is seen as a linear process where scientists develop technology, demonstrate it to farmers through the extension agents, and the farmers adopt it in the final stages. In this model research institutions are the sole source of technology. The farmers' experience, knowledge and resources are overlooked and farmers are thus seen as passive receivers of technology (Leeuwis and van den Ban, 2004). However, this paradigm has proved inadequate for managing the emerging challenges in agricultural research and technology diffusion today. These challenges include: diverse biophysical environments, multiple livelihood goals, rapid changes in local and global economies, the expanded range of stakeholders over agriculture and natural resources, drastic decline in resource investment for the formal research and development sector (Gonsalves *et. al*., 2005). These new challenges suggest that research and development can no longer be the exclusive domain of scientists, but must be a joint process requiring the participation of a wider range of actors.

The multiple source of innovation model focuses on understanding the clients' diverse needs and resources and views the users not merely as adopters but as active participants in the process of technology development and adoption. This model emphasizes that agricultural innovations are derived not only from agricultural research institutions but from multiple sources.

These sources include farmers, innovative research practitioners, research-minded administrators NGOs, private corporations and extension agents (Biggs 1990). 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). Furthermore, it redefines the role of farmers from being simply recipients to actors, who influence and provide inputs to the process.

There is also the innovation diffusion model. This diffusion model was highlighted by Rogers (1995). According to Rogers (1995) the innovation diffusion model involves various components: the innovation decision process, the perceived attributes of the technology, and individual innovativeness among others. For example, the innovation decision process is characterised by five stages: knowledge, persuasion, decision, implementation and confirmation. Rogers (1995) identified five attributes upon which an innovation is judged. These are relative advantage, compatibility, complexity, triability and observability. This theory posits that innovations spread gradually over time and among people resulting in various adopter categories. This study is interested in understanding how the characteristics of an innovation will influence the utilization of the innovation.

However, the innovation diffusion model has several limitations. One of the major shortcomings of the model is that it generally assumes that the most important variable is information and the willingness of the individual to change. There are other factors are known to influence the adoption of an agricultural innovation. 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.

Despite the above limitations, several studies done in Uganda shed light on the gaps assumed by the innovation diffusion model. In a study by Natukunda (2011) education level of farmer, availability of income to hire extra labour, price and availability of market affected adoption of vanilla growing. Kasirye (2013) reported education level, land holding and peer effects as major factors affecting adoption of technologies.

2.4 Determinants of adoption of agricultural innovations

The development of most countries in the World with rural populations has come through industrial revolutions with agricultural revolutions preceding the former. According to NDPII (2015), agriculture is considered as central for economic growth and poverty reduction and as a source of raw materials for agro-processing in Uganda. One of the strategies to enhance agricultural growth involves strengthening research and building human capacity to enhance technology improvement and adoption.

The Uganda Vision 2040 identified limited application of technology and innovation as one of the challenges to be addressed to transform agriculture from subsistence to commercial farming. According to Schumpeter (1934) innovations are considered as new products, new methods of production, new sources of supply, the exploration of new markets and new ways of organizing business to remain competitive. There is evidence that for the last 10 years the Uganda government either directly or indirectly has supported agricultural research to generate technologies and innovations that improve productivity and enhance farmer income. However, the uptake and utilization of agricultural research innovations has been low. For example, it was reported that in Uganda, 10% of households planted improved seed (UBOS, 2011).

The adoption of innovations in agriculture is influenced by the extent to which farmer finds new technology complex and difficult to comprehend, the financial cost of technology, farmers beliefs and opinions towards the innovation, the farmers perception of the relevance of the new innovation, and the farmers attitude towards risk and change (Guerin and Guerin, 1994). In a study by Katungi and Akankwasa (2010) on adoption of banana technologies in Uganda, it was highlighted that farmers' adoption decisions depend on farm and farmer socio-economic and institutional characteristics, technology characteristics and dissemination approach used. In another study by Jogo *et al*. (2013) it was reported that labour availability increased the chance of adopting bacterial wilt management practices while on the other hand practices which were labour intensive reduced the probability of adopting the management practices. From the same study it was also pointed out that farmers who perceived the agricultural innovation to be ineffective were less likely to adopt the innovation. On the other hand farmers endowed with resources are more likely to adopt innovations compared to resource limited farmers. Kalyebara (1999) reported that high income farmers are about twice as likely to adopt soil conserving measures than poor farmers.

2.5 Estimating adoption of agricultural innovations

In agricultural research and development, adoption can be defined as the use and uptake of research innovations by the end users and it has become a necessary condition to achieving impact. Since adoption is a process, it starts with few individuals and later the number of individuals using the technology increases over time. Therefore the number of individuals using a technology can be a measure of adoption. Mugisha *et al*. (2004) while investigating performance of farmers-led extension system in agricultural technology transfer and adoption in Uganda considered using number of practices of a technology package repeatedly applied to measure technology adoption. From this study, time is also crucial as a measure of adoption since technologies applied for less than 2 years could not be used for adoption studies. Omadi *et al*. (2015) while studying agricultural technology adoption for orphan crops among rural poor farmers in Uganda estimated level of adoption by considering, the percentage proportion of farmers using the introduced technologies. In addition to estimating proportion of farmers using an innovation CIMMYT also considered the areas under the innovation. In this study utilization of innovation/adoption was considered as the percent use/coverage of the innovation.

2.6 Effect of innovation characteristics on the utilization of innovations at farm level

It is important to understand how innovation characteristics affect the utilization of innovations in agricultural research systems. Jones (1989) reported that the demand for products or innovations is significantly affected by the perceptions of product attributes. For example the quality of sorghum varieties significantly influenced their adoption in Burkina Faso (Adesina and Baidu-Forson, 1995). Similarly, Rogers (2003) reported that relative advantage (how the innovation is subjectively perceived superior to the previous one), compatibility (how the innovation is perceived consistent with the existing values, past experience and needs of potential adopters), complexity (perceived difficulty to understand and use the innovation), trialability (degree to which an innovation may be experimented with on a limited basis), and observability (how the results of an innovation are visible to others) of innovations account for their rate of adoption.

The dimensions of relative advantage include the degree of economic profitability, low initial cost, a decrease discomfort and effort. Joo and Kim (2004), Miller and Meek (2004) and Liao and Lu (2008) studied the relative advantage of Integrated Pest Management (IPM) practices and found that additional IPM practices benefits such as economic profitability, decreasing production cost and effort saving influence farmers' decision to adopt an innovation. For example, Mugisha *et al*. (2004) reported low adoption of rice production technologies in Uganda to have been caused by expensive and tedious practices/innovations.

An innovation can be compatible with social norm, previously introduced ideas and client need for innovation. If an innovation is incompatible with the grower's social values and beliefs, it will not be adopted as rapidly as an innovation that is compatible. For example, a study by Sarel and Marmorstein (2003) showed significantly positive relationship between compatibility and perception for adoption. Hence, if an innovation is compatible with an individual needs, then uncertainty will decrease and the awareness and adoption of the innovation will increase. Thus, compatibility is an important part of innovation.

Complexity is the degree to which an innovation is perceived as relatively difficult to understand or use (Rogers, 2003). New ideas that are simpler to understand by members of a social system are adopted more rapidly than innovations that require the adopter to develop new skills and understanding. A low level of complexity lead to higher adoption rate or complexity increases the rate of rejection (Rogers, 2003; Sarel and Marmorstein, 2003).

Trialability, on the other hand, refers to the degree to which an innovation may be experimented on a limited basis (Rogers, 2003). For example, Rogers (2003) argues that latent adopters, who are invited to experiment an innovation for trials, would feel more comfortable to adopt innovations. However, it is positively related to perception of adoption and awareness. Furthermore, according to Kolodinsky *et al*. (2004) sometimes trialability provides farmers the ability to evaluate innovation benefits. Consequently, if farmers are given the opportunity to try the innovation certain fears of the unknown and inability to use can be reduced.

Finally, observability is the degree to which innovations are visible to others. The results of some ideas are easily observed and communicated to other, whereas some innovations are difficult to observe or to describe with others. Role modeling is the key motivational factor in the adoption and diffusion of technology (Parisot, 1997). Hence, there is a positive relationship between observability and perception for adoption and awareness.

Although the National Agricultural Research Organisation has generated a number of innovations over time, there is lack of information on the how the characteristics of these innovations affect their utilization. Availability of information could guide NARO in developing appropriate innovations that will enhance agricultural productivity once they are adopted.

2.7 Effect of demand (Market) on utilization of innovations in agriculture

Marketing which is the management process through which goods move from concept to the customer affects the utilization/adoption of business innovations. Marketing is based on the thinking about the business in terms of customer needs and their satisfaction. In agricultural research systems, the market determinants of adoption of agricultural innovations include: demand of innovation, differences in market prices, profitability, and labour intensity among others.

According to Hall and Khan (2003), innovation diffusion results from a series of individual decisions to begin using the new technology, decisions which are the result of a comparison of benefits and costs of adopting the new invention (demand and supply-side perspectives). From the demand-side the main conditions are awareness of the new technology and being able to use and adapt the new technology and the profitability of adopting the new technology (depending on the price, on the expected returns, and on the level of risk). The larger the market share, the higher the incentives to adopt, because a large market share increases the ability to appropriate the returns from adoption (Hall and Khan, 2003).

Surinac *et al* (2009) reported that the average productivity level is positively and significantly correlated with the innovation adoption rate in the developed world. However, the authors also reported lack of a clear relationship for the countries with low levels of productivity. For the case of agricultural research systems in Uganda, it would be interesting to note how labour productivity affects the adoption of agricultural innovations.

2.8 Effect of policies, communication and social influence on utilization of innovations

Pestre (2003) in his concept of knowledge production regimes believes that beliefs, practices as well as political and economic regulations that define the place and role of sciences influence innovations. The favourable policies that support research, infrastructure and a trained workforce will lead to the generation and utilization of innovations. For example availability of policies that discourage importation of sugar, rice and wheat in Uganda during 2005-2010 period gave incentives to farmers to produce more of these commodities (MAFAP, 2013). The supportive policies have also been reported to attract private sector to invest in agricultural research in the developed world (Slaughter and Leslie, 1997). However, there is need to refocus policies in Uganda to attract private sector to invest in agricultural research in order to contribute to agricultural development.

Communication of research innovation to end-users also plays a major role in the adoption/utilization of innovations. For example, scientists aim to improve scientific knowledge and share discoveries through research, development and publications. However, there has been a stagnant or declining support to knowledge dissemination in most African countries which has significantly affected adoption of agricultural research innovations.

2.9 Synopsis of the literature review

From the literature reviewed above, it is clear agricultural research system in Uganda have generated innovations. It is also important to note, that there is low adoption of the innovations generated by NARO. Factors that affect generation and utilization of agricultural innovations in NARO have also been reviewed. However, what is not clear is what are the factors that determine the generation of agriculture innovations, the relationship between the characteristics of innovations and their utilization, and the effect of market on the utilization of innovations in agriculture.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This section presents the research methods that were adopted by the researcher to carry out the study. It focuses on the research design, study population, sample size, sampling procedures, sources of data, methods of data collection, data analysis, limitations to the study and validity of tools to use.

3.2 Research Design

The cross sectional survey research design was used for the study. This was because this study was based on a sample drawn from a population and this design is normally used for population based studies. The design was preferred because it allows data to be collected from different individuals (respondents) at a single point in time and can handle multiple variables such as agricultural innovation characteristics at data collection. The design is inexpensive and fast to accomplish data collection. Therefore the researcher found it appropriate to apply this design to collect data on maize, cassava and rice farmers in Kihiihi sub county, Kanungu district.

3.3 Target population

Kihihi sub-county is one of the sub-counties in Kanungu district where the NARO innovations on cassava, maize and rice have been promoted. Information available from the district profiles indicated that a total of 180 households were involved in utilization of technologies on cassava, maize and rice in Kihihi sub-county. On the other hand, according to NARO staff payroll, 25 and 35 staff from Kawanda and Namulonge respectively were directly involved in generation of innovations.

3.4 Sample size determination

The sample size that was used for this study was 125 respondents which was a deviation from the original target of 148 respondents. The original sample size was estimated based on Krejcie and Morgan Table of 1970 (Appendix 1) where it was given that a sample size of 148 was appropriate for a population of 180. The sample size was supposed to consist of 56 NARO staff and 92 households from Kihihi sub-county, Kanungu district (Table 1). However, the study missed one household from Kanungu when the enumerator accidentally missed to interview the respondent and this error was discovered at data entry and it was difficult to go back to interview the respondent because of resources. However, it is believed that the data that was collected would fully be representative. From NARO there was a relatively big drop from the target of 56 to what was achieved (34). This deviation came as a result of staff being on annual leave, study leave, short term trainings, field engagements and some resignations. Nevertheless, from the respondents interviewed all the target categories were proportionately represented.

Table 3.1. Study population and sample size

SN	Institute	Study population	Sample size	Sampling method
1	National Agricultural research Laboratories (Kawanda)	25	24 (15)	Purposive sampling
2	National Crops Resources Research Institute (Namulonge)	35	32 (19)	Purposive sampling
3	Kihihi sub-county	120	92 (91)	Stratified sampling
	Total respondents	180	148(125)	

Values in parentheses are the actual number of respondents that were interviewed. The target respondents were 148 individuals while the actual respondents were 125; giving a response rate of 84.4%. The reasons for deviations from target responses were due to staff being on study leave, short term trainings, field engagements among others while for the farmers one respondent was accidentally missed during the interview process.

3.5 Sampling techniques and procedures

The study employed purposive, stratified and random sampling techniques. Purposive sampling was used because it helped the researcher to select scientists and technicians who were directly involved in generating innovations within NARO. At the sub-county level, the households were stratified according to the commodities of interest (rice, cassava and maize). Stratifying farmers into different groups helped focus the study because those farmers who had an experience in the commodities of interest were interviewed. However, to select the actual households to be interviewed, a list of households in the different categories was generated, given numbers and using random numbers generated by a computer a sample of the households was selected for the interview.

3.6 Data collection methods

After proposal presentation and clearance, the researcher engaged and trained enumerators to collect the data in the field. Although it was costly and time consuming, training improved the reliability of data. The enumerators were able to make personal observations which were recorded to enrich the investigation.

3.7 Data collection instruments

The most commonly used data collection tools in social research include questionnaires, personal interviews and or focused group discussions. This study employed questionnaires and interviews as primary data collection methods as well as documentary reviews to collect secondary data. Two questionnaires were designed; one for NARO staff and the other for the households using NARO innovations. The questionnaires consisted of mainly closed questions using a 5 point scale, ranging from 1 strongly disagree to 6-strongly agree for the innovations. For utilization 1 represented very low and 5 represented very high utilization.

3.8 Quality control

The researcher ensured the validity of the questionnaire after consulting technical people especially the supervisors and other qualified people in the field of innovations. The questionnaire was pre-tested on a sample of 20 farmers in Kihihi sub-county where the study was to be conducted. The validity of the data was tested using pearson product moment correlation using SPSS. Based on the significant value (2-tailed) of 0.0001 which was less than 0.05, it was concluded that the instrument was valid and the data collection proceeded as planned.

3.9 Data analysis and management

Data analysis was done after collecting the raw data from the field, editing and checking for accuracy of information, consistency and uniformity. The collected data was analyzed both qualitatively and quantitatively. Descriptive statistics such as tables showing frequencies and percentages were generated and presented using SPSS statistical package. The following detailed analysis was out as follows:

3.9.1 Factors influencing development of innovations

This data was obtained from agricultural staffs who are involved in generating agricultural innovations. Using SPSS frequency tables were generated and based on total observations percentages were computed into respondents who strongly agreed, agreed, not sure, disagreed and strongly disagreed and presented as per the different components that constitute the different determinants of agricultural innovations.

3.9.2 Relationship between innovation characteristics and their utilization

The frequency of observations based on innovation characteristics per commodity were computed and presented. A chi-square at a probability level of 5% was used to test the relationships between commodities and innovation utilization as per farmers' responses. Frequencies of different parameters that defined the innovation and market attributes were computed and presented. Regression analysis was also used to estimate the relationship between innovation attributes and their level of utilization.

3.9.3 Effect of innovation and market attributes on utilization of innovations in Agriculture

The utilization attribute was considered as the response/ dependent variable and the predictor variables included gender, age, commodity, education, market attributes, relative advantage, compatibility, trialability (degree of experimentation), complexity and quality. In order to carry out an ordered logistic regression of innovation and market attributes on utilization of innovations in agriculture, the model was first tested on how well it fitted with the explanatory variables compared to an empty model. The effects were tested at a 5% probability level.

3.10 Ethical considerations

The main ethical considerations were voluntary participation, ensuring confidentiality and privacy of respondents. The protection of rights and integrity of participants was observed as their names were not recorded on any questionnaire. The enumerator introduced himself to the head of the institute, explained the purpose of the investigation and sought authorization to conduct interviews with staff. Due to the nature of the agricultural innovations the researcher respected intellectual property and will never disclose it to any third party at any time even beyond this investigation.

For the farming community, the respondents were accessed by going through the district and administrative structures of the local councils in the area. The respondents were given the confidence that the information provided is confidential and will be used only for research purposes.

3.11 Limitations to the study

a) There was a problem of inadequate funds. This study was self sponsored and depended entirely on savings by the researcher. Strong negotiations were done with the enumerators and a compromise was reached which was a win-win for both the researcher and enumerators.

b) The time and timing of the data collection. Time was always not enough as the researcher is a full time public servant. To create time the researcher had to use week-ends and work for late hours to create time for this study. On the part of respondents, the parameters to collect had already taken place, so the researcher relied on the memory of respondents. Enumerators were encouraged to be patient with respondents during the interview process.

CHAPTER FOUR

DATA PRESENTATION AND ANALYSIS

4.1 Introduction

This chapter covers data presentation, and analysis of the findings the researcher obtained from the field based on the above research objectives. This analysis guided the discussion, conclusions and recommendations in the following chapter. The findings are presented in the tables below.

4.2 Factors influencing development of innovations in agricultural research

Table 4.1. Percentage respondents involved in generating innovations on maize, cassava, rice and agricultural machinery

	Strongly agree	Agree	Not sure	Disagree	Strongly disagree
Generation of new crop varieties	44	44			12
Developing new products	47	41	3	9	
Developing new protocols	23	68	3	6	
Improving existing technologies	30	64	6		
Designing new processes	20	62	18		

In the National Agricultural Research Organisation (NARO) agricultural innovations were considered as generation of new crop varieties, developing of new products that have commercial value, developing new protocols, improving existing technologies/innovations and designing new processes. Table 4.1 shows percentage of respondents involved in generation of agricultural innovations. Forty seven percent and 44% of respondents strongly agree that they are involved in developing new products and generating new crop varieties respectively. Similarly 68%, 64% and 62% of the respondents agree that they are involved in developing new protocols, improving existing technologies and developing new processes respectively. Only a small percentage of 12% strongly disagreed to be involved in generation of crop varieties and 18% of the respondents were not sure that they were involved in designing new processes (Table 4.1).

Table 4.2 Factors considered by respondents generating agricultural innovations in National Agricultural Research Organisation (N=34)

	Strongly agree	Agree	Not sure	Disagree	Strongly disagree
Difficulty in understanding innovation	15	27	30	25	3
Cost of innovation	21	47	24	6	2
End-user belief/opinion of innovation	21	41	29	9	
Relevance of the innovation	41	15	32	9	3
End-user attitude towards risk and change	9	45	40	3	3

On the factors considered by respondents to generate innovations within NARO, there were mixed responses. The results presented in Table 4.2 indicate that 39% of the respondents were not sure that the end-users of the innovation will consider difficulty in understanding the innovation as a factor that will influence the innovation utilization, although a small proportion of 27% of the respondents agreed that this is an important factor to consider when generating innovations. On the factor of cost of the innovation 27% and 47% of the respondents strongly agree and agree respectively that this is an important factor to be considered when generating innovations. On the other hand, 21%, 41% and 29% of the respondents strongly agree, agree and are not sure respectively that the belief of the end user will affect the utilization of innovation. Forty one percent of the respondents strongly agree that the relevance of the agricultural innovation will affect its utilization, although 32% of the respondents were not sure that the relevance of the innovation will affect its utilization. Another important factor that was considered was end-user attitude towards risk and change, with 45% of the respondents agreeing that this is an important factor while 40% of the respondents were not sure that the end user attitude towards risk and change will affect utilization of innovation.

Table 4. 3 Sustainability of innovations in agricultural research in Uganda (N=34)

	Strongly agree	Agree	Not sure	Disagree	Strongly disagree
A clear plan on how innovations should be done	14	74	12		
Sharing information with colleagues on regular basis	23	68	9		
Bureaucracy is involved in clearing innovations	18	41	29	9	3
Existence of incentives for generating innovations	12	21	35	26	6
A reward system for teams that generate innovations	6	12	56	26	
Tolerance to a certain degree of failure in generating innovations		41	44	15	
Abandoning projects and processes that no longer make a contribution	12	29	44	15	
There is consideration to cost during the process of generating innovations	35	59	6		

For sustainability of agricultural innovations, there are a number of factors to be considered. In agricultural research in Uganda, the results of respondents from NARO are presented in Table 4.3. According to the results, 74% of the respondents agree that the organisation has a clear plan on how agricultural innovations should be generated. Similarly, 68% of respondents agree and 23% of respondents strongly agree that colleagues involved in generating innovations share information regularly. However, among the respondents 41% agree and 18% strongly agree that bureaucracy is involved in clearing innovations within the organisation.

It is important to note what respondents perceive about incentives and a reward system within the organisation concerning generating innovations. Thirty five percent are not sure and 26% disagree that incentives exist within the organisation for generating innovations. Similarly, 56% and 26% of respondents are not sure and disagree that the organisation has a reward system for teams that generate innovations. However, there is a strong agreement that considering costs of generating an innovation is important. For example, results from Table 4.3 indicate that 59% of the respondents agree that considering cost in important while 35% of respondents strongly agree with cost considerations in sustaining agricultural innovations.

Table 4.4 Innovations recommended by agricultural research

1. Agronomy: Timely planting, proper spacing, weed management, fertilizer application
2. New crop variety: variety descriptors, different uses of the variety, yield advantages
3. Disease and pest management: information on resistance to pests and diseases provided, spraying regimes, other disease and pest management practices
4. Value addition: different products that can be made from the variety
5. Seed system: importance of using clean seed, seed storage and handling
6: Appropriate machinery to handle different practices

Agricultural research innovators (respondents) were requested to list the recommended packages of innovations under the commodity of interest. Table 4.4 shows the recommendations (packages) from agricultural research in the areas of agronomy, new crop varieties, disease and pest management, value addition, seed systems, and appropriate machinery among others.

4.2 Relationship of innovation characteristics on the utilization of innovations at farm level

Table 4.5. Agricultural innovations used by farmers on different commodities in Kihiihi sub-county, Kanungu district (N=91)

	Agricultural innovations				
Commodity	New variety	Weed management	Spacing	Mechanisation	Fertilisers
Cassava (30)	56	21	9	35	
Maize (31)	48	7	4	31	39
Rice (30)	54	16	2	31	

At farm level, a profile of agricultural innovations used by farmers was recorded and results are shown in Table 4.5. On cassava, 56% of the respondents were using new crop varieties, 21% were using proper weed management practices and 35% were using agriculture machinery especially during land opening before planting. On maize, 48% of the farmers were using new varieties, 31% using machinery in land opening and shelling of maize and 39% were using agricultural inputs such as fertilisers. On rice, 54% of the farmers were using new varieties, 16% of the farmers were using herbicides in weed management, and 31% of the respondents were using machinery to open up land for planting. It should be noted that the machinery used was in most cases hired as farmers did not personally own the different categories of machinery. Also hiring was not consistent every season.

Table 4.6. Frequency of innovation characteristics reported in different commodities in Kihihi sub-county, Kanungu district

Commodity	**Frequency of observations based on innovation attributes**					
	Relative Advantage	Compatibility	Trialability	Complexity	Quality	**Total**
Cassava	165	275	55	110	55	**660**
Maize	180	299	61	120	60	**720**
Rice	172	283	57	114	57	**683**
Total	**517**	**857**	**173**	**344**	**172**	**2063**

Generally, of the 2063 observations made as shown in Table 4.6, 517 were on relative advantage, 857 on compatibility, 173 on trialability, 344 on complexity and 172 on quality of the innovation. The trend was consistent among the different commodities.

Table 4.7. Chi square table showing relationship between commodity and innovation utilization of respondents in Kihihi sub-county, Kanungu district

	Innovation Utilization					
Commodity	Very low	Low	Moderate	High	Very high	**Total**
Cassava	89	241	196	87	44	**657**
Maize	42	234	273	67	63	**676**
Rice	103	180	165	91	26	**565**
Total	**234**	**655**	**634**	**245**	**133**	**1,899**
Pearson chi^2 (15) = 234.0134 Pr = 0.000						

The Results from Table 4.7 show the relationship between commodity and innovation utilization of farmer respondents in Kihihi sub-county, Kanungu district. From the total 1899 observations made 234,655,630,245,133 utilized innovations at a very low rate, low, moderate, high and very high respectively. Among the 234 who utilized the innovations at a very low stage, 89, 42 and 103 observations were for cassava, maize and rice respectively. Likewise for low utilization, 241, 234 and 180 observations were for cassava, maize and rice respectively. At the moderate level, 196 were for cassava, 273 for maize and 165 for rice. Similarly, at very high level of innovation utilization 44 were for cassava, 63 for maize and 26 were for rice. It is evident from results that innovations were highly utilized in maize than cassava and rice and the relationship between commodity and utilization of innovation was highly significant (Pearson Chi^2 (15) = 234.0134, Pr = 0.000) (Table 4.7).

Table 4.8. Relationship between innovation characteristics and utilization of new variety for cassava, maize and rice in Kihihi sub-county Kanungu district

Commodity	Compatibility	Relative advantage	Complexity	Trialability	Quality	**Total**
Cassava	372	132	36	108	NIL	**648**
Maize	348	60	24	144	144	**720**
Rice	372	120	12	120	NIL	**624**
Total	**1,092**	**312**	**72**	**372**	**144**	**1,992**

Pearson chi^2(21) = 2.5e+03 Pr = 0.000

From Table 4.8 the results indicated that all the three commodities cassava, maize, and rice used new variety as one of the major innovations. The results from Table 4.8 show relationship between innovation characteristic and utilization of new variety for cassava, maize and rice in Kihihi sub-county Kanungu district. Since p value is less than 0.05, this shows that there is a positive significant relationship between commodity and innovation characteristic. According to observations, compatibility (1092) was the highest attribute followed by trialability (372) and relative advantage 312. It should also be noted that relative advantage, compatibility and complexity had a subset of parameters under them.

Table 4.9. The regression results of innovation utilization with a combination of all study parameters

Source	sum of squares (SS)	degrees of freedom (df)	mean squares (MS)
Model	547.41656	10	54.741656
Residual	2717.13291	2051	1.32478445
Total	3264.54947	2061	1.58396384

Number of obs	=	2062
F (10, 2051)	=	41.32
Prob > F	=	0.0000
R-squared	=	0. 6771
Adj R-squared	=	0.7136
Root MSE	=	1.151

Utilization attribute	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
Gender	.1365483	.0538004	2.54	0.011	.0310393	.2420574
Age	-.03589	.0217804	-1.65	0.100	-.078604	.006824
Education	.0617118	.0257539	2.40	0.017	.0112053	.1122183
Commodity	-.2437981	.032519	-7.50	0.000	-.3075718	-.1800243
market attribute	-.0478834	.0263708	-1.82	0.070	-.0995998	.003833
relative advantage	2.384769	.5804827	4.11	0.000	1.246372	3.523166
Compatibility	1.905091	.5795687	3.29	0.001	.7684867	3.041696
Trialability	1.024452	.5846841	1.75	0.080	-.1221842	2.171089
Complexity	-1.042043	.5813884	1.79	0.073	-.0981298	2.182217
Quality	1.807705	.5847275	3.09	0.002	.6609832	2.954426
_cons	.9673114	.590062	1.64	0.101	-.1898718	2.124495

Table 4.9 shows regression results of innovation utilization with a combination of all study parameters. The R^2 of 0.67 is the proportion of the variation in the response that can be explained by the regressors. The adjusted R^2, determines the extent of the variance of the dependent variable which can be explained by the independent variable. The adjusted R^2 of 0.71 shows that the data in the regression equation is a good fit by predicting 71% of the variation in the response variable. Therefore a combination of all the regressors explains 71% of variation in the utilization of given innovation. The results show that among other predictor variables, innovation attributes such as relative advantage, compatibility, trialability, complexity and quality had a significant relationship on utilization of a given innovation of a given a commodity.

Table 4. 10. Relationship between different parameters of relative advantage and frequency of utilization of innovations

	Innovation Utilization					
Parameter	Very low	Low	Moderate	High	Very high	Total
Economic profitability	2	3	11	68	80	*166*
Low initial cost	6	67	64	24	4	*165*
Decrease in discomfort	18	64	66	14		*162*
Total	26	134	141	106	84	493

From Table 4.10, economic profitability of the innovation highly (68) and very highly (80) influence utilization of the innovations. Low initial cost influenced utilization of innovation from low to moderate 64 and 66 observations respectively. The decrease in discomfort had almost a similar trend with low initial cost of the innovation.

Table 4. 11. Relationship between different parameters of compatibility and frequency of utilization of innovations

	Innovation utilization					
Parameter	Very low	Low	Moderate	High	Very high	**Total**
Labour	4	37	94	27	2	**164**
Cropping system	38	31	70	23	2	**164**
Soil type	3	19	130	8	4	**164**
Climate	1	42	101	18	2	**164**
Risk	12	122	25	4	14	**177**
Total	**58**	**251**	**420**	**80**	**24**	**833**

From the results in Table 4.11 compatibility of the innovations with the soil type moderately influenced utilization of innovations with 130 observations, followed by climate with 102 observations. The parameter of risk led to utilization of innovations at a low level with 122 observations.

Table 4. 12. Relationship between different parameters of complexity and frequency of utilization of innovations

			Innovation Utilization			
Parameter	Very low	Low	Moderate	High	Very high	Total
Difficult to understand	13	108	34	5	2	162
Difficult to use	48	67	13	2	2	132
Total	61	175	47	7	4	294

The findings from Table 4.12 about complexity of the innovation indicate that the difficulty to understand an innovation influenced the utilization of innovations to a low level with 108 observations. Similarly difficulty to use also led to very low and low utilization of innovations with 48 and 67 observations.

Table 4.13. The combined effects of relationships of study variables

Number of obs = 2063
Wald chi^2(6) = 233.92
Log likelihood = -3289.9645
Prob > chi2 = 0.0000

Utililzation attribute	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
Gender	0 .1486302	0 .0556394	2.67	0.008	0.039579	0.2576814
Age	-0.0426956	0.0225025	-1.90	0.058	-0.0867996	0.0014084
Education	0.063293	0.0266745	2.37	0.018	0.011012	0.115574
commodity	-0.2431445	0.0336455	-7.23	0.000	-0.3090886	-0.1772005
Innovation attribute	-0.2702627	0.0239429	-11.29	0.000	-0.3171898	-0.2233355
Market attribute	0.0028092	0.0262416	0.11	0.915	-0.0486233	0.0542417
_cons	3.371554	0.1526844	22.08	0.000	3.072298	3.67081
Random-effects	Parameters Estimate		Std. Err.		[95% Conf. Interval]	
var(Residual)	1.421366		0 .0442559		1.33722	1.510807

The mixed effects model combines the effects of different predictor variables. The probability of 0.000 shows that the model is fit and thus combined effects of the variables have an overall significant effect on the response variable (innovation utilization). If all the factors are held constant, there is a 3.37 unit change in the innovation utilization which is brought about by residuals/random effects/extraneous variables (variables not observed in the model). However, a combination of all predictor variables have a significant (p=0.000) explanation of the variation in the response variable. All the observed variables show a significant relationship with the innovation utilization except market attributes (Table 4.13).

4.3 Effect of innovation and market attributes on utilization of innovations in Agriculture

Table 4. 14. Results of Ordered logistic regression of innovation and market attributes on utilization of agricultural innovations

Number of obs = 2061
LR $chi^2(10)$ = 388.64
Prob > chi^2 = 0.0000
Log likelihood= -3115.0552
Pseudo R^2=0.0587

Iteration 0: Log Likelihood = -3309.3744
Iteration 1: Log Likelihood = -3118.4982
Iteration 2: Log Likelihood = -3115.0649
Iteration 3: Log Likelihood = -3115.0552
Iteration 4: Log Likelihood = -3115.0552

Utilization attribute	Coef.	Std. Err.	Z	P>z	[95% Conf.	Interval]
Gender	0.19	0.08	2.30	0.022	0.03	0.36
Age	-0.06	0.03	-1.66	0.096	-0.12	0.01
Education	0.09	0.04	2.26	0.024	0.01	0.17
Commodity	-0.34	0.05	-6.54	0.000	-0.44	-0.24
Market attribute	-0.04	0.04	-0.97	0.332	-0.12	0.04
Relative Advantage	4.65	1.23	3.78	0.000	2.24	7.06
Compatibility	3.93	1.23	3.20	0.001	1.52	6.34
Triability	2.50	1.23	2.03	0.043	0.08	4.91
Complexity	-2.52	1.23	2.05	0.040	0.11	4.93
Quality	3.96	1.24	3.18	0.001	1.52	6.39
/cut1	0.59			1.23	-1.83	3.01
/cut2	1.69			1.24	-0.73	4.11
/cut3	3.38			1.24	0.96	5.81
/cut4	5.01			1.24	2.58	7.44
/cut5	6.26			1.24	3.83	8.69

Table 4.14 shows results of ordered logistic regression of innovation and market attributes on utilization of innovations in agriculture. The model p-value of 0.000 shows that the model is statistically significant and was well fitted with the explanatory variables compared to an empty model. The model stabilized at iteration 4, with the log likelihood of -3115.0552. The cut 1 up to cut 5 are just ancillary parameters and thus don't have to be interpreted. The pseudo-R^2 is positive which measures the predictive strength of a model relating the logistic responses to some covariates. Note that the positive pseudo-R^2 observed indicates more significant covariates were included in the model such that if a significant variable is dropped, the pseudo-R^2 tends to reduce. The coefficient values indicate the expected change in the log odds of the response variable due to one unit change in the predictor variable. The log odds is the natural log of odds

where odds is the probability that an event will occur divided by the probability that the event will not occur that is probability(success) / probability(failure).

All factors analyzed in the logistic model except market attributes showed a significant effect on utilization of innovations with $p<0.05$. Gender had a positive significant effect on innovation utilization. Movement from male to female increases the log odds of innovation utilization by 0.19 from very low to very high holding other factors constant. The age of respondents has a negative significant effect on the utilization of innovation, implying if other factors are held constant, increasing in the number of years reduces the log odds of utilizing a given innovation by 0.06.

Education had a positive significant effect on utilization of innovation such that increasing the level of education increases the log odds of innovation utilization by 0.09 from very low to very high. Commodity had a negative significant effect on innovation utilization *ceteris paribus*. Moving from commodity 1 (cassava) to commodity 3 (rice) reduced the log odds of innovation utilization by 0.39 from very high to very low.

The innovation characteristics in form of relative advantage, compatibility, trialability, and quality had a positive significant effect on innovation utilization while complexity had a negative significant effect. Holding other factors constant, improvement in a given innovation characteristic increases the log odds of innovation utilization by the given coefficient value from very low to very high. For example, relative advantage increases the log odds of innovation utilization by 4.65, compatibility by 3.93, trialability by 2.5, and quality by 3.96 (Table 4.14).

Table 4. 15. Frequency of market attributes with commodities and the level of utilization of the innovations in Kihiihi sub-county, Kanungu district

		Utilization of innovation					
Market Attribute	Commodity	Very low	Low	Moderate	High	Very high	Grand Total
Demand of innovation	Cassava	1	1	4	13	21	41
	Maize	3		4	10	24	41
	Rice			4	28	24	56
Profitability	Cassava	3	35	23	33	32	126
	Maize	4	19	41	22	36	122
	Rice	1	51	25	71	23	171
Market share	Cassava	1	4	27	37	14	83
	Maize	2	6	27	19	27	81
	Rice		1	35	71	4	111
Grand Total		15	117	190	304	205	832

Table 4.15 shows the frequency of market attributes with commodities and the level of utilization of the innovations in Kihiihi sub-county, Kanungu district. Considering the demand of an innovation as it affects the utilization of new varieties on cassava, out of 41 observations 21 and 13 were considered to affect utilization of innovation as very high and high respectively. The trend was similar with other commodities maize and rice for the market attribute and utilization of the innovation.

The respondents suggested that the profitability and market share affected the level of utilization of rice more than maize and cassava. For example 71 out of 171 observations indicated that the profitability of rice affected highly the utilization of new rice varieties while 71 out of 111 observations indicated that the market share highly influenced the utilization of rice innovations.

CHAPTER FIVE

DISCUSSION, SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The study investigated agricultural innovation characteristics and their utilization; A Case of National Agricultural Research Organisation (NARO). This study was interested in establishing why there was limited adoption/utilization of innovations in agriculture by end-users despite the existence and awareness of the innovations. Therefore, the study aimed at establishing factors influencing development of innovations in agricultural research, determining the effect of innovation characteristics on the utilization of innovations at farm level, and examining the effect of demand (market) on utilization of innovations in agriculture. This chapter discusses the findings reported in chapter four, draws conclusions, suggests recommendations and proposes some areas for further research.

5.2 Discussion of findings

5.2.1 Factors influencing development of innovations in agricultural research

The results on Table 4.1 indicate that all the NARO staffs interviewed were involved in generation of agricultural innovations on cassava, maize, rice and agricultural machinery. For example, 68%, 64% and 62% of the respondents agree that they are involved in developing new protocols, improving existing technologies and developing new processes. The results show that staff activities are aligned with the NARO mission "To innovate for sustainable agricultural transformation" which focuses on developing and promoting technologies and innovations for agricultural transformation through creating businesses that generate revenue for the organisation (NARO, 2018).

However, in order for the innovations to be adopted / utilized, they need to address the needs of the end-user. Therefore, one of the areas of concern for this research was whether innovators in agriculture consider the needs of their clients. The researchers were interviewed on factors they would consider before generating innovations in agriculture. The results are presented in Table 4.2. The results indicated that 30% of the respondents were not sure while 25% disagreed that it is important to consider the difficulty in understanding the innovation by the end-user. In a study by Abebe *et al*. (2013), farmers perceived that improved potato varieties are difficult to use because they require intensive crop management regimes than local varieties and this affected adoption of new potato varieties. It is therefore important that innovation developers understand their clients through participatory rural appraisals, market surveys and baseline studies to understand client needs. Nevertheless, access to wider information helps to broaden farmers' understandings of new technologies (Abebe *et al*., 2013) although this could increase costs through promotional programmes of innovations.

Similarly 40% of the respondents were not sure that it is important to consider end-user attitude towards risk and change. However, according to Guerin and Guerin (1994) end-user attitude towards risk and change will affect adoption of innovations. Therefore, innovation developers should consider taking into consideration the end user attitude towards a new innovation before investing resources into technology development.

Otherwise from Table 4.1 respondents agreed that it is important to consider the cost, relevance, and end-user opinion of innovations as important determinants of developing agricultural innovations. This is in agreement with existing information (Guerin and Guerin, 1994; Katungi and Akankwasa, 2010). In a study on management of bacterial wilt disease on bananas, the end-users perceived effectiveness of the disease management practices significantly affected the adoption of the practices (Jogo *et al*., 2013).

Another important factor to consider as determinant of developing agricultural innovations concerns sustainability. Table 4.3 shows results on some of the parameters that were considered in order to sustain development of innovations. The respondents (41% agree and 18% strongly agree) that there is bureaucracy in clearing innovations in agriculture research, (31% not sure and 26% disagree) that incentives exist within the organisation, (56% not sure and 26% disagree) that there is a reward system for teams that generate innovations within the organisation.

Bureaucracy can promote or discourage innovation depending on the culture and environment of the organisation. Dyer and Dyer (1965) suggested that innovation can occur in organisation if some rigidities in bureaucracy are overcome. The authors suggested that one way of avoiding rigidities is not to suppress information flow. From this research (Table 4.3) there is a perception among respondents that there is free exchange of information among developers of agricultural innovations. Therefore, it can be postulated that in the organisation, bureaucracy does not suppress innovation. There are structures within the organisation (scientific committees, top management, planning and reviewing committees) which align and prioritize resources as research innovations are cleared. In my opinion this has been effective as shown by the number of high innovations generated by the organisation (NARO, 2018).

Fontana *et al*. (2015) reported that incentives can spur innovation among staff. From this study it is perceived that there are inadequate incentives and rewards to motivate staff carry out innovations. However, there are incentives such as promotions within the organisation that are based on staff performance. One of the criteria of promotions is number of innovations generated and published. It is possible that some staffs are expecting other incentives and rewards. Recently the organisation developed policies (such as the Intellectual Property), among other national policies that recognize inventors rights and patents under a benefit sharing arrangement between the individuals involved and the organisation. It is very important for the organisation at this time to pursue the implementation and access of benefits so that the staffs get motivated to carry out more innovations.

From Table 4.4 it was clear researchers had clear recommendations to improve agriculture productivity. However from the end-users point of view, farmers were not clear about the recommended packages. The end users were mainly aware of new varieties. This implies that the end-users do not receive the innovations as a package. This could possibly explain the constant low productivity levels at farm level despite the existence of technological innovations from research institutes to enhance agricultural productivity. There is need to clearly understand the technology pathway from developers to end-users.

5.2.2 Relationship of innovation characteristics and the utilization of innovations at farm level

The results from Table 4.6 indicate that respondents chose innovations based on compatibility (857), relative advantage (517), complexity (344), trialability (173) and quality (172) in that order. This implies that although all the characteristics are important in relation to utilization of innovations, their relative importance differs. Table 4.10 shows that among the relative advantage parameters economic profitability highly (68 observations) and very highly (80 observations) influenced utilization of innovations. This is in agreement with Mugula and

Mishili (2018) who reported that a decision to adopt sustainable agricultural practices was largely influenced by the profit margin between different practices and that a farmer was likely to adopt sustainable agricultural practices after comparing the returns obtained to a number of agriculture practices. Similar results were reported by Liao and Lu (2008) who studied the relative advantage of Integrated Pest Management (IPM) practices and found that additional IPM practices benefits such as economic profitability, decreasing production cost and effort saving influence farmers' decision to adopt an innovation. Therefore it is very important for agricultural researchers involved in generating innovations to consider the economic returns from the innovations.

Table 4.11 shows that soil type and climate led to moderate level of utilization of agricultural innovations. Innovation end-users are interested in having innovations that are compatible with their farming systems. For example the farmers expect to have new varieties that are adapted to marginal soils, and drought among other harsh environmental conditions. Similarly as risky innovations such as those that are susceptible to pests and diseases were associated with low utilization of innovations. In case an agricultural innovation is incompatible with the grower's farming system, it will not be adopted as rapidly as an innovation that is compatible. For example, a study by Sarel and Marmorstein (2003) showed significantly positive relationship between compatibility and perception for adoption. Thus, compatibility is an important part of innovation.

The difficulty to understand an innovation can cause low levels of utilization of an innovation as shown in Table 4.12. The results agree with similar works by (Rogers, 2003; Sarel and Marmorstein, 2003).who reported that a low level of complexity led to higher adoption rate and complexity increased the rate of rejection.

Overall, Tables 4.9 and Table 4.13 summarise the relationships between innovation and market attributes on the utilization of innovations on cassava, maize and rice in Kihihi Sub County, Kanungu district. The adjusted R2, of 0.71 shows that among other predictor variables, innovation attributes such as relative advantage, compatibility, Trialability, Complexity and Quality had a significant relationship on utilization of a given innovation of a given a commodity. The results from the mixed effects model (Table 4.13) all predictor variables have a significant (p=0.000) relationship with the innovation utilization except market attributes.

5.2.3 Effect of innovation characteristics and market attributes on utilization of innovations in Agriculture

All innovation attributes had a positive significant effect on utilization of innovations implying that improvement in a given innovation attribute increases the log odds of innovation utilization by the given coefficient value from very low to very high. On the other hand, complexity had a negative significant effect (Table 4.14). These results agree with what has been reported about innovation characteristics (Kolodinsky *et al*., 2004; Sarel and Marmorstein, 2003; Rogers 2003). This implies that to enhance adoption/utilization of innovations the developers/generators should take into consideration the innovation characteristics. Innovators should try to ensure that their products are easily adaptable to the life styles of their clients.

Although market attributes did not significantly have an effect of utilization of innovations according to the ordered logistic regression model, results in Table 4.15 shows that profitability and market share influenced more of the utilization of innovations on rice than on maize and cassava. This could be due to the fact that rice is more of a commercial crop than maize and cassava. Besides there is a lot of price fluctuation in maize prices than for rice.

Other significant effects include gender, age and education level. The effect of gender is ascribed to the fact that female involvement in intervention has proven success due to maximum human resource participation and utility. For age it could be attributed to the fact that aging may result in losing interest to utilization of innovations, while education could be associated with the fact that increase in education increases the chances of technical know-how of utilizing emerging innovations.

5.3 Summary of findings

5.3.1 Factors influencing development of Innovations in Agricultural research

The results are presented in Tables (4.1, 4.2, 4.3 and 4.4) which indicated that there was a great involvement of respondents from National Agricultural research Organisation in generation of agricultural innovations. However, the results indicated that most of the respondents did not consider the difficulty in understanding the innovation by the end-user a d end-user attitude towards risk and change as important determinants of generating innovations. Nevertheless, respondents agreed that it is important to consider the cost, relevance, and end-user opinion of innovations as important determinants of developing innovations. Also to sustain agricultural research innovations, respondents agreed that the organisation has mechanisms of sustaining innovations such as having a clear plan of innovations, cost considerations of innovations among others although respondents noted that the organisation was weak on incentives and reward systems to motivate the innovators.

5.3.2 Relationship of innovation characteristics and the utilization of innovations at farm level

The results are presented in Tables 4.5, 4.6, 4.7, 4.8, 4,9, 4.10, 4.11, 4.12 and 4.13. The innovation characteristics in order of importance in relation to utilization of innovations were compatibility, relative advantage, complexity, trialability and quality in that order. Among relative advantage parameters economic profitability highly influenced utilization of innovations. The practices that such as soil type, climate and associated risks were associated with utilization of innovations among the compatibility characteristics. The difficulty to understand an innovation can cause low levels of utilization of an innovation as shown in Table 4.13. Generally Tables 4.9 and 4.13 analysed the relationships in detail and indicate that there is a significant relationship between innovation characteristics and utilization of innovations.

5.3.3 Effect of innovation and market attributes on utilization of innovations in Agriculture

The results are presented in Tables 4.14 and 4.15. Innovation characteristics (relative advantage, compatibility, trialability and quality had a positive significant effect on utilization of innovations. However, complexity had a negative significant effect on utilization of innovations. Although market attributes did not have a significant effect on utilization of innovations profitability and market share influenced more of the utilization of innovations on rice than on maize and cassava.

5.4 Conclusion

The study was initiated to assess agricultural innovation characteristics and their utilization in agricultural research in Uganda using a case of the National Agricultural Research Organisation with the three main objectives:

i. To establish the factors that influence development of agricultural innovations.

ii. To determine the relationship between agricultural innovation characteristics and utilization of innovations at farm level.

iii. To examine the effect of market attributes on utilization of innovations in agriculture.

In order to establish factors that influence development of agricultural innovations several approaches were used. In one of the approaches the respondents that were involved in agricultural research were given a chance to validate the agricultural innovations that they were involved in. These were generation of new crop varieties, development of protocols, improving existing technologies, and designing new process. There was an agreement (strong and very strong) that the respondents were involved in these activities. On the factors to be considered by respondents before embarking on generating innovations, cost of innovation, end user belief/opinion, relevance of the innovation came out strongly from the respondents. However, there was mixed feelings among respondents on other factors such as the difficulty in understanding the innovation and end-user attitude towards risk and change. Finally, respondents were given an opportunity to give their opinions on how the organisation sustains the momentum of innovations. It came out clearly that there is a clear plan on how innovations should be done, there is sharing information with colleagues on regular basis, bureaucracy/structures are involved in clearing innovations, there is tolerance to a certain degree of failure, and projects that no longer make a contribution can easily be abandoned. However, it was pointed out that the organisation does not have enough incentives ad a clear reward system to motivate the staffs that are involved in generating agricultural innovations.

The study also set put to establish the relationship between innovation characteristics and the utilization of innovations. The results from this investigation indicate that respondents chose innovations based on compatibility, relative advantage, complexity, trialability and quality in that order. The results also indicated that the respondents utilized innovations at different rates ranging from very low to very high and the differences were highly significant. The results indicated that there was a significant relationship between innovation characteristics and utilization of innovations by the farming community in Kihiihi sub-county, Kanungu district. Finally it was also interesting to note that innovations were highly utilized in maize than cassava and rice.

The final objective was to determine the effect of innovation and demand (market) attribute on the utilization of innovations. The results indicated that all innovation characteristics except complexity had a positive significant effect on utilization of innovations. One of the attributes, complexity had a negative significant effect. Although market attributes did not significantly have an effect of utilization of innovations according to the ordered logistic regression model, profitability and market share influenced more of the utilization of innovations on rice than on maize and cassava.

5.5 Recommendations

Based on the study findings, the researcher makes the following recommendation:

1. Before initiating any programme on generation of agricultural innovations, agricultural researchers should carry out a needs assessment through participatory rural appraisals, market surveys and baseline studies to understand client needs. The identified needs should guide the generation of innovations.

2. There is need to motivate staff and teams involved in generation of agricultural innovations. From this study it was perceived that there are inadequate incentives and rewards to motivate staff to carry out innovations. It is necessary for the organisation to address the issue of benefits so that the staff can get motivated to carry out more innovations.

3. The disparity between what is recommended by agricultural researcher and what the end-users apply indicates a need for further studies to identify the gaps and understand the challenges within the innovation pathway from research to end-users.

4. In order to enhance adoption/utilization of innovations the developers/generators should take into consideration the innovation characteristics. Innovators should ensure that their products are easily adaptable to the life styles of their clients.

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APPENDIX I. A QUESTIONNAIRE FOR RESPONDENTS

Questionnaire for NARO staff

I am a final year student at Kabale University conducting a purely academic research on **Adoption of Business Innovations in Agricultural Research in Uganda. A Case of National Agricultural Research Organisation**. This is partial requirement for the award of a degree of Masters of Business Administration of Kabale University. The responses provided in this study will be treated with utmost confidentiality and only used for academic purposes.

Thank you in advance

Section A. General information

1. Gender: Male […….] Female [………]

2. Age group

a) 18-24 b) 25-29 c) 30-39 d) 40-49 e) 50 and above

3. Highest qualification attained

a) Diploma b) First degree c) Masters degree d) Doctor of Philosophy

4. Name of institute ………………………………………………………………………..

5. What is your designation in National Agricultural Research Organisation

………………………………………………………………………………………

6. For how long have you worked with the organisation?

a) Less than 1 year [ ] b) between 1 yr&6 years [ ] c) 6 to 10 years [ ] d) More than 10 years]

In the following section, tick in the appropriate space to give your opinion on the claims given below

5 = Strongly Agree 4 = Agree 3 = Not sure 2 = Disagree 1 = Strongly Disagree

SN	Claims	5	4	3	2	1
	a) Business innovations in Agriculture					
1.	I am involved in generation of new crop varieties					
2.	I am involved in developing new products besides crop varieties					
3.	I participate in developing new protocols					
4.	I often participate in improving existing technologies					
5.	I often participate in designing new processes					
6.	Others (specify)					
	b) Consideration for business innovations	**5**	**4**	**3**	**2**	**1**

7.	Difficulty of innovation to understand or use					
8.	Cost of innovation					
9.	End-user belief/opinion towards innovation					
10.	Relevance of the innovation					
11.	End-user attitude towards risk and change					
12.	Others (specify)					
c) Sustainability of business innovations in agricultural research		**5**	**4**	**3**	**2**	**1**
13.	In the organisation we have a clear plan on how innovations should be done					
14.	We share information with colleagues on regular basis					
15.	Bureaucracy is involved in clearing innovations					
16.	Incentives for generating innovations exist in the organisation					
17.	There is a reward system for teams that generate innovations					
18.	There is tolerance to a certain degree of failure in generating innovations					
19.	Projects and processes that no longer make a contribution are easily abandoned					
20.	There is consideration to cost during the process of generating innovations					

7. List the recommended packages of innovations under the commodity of interest (Maize, rice and cassava)

1

2

3

4

5.

Thank you for your time

Household survey questionnaire

I am a final year student at Kabale University conducting a purely academic research on **Adoption of Business Innovations in Agricultural Research in Uganda. A Case of National Agricultural Research Organisation**. This is partial requirement for the award of a degree of Masters of Business Administration of Kabale University. The responses provided in this study will be treated with utmost confidentiality and only used for academic purposes.

Thank you in advance

1. Gender: Male […….] Female [………]

2. Age group

a) 18-24 b) 25-29 c) 30-39 d) 40-49 e) 50 and above

3. Highest qualification attained

a) None b) primary level c) ordinary level d) Diploma e) First degree f) Masters degree g) Doctor of Philosophy

4. Have you utilized any innovations from NARO on cassava, rice and Maize? ………….

5. List the innovations that you have utilized and rank them according to use.

a) .
b) .
c) .
d) .
e) .
f) .
g) .
h) .

6. Please fill the table below, while comparing the top three NARO technologies you are utilizing with the existing ones using the parameters and scale given below:

5 = Very high   4 = High   3 = Moderate   2=Low   1 =Very low

Innovation attributes

Innovation	**Attribute/characteristic**	**Description of attribute**	***Utilization(Percent use, percent coverage)***				
			5	4	3	2	1
	Relative advantage	Degree of economic profitability					
		Low initial cost					
		Decrease discomfort and effort					
	Compatibility	Labour					
		Cropping system					
		Soil type					
		Climate					
		Risk					
	Triability	Degree of experimentation on a limited scale					
	Complexity	Difficulty to understand					
		Difficulty to use					
____________	**Quality**	Quality of the product					
	Relative advantage	Degree of economic profitability					
		Low initial cost					
		Decrease discomfort and effort					
	Compatibility	Labour					
		Cropping system					
		Soil type					
		Climate					
		Risk					
	Triability	Degree of experimentation on a limited scale					
	Complexity	Difficulty to understand					
		Difficulty to use					
	Quality	Quality of the product					

Innovation	Attribute/characteristic	Description of attribute	*Utilization(Percent use, percent coverage)*				
			5	**4**	**3**	**2**	**1**
	Relative advantage	**Degree of economic profitability**					
		Low initial cost					
		Decrease discomfort and effort					
	Compatibility	**Labour**					
		Cropping system					
		Soil type					
		Climate					
		Risk					
	Triability	**Degree of experimentation on a limited scale**					
	Complexity	**Difficulty to understand**					
		Difficulty to use					
	Quality	**Quality of the product**					

Market Attributes

Innovation	Market attribute	Description of attribute	*Utilization(Percent use and percent coverage)*				
			5	4	3	2	1
	Demand of innovation	Demand for innovation					
	Profitability	Price of the innovation					
		Expected returns					
		Level of risk					
	Market share	Awareness of innovation					
		Able to be trusted					
	Demand of innovation	Demand for innovation					
	Profitability	Price of the innovation					
		Expected returns					
		Level of risk					
	Market share	Awareness of innovation					
		Able to be trusted					
	Demand of innovation	Demand for innovation					
	Profitability	Price of the innovation					
		Expected returns					
		Level of risk					
	Market share	Awareness of innovation					
		Able to be trusted					

APPENDIX II. KREJCIE AND MORGAN (1970) TABLE FOR DETERMINING SAMPLE SIZE

Table 1: Table for Determining Sample Size for a Finite Population

N	*S*	*N*	*S*	*N*	*S*
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	1000000	384

Note.—*N* is population size. *S* is sample size.

Source: Krejcie & Morgan, 1970