INFLUENCE OF TECHNOLOGY-RELATED FACTORS ON USAGE OF e-EXTENSION SERVICES AMONG SMALLHOLDER FARMERS IN NAKURU COUNTY, KENYA

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DECLARATION AND RECOMMENDATION

Declaration

I hereby declare that this thesis is my original work and has not been presented in part or as a whole for any academic award in any university.

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Recommendation

This thesis has been submitted for examination with our approval as University Supervisors.

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DEDICATION

I dedicate this work to my late parents Daniel and Hellen Kirui, daughter Kelsy Chebet and Siblings Florence, Leonard and Peter.

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ABSTRACT

Agricultural extension is a critical agent for transforming subsistence farming to modern and commercial agriculture through the dissemination of agricultural information to farmers. Despite this, extension services are still limited in most parts of the Kenya. This has necessitated a move towards more innovative methods of extension service delivery for effective coverage by the Government of Kenya through the introduction of ICT-based e-Extension programme. The adoption and usage of ICTs in accessing agricultural information among farmers remain low. This has been attributed to socio-economic, cultural and technological factors. The overall objective of this study therefore, was to establish the influence of technology-related factors on usage of e-Extension services among smallholder farmers in Nakuru County, Kenya. Descriptive survey research design was used in the study whereby questionnaires and focus group discussion guides were used to collect data from 130 smallholder farmers, 25 extension agents and three focus group discussions held with eight participants each. The face and content validity of the instruments were examined by five experts from the Department of Agricultural Education and Extension, Egerton University.The questionnaires were piloted and reliability coefficients were 0.87 and 0.71 respectively. Statistical Package for Social Sciences (SPSS) was used for data analysis. Descriptive statistics, namely frequencies, percentages, means and standard deviation were used to describe and summarize qualitative data. Ordinal logistic regression and Chi square tests were used to test the hypotheses at $\alpha = 0.05$ level of significance. Results of hypotheses testing indicated that access to ICTs and ICT skills of farmers' influences usage of e-Extension services among smallholder farmers. Furthermore, the study established that availability and characteristics of digital content had an influence on usage of e-Extension services. In addition, the findings of the study indicated that the type of e-platforms had a significant influence on the usage of e-Extension services. This study therefore, concludes that e-Extension services can be used to complement other extension methods in dissemination of agricultural information to smallholder farmers. The study recommends that for this to be achieved there is need for national and county governments to invest in the development of ICT skills of farmers as well as coordination and regulation of available agricultural digital content. It also recommends partnership between the national government, county governments and other stakeholders in the provision of e-Extension services. The County government of Nakuru should also create awareness and sensitize of farmers on the availability of e-Extension services through the Nakuru Farmer Call Center (NFCC).

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LIST OF ABBREVIATIONS AND ACRONYMS

FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GIS	Geographical Information System
GOK	Government of Kenya
ICTs	Information Communication Technologies
MOALF&C	Ministry of Agriculture, Livestock and Fisheries and Co-operatives
NAFIS	National Farmers Information Service
NCIDP	Nakuru County Integrated Development Plan
NFCC	Nakuru Farmer Call Centre
NGO	Non-Governmental Organization
SMS	Short Messaging Service
SIM	Subscriber Identification Module
UNECA	United Nations Economic Commission for Africa
USSD	Unstructured Supplementary Service Data

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The world's population is projected to hit 9 billion by 2050. Agriculture need to increase its production to meet the growing demand and ensure food security for all. Most of the increase in food production will have to take place in developing countries (Food and Agriculture Organization [FAO], 2017a). African countries rely heavily on the agricultural sector as the mainstream for economic growth, employment creation and foreign exchange earnings. In 2020, agriculture was the main driver of East Africa's economy accounting for 0.6 percentage point of the region's 0.7 percent economic growth (East Africa Economic Outlook, 2021). The sector also employs 90 percent of the rural workforce, contributes 40 percent of the total export earnings as well as providing over 50 percent of household needs (World Bank, 2017a). There are approximately 1.5 billion smallholder contributing 80 percent of the food in many developing countries. Given their numbers, their importance to their local economies and their vulnerability, support for smallholder farmers is essential to improving food and nutrition security, climate change resilience, and reducing poverty worldwide.

The success of agriculture and rural development has been attributed to the actions of the millions of smallholder farmers whose decisions are influenced by the information, technologies and knowledge at their disposal (FAO, 2015). Despite this fact, these farmers tend to be under-resourced and lacking access to improved inputs, rural services and markets which leads to low agricultural productivity and hence lacking the opportunity to break the cycle of poverty. Smallholders in many developing countries remain disadvantaged when it comes to accessing quality Extension and Advisory Services (EAS) (Davis & Franzel, 2018; Glendenning et al., 2010).

Kenya's agriculture sector contributes 51 percent of Gross Domestic Product (26 percent directly and 25 percent indirectly) and accounts for 60 percent of employment and 65 percent of exports (World Bank, 2018). This source further indicates that the growth of the Kenyan agricultural sector accounted for the largest share of poverty reduction between 2005 and 2015. Despite the country identifying agriculture to deliver sustainable economic growth and improved livelihoods for the poor in rural areas in the strategic plan Kenya Vision 2030, the

sector continues to face several constraints at the global, regional and national level that require special attention (Koome & Wanjohi, 2017). The sector is majorly dominated by smallholder farming systems carried out on farms of between 0.2 and 3 hectares. This accounts for 78 percent of total agricultural production and 70 percent of marketed produce (Birch, 2018). Millions of these farmers are confronted by constraints such as poor access to markets and financial services, low levels of human and physical capital, poor access to education and weak information flows (FAO, 2017a). Among the factors that have led to low agricultural productivity is lack of agricultural information, a factor which has the potential to increase farm productivity by up to 6% (ibid). One of the main sources of information for farmers in Kenya has been the public agricultural extension service (Wanyama et al., 2016).

The Kenyan agricultural extension system has been undergoing gradual evolution from top down to bottom up approaches, from conventional to participatory approaches and from face to face to ICT-based extension communication methods (GOK, 2012). Until the late 1980s, public extension service was well staffed up to the grass root level, and adequately facilitated to perform its duties. However, there has been a decline in the staffing and facilitation of public sector extension over the years due to reduced funding for operations and maintenance and freeze of employment of extension workers. In addition, following devolution, agricultural extension services have also not been readily available due to high cost of extension service delivery, inability of farmers to make follow-ups on technologies delivered and institutional rigidities where the extension agent has to deliver information in person (Otieno, 2018). Available data shows that, extension agent to farmer ratio in Kenya is estimated at 1: 1,500 against the FAO recommended ratio of 1:400 which indicates a constraint in the effectiveness of extension service delivery in terms of reaching many and diverse farmers when and where they require the services (Michura, 2016; World Bank, 2019). There has been an increase in the demand for agricultural information among farmers as a result of technological advancement and climate change conditions.(Wanyama et al., 2016). This demand calls for innovative approaches in agricultural extension service delivery.

One of the innovative and cost-effective ways of bridging the gap of reaching large number of farmers is using information communication technologies (ICTs). The development of ICTs has facilitated the dissemination of knowledge, skills, technologies and information in all aspects of agriculture and food systems which has been identified as a major driver of economic growth (FAO, 2017b). According to the source new opportunities to address the

challenges faced by agriculture have been provided by ICTs. For instance, increasing use of mobile phones for information exchange is now a common practice. Therefore, ICTs can bridge the information gaps. Haruna and Baba (2017) posits that in the 21st century, information dissemination and retrieval depend largely on the ability of one to access and utilize the internet effectively through the use of various technological means. As noted by Naruka et al. (2017), timeliness of agricultural information is very crucial to farmers' success because they need to be provided with the information at the right time so as to apply that information in their farming activities across the food systems. Access to reliable, timely, and relevant agricultural information can help significantly and in many ways to reduce farmer's risks and uncertainty, empowering them to make good decisions (Mittal & Mehar, 2013). ICT's facilitate the availability and accessibility of information to smallholder farmers and reduce the cost of sharing and disseminating information (Okello et al., 2014). Barguma and Ndaghu (2014), argue that unlike the traditional agricultural information dissemination methods, ICT tools have the benefit of offering a cheaper way of communicating and sharing knowledge and information to farmers in the fastest way; delivering training and education modules to farmers; and improving farmers' access to markets and credit. Moreover, ICT tools empower farmers to negotiate better prices and facilitate and strengthen farmer networking (Barghuma & Ndaghu, 2014). In addition, Okello et al. (2014) also argue that farmers can apply ICTs to enhance access to information across all the agricultural food systems by matching cropping practices to climatic trends, use inputs and resources optimally, and ensure good farming practices through improved breeds, feeds and farm management.

According to Mansour (2013), the application of ICTs in agricultural extension systems, and delivery of agricultural information to users on the internet network has led to the emergence of the electronic agricultural extension (e-Extension). e-Extension system relies on ICT's like mobile phone, radio and television programs, mobile phones in combination with radio, video shows, information kiosks, web portals among others (Asenso-Okyere & Mekonnen, 2012). ICT based agricultural extension brings incredible opportunities and has the potential of enabling the empowerment of farming communities (ibid). According to Gichamba et al. (2017), e-Extension system enables extension officers to reach out to farmers using more efficient alternatives to traditional extension system of agriculture using platforms like Short Messaging Service (SMS), Interactive Voice Response (IVR), downloadable applications, Unstructured Supplementary Service Data (USSD) and mobile web and most services would

be duplicated across different technologies in order to accommodate a larger clientele given the wide array of mobile devices among the target users. This helps to increase productivity, profitability and global competitiveness. Some approaches enables farmer to respond to or request from the provider which supports two-way interaction (Barber et. al., 2016). e-Extension services can speed up the process of agricultural technology transfer from research to farmers and improve adoption of agricultural technologies by supporting farmer learning, problem solving and accessibility to profitable markets for their crops (Munyua et al., 2009).

Research findings reveal that ICTs do improve the profitability and livelihoods of poor smallholder farmers (World Bank, 2011). Qianget et al. (2011) further argues that, text messaging services or websites has the potential to increase smallholder farmers' access to market links, distribution channels, finance services and extension services which were not there before. Dannenberg and Nduru (2013) also elaborate that the usage of mobile phones can support farmers in linking up with local organizations in order to access knowledge and fulfill the process requirements of their respective buyers. Covid -19 pandemic also has shown that provision of extension service still remains critical for immediate response to farmers' needs which has now become a challenge due to government regulations such as lockdowns. A shift towards digitization of agricultural extension and advisory services has therefore, become very handy during the pandemic period where farmers need to cope with delays in access or unavailability of inputs, labor and markets and at the same time adapting to the health emergency, government regulations and health protocols (Even & Nyathi, 2020).

Kenya like the rest of the word is undergoing digital revolution with the Covid -19 pandemic having presented a weakness in the Kenyan food systems highlighting the need for access to ICTs and digital connectivity for all. The Kenyan government has embraced interventions to promote ICTs use in agriculture through its wide-ranging digital applications opportunities and analytics in agriculture which is envisioned under the Agricultural Sector Transformation and Growth Strategy (ASTGS) 2019-2029. The targets of ASTGS included creation of digital products such as ICT-enabled extension agents, digitally trained youth extension agents, digitization of existing data in the agriculture sector, real-time data collection systems, digitally developed platforms to provide services to farmers and digital subsidy registration and stock monitoring delivery system (MoALF& C, 2019).These advancements have seen the introduction of e-Extension programme through the Ministry of Agriculture, Livestock,

Fisheries and Co-operatives (MOALF&C). The progamme was introduced nationally by the government of Kenya in 2014, to support agricultural extension services in the country. The Ministry of Agriculture trained 654 e-Extension agents nationally and each equipped with a smart phone, a laptop and modem to enable them to reach farmers effectively. Through an innovative approach of using SMS, farmer training, WhatsApp messaging tools and farmer visits, extension agents are placed at the county and ward levels and use a push and pull technique to disseminate agricultural information to farmers (Rono, 2013). It is a cost sharing approach where farmers have to incur cost in the form of airtime to be able to make calls or send SMS inquiries. The aim of e-Extension services was to complement the traditional extension channels used to disseminate information to farmers. The programme was expected to use bulk SMS and internet by overstretched extension staff to reach more farmers, provide highly captivative and interactive packages, partner with other stakeholders in development of content and capacity and to improve ability to access and share knowledge and skills on farming technologies among extension agents and farmers (ibid).

Despite rapid spread of ICTs, their use still faces challenges like affordability, ease of use, accessibility, scalability, and availability of relevant and localized content in an appropriate language (Saravanan, 2010). Social interactions still dominate the agricultural information systems of most rural areas of developing world Kenya included, where farmers rely on interactions among themselves to get crucial agricultural information (Centre for Agriculture and Biosciences International, 2014; Nain et al., 2015;). Low level of utilization of ICT's in Kenya, has been found to be influenced by a number of factors. These include low information literacy, lack of sufficient government involvement, lack of access to ICT's, lack of sufficient training, lack of ICT proficiency, lack of benefit awareness, difficulty in use, lack of appropriate technological infrastructure, the cost of technology, lack of trust in the ICTs and system complexity all of which have limited the use of ICT's among farmers in one way or the other (Thiga, 2013). An assessment study carried out by Agricultural Information Resource Centre (AIRC) in Kenya in 2015 to gauge e-Extension adoption in various counties observed that majority of the counties did not get the required support from the county governments to implement the e-Extension programme. Notably, in Nakuru County, extension agents had embraced e-Extension services and indicated that it had reduced the overall cost of extension in their respective sub counties (Agili & Rono, 2015). The County has also gone a step further to relaunch e-Extension services, which are offered to farmers through the Nakuru Farmer Call Centre (NFCC). The center provides farmers with e-

Extension services through use of SMS, mobile calls and social media platforms. The initiatives could go a long way in filling the gaps in extension service delivery in the county were the extension to farmer ratio stands at 1:779 which is way higher that the FAO recommended ratio of 1:400 (World Bank, 2019). The factors that influence use of ICTs in accessing agricultural information among farmers are socio-economic, cultural or technological related (Jose & Lokeswari, 2018). Most studies that have been done to explain the low adoption of ICTs among smallholder farmers have mainly focused on the socioeconomic factors (Abebe et al., 2018; Alavion et al., 2017; Benard et al., 2019; Fahad et al., 2017; Marwa et al., 2020; Mittal, 2015; Sam, 2016) with limited consideration on technology-related factors and its influence on the use of ICTs being among the possible causes. This study aimed at filling this gap by establishing the influence of technology-related factors on usage of e-Extension services among smallholder farmers in Nakuru County, Kenya.

1.2 Statement of the Problem

Smallholder farmers in Kenya have over the years experienced low agricultural productivity leading to increased incidences of poverty, hunger and food insecurity. One of the contributing factors has been as a result of inadequate access to accurate, relevant and timely agricultural information. This situation has been worsened by poor access to agricultural extension services due to high extension to farmer ratio and inadequate funding of the public extension system in the country. Integration of (ICTs) in the provision of agricultural extension services can improve farmers' access to agricultural information. The Kenyan government has facilitated the use of ICTs in the agricultural extension system through the introduction of e-Extension programme at the county level. The extensive coverage of mobile phones, low call rates, affordable data bundles and increasing internet connectivity available to smallholder farmers has also opened an opportunity for access to e-Extension services. Low adoption of ICTs in accessing agricultural extension services by farmers however, has been attributed to among others socio-economic, cultural and technological factors. There is limited information on the influence of the technology-related factors on usage of e-Extension services among smallholder farmers. This study aimed at filling this gap by establishing the influence of technology-related factors on usage of e-Extension services among smallholder farmers in Nakuru County, Kenya.

1.3 Purpose of the Study

To contribute to increased efficiency in accessing agricultural information through the determination of the influence of technology-related factors on usage of e-Extension services among smallholder farmers Nakuru County, Kenya.

1.4 Objectives of the Study

The objectives the study were:

i) To determine the influence of access to ICTs on usage of e-Extension services among smallholder farmers' in Nakuru County, Kenya.
ii) To establish the influence of ICT skills of farmers on usage of e-Extension services among smallholder farmers in Nakuru county, Kenya.
iii) To establish the influence of agricultural digital content on usage of e-Extension services among smallholder farmers in Nakuru county, Kenya.
iv) To establish the influence of type of e-Extension platform on usage of e-Extension services among smallholder farmers among smallholder farmers in Nakuru County, Kenya.

1.5. Hypotheses

The following hypotheses guided the study:

$H0_{1:}$ There is no statistically significant influence of access to ICTs on usage of e-Extension services among smallholder farmers' in Nakuru county Kenya.

$H0_{2:}$ There is no statistically significant influence of ICT skills of farmers on usage of e-Extension services among smallholder farmers' in Nakuru County Kenya.

$H0_{3:}$ There is no statistically significant influence of agricultural digital content on usage of e-Extension services among smallholder farmers' in Nakuru County, Kenya.

$H0_{4:}$ There is no statistically significant influence of type of e-Extension platform on usage of e-Extension services among smallholder farmers' in Nakuru County, Kenya.

1.6 Significance of the Study

The study was deemed important because of the following reasons: It established ways in which ICTs accessible to smallholder farmers' influences the use of e-Extension services. Accessing agriculture information depends on, access to and use of ICTs which in turn leads to improved agricultural production systems. The study further established the ICT skills of smallholder farmers as well as the availability and characteristics of agricultural digital content. Examining the skill and capacity that farmers have in using ICTs will help them to reap the benefits of accessing valuable agriculture information. The availability and characteristics of agricultural digital content was also established in the study. Understanding ways in which these factors influences usage of e-Extension services among smallholder farmers will provide entry points in improving access to agricultural information among farmers. The study may also assist the extension agents to utilize the available ICTs to enable access to knowledge, information and technologies that farmer require in their farming activities. The study was also projected to inform policy makers when designing plans and policies for improving accessibility to, and use of ICTs in extension system in the country. The results of the study may also inform the national and county governments in making necessary adjustments to ICT related programs in order to improve agricultural productivity by use of ICTs.

1.7 Scope of the Study

The study was carried out in Nakuru County, Kenya with the respondents including extension agents and smallholder farmers in three sub counties namely; Molo, Subukia and Gilgil. The study examined the influence of technology-related factors on usage of e-Extension services among smallholder farmers in Nakuru County. The technology related factors that the study examined were: ICTs accessible to smallholder holders, ICT skills that farmers have, digital content availability and characteristics and the type of e-Extension platforms available. Consequently, independent variables included ICTs accessible to smallholder farmers, ICT skills that farmers have, digital content availability and characteristics and the type of e-Extension platforms available for use among smallholder farmers in accessing agricultural information. The dependent variable included the usage of e-Extension services among smallholder farmers which included frequency of use of ICTs and e-platforms, type of information accessed and knowledge of use of ICTs. The extension agents were involved in

the study to corroborate the information provided by the farmers in the ward level and also those working in the Nakuru call center in the county office.

1.8 Assumptions of the Study

The study assumed that farmers were aware and exposed to e-Extension services in Nakuru County, Kenya.

1.9 Limitation of the Study

The study relied on interpreters due to different languages among the communities in the county. This was considered to be a limitation because a study by Pan (2007) has shown that interpreters could add or omit information or give inaccurate translation of what is expected thereby affecting the quality of data which in turn affect findings. To minimize on this limitation, the researcher ensured that the research assistants were adequately trained on the data collection instruments and other pertinent issues like confidentiality and informed consent.

1.10 Definition of Terms

In this study the following terms assumed the indicated meanings:

Access to ICTs - This is an individual's unrestricted ability, right, or permission to locate and use of an information and communication technology device such as computers, mobile phones, and the internet for the receipt, processing, storage, retrieval, consumption, and dissemination of information (Mehdi,2020). Level of access to ICTs in this study adopted the same definition.

Digital Content - Refers to information created and delivered through various electronic tools and platforms such as the internet and is packaged to minimize distance, cost, user-friendliness and enable adaptability to local context (Saxena, 2011). In this study, digital content referred to availability of agricultural digital content to smallholder farmers be it for online learning and delivery such as, SMS, phone calls, pictures, content through radio and TV programmes, audio, video, agricultural blogs, agricultural e-books, agricultural e-journal, images or offline learning such as Ms Office applications, power point presentations, downloaded documents, CD-ROMs, DVDs, downloaded audio and videos. It also entailed the characteristics of the digital content which include relevance, timeliness, details, reliability, language, adequacy and cost.

e-Extension Platforms- defined as an integrated set of interactive online services that provide trainers, learners, and others involved in extension services with information, tools and resources to support and enhance extension service delivery. In this study it entailed different platforms available to smallholder farmers for example those created by the extension agents and Nakuru Farmers' Call Center staff for communicating with farmers such as mobile calls, SMS, WhatsApp groups, Facebook pages, twitter handles, Interactive Voice Response and other social media platforms.

e-Extension Services - Refers to the delivery of extension service using web tools, which allow online sharing, collaboration, and networking to enhance face-to-face and paper-based transactions in delivering sound and the latest information on agriculture that provides a more efficient alternative to the traditional extension system of agriculture (Renwick, 2013). e-Extension services in this study, would mean access to agricultural information by smallholder farmers by use of ICT tools such as mobile phones through calls and SMS and

internet, computers through emails and websites and internet, and social media platforms such as Facebook, twitter and WhatsApp.

Information Communication Technologies – Refers to any device, tool or application that are used to transmit, store, create, share or exchange information. They include computers, internet (websites, emails, blogs), live broadcasting technologies (radio, television) recorded broadcasting technologies (videos and audio, podcasting and storage devices) and telephony (satellite,vision/video-conferencing and fixed and mobile phones (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2009). In this study ICTs include mobile phones, computer, radio, TV and internet connectivity either owned or accessed by smallholder farmers to enable them access e-Extension services through Calls, SMS, and social media platforms.

ICT Skills - It is the ability to use efficiently the elementary functions of Information and Communication Technologies to retrieve, assess, store, produce, present and exchange information, and to communicate and participate in collaborative networks via the internet (Cedefop, 2014). This study looked into the skills of farmers or the training they have undergone to enable them access and use e-Extension services. The skills were measured in terms of ability to use the ICTs skills to search for and access agricultural information.

ICT Usage – Described as the confident and critical use of ICTs for work, leisure, learning and communication (Hall et al., 2012). In this study ICT userefer to adoption and intensity of use of the following ICTs (mobile phones, computer, radio, television and the internet) for purposes of receiving e-Extension services such as weather, input and output market information, connect with service providers, customers, and coordinating day to day agricultural activities. The level of usage of ICTs for accessing e-Extension services was measured by a five-point continuum of never to always with corresponding score of 1to 5 respectively.

Influence - Hall (2007) defined influence as a force one person or agent exerts on someone else (the target) to induce changes in behavior, opinion, attitudes, goals, needs and values and the ability to affect the behavior of others in a particular direction. In this study, influence referred to the technology-related factors and its influence on usage of e-Extension services by smallholder farmers

Smallholder Farmers-Defined as farmers owning small plots of land (less than 2.0 hectares) on which they grow subsistence crops and one or two cash crops and who rely almost exclusively on family labor (Republic of South Africa, 2012). This study adopted the same definition.

Social Media –These are web based tools of electronic communication that allows users to personally and informally interact, create, share, retrieve, and exchange information and ideas in any form (text, pictures, video, etc.) that can be discussed upon, archived, and used by anyone in virtual communities and networks (Suchiradipta & Saravanan, 2016). This study adopted the same definition.

Technology-related Factors – a technology is defined as a tool, a control device, organizational technology, media, and development process as well as technical practice (Molnár, 2008). Technology-related factors in this study would mean the ICT factors that include ICTs accessed, ICT skills, digital content availability and characteristics, type of e-Extension platforms and how these factors influence use of e-Extension services among smallholder farmers.

Farmer Call Centre: Refers to a central location where operators answer questions on phone from farmers (McGuire et al., 2015). The study adopted the same definition and focused on Nakuru Farmer Call Centre which provides e-Extension services to farmers in the county. The study will look into e-Extension services being offered to and received by the farmers through the call center.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The chapter is structured to cover evolution of agricultural extension, agricultural extension service delivery in Kenya, smallholder agriculture in Kenya, role of ICTs in agricultural extension, factors affecting use of ICT-based extension, e-Extension services in Kenya, theoretical framework and conceptual framework.

2.2 Evolution of Agricultural Extension

The potential role of agriculture as an enabler to economic growth and development has long been recognized worldwide. Most economies in Africa depend on the agricultural sector as for economic growth, employment and foreign exchange earnings. The sector accounts roughly for 32 percent of the continents GDP, employs 90 percent of the rural workforce and 60 percent of the total labor force (both rural and urban), contributes 40% of the total export earnings as well as providing over 50 percent of household needs and income (Mckinsy, 2011; Oluoch-Kosura, 2013). The share of GDP in many African countries is much smaller often 30 percent or less indicating low productivity in the sector (Chavula, 2014; United Nations Econonic Commission [UNECA], 2012). Despite its importance agricultural production and yields has continued to lag behind over a long period of time. The stagnating yields is attributed to lack of utilization of improved agricultural technologies, critical rural infrastructure, limited access to affordable financing, inequitable market conditions, high transport and production and costs and lack of adequate and appropriate agricultural information (Aker 2011; Chavula, 2014).

Agricultural extension is an integral process of agricultural production processes that seeks to supply farmers with information such as crop prices, crop management, marketing and new seed varieties (Muyanga & Jayne, 2006). Adejo et al. (2012) also acknowledge that agricultural extension still remains the most crucial and critical means to reach farming households in the rural areas. Anderson and Feder (2007) define agricultural extension as the delivery of information inputs to farmers. According to Anderson (2008), the term agricultural extension or agricultural advisory services refer to the entire set of organizations that support and facilitate people engaged in agricultural production to solve problems and to obtain information, skills and technologies to improve their livelihoods. Richardson (2009)

adds a sustainability dimension and defines agricultural extension as "a service, public or private that responds to the needs of farmers and rural people for knowledge they can use to improve their productivity, income and welfare and to manage the natural resources on which they depend in a sustainable way". Globally, studies have shown that levels of returns to extension and research are as high as 80 percent. Therefore, strengthening and supporting agricultural extension at the county level would foster an enabling environment for innovation and entrepreneurialism and empower local farmers to solve their own problems (Otieno, 2018).

Since the 1960s, agricultural extension has been put forth as a means of reducing the information asymmetries related to technology adoption in both developed and developing countries. There are approximately 500,000 agricultural extension workers worldwide, and 80 percent of these are publicly funded and delivered by civil servants (Aker 2011; Anderson & Feder 2007; Raidimi & Kabiti, 2013). Anderson (2007) attests that 90 percent of the extension workers in the world are found mostly in developing countries. Across Africa and Asia agricultural extension has been reported to be one of the major conduits to rural development and transformation leading to poverty reduction and increased food security (Danso-Abbeam et al., 2018). This is by ensuring access to agricultural information, inputs, facilitating access to markets and credit facilities, promoting farmer organizations and training for improved agricultural production livelihood, improved household income and standard of living (Akpalu, 2013; Myeni et al., 2019; Swanson & Rajalahti, 2010).

Despite numerous investments on public extension programs their impact on agricultural knowledge, adoption and productivity remains inadequate and has failed to effectively push smallholder commercialization agenda (Aker, 2010; Cook, 2021; FAO, 2017). Agricultural dissemination methods and approaches that include field days, mass media, information desks, Farmer Field Schools, Training and Visit, demonstration, common interest groups, agricultural shows and exhibitions have been widely used to disseminate agricultural information and technologies to farmers. However, there has been limited achievement in terms of number of farmers reached and successful technologies adopted (Dixon, 2010). This has been attributed to reduced number of public extension agents and increased number of farmers' inadequate infrastructural support.

Extension systems in Kenya for example, are faced with the challenge of declining human and other supportive resources (Birch, 2018). The extension agent to farmer's ratio in Kenya for example is 1:1,500 which is way below the FAO recommended ratio of 1:400 while in Nakuru County the ratio is 1:779 (Manfre & Nordehn, 2013; World Bank, 2019). Each extension officer covers a large territory, ranging from 20 to 50 square kilometers, with large distances between farmer groups. Like many extension systems, operational expenses are underfunded, and the Ministry of agriculture lacks the resources to cover transport costs to visit farmer groups and provide services in remote locations. Furthermore, the Kenyan government has devolved its functions from a national system to a county-led system in which funding decisions become the responsibility of the county governments. County offices rely on both national government and project funding for their operations (Tata & McNamata, 2018). Given the challenges of managing a large labor force over a vast territory, and to ensure that farmers receive quality services, the Ministry of agriculture in Kenya began transitioning to an electronic management system in 2013. The Ministry launched a national e-Extension project in order to strengthen its management system and to provide up-to-date advisory services to the farmers they serve. The county government of Nakuru is also providing e-Extension services to its farmers through the Nakuru Farmer Call Centre. Generally, it was predicted that e-Extension will enhance service delivery and enable extension agents to access more farmers with better services (Gichamba et al., 2017). However, the extent to which technology-related factor influences usage of e-Extension services among smallholder farmers not been established. This study therefore aimed at filling this gap.

2.3 Agricultural Extension Service Delivery Systems in Kenya

Smallholder farmers in Kenya have accessed Agricultural Extension Services (AES) through different models of extension systems. The first one is the government led extension system whereby the Ministry in charge of agriculture takes the leading role in the provision of extension services to farmers. The system mainly focuses on food crops and livestock. The second system is commodity based extension system which is run by government parastatals, cooperatives and out grower companies and mainly focuses on commercial crops such as coffee, tea, sisal and pyrethrum. This system is mainly profit inspired. The third system is private-based and is made up of private companies, Non-Governmental Organizations (NGO's), Community Based Organizations (CBO's) and Faith Based Organizations (FBO's) (Kingiri, 2020). The public agricultural extension services provided by the Ministry of

agriculture have been reported to have a wider coverage in Kenya compared to the other extension systems (Kiara, 2011).

Over the years Kenya has embraced various extension approaches as a means through which information is passed to farmers (Kedera et al., 2014; Kimani, 2015). The approaches have evolved over time beginning with Transfer of Technologies Approach (TOT) which emphasized on the adoption of agricultural technologies with no regard of how the knowledge and skills about the technologies were acquired by farmers. Due to failure of the adoption of the agricultural technologies by farmers there was the introduction of Farming Systems Approach (FSR) in 1970's which mainly focused on on-farm testing and refining of the technologies. This approach also was found to be inadequate in addressing the diverse needs of farmers (Mukembo & Edwards, 2016). In 1980's Kenya's Agricultural Extension Services adopted Training and Visit (T&V) approach which was promoted by the World Bank. It aimed at transferring agricultural information and technologies to the farming communities through extension workers and contract farmers. This approach however did not still address the varying needs of farmers majorly due to associated high expenses and low coverage by extension agents. Farmer Field Schools (FFS) was then introduced in early 1990's to curb the situation. These approach involved use of participatory methods with the aim of enhancing knowledge and skills in using agricultural technologies. Farmer Field Schools are groups of people with a common interest getting together regularly to discuss, observe, understand, and practice the 'how and why' of particular topics in agriculture. Though the approach was reported to improve the agricultural productivity of farmers it was still limited in fully meeting farmers' diverse needs (Mukembo & Edwards 2016).

The National Agricultural and Livestock Extension Program (NALEP) program was developed by the Government of Kenya to put into operation the Nation Sector Extension Policy (ROK, 2012). The program aimed at responding to the demands emerging in extension such as information sharing and participation of excluded stakeholders. The efforts of NALEPwas characterized by participatory and gender inclusive approaches that led to demand driven extension service delivery made up of development partners and policy makers targeting poor farmers and marginalized groups (Manfre et al., 2013; Kiara 2011, citied in Kingiri, 2020). The Kenyan extension system has also not been privatized but also the government has implements a pluralistic demand driven extension policy where farmers can demand but also pay for the services they need (Ongayo et al., 2016). This has resulted in commercialization of extension services which has increased the number of stakeholders

providing extension services including private extension services. The source further indicate that private extension providers however have been reported to work only on areas that are productive and therefore leaving smallholder farmers without access to the services.

The extension approaches previously used however, have had challenges mainly because they have been perceived to be top-down approaches where farmers are not consulted and the extension information is packaged one way leading to high demand on human, capital and financial resources (Kedera, et al., 2014). The shortcomings with agricultural extension advice have been reported majorly to be its unavailability where and when needed and that there are inefficiencies in its delivery which include repetitions of solutions to common problems for different clients. In 2012, the Ministry of Agriculture issued a National Agricultural Sector Extension Policy (NASEP) which outlines how extension advisory services in Kenya will meet future challenges of enabling farmers to receive the services they require to become more productive agricultural actors (GOK, 2012). Currently, the extension system in Kenya is dominated by the public sector. The government service, however, is increasingly using hybrid models of service delivery involving private-sector entities and farmer-to-farmer extension. Like many extension systems, the Kenyan extension system is also constrained by declining human and financial resources (Tata & McNamata, 2018).

The Kenyan Extension service delivery has also been devolved to the counties which have been reported to present a new challenge in accessing the services particular among the farmers in remote areas. Although the intention of the devolved system was to make governance more efficient and locally relevant, the consequences is that there is not a central authority issuing policies related to local extension programming (Mwololo et al., 2019). Farmers however have continually reported poor access to agricultural extension services in the country. Word Bank, 2018 report shows that 21 percent of sampled households in 38 out of the 47 counties in Kenya accessed extension services between 2013 and 2014,where 81 percent were male headed and 19 percent were female headed. A major constraint has been insufficient qualified personnel with the ratio of frontline extension workers to farmers in Kenya standing at 1:1500 which is way below the FAO recommended ratio of one officer for every 400 farmers (Wanyama et al., 2016). In Nakuru County for example, it has been reported that extension services are available but not well structured to meet the needs of small holder farmers with the extension workers to farmers' ratio standing at 1:779 (GOK, 2015; Michura, 2016; World Bank, 2019).

The Government of Kenya moved towards a system that encourages farmers to demand and access appropriate quality extension services from the best providers in order to attain higher productivity, increased incomes, and improved standard of living (GOK, 2012). This shift away from providing top-down, supply-driven assistance requires strengthening the ability of farmers to communicate, share and demand the information they need. Part of Kenya's vision for this more responsive and demand-driven extension system is to harness ICTs and other mass media to enhance coverage and improve information sharing (Manfre & Nordehn, 2013).Agricultural extension services to the farmers have been perceived to be transformative through electronic based extension which has the potential to deliver relevant and timely agricultural information FAO & International Telecommunication Union [ITU], 2016; Ministry of Agriculture Livestock and Co-operatives [MOALF&C], 2019). Using ICTs to complement face-to-face extension services has the potential to overcome the human and financial constraints on the public extension system. Utilization of ICTs in extension service delivery among the extension agentsin Kenya however, is reported to be constrained by lack of ICT tools and services and lack of knowledge and skills of using them (Thiga, 2013). This study therefore, sought to establish how the technology-related factors have influenced use of e-Extension services among smallholder farmers.

2.4 Agricultural Information Needs of Smallholder Farmers

Agricultural sector in Kenya is characterized by the existence of both large scale and smallholder farmers. There are more than five million smallholder farmers who account for about 75% of the total agricultural production in the country (Strategy for Revitalizing Agriculture [SRA], 2004-2014). Land size is often used as a primary indicator to define of small holder farmers. The FAO and the World Bank generally adopt a threshold size of 2 hectares as a broad measure of a small farm (Khalil et al., 2017). Smallholder agricultural production is largely characterized by growing of staple food like maize and beans, which are primarily targeted for own consumption with little marketable surplus. In Kenya, landholdings have become smaller due to population pressure, hence farmers have transformed from staple crop production to highly market-oriented crops. This agricultural transformation has been a vital development tool for achieving the Sustainable Development Goals (SDGs) that calls for reduction of the percentage of people suffering from extreme poverty and hunger by 50% (Cervantes-Godoy & Dewbre, 2010).

Smallholder farmers play different and often multifunctional roles. They are the key drivers of economy providing sources of employment, food security, poverty reduction and ecosystem services (Deininger & Squire, 1998 as cited by Langat et al., 2016). According to Munyua and Stilwell (2009) 80 percent of farmers in Kenya are small holders. In Nakuru county agricultural land holding is dominated by smallholder farmers with an average of 0.8 ha involved in growing of maize, beans, Irish potatoes wheat, sweet potatoes and horticultural crops (GOK, 2018). These farmers face many barriers to attain full agricultural production including poor access to agricultural information, low output and productivity, weak institutional capacity and coordination, inadequate markets and market information. Kalusopa (2004) observed that most rural communities and smallholder agricultural producers in the developing countries are now influenced by global economic, environmental and political trends which place smallholder farmers squarely in the middle of global market realities (Richardson, 2009).

Grain (2014) also asserts that smallholder farmers are the largest production category in sub Saharan Africa, responsible for feeding very large numbers of people but are often marginalized and food-insecure. They are also the most vulnerable group to the impacts of climate change and environmental degradation as well as disasters and shocks in the food and economic system (International Fund for Agriculture and Development [IFAD], 2013). These farmers also are faced with lack of access to capital, credit and information about both growing conditions and markets which together they limit the farmers' ability to take risks, and reduce the scope for realizing profits. The food security assessment reports by IFAD (2012) and FAO (2017) also further shows food insecure people majorly live in the rural areas and lack access to technology and information that are very key in enhancing agricultural productivity.

These are people, for whom farming is a major source of livelihood, yet they have insufficient assets to produce a surplus from their agricultural activities and whose non-farm activities are unreliable for them to rely on market purchases for adequate food intake (Kent & Poulton, 2008). Ballantyne (2009) emphasized that more than ever, the developing world needs reliable information and knowledge on agricultural issues. It needs this knowledge to be accessible and well communicated. On its own, more information is not enough: access is needed and this is where agricultural information channels, ICTs included, come in. However, farmers as agricultural entrepreneurs must receive the information on time, and in a

manner and format best suited to their needs and their ability to understand (Langat et al., 2016).

Studies have shown that the information needs of farmers differ significantly between and within countries among farmers producing different produce. The differences when seeking for information occurs due to their perceptions of the information they require and their priorities. The disparities have been reported to occur due to changes in priorities of farmers throughout the production cycle (World Bank, 2011).The bottom line is that all farmers seek high quality information in order to make informed decisions during production period. These information ranges from government regulations, crop production and management, disease outbreaks, availability of agricultural support services, agricultural technologies by among others. Information therefore, is seen to be a basic element for development of the agricultural sector and must be made accessible to all farmers. Farmers can reduce the probability and magnitude of losses due to risk and uncertainty, if they are able to access relevant and timely information. Farmers need both technical and awareness information corresponding to different farm activities (Mittal, 2012).

Smallholder farmers continue to lack access to knowledge about best practices and therefore end up misusing input resources at heavy cost and great crop loss. The barriers to extension services delivery continue to pose great challenge ranging from too few extension agents, farmers growing too great a variety of crops and speaking too many languages for service providers to develop and apply a standard approach or methodology; transportation infrastructure is inadequate, making it difficult for extension agents to reach rural communities (Gandhi, 2016).Limited access to Agricultural Advisory Services (AAS); technical knowledge; market information; training; quality inputs; are among the major challenges to smallholder farmers in SSA towards improving their productivity, increasing their income and strengthening food security (Elliot, 2015). Studies have shown that smallholder farmers face numerous information gaps in the agricultural value chain. For example, they may not have access to information on how to respond to new pests and diseases which is associated with climate change issues or do have access to local markets that offers the best price for their produce (Aker & Mbiti, 2014). Furthermore, they may not have access to government extension agent and are left to rely on an input supplier representative. This thus results in decreased production, high cost of inputs, dangerous use

of agro-chemicals, and low profitability (Aker & Mbiti, 2014). ICTs can provide an opportunity through which farmers can be able to access the information they need.

2.5 Role of ICTs in Agricultural Extension

World population is expected to surpass the 9 billion mark by 2050, and food supply would need to be increased by 60 percent through increased agricultural production in order to meet this demand. ICT applications can make a significant contribution to meet this future global food needs. Information and Communication Technology can do so by collecting and sharing timely and accurate information on weather, inputs, markets, and prices; by feeding information into research and development initiatives; by disseminating knowledge to farmers; by connecting producers and consumers, and through many other avenues. Already, in the agricultural and food sectors of many countries, ICT companies, multinational farm input business, large machinery manufacturers, but also small and medium farm input suppliers provide a number of services to farmers through ICTs, including extension advice. Downstream, supermarket and agricultural product buyers also engage in the food value chain through ICTs, where the technology is also used by farmers' cooperatives, international organizations, the civil society and governments to effectively provide information on many aspects of farming, including regulation. In a number of cases, ICTs form an integral part not only of information flows, but of the actual farming operations and food processing from testing the soil in the farm to using 3D printers to process food (Barber et al., 2016).

The growth and development of the agriculture sector can be achieved through the effective utilization of Information Communication Technology (ICT). FAO, 2017 reports ICT as a significant contributor to the growth and socio-economic development in countries and sectors where they are well deployed. The increasing need for the provision of accurate, timely and relevant information and services to farmers across the world has led to the widespread adoption of various ICT's in the agricultural sector (Thiga & Ndungu, 2015). Africa, in particular, has received a significant amount of attention and investment from private enterprises, multinationals and governments for the development of suitable ICT's for the agricultural sector (ITU, 2015). The number ICT initiatives using voice, radio, mobile and video to reach farmers in order to provide extension services, market information and knowledge sharing in African countries have continued to increase over the years (Thiga & Ndungu, 2015).

Agricultural extension has been acknowledged as an essential means for disseminating information great input into modernizing farming. The conventional agricultural extension is mainly achieved through extension agents visiting a farmer or Farmer Field Schools which has been limited in most developing countries due to few extension workers serving many farmers (Aker, 2011; World Bank, 2019).Therefore, innovative ways of serving the same large numbers of farmers by the few extension agents needs to be determined (Lwoga et al., 2011). ICTs could have a significant impact in agricultural extension which depends on information exchange between researchers and farmers and among farmers and a broad range of other actors. ICT has the potential to respond to a number of challenges that confront public extension systems ranging from being heavily under-resourced, lack of skilled human resource and infrastructural support, high farmer to extension ratios and government reduced budgets in the agriculture sector (Davis &Terblanche, 2016; FAO,2017; Liebenberg, 2015). Cook et al. (2021) also notes that the Covid-19 pandemic has also disrupted the provision of extension services making it difficult for extension agents to physically meet all farmers and communities. This has also been further exacerbated by the fact that farmers are sparsely populated across large areas and often times isolated. Strong public extension services only manage to directly reach about 10 percent of the farmer population, and this is even less where operating funds are limited (Bell, 2015).

Another key challenge is due to the market oriented nature of farming that has seen farmers request for specified and varied information. Even farming systems in relatively homogenous agricultural areas differ in type of crops cultivated, farm inputs, labor, machinery and quality standards used. In order to be effective, information and knowledge has to be tailored to meet the needs of individual farmers. Therefore, there has been a major shift in modernizing extension and advisory services and key studies done by Bell (2011) and Vignare (2013).

The application of ICTs in agricultural extension programs, and delivery of agricultural information to users, and on the internet network has led to the emergence of the Electronic Agricultural Extension (e-Extension). e-Extension is a system which depends on ICT's such as mobile phones, radio and television programs, mobile phones in combination with radio, video shows, information kiosks, web portals, farmer call centers, video-conference, offline multimedia CDs and open distance learning (Asenso-Okyere & Mekonnen, 2012).e-Extension systems includes a wide range of tools, hardware and software, devices and platforms with diverse sources of information. Presently, a wide variety of approaches are being tried to use ICT to enhance extension services. Approaches differ in the format and the

means by which the information is transferred; for example, by text, voice or picture, and through queries or SMS messages (Bell, 2015). In some cases, there is direct communication between the sender and the farmer. In others, the messages are disseminated through a farmer extension worker or a local facilitator that has access to the Internet. Some ICT approaches support two-way interaction enabling back to back and timely sharing of information between farmers, extension agents and researchers (Barber et al., 2016; FAO, 2017). ICT-based extension advisory methods are relevant in areas such as preproduction, production, post-harvest and marketing, financial services, and gathering and distributing of data. Different tools are suitable for different applications (Saravanan et al., 2015).

The e-Extension system can also be in the form of information bank with specific information on best practices for different crops suited for different agro ecological conditions or a database of input retailers and prices. It can also be in the form of participatory training videos disseminated though farmer groups and cooperatives for sending real time updates and pictures of damaged crops such as those for identifying the cause and advice for treatment. In rural areas, e-Extension could add value through communication tools such as mobile phones where the extension officers can reach out many more farmers than solely relying on field visits, especially in a situation where the extension to farmer ratios stands at 1:1000, a case common in many Sub-Saharan African countries (Diechmann et al., 2016). Research findings reveal that ICTs do improve the productivity and livelihoods of poor small holder farmers (Munyua et al., 2009). GSMA, 2018 reports that agricultural digital platforms are driving e-commerce and provision of digital agricultural services in developing countries. Nigeria, Cote d'Ivoire, Senegal, South Africa, Zimbabwe, Ghana, Kenya and Uganda have been identified to be on the lead in digital technology solutions in Africa. According to Krishnan (2020) a study done in 2018 in the East African Community among a sample of 70 agricultural technology firms, between 66 percent and 86 percent specialized in farming application and enabling service applications for development.

While there are a wide array of projects using ICTs in developing countries to improve the spread of information related to improved agricultural technologies and management practices, only a few evaluations have been conducted. Fu and Akter (2012) investigated the impact of "Knowledge Help Extension Technology Initiative" (KHETI) Programme in Madhya Pradesh, India. While KHETI does not provide information directly to farmers, it operates through agricultural specialists who travel across villages with special mobile

phones. These phones are able to record Short Dialogue Strips (SDSs), short videos depicting a particular problem faced by farmers. The specialists send these SDSs to scientists, who determine solutions for each case presented; these solutions are then passed back to the farmers. Using difference-in-differences estimations, it is further reported that those in the programme group increased their awareness and knowledge of extension services compared to a control group. The authors also provide before-and-after comparisons for beneficiaries, indicating that they perceive programme as more useful, faster, and of better quality than other services. Other studies that have shown positive results of application of ICTs in agricultural service deliver include the use of digital green video technologies in India to train farmers in rural areas to produce videos amongst themselves and share the good practices to boost agricultural productivity and nutrition. The African Farm Radio Research Initiative(AFRRI) uses radio for education rural farmers in Africa (FAO, 2017).

A study by Wamwea and Mutiga, 2013 on the Kenya Seed maize variety SMS system revealed that agricultural extension officers were largely not aware of the existence of the system and those who were aware did not make much use of it. Low level of utilization of ICT's has been found to be influenced by a number of factors. These include low information literacy, lack of sufficient government involvement, lack of access to ICT's, lack of sufficient training, the lack of ICT proficiency, lack of benefit awareness, difficulty in use, lack of appropriate technological infrastructure, the cost of technology, lack of trust in the ICT and lack of training have also been found to limit the use of ICT's among farmers and system complexity (Thiga, 2013). It has also been observed that even though there are a number of ICT platforms in Kenya, the extent to which farmers are utilizing such e-platforms has not been established (Wanyama et al., 2016). This study is therefore, sought to establish the influence technology-related factors on use of e-Extension services among smallholder farmers in Nakuru County, Kenya.

2.6 Factors Influencing use of ICT Based Extension

Global Information age has underscored the role of ICTs as instruments for progress and development and observed that people of all walks of life have been in one way or another impacted by the information technology sector. ICTs have facilitated the dissemination of knowledge and information and its revolutionizing the use of technology in agricultural production and provision of market information to maximize the returns of agriculture (Asenso-Okyere & Mekonnen, 2012). ICTs in the delivery of agricultural extension services

provides opportunities of enabling the empowerment of farming communities by bridging the gap few extension agents proposition for an increasing number of farming communities that require diverse information. Furthermore, the use of ICTs to access information and to connect people within the rural areas has shown that illiteracy of farming communities may not act as a reason to prevent them from accessing extension services (Saravanan, 2010). Haruna and Baba (2017) posits that in the 21st century, information dissemination and retrieval depend largely on the ability of one to access and utilize the internet effectively through the use of various technological means.

In the modern era, agriculture sector requires access and adoption of ICT tools which emphasizes modern information system. ICT has been indicated to be an enabler to an informed society were each member has the ability to create, share, access and utilize information knowledge and skills (Okello, 2010). Three prerequisites requirements have been reported to determine the full potential benefits of utilizing ICTs. These include access to ICTs, ICT skills and available ICT services. Accessibility to ICTs includes the hardware, software and the underlying infrastructure. ICT capacity includes varying degrees of skills along a continuum ranging from basic ICT skills to specialized technical skills. Finally, the application or services must be localized affordable and relevant local content (Nyirenda, 2010). Access to ICTs is dependent on the availability of ICT infrastructure and content, while taking up of the services offered through ICT applications dependent on the value an individual places on the available information.

There are numerous challenges that have hindered the penetration of ICT in agriculture in Kenya. Notably, on the nature of communities a number of challenges have been identified which include their ability to use the technology to access information for their work, gender and social differences (Awuor, 2016). A study conducted by Munyua and Adera (2009) summarizes the main challenges that influence the use of ICT as: high cost of available technologies, inadequate infrastructure and lack of ICT skills, poor and expensive connectivity, inappropriate ICT policies, language barriers, low bandwidth, inadequate and/or inappropriate credit facilities and systems. Other challenges identified are poor involvement of women and other disadvantaged groups, inappropriate local content, weak institutions and inadequate collaboration and awareness of existing ICT facilities and resources, a poor information sharing culture and low awareness of the role of ICT in development at all levels. Some of the challenges which include access to ICTs, ICT skills, and availability of relevant local content are technology-related and therefore, this study sought to determine the

influence of these factors on usage of e-Extension services among smallholder farmers in Nakuru county.

2.7 e-Extension Models in Kenya

ICT tools and services in the have revolutionized key economic activities such as agriculture in the world. The integration of ICT in agricultural sector enables access to technical and market information that contributes to effectiveness, efficiency and improvement of productivity the agricultural value chains (Mwantimwa, 2019). ICT based applications and services in extension service delivery has also provided an enabling tool targeting poor rural farmers particularly smallholder farmers' women and youth (Manfre & Nordehn, 2013). These service ranges from weather forecast information, agricultural technologies, marketing information, pest and diseases information early warning information and information on input availability which are key in allowing farmers make informed decisions (Kansiime et al., 2019).

According to Gichamba et al. (2017), e-Extension system enables extension officers to reach out to farmers using more efficient alternatives to conventional extension system of agriculture using platforms like Short Messaging Service (SMS), Interactive Voice Response (IVR), downloadable applications, Unstructured Supplementary Service Data (USSD) and mobile web and most services would be duplicated across different technologies in order to accommodate a larger clientele given the wide array of mobile devices among the target users. This helps to increase productivity, profitability and global competitiveness. Some approaches support two-way interaction enabling the farmer to respond to or make request for the information from the provider (Barber et. al., 2016). e-Extension services can speed up the process of agricultural technology transfer from research to farmers and improve adoption of agricultural technologies by supporting farmer learning, problem solving and accessibility to profitable markets for their crops (Munyua et. al., 2009). ICTs encompass many different types of technologies, from computers and the Internet to radio and television to mobile phones. Their impact varies widely depending on which specific technology is used, but also on farmers' level of literacy. Short message services (SMS), voice messages, short video trainings, audio messages, social media interventions and virtual extension platforms that can improve peer networks (though online platforms/websites) can effectively enable farmer-to-farmer and farmer to experts' information sharing. Audio or voice-based question and answers services may overcome the limitations of text-based platforms. SMS

messages can be effective for simple price or weather information, but to facilitate and revolutionize learning and make knowledge widely accessible, especially in the context of adapting agriculture to climate change, other methods and modes will be necessary.

Research by Heeks (2018) on the impact of e-Extension on rural resilience in developing countries and found out that the use of ICTs in agriculture makes the sharing of conventional and new agricultural knowledge stronger and easier. In addition, ICTs facilitate farmers to receive and use agricultural skills like market information, management of pest and diseases, information about climate patterns, techniques of farming and livestock management. ICTs can also enhances the ability of farmers to learn by providing audio and video conveying agricultural information thus, enabling illiterate farmers to listen, watch and learn (Bhattacharyya et al., 2018; Narine et al., 2019).

Mobile phones and platforms are the major ICT devices for most developing countries. In addition, they have been recognized as a tool with enormous potential for transforming sectors and empowering most social and economic activities in developing countries (Aker & Mbiti, 2010). Kenya is one of the countries that have been recognized to be on the forefront in m-services development in the continent tapping into the accelerated mobile penetration over the years in the country. For example, in 1999 only 10 percent of the rural population in Africa had mobile phone coverage, in 2013 the mobile coverage among the Kenyan population stood at 93 percent and by 2019 it had hit 100 percent coverage (ITU, 2008; Communications Authority [CA], 2019). As at the end of September 2019, Kenya had 53.2 million subscribers up from 52.2 million subscriptions reported at the end of June 2019 (CA, 2019). This translates to 96 percent and 93 percent of at least 2G and 3G coverage respectively, which is relatively high for a developing nation within the African Caribbean and Pacific (ACP) countries. Figure 1 shows the mobile penetration growth in the country which remains above 100 percent due to multiple SIM (Subscriber Identification Module) ownership users of cellular services (CA, 2019).

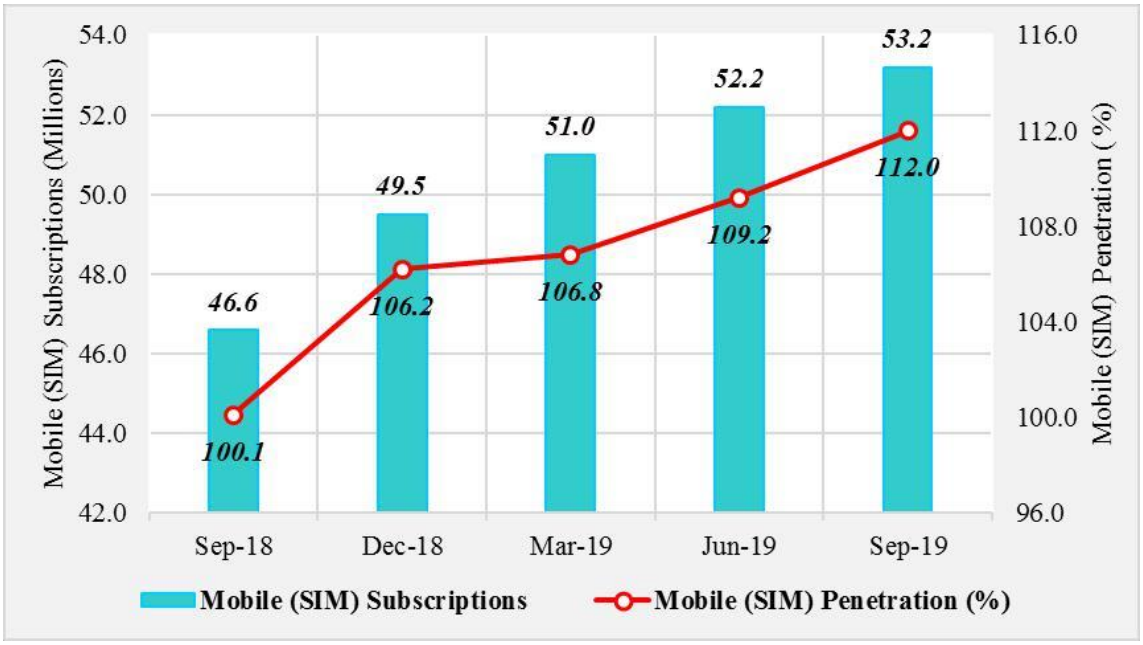

Figure 1: *Growth in Mobile Subscriptions Reported in Kenya in the Last Quarter Of 2019*
Source: (CA, 2019)

The report further indicated that the total data/internet subscriptions during the quarter rose by 4.1 percent to 52 million subscribers with mobile data accounting for 99 percent of the total subscriptions (CA, 2019). This shows that there is a high potential of transforming Kenya's agricultural food systems through mobile platforms in accessing agricultural information given the high mobile and internet penetration among the population majority of which are involved in agricultural activities. The Kenyan government also has wide-ranging digital applications opportunities and analytics in agriculture which is envisioned under the Agricultural Sector Transformation and Growth Strategy (ASTGS) 2019 - 2029. The targets of ASTGS included creation of digital products such as ICT-enabled extension agents, digitally trained youth extension agents, digitization of existing data in the agriculture sector, real-time data collection systems, digitally developed platforms to provide services to farmers and digital subsidy registration and stock monitoring delivery system (MoALF&I, 2019). Challenges still exists in the realization of this targets with progress being identified to be uneven particularly in the rural areas due to geographic and socio-economic factors which has hindered access to digital services (MoALF& I, 2021).

The government of Kenya has also tapped into this create opportunity through the introduction of e-Extension programme nationally in 2014 to support agricultural extension

service in the country. Through the Ministry of Agriculture, 654 e-Extension agents were trained nationally and equipped with a smartphone, a laptop and a modem to enable then reach farmers efficiently. using innovative approach such as SMS, farmer training, WhatsApp messaging and social networking extension agents were expected to be placed at the county and ward level and use push and pull method to disseminate information. The farmers were also expected to incur a cost in the cause of this in the form of airtime to be able to make calls send SMS inquiries or buying internet bundles to access information online (Gichamba et al., 2017).

The Government provided a number of online and mobile based platforms that the extension agents could use for to access agricultural information for their extension work. The officers were issued with mini-laptops and internet modems and were trained on how to get content from the various platforms and disseminate them to farmers. They were then expected to provide e-Extension services to farmers to enable them to get efficient and efficient extension service delivery. The major platforms listed by the government included ikilimo, National Farmers Information Service (NAFIS), the Infonet-Biovision Platform and the Plantwise Platform. These platforms have been used by the extension agents working in the national and the county governments in Kenya. Other enormous numbers of e-Extension models have also been developed in the country and are providing farmers with different customized e-Extension services (Gichamba et al., 2017).

2.7.1 Mobile Phone Based e-Extension Model

As of 2018, two-thirds of the world's 7.6 billion population owned mobile phones. Increasing penetration of mobile phones makes it a potential tool to overcome social development barriers such as technology, literacy and gender that cause inequality and the digital divide (FAO, 2019).The rapid growth of mobile telephony has emerged as a communication tool which has not only transformed many sectors including agriculture (Asongu & Asongu, 2018). In developing countries Information asymmetry still exists between different actors in due to lack of resources and poor infrastructure. Given this scenario, ICT and in particularly the mobile phone has shown a great potential to facilitate communication by enabling the smooth exchange of knowledge between the various stakeholders in agriculture (Aker, 2011). In the context of agriculture, mobile phones have empowered the farmers to communicate at all levels from local to administrative regarding various aspects ranging from marketing, information exchange, and buying and selling inputs and farm commodities (Ogutu et al.,

2014). Compared to other ICT tools mobile phones have been diffused tremendously even to the marginalized and underdeveloped rural farming communities due to its flexibility, affordability and user-friendly nature (Osabutey & Jin, 2016).

Mobile telephony has disrupted the conventional agriculture extension system by connecting farmers directly with researchers and other critical information service providers, thereby creating a new order of remote farm advisors with different skills and work processes than the conventional extension agents (FAO, 2019). Existing agricultural extension systems in many developing countries Kenya being among them is unable to meet the information needs of farmers due to limited resource (Aker 2011). Due to these challenges therefore, mobile phones can play a crucial role in providing these services to farmers.

Information and extension services through the mobile phones also better known as m-services has transformative potential in accessing important agro-meteorological information among rural African farmers (Krell, 2020).The dissemination of agro-meteorological information could enhance farmers livelihoods by improving access to farm inputs and technology adoption (Hansen et al., 2007). m-services deliver electronic content through mobile phones that include services such as m-commerce, m-payment, m-agri, and m-banking. The services are delivered in form of Short Message Service (SMS), Unstructured Supplementary Service Data (USSD), mobile applications and help lines. The difference between SMS and USSD protocol is that SMS is a text messaging service, whereas USSD protocol are in the form of 'Quick Codes'. Depending on the electronic media m-services contain, they can be accessed by phones with and without internet access.

According to Baumüller (2016) m-services are grouped into the following categories; financial services information and learning, agricultural inputs and access to markets. m-services can be to disseminate general information about farming and livestock, connect buyers to sellers used, access market information on prices, send alerts on pest and disease threats (Baumüller, 2018). Some m-services offer free services to users while others require a cost to use advanced features or entirely proprietary in nature. *Ujuzi Kilimo* (meaning skillful farming) is a good example of a service available to Kenyan farmers and offers recommendations for action through subscription-based SMS and USSD services (Krell, 2020) in order to receive highly localized real time diagnostic soil analysis. Though these services are available to farmers in Kenya its impact measurers however, has not been validated (Tsan et al., 2019).

Access to information to better manage climate change risk and vulnerabilities as well as reaching many farmers in rural areas can be achieved through mobile phones and the internet. (Baumüller, 2013; Santosham & Lindsey, 2015; World Bank Group, 2018). A study by Eakin et al., 2017 on ICTs and climate change adaptation in the Caribbean and Latin America shows that ICTs support adaptation to climate change through increased communal capital, access to critical information for decision making and organization of actors. Ogelleh at al. (2012) also reported that limited access to agro-meteorological information hindered adaptive capacity.

Harnessing the growth of internet use and associated digital technologies such as the mobile phone can help farmers retrieve the information they need as well as overcome constraints faced by the traditional agricultural extension and advisory services (World Bank, 2016). Mobile phone ownership and internet access has become possible for populations in the continent's lowest-income areas due to reduced cost of mobile phones and widespread internet connectivity (Wyche & Olson, 2018). The vast uptake of users of mobile phones can enable subscription to mobile enabled m-services to access e-Extension services, agro-meteorological information as well as market information (Baumüller, 2013; Wyche & Steinfield, 2016). Mobile phones have also been reported to strengthen and expand social networks, reduce travel costs, manage human-wildlife conflict, conduct business and financial transactions, and increase efficiency of livelihood activities to help reduce poverty in sub-Saharan Africa (Lewis Baird & Sorice, 2016). In Kenya access to mobile money transfer services has been reported to reduce poverty by 22 percent among female headed household and to have a positive impact on agricultural household income (Kikulwe et al., 2016; Suri & Jack, 2016).

Mobile phones can provide opportunities strengthen and complement existing methods of agricultural extension. Many agricultural extension workers already have smart phones that can be used to download information on pests and diseases, available technologies, or other issues arising in their extension work, as well as necessary information required to respond to farmer questions (Lewis et al., 2016). Mobile phones could also be used to improve accountability among extension workers through setting of goals and tracking performance hence enabling automatic collection of feedback from farmers and confirming farm visits by extension agents and their supervisors (Nakasone et al., 2014). An example of this is a mobile based application called e-diary in Uganda that is used to strengthen accountability in agricultural extension service delivery. The extension agents are able to report their daily

activities in real time through the application which integrates farmer profiles, Global Positioning System (GPS) and photograph recording to allow for feedback from beneficiaries and remote supervision. Namyenya et al. (2021) reports that e-diary had a potential to strengthen upward accountability in agricultural extension through enabling remote, real-time and distant reporting as well as extension activity supervision.

M-services deliver electronic content through mobile technologies and is an umbrella term that includes m-commerce, m-agri and m-payments. They come in varied forms, including Short Message Service (SMS), Unstructured Supplementary Service Data (USSD), mobile applications and helplines. The diff erence between SMS and USSD protocol is that SMS is a text messaging service, whereas USSD protocol are in the form of '*Quick mCodes*' where a user can send messages between a mobile phone and an application programme which create a real time connection allowing two-way exchange of a sequence of data. m-services can be used to connect buyers to sellers, disseminate general information about farming and market information on prices, and send alerts on pest and disease threats (Baumüller, 2018). Some m-services are free to use or may require a cost to use advanced features, while others are entirely proprietary. Baumüller (2016) however, points out that though Kenya is seen to be on the lead in sub-Saharan Africa with regards to agricultural m-service innovations their impact is difficult to critically evaluate due to limited availability of data on the actual experiences of users.

Examples of m-services that are currently available to farmers in Kenya include but not exclusive icow, ikilimo and M-farm, NAFIS and KACE.

2.6.1.1. iKilimo

ikilimo is a mobile based tool developed by Avalian foundation to provide farm based and advisory services to farmers on topics ranging from plant production, farm machinery & equipment's, food processing, animal production, high value crops, and marketing. It is a mobile based application providing information that has been created by agricultural experts and agronomists hence ensuring reliable and up to date content. The Avalian limited foundation, the organization that created *ikilimo* works with e-Extension department in the Ministry of Livestock, Fisheries and Cooperatives in Kenya in order to avail information to agricultural extension workers attached to different counties in order to offer training and extension services to framers. The services can also be accessed directly by the farmers. It

has been reported that since its inception in 2013, *ikilimo* platform attracted 5,000 farmers within the first year with the number continually increasing annually (Gichamba et al., 2017).

2.6.1.2. icow

icow is a mobile based application developed by Green Dreams limited and distributed in partnership with Safaricom, Kenya's largest mobile telecom provider. The application is available to Kenyan farmers and provides extension and advisory services to farmers using the web USSD, SMS platforms (Qiang al., 2012). The advisory services are offered to dairy farmers through fertility cycle tracking of their cows, breeding tips, animal nutrition, milk production efficiency for increased milk yield and income (Brown, 2014). A farmer register to icow platform through a USSD code, subscribes for the services and register their cows and their insemination date by SMS short code. They are then able to receive periodic SMS prompts timed with vital days during the gestation period. The service also sends weekly SMS messages to the subscribers with information on breeding tips, diet and nutrition and other dairy best practices. There are several services available in icow application that include "kalenda cow" a gestation calendar which send a farmer timely messages once registered, "imashauri" which is a weekly prompt that gives farmers important tips on farming practices and "vetinari "which is a tool for finding the nearest vet or an artificial inseminator. A study by Marwa et al. (2020) shows that the use of icow services by smallholder farmers in three counties in Kenya had a positive and significant effect on milk production and income. Similarly, it has also been reported that farmers using icow platform increased their yields by 3 litres per cow resulting in increased income (Gichamba et al., 2017).

2.6.1.3. M-farm

M-Farm was launched in Kenya in 2010 with the aim of linking smallholder farmers' participation in the market through improving their bargaining power and linking them to buyers. It provides crop price market information for 42 crops in five markets (Eldoret, Kisumu, Kitale, Mombasa and Nairobi) in Kenya. It is a mobile service and a web platform aimed at improving Kenya's agricultural sector by connecting farmers with one another because by collaborating with one another they are able to improve market information (Baumüller, 2015). The farmers can have the price of agricultural inputs and make a decision on when to buy and where to buy it. With M-Farm, Kenyan farmers can either collectively sell their produce to large buyers through contracts or are connected to buyers and sellers via an internet- and mobile phone-enabled platform (Wyche & Steinfield, 2016).It groups

farmers' orders, provide them with current market prices as well as linking them to exporters, wholesalers and retailers and is also possible to purchase and deliver some products.

To sell their produce through the marketplace, farmers can send an SMS to the same short code if they would like to sell their produce and offers are posted on the website where buyers can contact the supplier directly to express their interest in purchasing the crop (Magesa, 2015). According to Baumüller (2016) such kind of services could improve agricultural productivity in two ways. One by encouraging technology adoption, since access to information about price and demand can reduce uncertainty about the likely profitability of a technology. Two by increasing prices market information which could widen competition and improve farmers' bargaining position. The author also reports that information about prices influences production processes, such as deciding what to grow and when to harvest, and encourages farmers to expand certain crops, but is less influential in introducing new ones. It further showed that One-third of farmers using M-Farm combine it with radio where they use radio for price information and regard it as comparable in quality. Radio is seen as a good source of information in the early stages of production, while M-Farm becomes more important closer to selling the farm produce. While the study finds potential to expand these services, Moore (2018) also cautions that the relevance of mobile phones for development lies not just in their potential to facilitate trade or convey technical information but in the way they strengthen social capital. This is by allowing both rural and urban residents to stay connected, provide mutual support, and contribute to agricultural decision-making. A study investigating the factors that hinder the adoption of M-Farm services in western Kenya by Wyche and Steinfield (2016) showed that farmers who owned feature phones did not use them to access M-Farm services due to a number of factors. They report that the factors included lack of mobile phone credit which limited use of SMS, lack of electricity which limited charging of phones, wear and tear of phones limiting its use, user perceptions toward mobile phones where preference is for voice communication rather than SMS-interaction.

2.6.1.4 NAFIS (National Farmers Information Service)

Kenya the National Farmers Information Service (NAFIS) through the National Agricultural and Livestock Extension Programme (NALEP) was established in 2008. It is aimed at serving Kenyan smallholder farmers in rural areas where there is limited internet access. The comprehensive information service packages agricultural information in Kiswahili, English and local languages and distribute it to Kenyan farmers through cell phones, internet and the

website. The information is updated by officers and can be accessed by farmers through their mobile phones. The services ranges from electronic trading platforms, market information traders and provides farmers with prices of agricultural produce and is available in form text, graphics, audio and video for improved accessibility and format (Odinga, 2018; Waruingi & Muriithi, 2016). Although various m-services available to Kenyan farmers NAFIS being among them, it has been difficult to assess their reach and impacts due to absence of data available publicly and impact assessments. It also been reported that though NAFIS provides price information for inputs, it's unclear to what extent the function is operational Baumüller (2016).

2.6.1.5 KACE (Kenya Agricultural Commodity Exchange)

Kenya Agricultural Commodity Exchange was established in Kenya in 1997. It is a micro, small and medium enterprise that provides a forum to be used by farmers in accessing markets for their agricultural commodities. It was the first national agricultural commodity exchange to be initiated in Kenya and deals with maize and beans majorly as they are traded heavily in the country. It is also an intermediary that empowers farmers with market information, business training, technical assistance and capacity building. It's main activities are to collect, update, analyze and provide reliable and timely market information and intelligence on a wide range of crop and livestock commodities and government alerts targeting actors in commodity value chains, with particular attention to smallholder farmers and small scale agribusinesses (KACE, 2011). The collated information is then forwarded to the KACE headquarters in Nairobi, Kenya where it is processed and published in the Regional Commodity Trade and Information System (RECOTIS) on their website and also on the notice boards at the Market Information Centres (consisting of field officers who act as a link between KACE and market information points (Karagu,2011).

KACE's services include SMS, Interactive Voice Response Services, daily radio bulletins, a live radio auction service and online computer services. All these applications help in accessing information on daily wholesale buying prices for about 20 commodities as well as offers to sell and bids to buy (KACE, 2011).Trades are made through competitive bids and offers. Once a buyer and a seller agree to trade, KACE acts as a clearing house for a commission and arranges the financial and logistical aspects of the sale thus giving the farmers options as well as bargaining power (Karoney, 2016). A study by KACE (2019) reports that in areas where they operate 80-90 percent of farmers use the service and have

achieved higher prices for their commodities. The marketing department at KACE confirms that it reaches millions of small-scale farmers in Kenya and surrounding countries particularly in Uganda and Tanzania. Since inception in 1997, KACE has empowered small scale farmers to receive fairer prices and access markets previously inaccessible to them. It mainstreams buyers such as manufacturers, cooperatives, wholesalers, and exporters who have also benefited through increased availability at fair price. Consumers ultimately gain through increased availability, better quality and reduced transaction cost (KACE, 2011; Karagu, 2011). The impact of these services however, has not been assessed due to lack of publicly available data (Baumüller, 2016).

2.6.2 Video Based e-Extension Model

The world's population is growing exponentially and feeding them requires that agricultural productivity needs to increase dramatically. Agricultural information through public extension has generally been undersupplied and its provision remains challenging particularly in most developing countries. One way in which this information can be accessed by farmers is through use of simple agricultural extension videos in local languages, which can be delivered in downloadable formats though their mobile phones. As access to smart phones continues to expand farmers are able take photos of pests and diseases affecting their crops and make requests for identification automatically, diagnosis and prescriptions as well as raising questions with agronomists and extension agents. They are also able watch videos demonstrating new agricultural techniques (Bentley et al., 2015; Van Campenhout et al., 2016).

Videos, especially digital ones may help to meet the challenges of disseminating information to farmers and reaching the poor, marginalized, women, and young people. Bentley et al. (2015) indicate that some uses of video in agriculture include raising awareness, stimulating demand for support, farmer-to-farmer extension, training on agricultural innovations, stimulating creativity, and as a tool for documenting and monitoring and evaluation. The authors also further attests that different types of videos include documentary for describing events, institutional for promoting a project of an organization, instructional developed mainly by researchers with limited input from farmers, farmer learning videos made with farmers and participatory videos which made by farmers themselves. Some of the evidence of the impact of videos in agricultural extension and potential scalability include studies done in Benin and Uganda on farmer-learning videos among rice-growing communities where it is

reported that they could remember the contents of rice videos five years after viewing them. They had also made follow-ups by contacting extension agents to request rice seed. Women groups also in Benin that watched videos where more innovative and had stronger groups that produce and sell parboiled rice. In Ghanavideo viewing clubs that trained cocoa farmers had significantly improved technical knowledge among the farmers trained compared to the control groups (Bentley et al., 2014). A study by Ongachi et al. (2017) also revealed that video mediated learning approach had a greater influence on the uptake of Maize Striga control strategies compared to Farmer Field Schools among farmers in western Kenya. This therefore shows that videos can be cost effective as a complement to traditional extension approaches.

An example of video based e-Extension model that has been used in Kenya is Access agriculture which provided a platform through which farmers can access downloadable videos that has been translated into different local languages. However, according to Karubanga et al. (2016) Video Mediated Learning cannot stand alone in both knowledge acquisition and application. Access to agricultural videos by rural farmers still remains a big challenge (Okry et al., 2014). Most rural farmers in third world countries like Kenya have little access to source of power and possess ordinary mobile phones without internet and memory card features; a fact which affects visualizations of the farmer-to-farmer video (Zossou et al., 2009). Furthermore, lack of adequate access to video related accessories, lack of personal access to the videos, inappropriate content that are irrelevant to the farmers' needs in most rural areas make it difficult for farmers to embrace Video Mediated Learning (Zoundji et al., 2016).

2.6.3 Social Media Based e-Extension Model

Social media refers to the web-based tools and media that allow users to personally and informally interact, create, share, retrieve, and exchange information and ideas in virtual communities and networks. Social media includes social networking sites, blogs and micro blogs, online forums, discussion boards and groups, wikis, socially integrated text messaging services, videos and podcasts, and many more (Suchiradipta & Saravanan, 2016). According to Saravanan et al. (2015), the basic philosophy of social media is the democratization of information that provides a medium for social interaction, community networking, intercrossing relationships and collective participation among stakeholders.

Social media sites enable users to share content or to participate in social networking. Through social media, users are able to access services using web-based technologies on desktops and laptops or download services which provide social media functionality to mobile devices, such as smart phones and tablets. These electronic services have led to the creation of highly interactive platforms through which individuals, communities and organizations can share, co-create, discuss and even modify user generated content (FAO, 2019). As noted by Gonte (2018), social media has developed significantly in the past few years, creating opportunities for rural farmers to obtain information and knowledge about agriculture. By changing the way groups of people interact, which is different from traditional paper-based media (such as newspapers and posters) and electronic media (such as television broadcasting), social media has enhanced quality, reach, frequency, interactivity, usability, immediacy and performance. Barber et al. (2016) viewed social media as integrating all functions; from providing advice and sharing knowledge to creating awareness, linking with other actors, and technology transfer. One key feature of the innovation systems perspective is that many actors are involved. It follows that many different sources, types and forms of knowledge and information need to be circulated, communicated and aggregated to support agricultural research and innovation for development (Ballantyne, 2010). This conforms very well to the strength of social media whose outlets operate in a dialogic transmission system involving many sources targeting many receivers, as opposed to traditional media that operates under a monologic transmission model involving one source targeting many receivers (Mojaki & Keregoro, 2019).

The agriculture sector has seen an increased usage of social media among various stakeholders. The use of social media in agricultural extension and advisory services has changed the conventional technology and information dissemination into a modernized form. The transfer of agricultural technology and information through social media has a tremendous potential to fill the gap of low extension to farmer ratio which is evident in most developing countries (Ali & Man 2017). Examples of social media platforms that have transformed the way farmers interact and are able to access agricultural information include platforms such as WhatsApp, Facebook, Twitter, YouTube among others. These platforms have presented a cost-effective means of communication with, and among, smallholder farmers and other key agricultural stakeholders such as extension officers, agro-dealers, retailers, agricultural researchers and policy makers (FAO, 2019). In Africa access to agricultural research findings, research output and services in public research institutions has

been a big challenge. A study by Paudel and Baral (2018) in Nepal and Barau and Afrad (2017) in Bangladesh revealed that a social media platform such as Facebook showed to be an important tool in communicating with farmers among agricultural extension professionals. Additionally, Byomire et al. (2016) in their study in Uganda reports that social media platforms such as WhatsApp and Facebook were the most often used by agriculturists. Social media has also been shown to provide an avenue that could enhance the search for, distribution and sharing of such new knowledge and technologies (Chisenga et al., 2014). A number of emerging issues and activities in agriculture such as innovations, trainings, conferences, workshops, reports and publications are either being tweeted, hash tagged or streamed live on a daily basis. Furthermore, agricultural organizations and researchers have created agricultural applications and platforms where farmers and extension agents can access new practices online as well as enabling direct interactions with agricultural experts and advisory services (Jijina & Raju, 2016).

In Kenya, mobile phone penetration is estimated at 100 percent, with 83 percent of these users having a smartphone (Communications Authrority of Kenya [CCK], 2018; Nguniri, 2018). Access to smartphones has led to a rise in the use of social networking platforms such as Facebook, Twitter, Skype, and WhatsApp. These platforms provide means for people of shared interest to interact with the help of Internet connectivity through phones, tablets, or computers despite the distance (Chesoli et al., 2020). Other than social purposes such as keeping in touch social networking has been used to promote products and services, data collection, dissemination of information and agricultural extension and advisory services (Welch et al., 2018). Examples of social media agricultural innovations that have been developed in Kenya include Mkulima Hub Kenya, Young Farmers Market, Digital Farmers Kenya, Mkulima Young and are enabling farmers to access agricultural information (Kipkurgat et al., 2016). Other Kenyan agricultural institutions such as the Kenya Agricultural and Livestock Research Organization and the Agricultural Information Resource Center have also incorporated social media platforms such as Twitter, YouTube, and Facebook and blogs as part of their information systems. It is also evident that there is convergence of traditional media and social media in providing and shaping agricultural content. Agricultural programs aired on Kenyan television such as *"Shamba shape up"* aired by Citizen TVand *"Seeds of Gold"* a pull out in the Saturday Nation Newspaper both have social media platforms. Other agricultural programs on local radio stations also have social media platforms for receiving feedback from farmers. Low usage social media among

farmers however, has been attributed to lack of awareness, lack of internet connectivity and data bundles, costs associated with using gadgets in accessing social media sites and lack of requisite skills (Kuria, 2014).

2.6.4 Mass Media Combined with Mobile phone e-Extension Model

Radio is one of the most extensively used media for disseminating agricultural information to rural farmer across Africa due to increased ownership among farmers (Hudson et al., 2017; Sousa et al., 2016). Therefore, it offers a create opportunity to reach often poorly underserved, widely dispersed farmers in remote areas thereby overcoming barriers of distance and poor road infrastructure which is most common in rural areas (Baumüller, 2018). Okello et al. (2010) reported that radio is the most widespread ICT platform in Kenya due to its wide coverage, availability of radio stations in various vernacular languages and its portability nature. Radio has also been well researched on in terms of ICT based extension advisory method which provides farmers with accessibility to agricultural information and extension services. Radio has been paired with other ICT applications to provide farmers with agricultural advisory services. An example of this is combination of radio and mobile phones, often though SMS and real time mobile calls in the Kenyan local vernacular stations which broadcast agricultural programmes with interactive sessions were farmers can ask questions and receive feedback from experts. This according to Hudson et al. (2017) has become avital tool in networking and exchange of information among communities.

There are studies that have assessed the impact of the use of radio and mobile phone in delivering agricultural information which shows that these tools increases awareness of agricultural technologies as well as their uptake(Aker, 2011; Baumüller, 2018; Hampson et al., 2016; Hudson et al., 2017; Kaskekacharo, 2016).Participatory radio campaignshave also been shown to increase knowledge and adoption of promoted agricultural practices in African countries(Hudson et al. (2017). A review of the literature by Baumüller et al. (2018) on the impact of mobile phone-based services for farmers in developing countries however, presented contrasting and limited evidence. Fafchamps and Minten (2012) on the other hand found that SMS did not impact the likelihood to change agronomic practices and crop varieties among Indian farmers. Other studies however, have reported mobile-based services paired with radio to improve gender equality and household welfare (Sebakira & Qaim, 2017), is linkedto improved knowledge and adoption of agricultural practices (Fu & Akter, 2016; Larochelle et al., 2019) and production of diversified crops (Aker & Ksoll, 2016).

Other studies in Tanzania, Uganda, Malawi and Ethiopia have shown that radio still remains the most widely used medium in disseminating agricultural information to rural farmers. The studies show that interactive radio programmes were widely used by farmers because they are broadcasted in local languages making it easy for them to understand the content (Barakabitze et al., 2017; Hudson et al., 2017; Misaki, 2016; Otene, 2018). In Kenya according to a study by Okello (2010), radio is mostly used in rural areas because ofits portability nature, extensive coverage of frequencies and availability of several vernacular radio stations. A number of vernacular radio stations in Kenya also airs agricultural content for example *Inooro* FM, *Kameme* FM, Citizen FM and *Utugi* FM with some complementing each other with the Television stations airing the same content (Okello, 2017). These stations also integrate use of other ICT platforms such as SMS, USSD, mobile calls and social media platforms such as Facebook and Twitter to engage their listeners.

Another Mass media ICT tool that has gained a lot of popularity among most Kenyan rural farmers is the Television mainly due to increased accessibility to electricity. This in turn has led to an increase in agricultural TV programmes that broadcast agricultural technologies and information and are also available in various languages. Examples of agricultural TV programmmes aired in Kenya include "*Shamba Shape Up"* aired by Citizen TV, "*Seeds of Gold"* aired by NTV, *"Mkulima Young*", "*Mugambo wa Murimi*" aired by Inooro TV, and "Mkulima ni Ujuzi" aired by QTV (Okello, 2017; Pauline, 2013). Therefore, Radio and Television have played, and still continues to play, an important role in agricultural extension and in getting farmers in touch with key extension services. Mtega and Msungu (2013) found a positive influence in the complementarities of TV, mobile phone and radio on use of these ICTs among farmers in Tanzania. The researchers found radio and TV were complementary with TV showing the same program where TV showed the program in the evening hours and radio in the morning hours. In addition, their study confirmed a positive effect of complementarities in using mobile phones for accessing information and mobile money services.

2.6.5 Farmer Call Center e-Extension Model

One of the major challenges facing farmers in developing countries is limited use of proven agricultural technologies, knowledge and skills which has led to low agricultural productivity. The situation has been exacerbated by inefficient extension services**,** poor infrastructure and limited knowledge and skills of professional among other factors (Mojaki

& Keregoro, 2019). These can be gapped through enhanced and consistent transfer of improved agricultural technologies, knowledge and skills which can be translated into practices for improved agricultural productivity. One way of achieving this is thorough complimenting existing public agricultural extension with emerging ICT technologies (McGuire et al., 2015). The decrease of government budgets among most developing countries as well limited resources has led to a shift to provision of extension services through ICTs to help disseminate agricultural information (Aker & Mbiti, 2014). The ICT tools, include radio, mobile phones, web, farmer call centers among others. The new ICT technologies are becoming high valued communication channels among different agricultural stakeholders including extension agents and farmers. The use of ICTs in extension can lead to a multi-stakeholder, people-centric, cross-sectoral system that brings together all stakeholders, especially farmers, to enable them to access timely and relevant information, and exchange opinions, experiences, good practices and resources related to agriculture (Bore et al., 2015).

The proliferation of mobile telephony particularly in developing countries is providing new opportunities for delivering timely and relevant agricultural information and advisory services for supporting large number of farmers across wider geographical locations and with fewer technical resources. Farmer call center is one of the emerging ICTs which have become the largest development intended to provide extension services where, operators answer farmers' questions at a central location. Call centers integrates different technologies to maximize the use of information and streamline its activities with operators (CoLab, 2018). Through their phones, farmers are able to access timely and relevant technical support at reasonable costs from the call centre (McGuire et al., 2015).

Farmer call centers are becoming popular in providing agricultural extension services in developing economies. For example, the Indian Kisan Sanchar Limited is a mobile information provider to rural farmers through 38,000 Indian Farmers Fertilizers Co-operative (IFFCO) societies throughout India and provides farmers with real time agricultural information through a call center and daily voice messages (Koshy & Kumar, 2016). In Kenya, the Farmers Helpline operated by KenCall, a for-profit call center, is a real time call service staffed by agricultural experts and subject matter specialists that provides agricultural information, advice and support to smallholder farmers over the phone, using voice and voice call-back to farmers, not SMS (Mojaki & Keregoro, 2019; USAID, 2010). The call centre primarily targets individual farmers but also the services are available to agricultural

extension agents. Farmers are provided with information on inputs, information on climate, market information improved agricultural production and processing through their mobile phones. In an event that the farmers' questions cannot be answered by the expert at once, the helpline agent contacts a second line consultant and reverts to the farmer within 24 hours and the services are available in English, Swahili and other local languages (Kiambi, 2018).

Nakuru Farmers Call Centre (NFCC) is another example of a farmer call center in Kenya. It an ICT platform that is supported by the County Government of Nakuru through the Department of Agriculture, Livestock and Fisheries as an extension methodology for the delivery of e-Extension services to farmers. The center borrowed heavily on the methodology from the India Kisan Call Centre based in Hyderabad in Telangana State, India. The purpose of the call center is to provide real time extension messages through phone calls, SMS and social media platforms such as Twitter, Facebook and Whatsapp to farmers (County Government of Nakuru [CGN], 2020). It is operated by four technical officers who include a Crops officer, Livestock production officer, Fisheries Officer and a technical officer in-charge. The farmers are also linked to other stakeholders for networking in areas of marketing, agrochemical companies, research institutions, Agriculture Universities, NGO's and other extension officers. The officers at the call center attempts to answer the problems or queries of the farmers immediately. In case the officer at the call centre is not able to address the farmer' questions, then it are forwarded to an identified agricultural specialists and the answer reverted back to the farmer. The center is supported by the Nakuru County Government through the Department of Agriculture, Livestock and Fisheries since 2018 and covers the entire county (Nakuru County Extension report, 2020). There is limited information however, that is available on the feedback on usage of the call centre among the farmers and therefore this study aimed at establishing whether farmers use the NFCC as one of the e-Extension platform to access agricultural information.

2.7 Theoretical Framework

The Diffusion of Innovations (DOI) Theory by Rogers and Technology Acceptance Model (TAM) theory was adopted for this study. Rogers (2010) defined diffusion as the process by which an innovation moves within a social system over time. While an innovation often refers to physical objects, it can also include ideas, behaviors, or practices that are new to the individuals within a system. An essential aspect of Rogers' DOI theory considers the specific characteristics of an innovation when explaining diffusion. This includes the innovation's

perceived costs and benefits, its ability to be tested, a person's familiarity with the innovation, the difficulty of use, and its compatibility with the pre-existing social, economic, and environmental systems (Elia et al., 2014). The intense data and information required and used in agriculture means that ICTs can play a crucial role in the development, flow, exchange, and management of agriculture information (Nwagwu & Famiyesin, 2016). However, the compatibility of a technology within a current system, including the availability of effective training, trust, and technology infrastructure, is necessary for innovation diffusion (Aubert et al., 2012; Nwagwu & Famiyesin 2016; Taragola Van Lierde & Gelb, 2009).

A review of precision agriculture adoption in Canada found that the "perceived ease of use" and the usefulness of technology were significant indicators of technology adoption. The compatibility of precision agriculture with existing farm equipment was also important (Aubert et al., 2012). In a study on ICT use among livestock innovation chains, researchers found that while farmers used ICTs for marketing, they did not see the relevance of ICTs for other areas of agriculture. For those that did utilize ICTs, the quality of telecommunication services, the ease in which they could be used, and how the technology fit into their enterprise were key aspects of the decision to use ICTs (Nwagwu & Famiyesin, 2016).

The advancement of the ICT sector offers opportunities for improving agriculture extension service delivery. The innovation in the study is e-Extension which is the delivery of agricultural information and knowledge services using the Internet and related technologies including computers, mobile phone and various services and applications including video conferencing, calls, text, WhatsApp messaging and social media platforms. The extension agents have been using conventional communication channels to disseminate agricultural information to farmers and other stakeholders. These channels however, have not allowed for much interaction. Communication of agricultural information via ICTs such as the internet, mobile telephony, videos and video conferencing among others are being adopted to complement the conventional extension methods.

Technology Acceptance Model (TAM) theory on the other hand has been widely cited by many studies to explain the usage of ICT and its services in various fields (Hao, 2013; Heili & Assar, 2009). It is derived from the theory of reasoned action (TRA) and it explains how users come to accept and embrace technology. The model suggests that the factors that influence consumers' decision about how and when to use a new technology are perceived in usefulness. The degree at which a person believes that using a particular system would

enhance his or her performance is perceived by ease of use. Thus, one will believe that using a particular system would be free from effort (Davis, 1989). However, TAM has been continuously upgraded to include other factors to help explain and predict the acceptance of new technology apart from using only perceived usefulness and perceived ease of use. TAM has been upgraded by incorporating Ajzen's (1991) Theory of Planned Behavior (TPB) and Roger's (1995) diffusion of innovation to include the subjective norms and perceived behavioral control. TAM is applied at an individual level and is based on the basis of individuals' use of technology for personal effectiveness, increasing work output and enhancing the decision-making process.

2.8 Conceptual Framework

The study focused on the influence of technology-related factors on usage of e-Extension services among smallholder farmers. The independent variable of the study included technology-related factors which entailed access to ICTs by smallholder; ICT skills of smallholder farmers, digital content available to the farmers and its characteristics and the types of e-Extension platforms available to the smallholder farmers. The dependent variablewas the usage of e-Extension services measured in terms of whether ICTs were used or not, frequency of use of ICTs, use of ICT skills and e-Extension platforms to access e-Extension services. The intervening variables of were; education level, age, gender, income and group membership level of smallholder farmers. The effects of the intervening variables were minimized through randomization. This method is recommended as an effective means of controlling the effect of intervening variables on an outcome (Best & Khan 2005). Figure 2 illustrates the interactions and relationship between the independent and dependent variables.

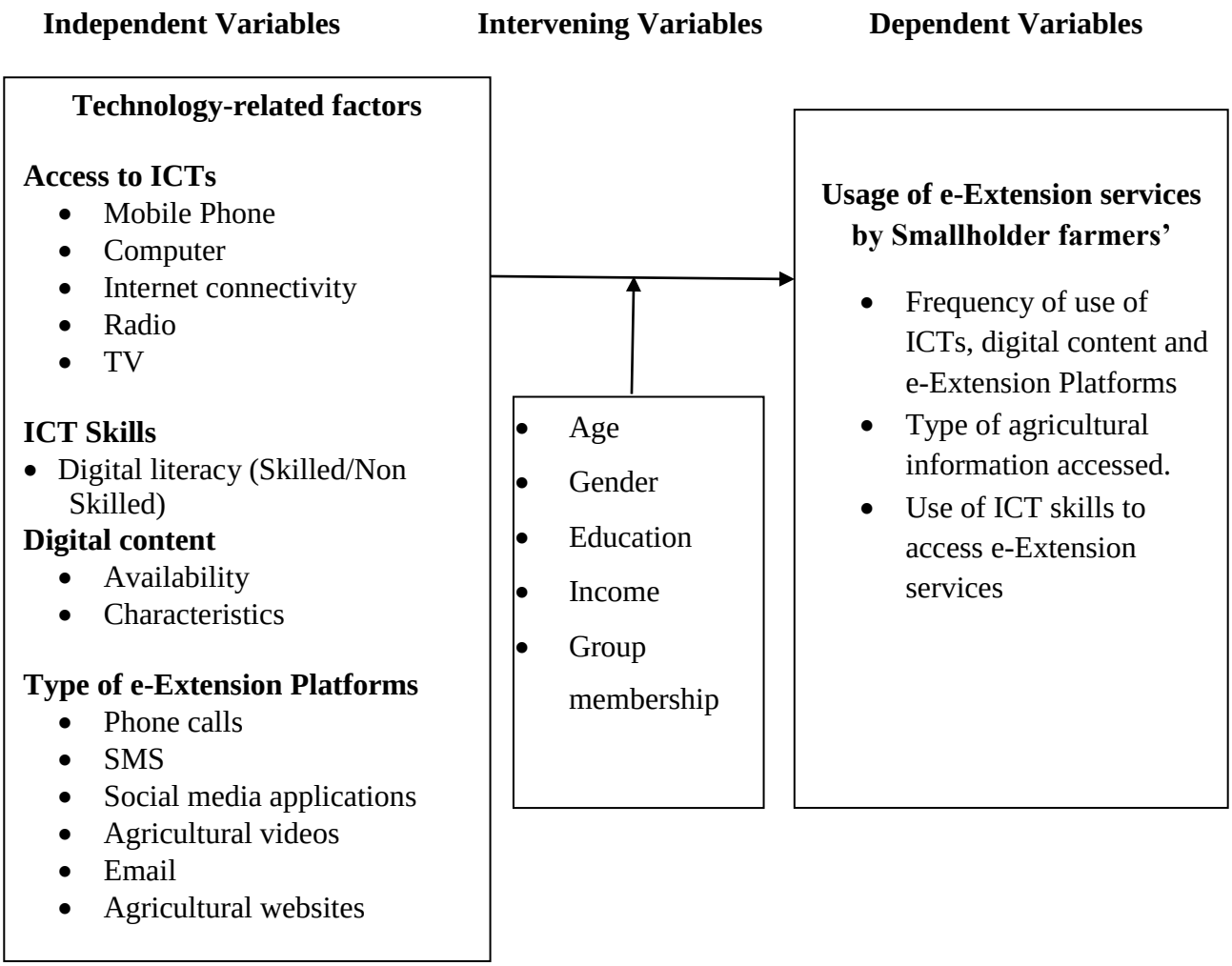

Figure 2*: Conceptual Framework Showing the Interactions between the Variables of the Study*

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

The chapter is organized into the following sections: introduction, research design, location of the study, population, sampling procedure, data collection instruments and data analysis.

3.2 Research Design

The study employed descriptive survey design. This design was considered appropriate as it facilitates the collection of data through direct enquiries and observations. Descriptive survey is suitable for collecting data that describes specific characteristics of a phenomenon for the purpose of reporting things the way they are (Ogula, 1998). Survey design entails making accurate assessment of the influence, distribution and relationship of phenomenon (Edwards, 2006). This study employed the survey design to establish the influence of technology-related factors on usage of e-Extension services among smallholder farmers in Nakuru County in Kenya.

3.3 Location of the Study

The study was carried out in Nakuru County which lies within the Great Rift Valley and borders seven other counties namely; Kericho to the west, Laikipia to the north-east, Narok to the south-west, Kajiado to the South, Baringo to the North, Nyandarua to the East and Bomet to the West. The County is divided into eleven administrative Sub-Counties namely: Naivasha, Nakuru Town West, Nakuru Town East, Kuresoi South, Kuresoi North, Molo, Rongai, Subukia, Njoro, Gilgil and Bahati; eleven constituencies and 55 electoral Wards. It covers 7498.8 Km^2 and has an estimated population of 2.1 million with 1,054,898 males and 1,049,490 females (Nakuru County Integrated Development Plan (GOK, 2018).The County is located between Longitudes 35.41 º East or 35 º 24’ 36” East and 36.6 º East or 36 º36’ 0” East and Latitude 0.23 º North or 0º13’ 48” North and 1.16 º South or 1º 9`36” South.

The land area under food crops and cash crops in Nakuru County is 243,711.06 Ha and 71,416.35 Ha respectively covering approximately 3,151.240 Km^2 of the total area of the county. Nakuru County has temperatures ranging between 10°C during the cold months (July and August) and 20°C during the hot months (January to March). The county receives between 500mm and 1800mm of rainfall annually, with average annual rainfall being an

approximated 800mm and two rainy seasons; long rains that runs from April to August and short rains from October to December. The climate of the County is strongly influenced by the altitude and the physical features. There are four broad agro-ecological zones; Zone 4 which cover an altitude of 2300m to 2700 m above mean sea level (amsl) and covers Kuresoi South and North, Zone 3 with an altitude of between 1800-2300 amsl and covers sub-counties of Molo, Njoro and Bahati, Zone 2 with an attitude of 900-1800amsl covering most parts of the county and Zone 1 with annual amount of rainfall of about 500 mm- 800 mm per annum predominantly experienced in Gilgil and Naivasha sub-counties.

Agriculture sector plays a critical role in the provision of food and creation of employment in the County. However, low food production has been identified as a major contributing factor to food insecurity and poverty in the county. Other challenges facing the food production systems in the county include diminishing agricultural land, climate change, market constraints, and lack of affordable credit facilities for farmers and high cost of farm inputs (GOK, 2018).

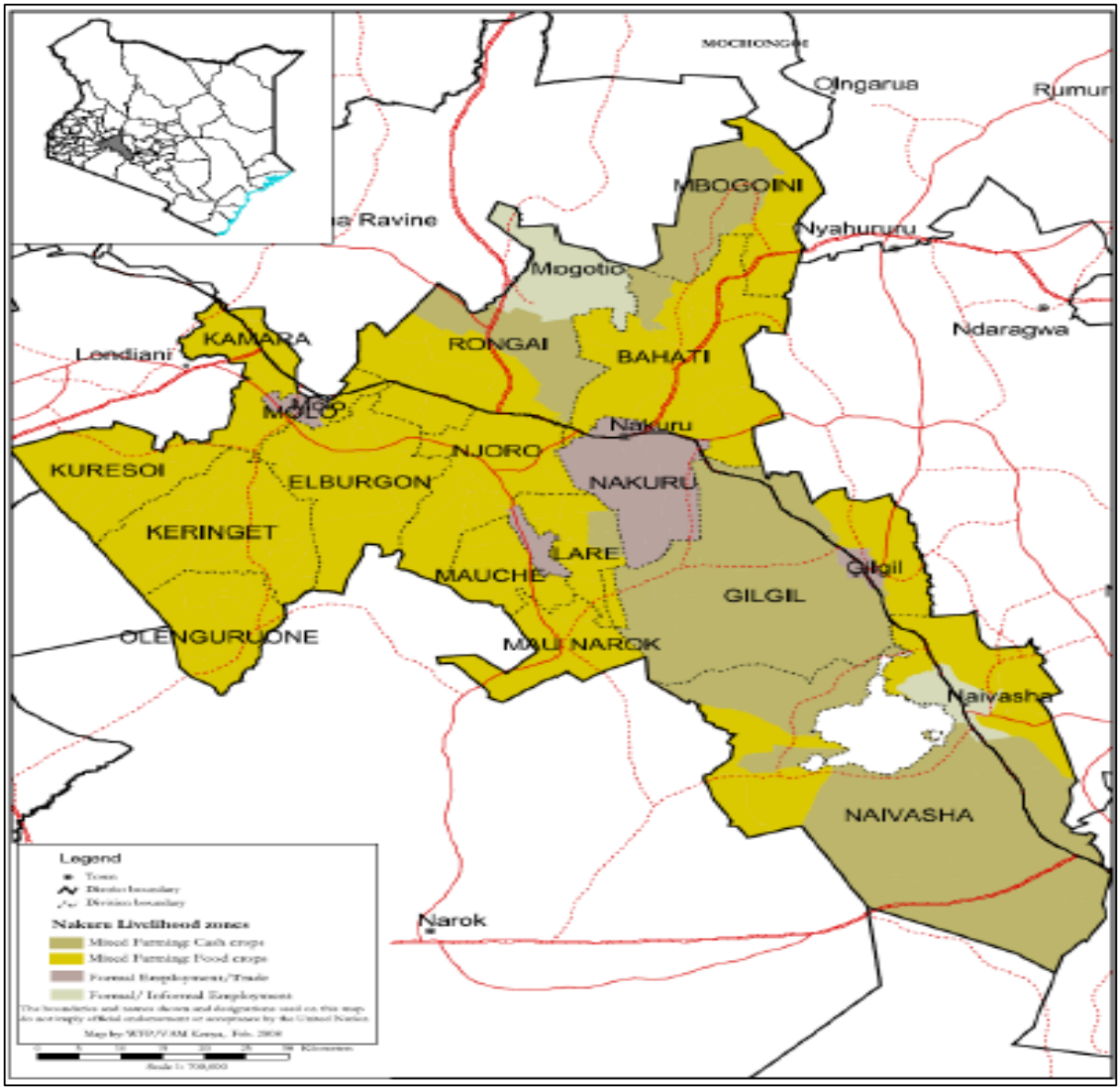

Figure 3: *Map of the Study Area*

3.4 Target Population

The target population for this study was 409,836 smallholder farmers distributed across eleven sub counties of Nakuru County. The accessible population however, was 83,213 smallholder farmers and 34 extension agents in three sub counties of Nakuru County. The three sub counties were selected purposively to represent the three agro-ecological zones in the county. In addition, all the 34 extension staff in the three sub counties was targeted in the study. The distribution of smallholder farmers and extension staff per sub-county is presented in Table 1.

Table 1

Distribution of Smallholder Farmers and Extension Staff per Sub County

Sub County	**Smallholder Farmers Population**	**Extension Staff Sample size**
Subukia	18,409	16
Molo	30,783	08
Gilgil	34,021	10
Total	**83,213**	**34**

Source: Nakuru County Integrated Development Plan 2018-2022 (GOK, 2018)

3.5 Sampling Procedure and Sample Size

Multi-stage sampling technique was used to select the representative sample. Purposive sampling was used to select Nakuru County due to its agricultural potential besides being among the first counties in Kenya to embrace the e-Extension programme launched by the government. In addition, the county was also the first County in the country to launch a farmer call center which offers e-Extension services to farmers (AIRC, 2015). Secondly, since the County is divided into three agro-ecological zones of high, medium and low potential, stratified sampling was used to select one sub county to represent each stratum. Using Kathuri and Pals (1993) recommendation of 30 percent of the population for achieving sample size, three sub counties were selected from the eleven sub counties in Nakuru County. Purposive sampling was used to select Molo Sub County to represent high potential area, Subukia Sub County medium potential area and Gilgil Sub County low potential area. Thirdly, required sample from each of the three selected sub counties was proportionately selected. In the final stage of sampling, simple random sampling was used to select the participants of the study from each of the sub counties.

The required sample size for the study for the smallholder farmer's category was then be calculated using the formula:

$n = NC^2 \div C^2 + (N-1)\, e^2$

Where;

n is Sample size: N is Population Size: C is Coefficient of Variation: e is Margin of Error

The study sample was calculated at 20 percent coefficient of variation and 2 percent margin of error (Nassiuma, 2000).

The expected sample size therefore was:

$$n= 83,213 \times 0.2^2 \div 0.2^2 + (83,213 - 1)\ 0.02^2$$

$$n= 99.9$$

The required sample size for farmer category according to the formula for sample size determination is 99.9 respondents was rounded up to 100 farmers. However, Borg and Gall (1989) suggest an inclusion of 20 to 30 percent of the actual sample size to cater for attrition and non-response as an estimate for a realistic level of planning. Taking the maximum percentage of 30 percent an additional 30 farmers were included making the total sample to be 130 farmers. In addition, to the farmer respondents all the 34 extension staff in the three sub counties were selected to participate in the study however, 25 extension staff participated in the study. Participants of the Focus Group Discussion (FGD) were selected purposively and comprised one farmer representatives from each of the three sampled sub counties, one extension agent staff heading the Nakuru Farmer Call Center, three Sub county agricultural officers and three ward extension staff representing each of the sampled sub counties. Therefore, total of eight participants for the FGDs were targeted. Farmers' distribution and extension agents per Sub County are presented in Table 2.

Table 2

Distribution of Smallholder farmers and Extension agents per Sub-county in Nakuru County

Sub County	**Farm Household's Population**	**Farm Household's Sample Size**	**Extension Staff Sample size**
Subukia	18,409	29	16
Molo	30,783	48	08
Gilgil	34,021	53	10
Total	**83,213**	**130**	**34**

3.6 Instrumentation

The data collection instruments for the study comprised of questionnaires for smallholder farmers and extension staff and a focus group discussion guide for key informants.

a) Small holder Farmer and Extension Staff Questionnaires

Structured questionnaires (Appendix A&B) were administered to smallholder farmers and extension agents respectively. A questionnaire was preferred because it allows the researcher to reach a larger sample of population within a limited time and is suitable for collecting basic descriptive information (Borg & Gall, 1989). The farmers' questionnaire had five sections. The first section captured information on farmers' characteristics including age, gender and education level while the second section captured information on access to ICTs by smallholder farmers'. The third section captured data on ICTs skills possessed by smallholder farmers to enable them use e-Extension services. Section four looked at information on digital content that farmers have access to and its characteristics while section five obtained information from smallholder farmers on type of e-platforms which are used to avail e-Extension services to them and also challenges that farmers face when utilizing the e-Extension services. A total 130 smallholder farmer questionnaires were administered out of which all the 130 were returned giving 100 % response rate. The agriculture extension staff questionnaire targeted 34 respondents and 25 were returned, giving a return rate of 91.7%.

The extension agents' questionnaire had six sections. The first section captured information on extension agents' characteristics such as age, gender and education level. Section two captured information on ICT skills that extension agents possess to use ICTs for providing e-Extension services to farmers while section three captured information ICT tools available to extension agents. Sections four looked at information on types of digital content availed to farmers. Section five obtained information on types e-platforms used to deliver agricultural information to farmers and constraints facing the extension agents in the use of e-Extension services in extension service delivery.

b) Focus Group Discussion Guide

Three Focus Group Discussions (FGDs) were conducted to obtain in-depth information about use of e-Extension services among smallholder farmers. A focus Group Discussion enables th researcher to gather information from the people with similar background and experiences in an interactive manner, which is not possible during structured interviews, surveys or semi-

structured key Informant Interviews (DzinoSilajdzic, 2017). Focus Group Discussion guide (Appendix C) was used to collect data from selected key informants. The participants of each FDG comprised of farmer representatives, extension staff heading the Nakuru farmer call center, Sub County Agricultural Officer and one extension staff representing each of the targeted Sub Counties. The FGD guide had a set of open-ended questions to enable the researcher to probe for in-depth information of the participants' ideas and thoughts about the topic of study. The FGDs captured data on ICTs that smallholder farmers' have access to, the level of farmers' ICT skills, the type of digital content farmers' have access to and its characteristics, the type of e-Extension platforms accessed and used by farmers and the type of agricultural information accessed using ICTs.

3.6.1 Validity

Validity refers to the accuracy and meaningfulness of the inferences a researcher makes based on the results of the data collected and consist of face and content validities (Kothari, 2004). It is related to how accurate the data obtained in the study would represent the variables under study. The instruments were validated in consultation with five experts in the Department of Agricultural Education and Extension to assess whether the instruments had clear and appropriate content to measure the objectives of the study. In addition, experts in measurement were consulted to further validate the research instruments. The comments and suggestions made were incorporated to improve the quality of the instruments and ensure the results and inferences of the study are accurate and meaningful.

3.6.2 Reliability

Reliability is the degree to which the measure of a construct is consistent or dependable in measuring results (Bhattacherjee, 2012). A pilot study of the farmer questionnaire and extension staff questionnaire was carried out in Kuresoi South Sub County in Nakuru County. The Sub-county is not among those used in the study but it has almost similar social-cultural, climatic and geographic conditions as the study site. Hill (1998) suggested 10-30 participants for pilot-testing in a survey research while Baker (1994) suggested a sample of 10-20 percent of the sample size for the actual study as reasonable number of participants in a pilot study. Taking 20 percent of the actual study sample yielded 26 smallholder farmers for the pilot-testing. Reliability of the study instruments therefore was estimated through a pilot study on 26 smallholder farmers and six agricultural extension staff in Kuresoi South Sub-county

which was outside the area of study but had almost similar social-cultural, climatic and geographic conditions as the study site. The outcome of the pilot testing was useful in revising the items on the questionnaires in order to improve its reliability. Cronbach's Alpha Coefficient was used to determine the reliability of the instruments. A reliability coefficient of 0.87 and 0.71 was obtained for smallholder farmers' questionaire and Agricultural Extension staff questionnaire respectively. According to Bland (1997), alpha values of at least 0.7 are regarded as satisfactory.

3.7 Data Collection Procedure

The researcher obtained a letter of approval from the board of postgraduate studies of Egerton University. The letter was then used to seek for a research permit from the National Council for Science, Technology and Innovation (NACOSTI). The research permit was then presented to the County Director of Education Nakuru County to be given permission to conduct research within the county. The researcher then reported to the Department of Agriculture in all the sub-counties where the study was to be conducted. Through the staff in the sub county agriculture offices, community leaders and respondents were contacted and informed of the exercise prior to data collection, to make appointments for convenient time and venues. Three research assistants were identified, trained on the procedure for conducting focus group discussions and questionnaire administration as well as recording in order to ensure valid information was collected. The farmers' questionnaires were administered by the researcher assisted by the research assistants. The agricultural extension agents involved in the study were contacted prior to the visit to the sub-counties in order to make arrangements on suitable time and venues. Questionnaires were administered to them by the researcher and once the exercise was completed the questionnaires were picked the same day. This was to avoid any contamination of the data (Borg & Gall, 1989). Three Focus Group Discussions were held in each of the three Sub-counties targeted for the study and each had eight participants and the researcher recorded the discussion points thematically based on the study objectives.

3.8 Data Analysis

Data cleaning was done to generate valid and usable data for analysis. Analysis then done using Statistical Package for Social Sciences (SPSS) version 22. Qualitative data was organized into categories by themes and then analyzed to obtain meaning and unique contributions based on the study objectives. Inferential statistical procedures were used to

analyze quantitative data. Responses were scored and coded then ordinal logistic regression model and Chi square test were used to establish influence at 0.05 level of significance. Inferential statistics was done using Ordinal Logistic Regression model presented below:

$$logit(P(Y \leq j)) = \beta_{j0} + \beta_{j1}x_1 + \cdots + \beta_{jp}x_p$$

Where Y = Dependent variable

J = Number of categories of the independent variable

X = Independent variables

$X = X_1, X_2, \ldots, X_p$

$\beta_j o$ = Constant of each j^{th} category

β_{j1} = parameter estimate for the j^{th} independent variable. $logit(P(Y \leq j)) = ln\frac{P(Y \leq j)}{P(Y > j)}$

p = Number of predictor variables

Where $P(Y \leq j)$ = Cumulative probability that the independent variable is less than or equal to a specific category j

j = 1, …, J-1

3.8.1 To Determine Influence of Access to ICTs on Usage of e-Extension Services Among Smallholder Farmers

The Ordinal Logistic regression model equation used for analysis was as follows:

$$logit(P(Y \leq j)) = \beta_{j0} + \beta_{j1}x_1 + \cdots + \beta_{jp}x_p$$

Where Y = Usage of ICTs to access e-Extension services

J = Five. (1 = Never, 2 = Rarely, 3 = Sometimes, 4 = Often, 5 = Always)

X = Independent variables

$X = X_1$ (Accessibility of ICTs (Yes/ No)), X_2 (accessibility of ICTs (1=very low access 2=low access 3=medium access 4=high access 5=very high access).

$\beta_j o$ = Constant of each j^{th} category

β_{j1} = parameter estimate for the j^{th} independent variable.

$$logit(P(Y \leq j)) = ln \frac{P(Y \leq j)}{P(Y > j)}$$

Where $P(Y \leq j)$ = Cumulative probability that the usage for ICTs to access agricultural information is less than or equal to a specific category j

j = 1, …, J-1

3.8.2 To Determine the Influence of ICT Skills on Usage of e-Extension Services Among Smallholder Farmers

The Ordinal Logistic regression model equation used for analysis was as follows:

$$Logit(P(Y \leq j)) = \beta_{j0} + \beta_{j1}x_1 + \cdots + \beta_{jp}x_p$$

Where Y = Usage of ICTs to access e-Extension services

J = Five. (1 = Not at all 2 = Low 3 = Moderate 4 = High 5 = Vey High)

X = Independent variables

X = X_1 (availability of skill in using ICTs (Yes/ No), X_2 (skill level of ICTs (1 = No skill 2 = Basic ICT skills 3 = Intermediate ICT skills 4= Skilled 5 = Advanced skills).

$\beta_j o$ = Constant of each j^{th} category

β_{j1} = parameter estimate for the j^{th} independent variable.

$$logit(P(Y \leq j)) = ln \frac{P(Y \leq j)}{P(Y > j)}$$

Where $P(Y \leq j)$ = Cumulative probability that the usage of ICTs to access agricultural information is less than or equal to a specific category j

j = 1, …, J-1

3.8.3. To Establish the Influence of Digital Content on Usage of e-Extension Services Among Smallholder Farmers

a) Availability of digital content

The Ordinal Logistic regression model equation used for analysis was as follows:

$$logit(P(Y \leq j)) = \beta_{j0} + \beta_{j1}x_1 + \cdots + \beta_{jp}x_p$$

Where Y = Usage of digital content to access e-Extension services

J = Five. (1 = Never, 2 = Rarely, 3 = Sometimes, 4 = Often, 5 = Always)

X = Independent variables (Accessibility to agricultural digital content, where 1=Very low 2 = Low access 3 = Medium access 4=High access 5= very high access)

$\beta_j o$ = Constant of each j^{th} category

β_{j1} = parameter estimate for the j^{th} independent variable.

$$logit(P(Y \leq j)) = ln \frac{P(Y \leq j)}{P(Y > j)}$$

Where $P(Y \leq j)$ = Cumulative probability that the usage for digital content to access agricultural information is less than or equal to a specific category j

j = 1, …, J-1

b) Characteristics of agricultural digital content

The Ordinal Logistic regression model equation used for analysis was as follows:

$$logit(P(Y \leq j)) = \beta_{j0} + \beta_{j1}x_1 + \cdots + \beta_{jp}x_p$$

Where Y = Usage of digital content to access e-Extension services

J = Five. (1 = Never, 2 = Rarely, 3 = Sometimes, 4 = Often, 5 = Always)

X = Independent variables (cost of digital content, timeliness of digital content, relevance of digital content, language of digital content, reliability of digital content, details of digital content; where 1=Very poor 2=Poor 3=Good 4= Very good 5=Excellent)

$\beta_j o$ = Constant of each j^{th} category

β_{j1} = parameter estimate for the j^{th} independent variable.

$$logit(P(Y \leq j)) = ln \frac{P(Y \leq j)}{P(Y > j)}$$

Where $P(Y \leq j)$ = Cumulative probability that the usage for digital content to access agricultural information is less than or equal to a specific category j

j = 1, …, J-1

3.8.4 To Determine the Influence of Type of e-Extension Platforms on Usage of e-Extension Services Among Smallholder Farmers

Pearson's Chi-square test was used to establish whether there was statistical significance between the type of e-Extension platforms and usage of e-Extension services among smallholder farmers. Cramer's V test was then used as a post-test technique to determine the strength of the association with values ranging from 0-1. The strength of association was interpreted as follows; 0 - 0.19 was considered "*very weak",* 0.2 - 0.39 as *"Weak",* 0.40-0.59as *"moderate",* 0.6-0.79 *as "strong",* and 0.8-1 as *"very strong"* association (Simar & Wilson, 2015). Table 3 presents the summary of data analysis.

Table 3

Summary of Data Analysis

Hypotheses	**Independent variable**	**Dependent variable**	**Statistical procedure**
$H0_1$: There is no statistically significant influence of access to ICT on usage of e-Extension services among smallholder farmers in Nakuru County, Kenya	Access to ICT resources • Mobile Phone • Computer • Internet connectivity • Radio • TV	Usage of e-Extension services	Frequency, Percentages, Means and standard deviation, ordinal logistic regression
$H0_2$: There is no statistically significant influence of ICT skills of farmers on usage of e-Extension services among smallholder farmers in Nakuru, County Kenya	ICT skills of farmers	Usage of e-Extension services	Frequency, Percentages, Means and standard deviation, ordinal logistic regression
$H0_3$:There is no statistically significant influence of Digital content on usage of e-Extension services among smallholder farmers in Nakuru county, Kenya	Digital content • Availability and Characteristics of digital content	Usage of e-Extension services	Frequency, Percentages, Means and standard deviation, ordinal logistic regression
$H0_4$: There is no statistically significant influence of Type of e-Platform on usage of e-Extension services among smallholder farmers in Nakuru county, Kenya	Type of platforms	Usage of e-Extension services	Frequency, Percentages, Means and standard deviation, Chi square test

3.9 Ethical Considerations

Research clearance was obtained from NACOSTI which was then used by the researcher to seek for permission to conduct research in Nakuru County from the County Director of Agriculture. Participants were briefed on the need of the study and their consent sought by the researcher. Ethical consideration of the respondents was ensured by assuring them the purpose of the research, expected duration and procedure for data collection. Participant's right such as right to decline to participate or withdraw from the research was communicated to them. Contacts of the researcher were also availed to the respondents in case of any questions arising from the exercise.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

The results and discussions of the study are presented in this chapter which is organized with reference to the objectives and the hypotheses in chapter one. The results are presented in six sections. Section one is an introduction while section two provides the demographic characteristics of the respondents. Section three and four examines the influence of access to ICTs and ICT skills of farmers on usage of e-Extension services among smallholder farmers. Section five and six discusses the influence of digital content and type of e-Extension platforms on usage of e-Extension services among smallholder farmers.

4.2 Demographic Characteristics of the Respondents

Demographic characteristics of the farmer respondents and agricultural extension staff were examined prior to testing the study hypotheses. Kothari (2004) asserts that, describing the characteristics of a sample provides a better understanding of the respondents and evidence that it has attributes of the population.

4.2.1 Characteristics of the Farmer Respondents

Under this section, the gender of the respondents, distribution per sub county, age, level of education, farm size, farming activities, income distribution and farmer group membership are discussed. These individual factors were pertinent to the study since they may affect the respondents' ability to access and use ICTs, digital content or e-Extension platforms for agricultural activities. The factors therefore, were considered as intervening variables in the study.

4.2.1.1 Gender of the Farmer Respondents

The study was interested in the gender of the farmers because it may influence access or uses the ICTs, digital content or e-Extension platforms for agricultural use and may likewise impact decision making both at household and farm level. Gender may also present different information needs for male and female farmers which will determine the type of ICTs used to access the information. The design of the instrument contained information to enable the researcher to collect information about gender of the respondents. Figure 3 presents gender distribution of the respondents across the three sub counties of the study location.

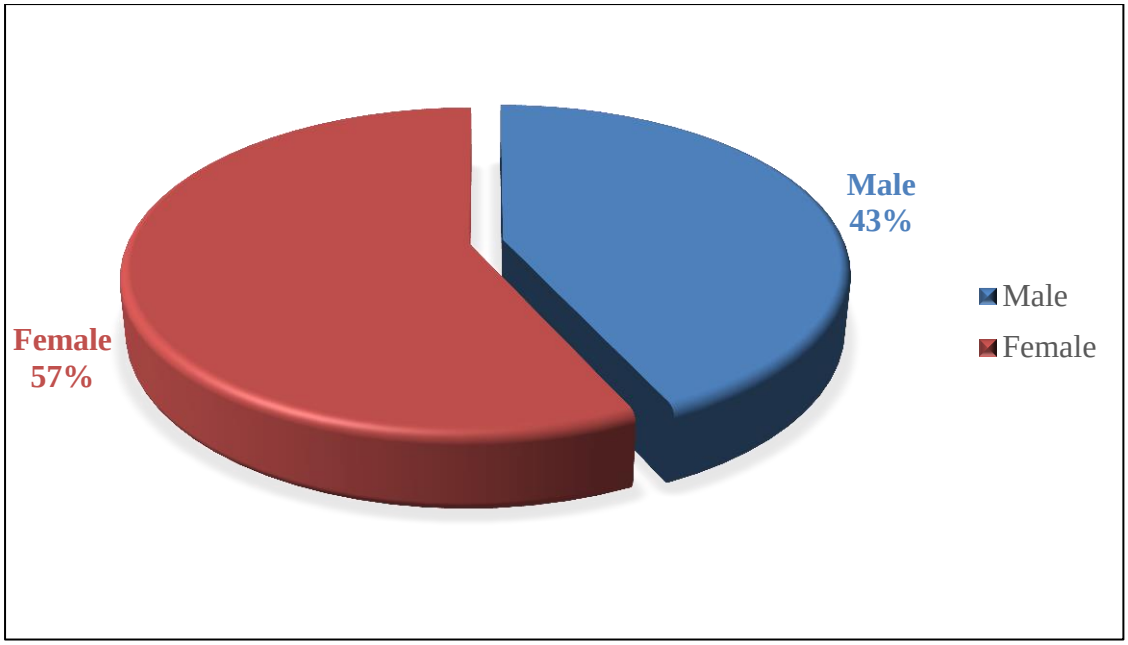

Figure 4: *Distribution of Farmer Respondents by Gender*

The information in Figure 4, reveals that 43.1 percent of respondents were male and 56.9 percent were female.The results indicate that majority of smallholder farmers in the study area were female. This implies that small holder farming in the study area is still dominated by women farmers compared to their male counterparts. According to Ramsomanikis (2015), women are still the predominant workforce in Kenya's subsistence smallholder farming activities.

Past studies have been used to show gaps in the adoption of ICTs due to the influence of gender differences. For example, Adejo et al. (2013) found that female farmers had less access to ICTs compared to their male counterpart. In Kenya, it has also been documented that mobile money services access was found to have a positive impact on agricultural household income (Kikulwe et al., 2016)and to reduce extreme poverty among female-headed households by 22 percent (Suri & Jack 2016) . FAO (2018) however, emphasises that women and men take part in different production, processing and marketing activities, even when they are working in the same value chain. As a result, women and men farmers do not always have the same information needs and therefore, the ultimate objective of enhancing access and use of ICTs in agriculture should be to improve livelihoods for all. Machina and Lubungu (2018) also assert that the gender of the head of household had influenced their ability to generate income due to their roles and responsibilities in the society. They further indicate that households headed by males have higher access to productive resources and

information which increases chances of using ICTs for farming activities. Male headed households also have been reported to access extension services more compared to female headed household. A study by the Word Bank (2018) shows that across 38 of the 47 counties in Kenya, 21 percent of sampled households accessed extension services in 2013-14 of which 81 percent were male headed and 19 percent were female headed.

4.2.1.2 Distribution of Farmer Respondents per Sub County

The specific location of the farmer may influence the technological development of the area, which in turn has an effect on the access or use of the ICTs, digital content or e-Extension platforms for personal or agricultural use. The respondents were asked to state the specific county in which they reside and practice agricultural activities and the findings are presented in Figure 5.

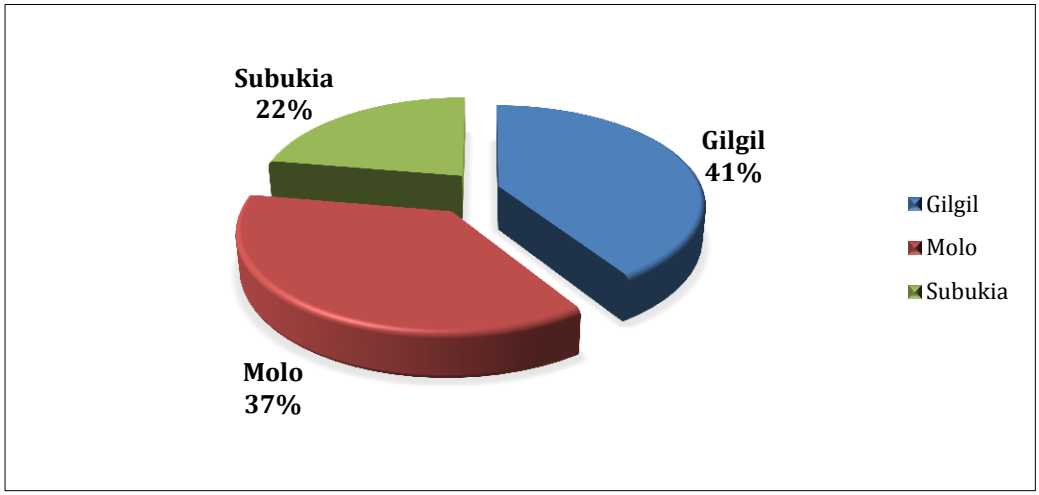

Figure 5: *Distribution of Respondents per Sub County*

The results seen in Figure 5 reveal that Gilgil had the highest number of respondents taking up 40.8 percent of all the respondents. Subukia on the other hand had only had 29 respondents, the least number of respondents of all the counties accounting for 22.3 percent, with Molo accounting for 36.9 percent of all the respondents. The number of respondents for each sub county was sampled proportionately to the number of smallholder farmers in each region. The specific sub county however, had little or negligible effect on the respondents' ability to access or use the ICTs, digital content or e-Extension platforms.

4.2.1.3 Age Distribution of Farmer Respondents

The study was interested in the age distribution of the farmer respondentsin the study area as it may influence access and use of ICTs for agricultural purposes. It is expected that the younger the respondent the more they are exposed to ICTs and are more skilled on its use compared to the older respondent. The findings are presented in Figure 6.

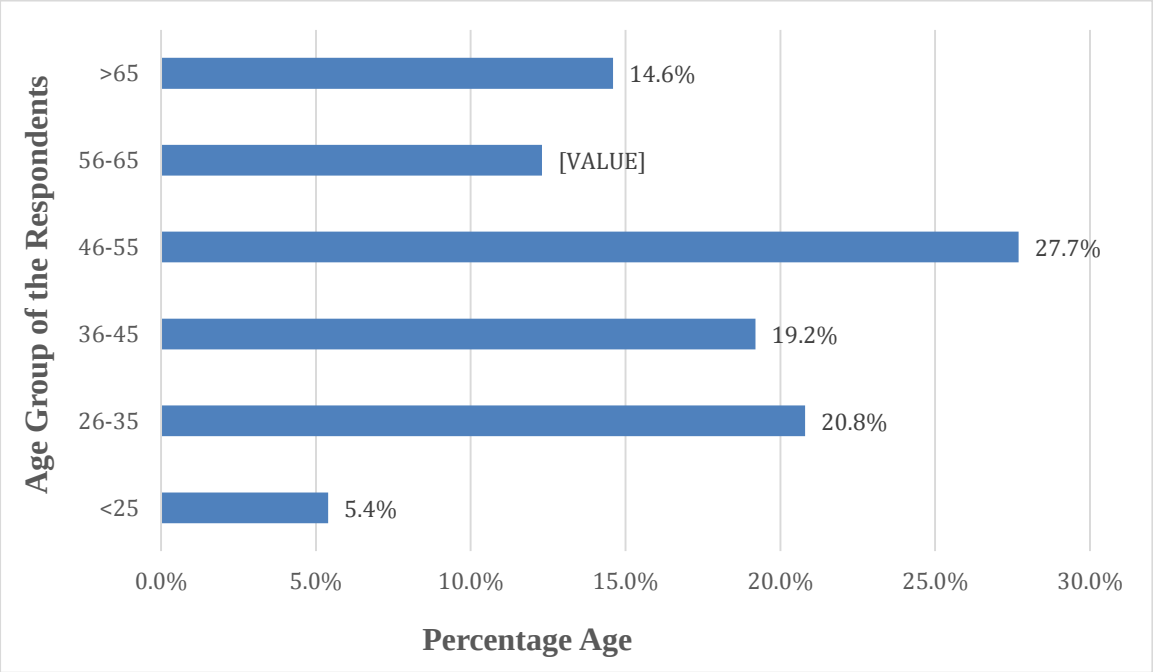

Figure 6: *Age Distribution of the Respondents*

Figure 6 shows that majority of the respondents (27.7%) were between ages 45 - 55 years with a mean age of 48 years. This thus shows that most of the respondents were middle aged which may imply possibility of little dependency since they are more robust and productive and can actively participate in farming and other economic activities and are more likely to adopt ICT tools. A study by Wawire et al. (2017) showed that with all other factors held constant, age was found to be inversely related to the likelihood of use of ICTs. They further noted that younger people are more likely than older people to be enthusiastic and receptive to new technology and hence more likely to purchase advanced technology. Mwombe et al. (2014) also showed that age, gender, income and acreage of bananas planted had an influence on the intensity of use of ICT tools, as a source of agricultural information for smallholder banana farmers in Gatanga Sub County, Kenya.

4.2.1.4 Education Level of Farmer Respondents.

The level of education was included to enable the researcher to understand the education level of the respondents in the study area. Education plays critical role in equipping farmers with the skills necessary for individual usage, adoption and understanding of various ICT tools. It is expected that farmers with a higher level of education will be able to use ICTs better than those with a lower level of education. Thus, level of education was also included in the instrument design with the respondents required to indicate the highest level of formal education they had attained at the time of the study. The education levels were categorized into 5 groups and the results are presented in Figure 7.

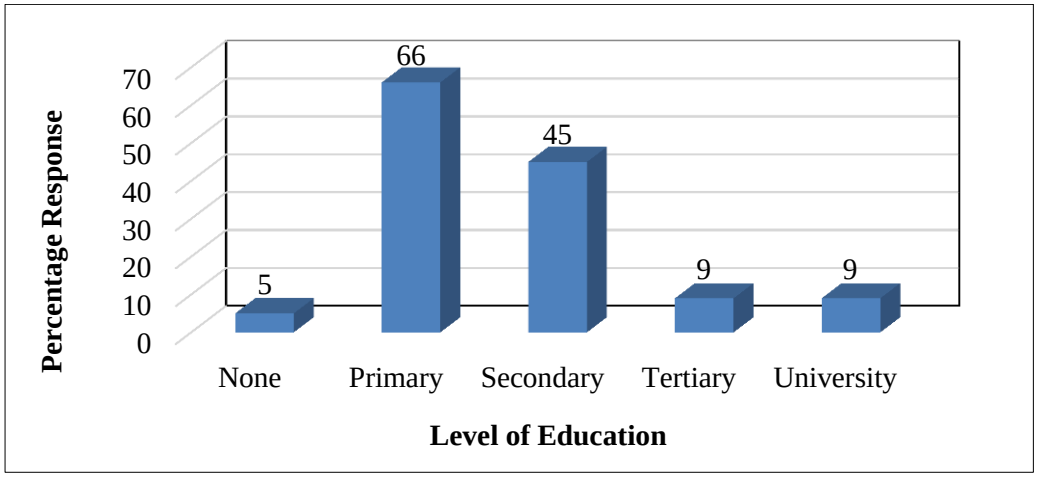

Figure 7: *Level of Education of the Farmer Respondents*

As depicted in Figure 6the distribution of respondents by education level indicates that 66 percent had attained primary level of education. The secondary level was attained by about 45 percent of the respondents with only 9 percent reaching the tertiary and university level. However, 5 percent of the respondents had no education at all. The overall findings therefore, shows that majority of the respondents had attained primary level of education and are able to read and write which could influence their ability to use ICT tools to access agricultural information. Studies have shown that the level of education influences the capacity of people to use technology because effective use of ICTs requires some level of knowledge, skills and innovativeness acquired through formal training and experiential learning (Kilima et al., 2016). The implication therefore, is that education is likely to increase the skills to operate modern ICT tools easily for example computers, mobile phones, the internet and social media. Krell (2020) reported that farmers who have completed primary school level of education were 3 to 4 times more likely for them to use m-services and alerts for farming.

Eskia (2019) also reports that the probability of educated farmers to use ICTs in accessing market information was 30 percent higher compared to farmers with low or no education.

4.2.1.5 Farm Size Used by Farmer Respondents for Agricultural Activities

The farm size was included to enable the researcher to know the general average farm size of the respondents in the study area. Farm size affects the scale of production thus can be an important factor in adoption of new technologies for agricultural activities. For example, the size of the farm influences the number of farming activities practised which will have effect on the type of information farmers seek for and the type ICTs possibly used. Farm size also has a positive correlation on the income that can be generated which in turn has a correlation with affording or accessing the ICTs. The respondents' farm size is presented in Table 4.

Table 4

Farm Size Used by Farmer Respondents for Agricultural Activities

Farm size	Frequency	Percent
0.1-1.99	69	53.1
2-3.99	51	39.2
4-6.99	8	6.2
7-10	2	1.5
Total	130	100.0

Results as shown in Table 4 revealed that the average farm size where the farmers practiced their farming activities was 1.9 acres with 92.3 percent of the respondents' farms falling between 0.1-3.99 acres. Only 7.7 percent had land that was more than 4 acres while 1.5 percent had farms that were more than 7 acres. This suggests that a large majority of the respondents were smallholders. According to the study, the average number of acres cultivated by a farmer was 1.9 acres, which confirms that they indeed can be characterized as smallholders. FGDs revealed that some of these farmers were carrying out their farming activities on either individually owned, family owned or rented farms. Others were those that had been allocated parcels of land to carry out farming activities under the Kenyan

government forest reclamation programmes which was indicated by those that were in Molo sub county. Smallholder farmers are described as small farms or household land which are smaller than 2 hectares (FAO, 2015; Lowder et al., 2016). According to smallholder data portrait by FAO, 81 percent of farmers in Kenya are smallholder farmers with less than 1.2 acres of land (FAO 2018). Katunyo et al. (2017) found out that land size had a positive significant effect on use of ICTs in agricultural. Okello et al. (2020) also found out that farm size had a positive significant effect on television and radio usage, with every additional acre increasing their usage by 29.1 percent and 21 percent respectively among smallholder pineapple farmers in Kiambu County, Kenya.

4.2.1.6 Income Distribution among Farmer Respondents

The income level of the farmers is expected to have an influence on their information seeking behaviours which may also lead to the desire to seek and obtain agricultural information using different ICT tools. The more the earning, the easier it is for the respondents to afford ICTs that are used to receive digital content and form the basis for use of the e-Extension platforms. The respondents were asked to provide information on how much of their earning from the past three months could be directly attributed to agriculture. Also, the respondents that only used their agricultural produces for subsistence only and had gained no direct income from their farm produces were noted. Table 5 presents the findings of the study.

Table 5

Income Distribution among Farmer Respondents

Income in KES(3 months)	Frequency	Percent
<10000	26	20.0
10001-20000	37	28.5
20001-30000	23	17.7
30001-40000	15	11.5
40001-50000	7	5.4
>50000	17	13.1
For subsistence use	5	3.8
Total	130	100.0

Table 5, shows that 66 percent of the respondents earned KES 30,000 or less in three months prior to this study while 11.5 percent earned 30001- 40000 Kenyan Shillings and only 5.4 percent earned 40001-50000 Kenyan Shillings. Only 13.1 percent of the respondents were earning greater than 50000 Kenyan shillings. A small percentage of 3.8 did not commercialise their produce and majorly practised subsistence farming. According to Nwafor and Abiodun (2020), an increased income showed to have a significant association with the use of ICT-based information sources. The study reports that income increases the ability to pay for possible cost involved in utilizing ICTs such as purchase of airtime, availability and payment for electricity, cost of batteries for radio among others. Also According to Wanyama et al. (2016) public extension providers and private for profit providers in Kenya tend to favour the wealthy and are better represented among the high income groups.

4.2.1.7 Farming Activities of Farmer Respondents

The farming activity variable was recorded to give the researcher a general picture of what farming activities are practised by the respondents. The main farming activities that were used in this study were; crop farming, livestock farming and mixed farming, which involved both crop and livestock farming. The results are presented in Figure 8.

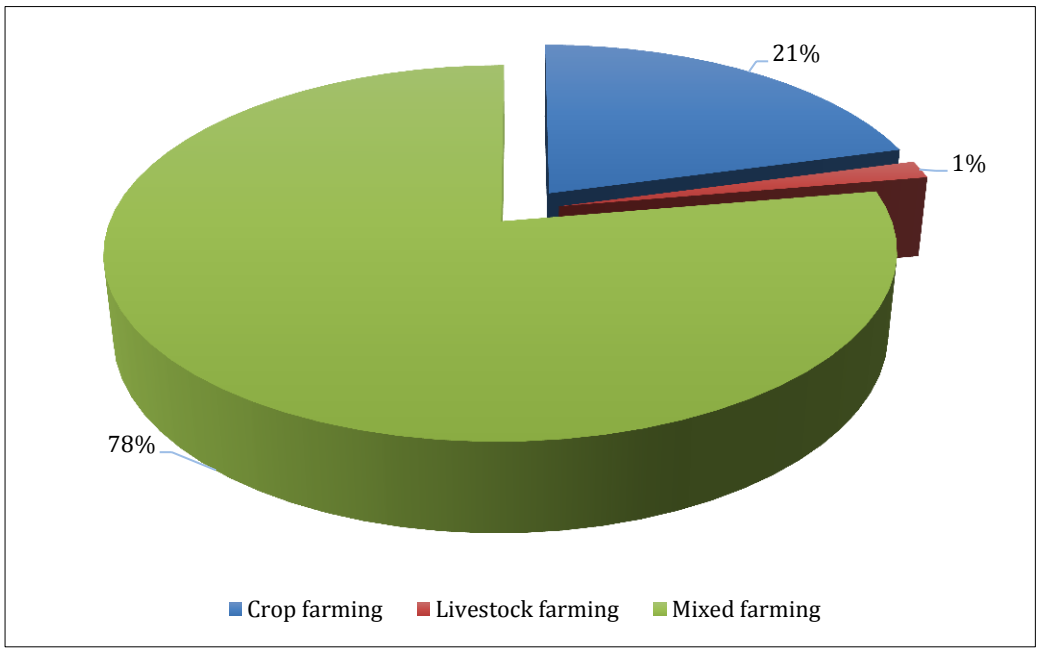

Figure 8: *Farming Activities of the Respondents*

The results in Figure 8 depicts that a great number of the respondents, 77.7 percent were involved in mixed farming involving both crop and livestock farming. Only 2 respondents solely practised livestock farming while 22 percent respondents were solely involved in crop farming. The type of farming activities will determine the type of information needs of the farmer which also determines the type of ICTs used to access the agricultural information. Studies have shown that some applications offer complete platform with multiple functionalities while others target specific type of agricultural activity with the aim of improving farmers' livelihoods. Examples include m-services in Kenya such as *icow* that purely serves livestock farmers, M-farm which helps farmers to make informed decisions about the best harvest, selling times, and pricing of their farm produce and Agri-Wallet, which is an agricultural financial service that allows farmers to borrow money to spend on their agricultural inputs and pay back their loans digitally through M-pesa (mobile money tranfer) (Baumüller, 2018; Gichamba, 2017; World Bank, 2016).

4.2.1.8 Farmer Respondents Group Membership

Farmers' group membership is an important factor when it comes to accessing and gaining skills in using ICTs, digital content or e-Extension platforms. These groups create a platform where the members can exchange agriculture related ideas and help each other out when it comes to dealing with new technologies. Figure 9presents the group membership of smallholder farmers that were studied.

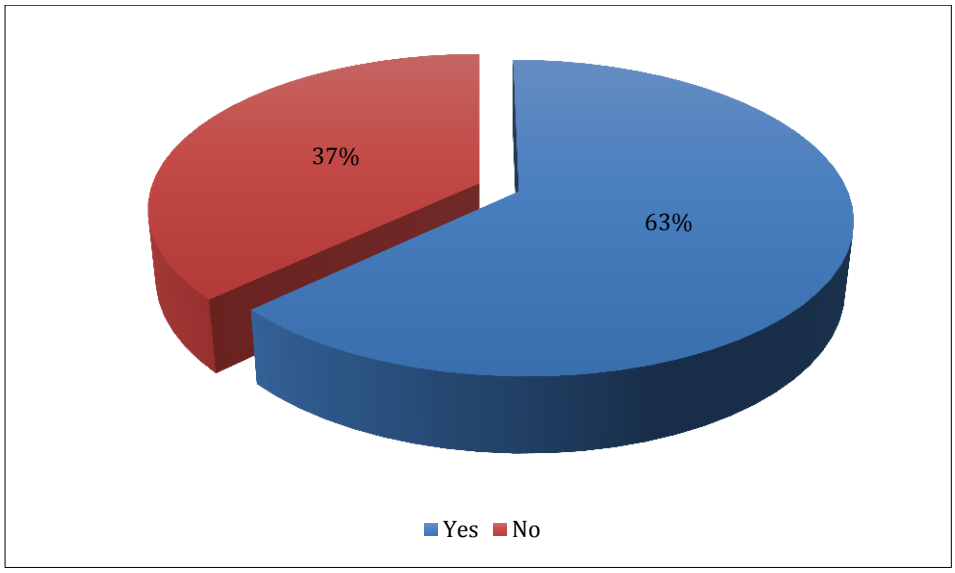

Figure 9*: *Farmer Group Membership

As seen in Figure 9, 63 percent of respondents were members of a farmer group organisation while 37 percent were not affiliated to any farmer group organisation. The results suggest that majority of the farmers belonged to a farmer group organization which could have an implication also in terms of accessing agricultural information through ICTs and also by extension belonging to social media groups associated to the farmer groups. Findings by Wawire et al. (2017) showed that farmers who belonged to a farmer group increased the likelihood of using ICT tools by 23.6 percent. According to the authors, information is disseminated well through farmer groups because members acquire more knowledge about existing services compared to non-members. Okello (2017) also found out that group membership among smallholder farmers had a positive significant effect on use of mobile phones in accessing agricultural information while Krell (2020) posits that farmer groups can serve as a key pipeline for creating awareness and adoption of m-services.

4.2.2 Characteristics of Agricultural Extension Agents

Twenty five extension agents across the three sub counties were involved in the study. Personal information including gender, age, Sub County represented, education level and length of service in extension was collected using extension staff questionnaire (Appendix B).

4.2.2.1 Age Distribution of the Extension Agents

Figure 10 presents the age distribution of the extension agents.

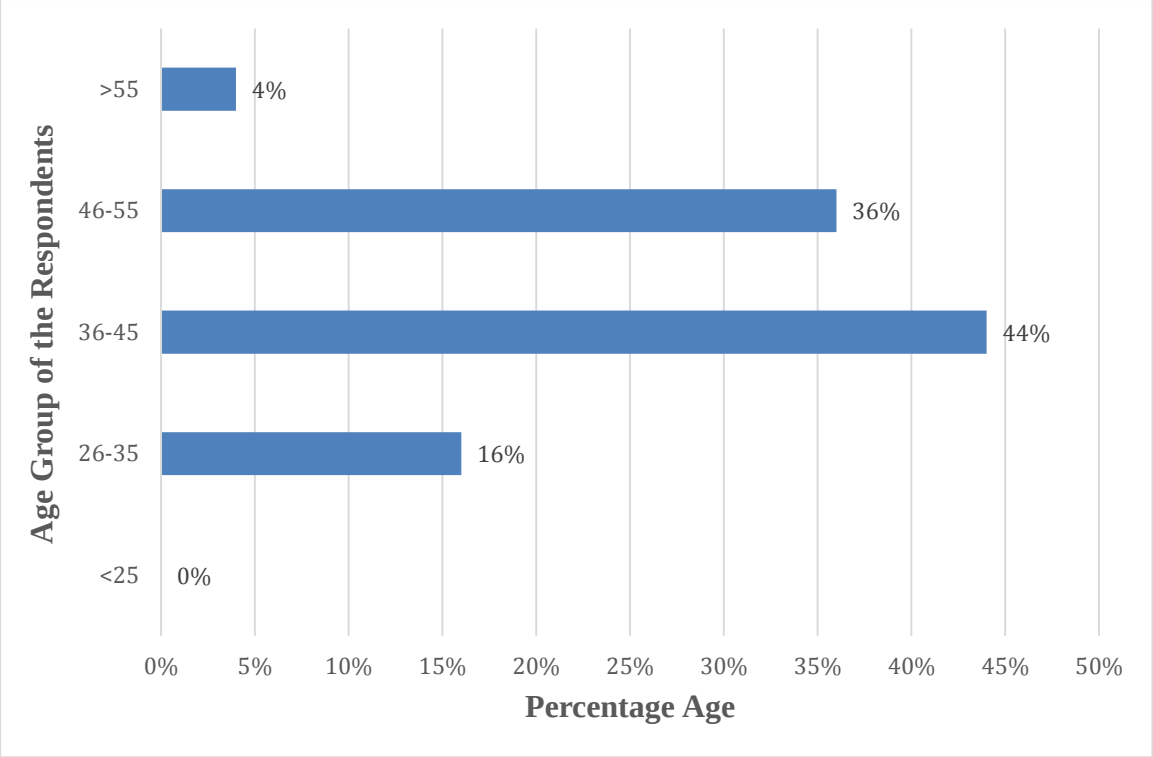

Figure 10: *Age Distribution of Extension Agents*

As shown in Figure 10 the age distribution of the respondents ranged from 26 to above 55 years with an average mean of 43 years. The results indicate that 44 percent of the respondents were between 36 and 45 years old while those with 35 years and below constituted 16 percent of the respondents. The results therefore, suggest that 60 percent of the respondents are still very productive in their extension work and therefore are expected that they are more likely to be open to adoption of ICT tools in their extension work. Cant and Shen (2006) asserts that younger people are more pragmatic, aware and open to new technologies compared to older people. The extension agents that were above 45 years were 40 percent which also shows that they constitute a large number of the extension work force who have been long serving and have experience in the extension work.

4.2.2.2Gender of the Extension Agents

Figure 11 presents the distribution of extension agents per gender.

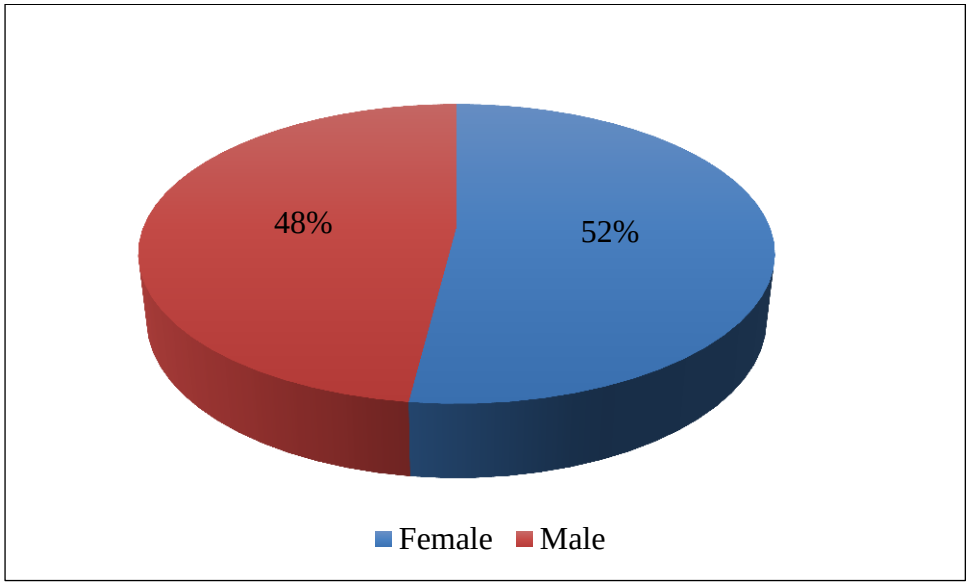

Figure 11: *Gender Distribution of the Extension Agents*

The results in figure 11 shows that 52 percent of extension staff in the study were female while 48 percent were male. This implies that there is a slightly high number of female extension agents offering extension services in the study area compared to their male counterparts. The results are contrary to the finding by McNamara et al. (2012) who reported that fewer women in agricultural extension service has been due to cultural bias towards women because of their social roles in the society. Studies have shown that a large proportion of women work in the agricultural sector in East African countries: 96 percent in Burundi, 84 percent in Rwanda ,77 percent in Uganda, 76 percent in Kenya and 71 percent in Tanzania (UNCTAD, 2017). Therefore, increased women extension personnel are likely to work well with their counterparts (Muthoni, 2018).

4.2.2.3 Education Level of the Extension Agents

Figure 12 presents the finding of the education level of extension agents.

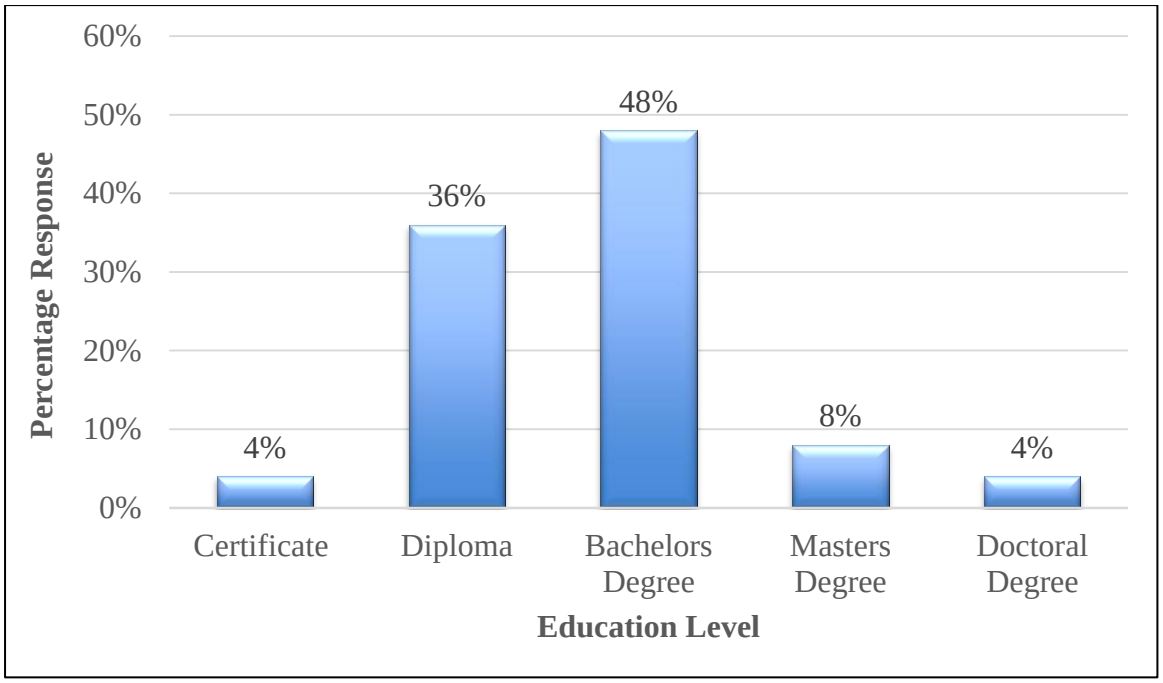

Figure 12: *Education Level of Extension Agents*

The study established that over 90 percent of the extension agent who participated in the study had a diploma and above in their education qualification as shown in Figure 11. These shows that extension service delivery to the farmers is offered by highly qualified personnel that can deliver quality services in terms of transfer of knowledge, skills and innovations that could have significant effect on livelihoods and reduce poverty among smallholder farmers. A study by Tata and McNamara (2016) in South Africa found that extension officers with advanced degrees (Masters) did not have any technical challenges when using ICT in compared with their less educated colleagues. Strong et al. (2014) further asserts that education level influenced technological preferences and competencies among agricultural extension officers in the in Caribbean. On the other hand, Doss and Morris (2018) also indicated that education level played a role in technology acceptance with higher levels of education earned resulting in an increase in technology use.

Contrary to these studies however, Mwansa (2004) reported that agricultural extension officers' attitude towards technology hindered the use of ICT in transferring information and teaching farmers.

4.3 Influence of Access to ICTs on Usage of e-Extension Services Among Farmer Respondents

Objective One of the study sought to determine the influence of access to ICTs on usage of e-Extension services among smallholder farmers. The data on level of access to ICTs by smallholder farmers in the study area were collected using both farmer and extension agent questionnaires. Focus group discussions involving smallholder farmers and extension agents were also used to obtain in depth information of the ICTs accessed and used to access e-Extension services among smallholder farmers.

4.3.1. Access to ICTs among Farmers Respondents

The ICTs accessed by farmers was one of the most important technological factors that was investigated by the researcher. They provide the basis in which digital content can be received and also e-Extension services can be accessed. ICTs that were studied included mobile phone, computer, radio, TV, internet, YouTube, WhatsApp, Facebook and Twitter. In order to use the ICTs, for personal or agricultural use, one has to have access to them. Access to ICTs determines exposure to them and hence could directly influence the ability to use and the level of skill in using the ICTs. Table 6 presents the findings.

Table 6

Access to ICTs among Farmer Respondents

ICT	Accessible (%)	Not Accessible (%)
Mobile Phone	75.4	24.6
Computer	9.2	90.8
Internet	27.7	72.3
Radio	86.9	13.1
TV	72.3	27.7
YouTube	19.2	80.5
WhatsApp	33.1	66.9
Facebook	26.2	73.8
Twitter	5.4	94.6

The information from Table 6 indicates that over 70 percent of the respondents had access to mobile phones (76.2 percent), radio (86.9 percent) and TV (72.3 percent). These shows that mobile phones, radio and television are the most accessed ICTs among the smallholder farmers in the study area. This therefore, implies that these ICTs could provide opportunities for reaching farmers with various e-Extension services. Gwademba et al. (2019)also reported that, ICT tools such as mobile phones, the internet, radio, and television when properly applied in agricultural extension can help enhance the farmers' access to information relevant for their agricultural production. O'Dea (2020) also reports that mobile phones particularly those with internet connectivity being the most widely used ICT tool in the globe. Internet connectivity however, still remains a challenge among smallholder farmers in the study area with only 27.7 percent of them indicating to have access. Accessibility to the other ICTs also is still low with 19.2 percent for YouTube while twitter and computers (desktop and laptop) having the lowest frequency percentages of 5.4 percent and 9.2 percent respectively. Kenya National Bureau of Statistics household survey reports that 8.4 percent of the adult population in Kenya have access to computer and its use increases with age with its peak at 20-24 years then gradually declines (CA, 2018).

4.3.2. Type of Mobile Phone Accessed by Farmer Respondents

The type of mobile phone was an important variable for the researcher as it would determine its use to access agricultural information through the different platforms that can be accessed through the phone. Farmers were asked to indicate whether they owned or had access to either feature phone or smartphone. This was very important because the type of phone owned or accessed will determine the ability to access internet, download agricultural related applications as well as accessing information online. Figure 13 presents the results of the type of mobile phones the respondents had access to.

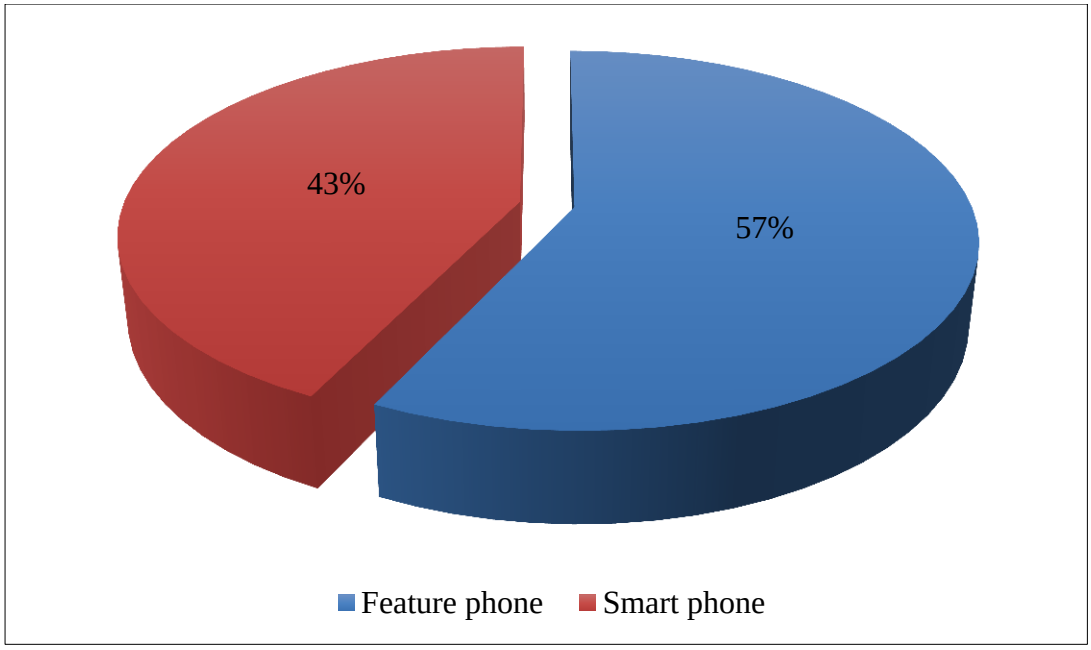

Figure 13: *Type of Mobile Phones Owned by Farmer Respondents*

Figure 13 shows that 57.1 percent of the respondents owned or had access to feature phones while 42.9 percent owned or could access smart phones. The type of mobile phone owned or accessed implies that it will also determine the type of agricultural information access capabilities among the farmers. The focus group discussions suggested that farmers with feature phones could only be able to make calls and write texts from their phones as compared to those who had smartphones. Other feature phones however, can be used to access the internet because they have applications that are pre-loaded such as Facebook and Twitter but on the other hand do not have the ability to download applications. According to Krell et al. (2020) Smartphone ownership increases farmer's likelihood to use mobile based services (m-services)to subscribe to farming applications and alerts and for buying and selling agricultural products. According to a study by Mercy Corps in (2016) among farmers in Kenya, ownership of smartphones was shown to be increasingly becoming widespread. This has been supported by growing network coverage in Kenya with 3G population coverage of 85 percent and 4 G penetration of 25 percent as at 2019 (CA, 2019). Krell (2020) however, notes that although smartphone ownership is expanding across rural areas in Kenya it is a factor that could separate the wealthy from the poor in agricultural m-services use.

4.3.3. Level of Accessibility to ICTs among Farmer Respondents

Table 7 presents the results of the respondent's access to the various ICTs scored at a 5 point Rating Scale of 1 = *No Access*2 = Low access 3 = Medium access 4 = High access to 5 = *Very high access.*

Table 7

Level of Farmers' Accessibility to ICTs

ICTs	N	Mode	Median	Mean	Std. Dev
Mobile Phone	98	5	5.0	4.4	0.84
Computer	12	3	3.0	2.6	1.16
Internet	36	4	4.0	3.5	1.03
Radio	113	4	4.0	4.2	0.70
TV	94	3	3.0	3.1	0.84
YouTube	25	2	3.0	2.9	1.26
WhatsApp	43	4	4.0	3.7	1.14
Facebook	34	3	3.0	3.1	1.05
Twitter	7	1	2.00	2.7	1.60

Table 7 gives the central tendencies for the level of accessibility of each ICT under study. Results indicates that mobile phone was the most accessible ICT with a mode and median of 5 and a mean of 4.4 (very high access); the internet, radio and WhatsApp also scored high with mode and median of 4 (high access) for both of them. Accessibility to TV, Computers and Facebook, were moderate with all the three having a mode and median of 3. YouTube had a low level of access with a mode of 2 and a median of 3 indicating low to moderate access to the ICT. Twitter had the lowest level of accessibility with a mode of 1 and a median of 2 indicating very low access among the respondents. The high accessibility to ICTs such as radio, mobile phones and TV and applications like WhatsApp as depicted by the results regardless of the rural nature of the populace is an indication that these resources could provide opportunities for utilizing them to provide e-Extension services to farmers. The

results are consistent to findings by Jere (2015), who observed that access to ICT was found to improve farmers' income, reduce gender imbalances to access to information and use of resources as well as boosting agricultural productivity and improving livelihoods.

4.3.4. Level of Usage of ICTs for Agricultural Purposes among Farmer Respondents

The researcher sought to find out the level of usage of ICTs in accessing agricultural information. The respondents were asked to give the frequency at which they use the ICTs to access agricultural information which was scored at a five-point Rating Scale of 1 = *Never* to 5 = *Always*. Since the respondents were smallholder farmers it was expected that they would use, to some extent, these ICTs to access agricultural information. Table 8 presents the results on the level of usage of ICTs among the respondents.

Table 8

Level of Usage of ICTs among the Respondents

ICTs	**Frequency**	**Percentage**
Mobile Phone	98	75.3
Computer	12	9.2
Internet	36	27.6
Radio	113	86.9
TV	94	72.3
YouTube	25	19.2
WhatsApp	43	33.0
Facebook	34	26.2
Twitter	7	5.3

n (130)

Table 8 shows that the most used ICTs tools to access agricultural information among the respondents were radio (86.9) mobile phones (75.3) and TV (72.3). This means that farmers use mobile phones, radio and TV majorly to access agricultural information as compared to

other ICTs. The implication means that farmers can be well targeted with e-Extension services through these ICTs. The farmers indicated that mobile phones were used for accessing agricultural information through making calls or writing SMSs to seek for various services across the food systems from production to storage and marketing. Radio and television was reported to be used also for accessing agricultural information such as weather forecast information, new crop varieties, pest and disease control among other and for learning new agricultural practices. This corresponds to other studies by Mtega and Msungu (2013), Norberth et al. (2018), World Bank (2017b) who found that radio, mobile phone, and television were still predominant ICTs among smallholder farmers. Findings by Krell et al. (2020) however, found that the type of mobile phone will determine the level of usage for accessing agricultural information. They report that according to their study, smartphone ownership is positively significant to usage of m-services among farmers and is not widespread in Kenya.

The findings in this study further show that different number of respondents use internet (27.6), YouTube (19.2), Facebook (26.2) and WhatsApp (33.0). Computer (9.2) and Twitter (5.3) just like level of access clearly shows that it is rarely used by smallholder farmers to access agricultural information.

4.3.5. Type of Agricultural Information Farmers Seek for Using ICTs

The researcher aimed to understand the type of agricultural information that farmers search for using ICTs. The respondents made selections from five categories namely; production information, processing and value addition, weather information, pest and disease control and market Information. They were also allowed to make multiple selections for each ICTs used. The findings are presented in Table 9.

Table 9

Type of Agricultural Information Accessed from ICT Tools

ICTs	Production information (%)	Processing and Value addition (%)	Weather Information (%)	Pest and Disease Control (%)	Market Information (%)
MobilePhone	71.4	1.0	29.6	33.7	52.0
Computer	58.3	16.7	0.0	16.7	50.0
Internet	63.9	5.6	2.8	22.2	33.3
Radio	87.6	6.2	31.9	35.4	48.7
TV	81.9	7.4	28.7	27.7	36.2
YouTube	60.0	8.0	16.0	28.0	16.0
WhatsApp	67.4	7.0	4.7	32.6	37.2
Facebook	61.8	2.9	14.7	14.7	32.4
Twitter	14.3	14.3	14.3	14.3	42.9
Average Percentage selection	**63.0**	**7.7**	**15.8**	**25.0**	**38.7**

(n=130)

Table 9 shows that production information was the most sort out information with 63 percent selection frequency. Market information came in second with a total selection frequency of 38.7 percent. Focus group discussions indicated that farmers sought to obtain production and market information to increase their production, secure reliable market and best prices for their produce. Pest and disease control information was selected 25 percent times while information concerning the weather had a selection frequency of 15.8 percent. Processing and value addition was least selected having only a 7.7 percent selection frequency. Mobile phone, radio and TV were the most frequently used ICTs to access production information. The respondents through focus group discussions indicated that they either made phone calls or texted to receive information such as inputs availability and listened to radio and TV programmes on agricultural sustainable practices such as input application rates, weed control, soil conservation, diversification among others. The findings correspond to other studies done by Matto (2018) in Malawi, Lwesya and Khambila (2017) in Tanzania and Ali et al. (2016) in Uganda, which depicted that farmers use ICTs to get information on post-

harvest handling, market information, pest and disease control, weather information and fertilizer application. All these information being critical in improving agricultural productivity and food security of resource poor rural communities.

4.3.6 Accessibility to ICTs Among Extension Agents

The study investigated the type of ICTs that were accessed by extension agents and the findings are presented in Table10.

Table 10

Access to ICTs among Extension Agents

ICTs (n=25)	**Lower Bound**	**High Bound**	**Mean**	**Std. Deviation**
Computer	1	5	3.92	.830
Mobile Phone	1	5	4.88	.332
Modem	1	5	2.72	.936
Data bundles	1	5	4.16	.943
Email	1	5	3.54	.977
Agricultural journals	1	5	2.64	1.075
CD-ROM databases	1	5	2.12	.781
Videos	1	5	2.64	1.114

Table 10 shows the results on the level of accessibility of ICTs among the extension agents. The researcher developed a scale for scoring the level of access in the study. The scores between 1- 1.5 was categorized as very low, 1.6-2.4 as low, 2.5-3.3 as moderate and 3.4 – 4.2 as high and 4.3-5.0 very high. Very high access to mobile phone was recorded among the respondents. Computer, data bundles and email were also highly accessed while agricultural journals, modem and videos were moderately accessed and CD-ROM databases access was low. The focus group discussions indicated that computers were accessed by the extension agents majorly in their offices while others owned either a laptop or a desktop. The data

bundles were also reported to be bought by the extension agents themselves and received little support from the county government. The findings indicating that the level of access to the ICTs could be greatly utilized to provide e-Extension services to the farmers by the extension agents particularly the mobile phones due tom high accessibility among the farmers.

4.3.7 Purposes of Using ICTs among Extension Agents

Respondents were asked to indicate the purpose for which they used ICT tools in their extension work as shown in Figure 14.

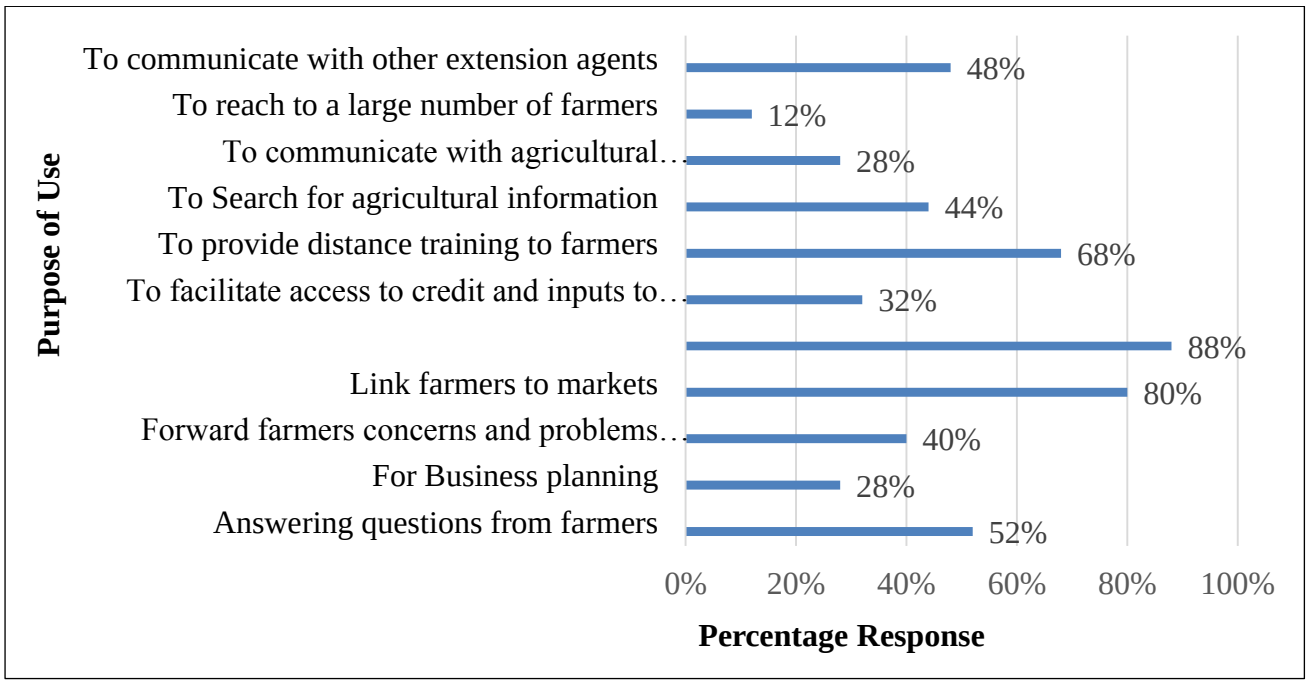

Figure 14: *Purpose of Using ICTs Among Extension Agents*

The results presented in Figure 14 shows that over 40 percent of the extension agent used ICTs for answering farmers' questions, linking farmers to markets, communicating agricultural information to farmers, communicating with other extension agents, providing distance training to farmers, searching for agricultural information, forwarding farmers concerns and problems to decision makers and searching for agricultural information. This is a good indication that the extension agents have embraced the use of ICT tools in their extension work. ICT tools were used to communicate to researchers and for business planning by 28 percent of the respondents while 32 percent used them to facilitate access to credit and inputs. The usage of ICTs among the extension agents to facilitate access to credit through lenders such as One Acre fund, Syngenta company, as well as accessing inputs such

as government subsidized fertilizers. Business planning on the other hand entailed assisting farmers in developing a viable farm plan and building farmers capacity through training on market oriented farming, record keeping, budgeting and risk management. Only 12 percent of the extension agents did not use ICTs to reach a large number of farmers which could be an indication that other extension methods are still also used among the extension agents. Ali et al. (2018) suggests that ICTs can improve extension service deliver as it could be used as a medium to promote education and practical learning among farmers.

4.3.8 Number of Farmers reached by Extension Agents using e-Extension Services

Table 11 presents the findings on the average number of farmers that extension agents were able to reach using ICTs that they had access to.

Table 11

Number of Farmers Reached using the e-Extension services by Extension Agents

Number of Farmers	Frequency	Percent
100-250	1	4.0
250-500	4	16.0
500-750	8	32.0
750-1000	4	16.0
>1000	8	32.0
Total	**25**	**100.0**

(n=25)

Table 11 indicate that majority (32 percent) of the respondents reached between 500 -750 farmers using ICTs over the past three months before the study which was on average 40 farmers per week while another 32 percent were able to reach more than 1000 farmers. Focus groups discussions indicated that the numbers varied depending on the season of agricultural production with high numbers being registered during planting seasons and after harvesting. Similarly,16 percent of the respondents indicated that they were able to reach 250-500 and 750-1000 farmers in three months. The results therefore imply that ICTs could provide an avenue for improving delivery of agricultural extension services could help to reduce

information asymmetries among farmer, cost and time as well facilitating information dissemination and uptake of agricultural technologies.

4.3.9 Test of Hypothesis One

The first objective of the study was to determine the influence of access to ICTs on usage of e-Extension services among smallholder farmers' in Nakuru County, Kenya. In order to determine existence of any significant influence between access to ICTs and usage of ICTs for e-Extension services, first hypothesis was generated which was stated as:

H01: There is no statistically significant influence of access to ICTs on usage of e-Extension services among smallholder farmers in Nakuru County, Kenya.

In order to test this hypothesis, the researcher focused on; access to ICTs and usage of ICTs to access agricultural information. Data on access to ICTs and usage of ICTs to access agricultural information was obtained through administering questions to all respondents. This was done in order to assess the level of access to ICTs and level of usage of the ICTs to access agricultural information, within the respondents. The level of access was measured in terms of whether the ICTs were accessed or not and then the level of access at 5 point Likert scale ranging from 1= *Very low access*to, 5 = *Excellent*. The level of usage of ICTs to access agricultural information was also measured at a 5 point Likert scale ranging from 1 = *Never*to, 5 = *Always*. The data was then analyzed using ordinal regression model and the results obtained are presented in Table 12.

Table 12

Model Summary of Ordinal Regression between Level of Access of ICTs and Usage of e-Extension Services by Farmers

ICTs	N	Sig value	Goodness-of-Fit sig value	Correlation Coefficient(r value)	R^2 Value
Mobile Phone	98	.004	.111	.391*	.158
Computer	12	.000	.999	.377*	.142
Internet	36	.023	.563	.539*	.291
Radio	113	.000	.445	.540*	.292
TV	94	.000	.706	.489*	.239
YouTube	25	.002	.402	.715*	.511
WhatsApp	43	.000	.611	.642*	.412
Facebook	34	.000	.257	.744*	.553
Twitter	7	.002	.999	.810*	.656

* = indicate significance of values at P=0.05 and 0.01goodness of Fit

The regression test results as shown in Table 12 indicates a positive relationship between access to ICTs and usage of e-Extension services by smallholder farmers which was statistically significant for all the ICTs at $\alpha = 0.05$ significance level and r values ranging from 0.377-0.810.The results further revealed that the predictor variables accounted for different variations in usage of e-Extension services using Pearson's goodness of fit of $\alpha = 0.01$ to test whether the observed data were consistent with the fitted model. The goodness of fit for all the ICTs under study had a significance value which was greater than $\alpha = 0.01$ as seen in Table 13, hence the null hypothesis was rejected indicating goodness-of-fit to the fitted model. The results also revealed that the predictor variables accounted for different variations in usage of e-Extension services with R^2 ranging from 0.142 to 0.656 for the various ICTs. This implies that that the variations accounted for 14.2 to 65.6 percent in usage of ICTs among the respondents. The results therefore, indicating that the farmers with higher

access to these ICTs have a higher level of usage of the ICTs to access e-Extension services. The results show that there is a significant influence between access to all the ICTs under studyon the usage of the ICTs for e-Extension services within groups. That is, the more access to these ICTs respondents had, the higher the level of usage of these ICTs to access e-Extension services. These results concur with the findings by Eskia (2019) in Tanzania who found that access and availability of market information increased with greater access to ICTs. The finding of in this study though it revealed that access to ICTs increased usage of the ICTs for e-Extension services, ICTs such as computer had very low accessibility with only 9.2 percent of the respondents having access while 90.8 percent did not have access. Other studies by Awuor et al. (2016), Barakabitze et al. (2015), Magwisi et al. (2015) and Kiambi (2018) revealed that technologies such as computers are mostly used by researchers and agribusiness experts. They identified computers as being inaccessible to most farmers due to lack of skills to use them and the financial means to own them.

4.4 Findings on ICT Skills and Usage of e-Extension Services among Farmer Respondents

The second objective of the study sought to establish the influence of ICT skills of farmers on usage of e-Extension services among smallholder farmers in Nakuru county, Kenya.The use of ICTs demands that the user has the ability to operate ICTs which in turn may require basic ICT to technical ICT skills. The ICT skills were rated at a five point Likert scale where ICT skill sets are specifically required to use a particular ICT. The ratings were as follows; 1 = No skill 2 = Basic ICT skills 3 = Intermediate ICT skills 4= Skilled 5 = Advanced skills. It was expected that the greater the ICT skill, the greater the extent of ICT use. Thus ICT skill level is expected to affect the extent of ICT use positively or negatively. The researcher therefore, sought to establish the level of ICT skills among smallholder farmers, sources of ICT skills and purposes of using the ICT skills in accessing agricultural information.

4.4.1 Level of ICT Skills among Farmer Respondents

The respondents were asked to give the most accurate response on the level of skills they have in using all the ICTs under study. The respondents' scores were at a 5-point Likert scale ranging from 1= *No skill* to 5 = *Advanced skills*. The ICT skills that were checked for radio and TV ranged from listening skills, questioning, note taking, recording, sharing of information with other farmers to application of the information in farming activities. The ICT skills for using computer ranged from basic skills such as ability to use computer

hardware and software creating, editing and saving documents to intermediate skills such as digital marketing ability to create content and desktop publishing to advanced skills such computer programming and mobile application development. The ICT skills checked for social media (Facebook, Twitter, WhatsApp) included ability to recognise applications, connect to the internet, create accounts, search for information, connect to relevant groups, post/share, delete and update information and upload videos. The ICT skills checked for YouTube included ability recognise the application, connect to the internet, search for information and download or upload videos. Internet skills included ability to connect and use the internet and online services such as email, chatting tools, file sharing and social media networking, locating required information, selecting and evaluating information. Table 13 presents the results of the scores.

Table 13

Mean, Mode and Median for Farmers' Level of Skills in Using ICTs

ICT	Mode	Median	Mean	Std. Dev.
Mobile Phone	3	3.00	3.14	0.82
Computer	1	1.00	1.37	0.77
Internet	1	1.50	1.77	1.10
Radio	4	4.00	3.68	0.70
TV	4	4.00	3.35	1.12
YouTube	1	1.00	1.63	1.04
WhatsApp	2	2.00	1.95	1.26
Facebook	1	2.00	1.84	1.22
Twitter	1	1.00	1.34	0.86

(n=130)

Table 13 indicates the level of ICT skills that farmers have whereby, majority of them have little or no skill in using some ICTs. However, the level of ICT skills for using mobile phones, radio and TV all had a median and mode of 3 and 4 which shows that the farmers were moderately skilled in using these resources. The skills that were checked for using mobile phones were basic skills such as ability to make calls without assistance, writing and sending SMS, retrieving and reading SMS, saving and retrieving contacts, to advanced skills

such as connecting to the internet, downloading audio or video and accessing the internet through the phones and searching for agricultural information.Twitter, YouTube, and computers all had the lowest bound in both median and mode of 1 which indicates that the farmers, in general, had no skills in using these resources.

The respondent showed some moderate skills in using WhatsApp with a mode and median of 2 while indicating very little skills in using the internet and Facebook with both having a mode of 1 and a median of 1.5 and 2 respectively. The findings correspond to other studies by Chikaire et al. (2017) and Nzonzo and Mogambi (2016) that revealed that smallholder farmers lack of adequate ICT literacy skills that would enable them to integrate ICTs into their farming activities. Other studies also by Lekopanye and Sudaram (2017) in Botswana, Angello (2015) in Tanzania and Chisango and Lesame (2014) in South Africa further affirms this. The studies also posit that low ICT literacy skills invariably result in digital divide and poverty among rural communities. This has been noted to be one of the possible key barriers to adoption of ICTs among farmers in their agricultural practices. Wawire et al. (2017) argues that lack of certain ICT skills could greatly affect adoption of ICTs by farmers' because the use of these tools relies on practical ICT knowledge of the users.

4.4.2 Training on ICT Skills among Farmers Respondents

The researcher sought to establish whether the respondents had received any form of ICT training that would enable them to use the ICTs. The source of these skills was also considered by the researcher as it shows what training methods the farmers had and where emphasis should be prioritised. The results are presented in Figure 15.

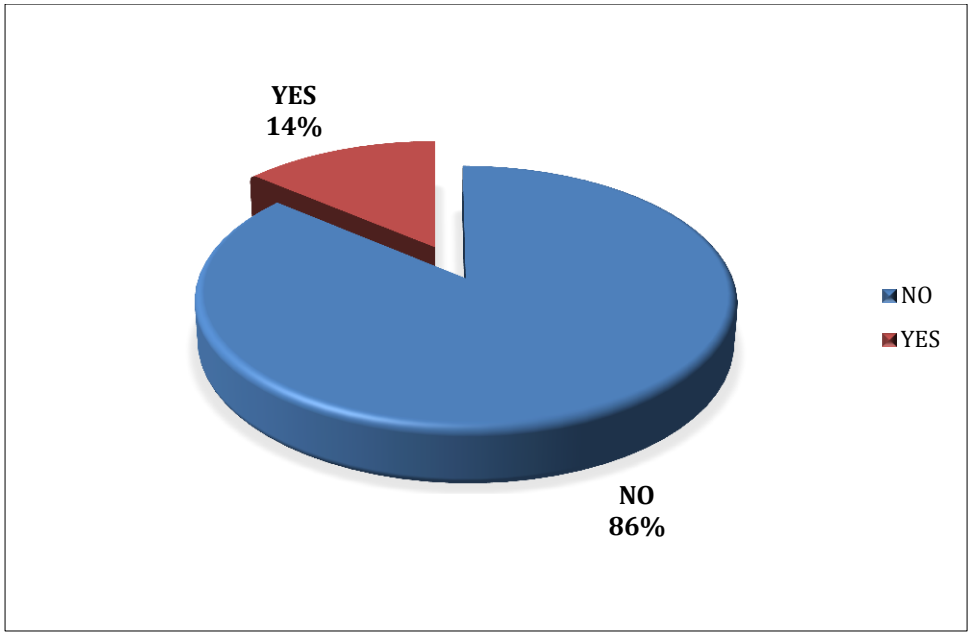

Figure 15: *ICT Training of the Farmer Respondents*

As shown in Figure 15, 86 percent of the respondents had not received any form of training in the usage of the ICTs by the time of this study, with only 14 percent having received some form of training. The farmers that indicated to have had some form of ICT training had either been trained in the cause of their formal education were it was incorporated within the curricular while others had done computer packages. The farmers indicated that these form of ICT training had given them ability to be able to use and apply ICTs in their agricultural activities. Farmers however, during focus group discussion raised issues on the need for ICT training to enable them to be able to fully utilize ICTs particularly computers and the internet. The results imply that ICT skills are directly proportional to the level of skill in using the ICTs by the farmers which were minimal especially on modern ICTs such as computers and the internet. This finding corresponds with the findings by Majani (2020) who found out that farmers still lacked training on ICTs which has been attributed to be a great challenge in implementation of ICTs in rural areas.

4.4.3 Means by which Farmer Respondents Acquired ICT skills

Table 14 presents the sources of ICT skills that farmers had to enable them utilize the ICTs because it was assumed that the skills cannot be attributed to training alone. The respondents also had other ways in which they used to gain the ICT skills.

Table 14

Sources of ICT Skills Among Farmers

Source of ICT skill	Frequency	Percent
Children	15	13.4
Extension officers	2	1.8
Fellow farmer	8	7.1
Individual learning	72	64.3
Individual learning, Children	12	10.7
Other	3	2.7
Total	112	100

Table 14 indicates that a very large proportion of the farmers, 64.3 percent gained their skill in using ICTs from individual learning and curiosity. Their children also helped 13.4 percent of the farmers to gain the basic ICT skills while 10.7 percent attributed their skills to both individual learning and children. Only one respondent accredited their skill to their spouse and only one indicated to have attended computer packages training. 1.8 percent attained their ICT skills from extension service agents while 8 farmers learned the skills from other farmers. The results show that as at the time of the study farmers did not have any formal training on ICT skills and majorly the basic skills that they had were acquired through self-learning and children. The results therefore, imply that there is need to develop capacity of farmers on ICT skills. These are consistent with the findings by Majani (2020) who established that training on ICT skills and knowledge positively influences the implementation of ICTs which in turn would affect their usage among farmers.

4.4.5 ICT Training Among Extension Agents

The respondents were asked whether they had undergone any ICT training or not. The results are presented in Figure 16.

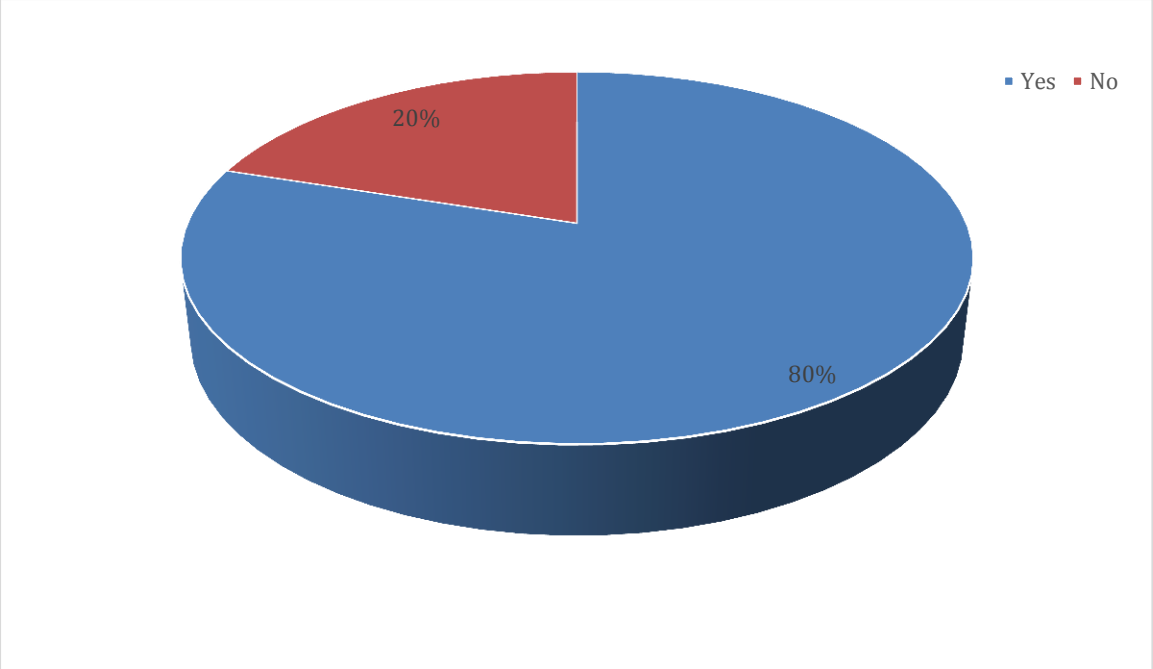

Figure 16: *ICT Training of Extension Agents*

Majority of the extension agents (80 percent) had undergone some form of ICT training and therefore have the capacity to use ICT tool while 20 percent had no professional ICT training. As indicated by the extension workers during focus group discussions some of them had undergone training through the e-Extension programme that had been carried out by the Kenyan national government. The e-Extension programme aimed at equipping the extension agents with both ICT tools and skills to be able to utilize them in providing e-Extension services to farmers. Others indicated that they had received other forms of ICT training such as computer packages and in-service job training. FGD's revealed that ICT skill gaps still exists among the extension agents. They identified use of computers, the internet and social media to be still the main challenge in communicating agricultural information to the farmers. These corresponds with findings by Dishant and Lakshminarayan (2018), Khamoushi and Gupta (2015) and Sulaiman et al. (2015) who found that training on ICT skills provided an opportunity for extension agents to develop knowledge and skills to effectively utilize ICT tools.

4.4.6 Usage of ICTs among Extension Agents in Accessing Agricultural information

Extension agents were asked to indicate the ICTs that they use in accessing agricultural information. Figure 17 present the findings**.**

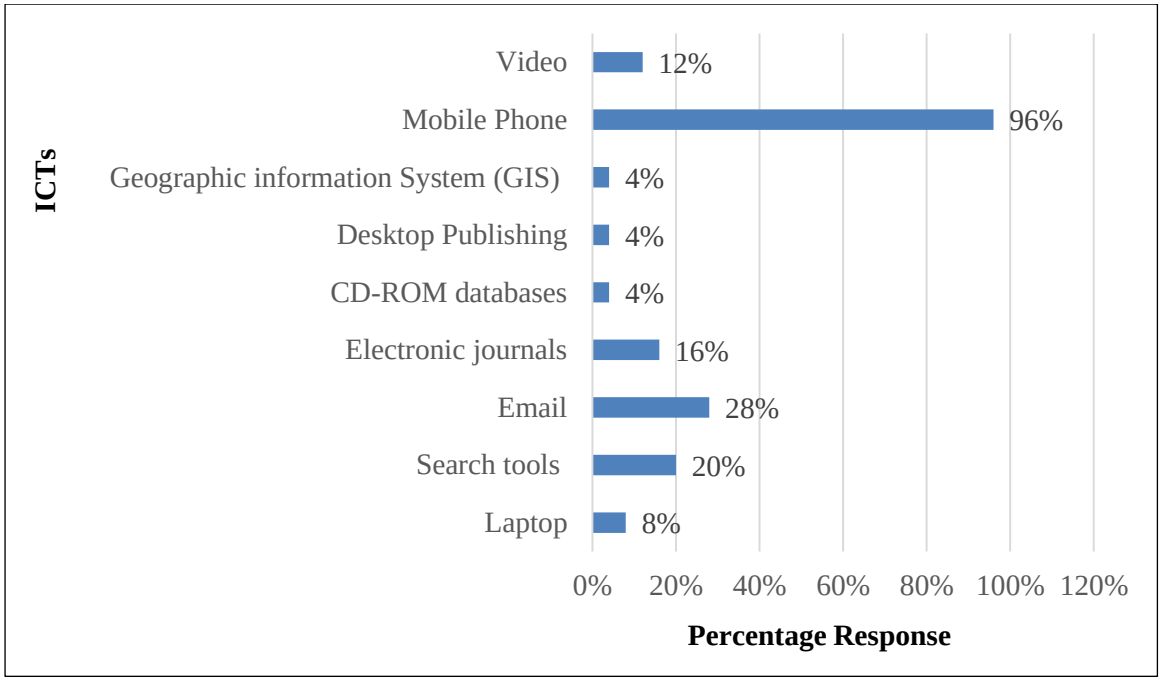

Figure 17: *ICTs Used by Extension Agents in Accessing Agricultural information*

Findings presented in Figure 17 shows that majority of the extension agents (96 percent) use mobile phones in accessing agricultural information. Email was used by only 28 percent while the other ICT tools that were studied registered very low number (below 20 percent) of extension workers using them.

4.4.6.1 Frequency of Usage of ICTs by Extension Agents in Accessing Agricultural Information.

The extension agents were asked to score the frequency of usage among ICTs in accessing agricultural information for their extension work. This was scored on a five point Likert scale of 1 = *Never* to 5 = *Daily*. The results are presented in Table 15.

Table 15

Averages of Frequency of Usage of ICTs by Extension Agents in Accessing Agricultural Information

ICT Usage	Mean	Standard deviation
World Wide Web	3.46	1.285
Email	3.44	.917
Discussion Groups	2.44	.821
Library online public access catalogue	2.09	.900
Agricultural electronic journals	2.32	1.069
Agricultural on-line databases	2.36	1.221
Mobile Phone Calls	4.56	.651
Short Messaging Service (SMS)	4.36	.860
Twitter	2.38	.924
WhatsApp Messaging	4.24	.879
Downloading software	2.48	1.046
Video Conferencing	2.00	.645
Downloading Videos	2.28	.843
Downloading Documents	2.72	.891

Results in Table 15 shows that mobile phone calls, SMS and WhatsApp messaging were the most frequently used ICTs by the extension agents in accessing agricultural information. Focus groups discussions indicated that the extension agents used their mobile phones for making calls, texting, downloading apps, accessing internet, accessing social media applications such as WhatsApp, Twitter and Facebook. Therefore, the mobile phone provided a wide range of services that could be used to access agricultural information among extension agents. The findings contradict the findings by Muthoni (2018) who found that only 10 percent of extension agents used SMS to communicate with farmers while only 12 percent made calls to farmers when there is an emergency.

Similarly, the results also indicate that worldwide web and emails were used on a monthly basis to access agricultural information among the respondents. Library online public access

catalog, agricultural electronic journals, downloading software, video conferencing, downloading Videos and downloading documents were occasionally used by the respondents.

4.4.7 Test of Hypothesis Two

The second objective of the study was to establish influence of ICT skills of farmers on usage of e-Extension services among smallholder farmers in Nakuru County, Kenya. Based on this objective the following hypothesis was generated:

$H0_2$: There is no statistically significant influence ofICT skills of farmers on usage of e-Extension services among smallholder farmers' in Nakuru County Kenya.

To investigate influence of ICT skills and usage of e-Extension services among the respondents the researcher focused on; ICT skills of farmers and usage of ICTs to access agricultural information. The test on both, ICT skills and usage of ICTs for e-Extension services, was done through administering questions to all the respondents. The ICT skills was measured at a 5 point Likert scale ranging from 1= *No Skill* 5 = *Advanced skills*. The level usage of the ICT skill to access agricultural information was also measured at a 5 point Likert scale ranging from 1 = *Never* to, 5 = *Always*. The data was then analyzed using ordinal regression model and the results obtained are presented in Table 16.

Table 16

Model Summary of Ordinal Regression between Skill level of Using ICTs and level of usage of e-Extension services

Skills of Using ICTs	N	Sig value	Goodness-of-Fit sig value	R value	R^2 Value
Mobile Phone	98	.003	.944	.375*	.141
Computer	12	.006	.105	.526*	.277
Internet	36	.013	.704	.479*	.230
Radio	113	.310	.560	$.338^{NS}$	.114
TV	94	.133	.339	$.447^{NS}$	.200
YouTube	25	.003	.867	.673*	.453
WhatsApp	43	.000	.973	.666*	.443
Facebook	34	.002	.870	.615*	.378
Twitter	7	.000	.902	.773*	.597

NS=Non-significant and * indicate significance of values at P = 0.05 and 0.01 goodness of Fit

As revealed by the ordinal regression test in Table 16 the results indicate a positive relationship (r = 0.38 - 0.773) existed between ICT skills on the usage of e-Extension services by smallholder farmers which were statistically significant for all the ICTs under study at α = 0.05 significance level except for radio and TV. Radio and TV had a p-value of .310 and .133 respectively, this was larger than the chosen level of significance of 0.05 under which the hypotheses of this study were investigated. A conclusion of not rejecting the null hypotheses for those two ICTs was made, since there was no statistically significant influence between skills in using radio and TV on their usage for e-Extension services among smallholder farmers in Nakuru County, Kenya. P-values of the other ICTs were all less than the selected 0.05 significance level consequently rejecting the null hypothesis as the p-value were significant at (α = 0.05 $p<0.05$).

The results further revealed that the predictor variables accounted for different variations in usage of e-Extension services using Pearson's goodness of fit of α = 0.01 to test whether the observed data were consistent with the fitted model. The goodness of fit for all the ICTs under study had a significance value which was greater than α = 0.01 as seen in Table 17,

hence the null hypothesis was accepted indicating goodness-of-fit to the fitted model except for radio and TV. The results also revealed that the predictor variables accounted for different variations in usage of e-Extension services with R^2 ranging from 0.114 to 0.597 for the various ICTs. This implies that that the variations accounted for 11.4 to 59.6 percent in usage of different ICTs among the respondents as shown in Table 17.

This implies that the farmers with ICT skills have a higher level of usage of ICTs to access e-Extension services. Meaning, the more skilled in using ICTs a farmer was, the higher the level of usage of the ICTs to access agricultural information. These results thus indicating that the influence of ICT skills, except for radio and TV, on the usage of the ICTs for e-Extension services within the smallholder farmers was significant. These findings are consistent with the assertion by Majani (2020) that, training on ICT skills increased farmers' ability to use ICTs which in turn also influenced its implementation.

4.5 Agricultural Digital Content and Usage of e-Extension Services among Farmer Respondents

Objective Three of the study sought to establish the influence of agricultural digital content on usage of e-Extension services among smallholder farmers in Nakuru County, Kenya. Agricultural digital content is among the most vital technological factors that were studied by the researcher. Information relayed to farmers through ICTs should be targeted and relevant in order to affect farmers' decisions and production. Content therefore is crucial and for it to have impact should be locally relevant and specific to the farmers, needs. Content was deemed important in the study in order to understand the level of availability of agricultural digital content as well and its characteristics. The researcher also sought to find the level of preference to the available digital content among the respondents.

4.5.1. Sources and Nature of Agricultural Digital Content Among Farmer Respondents

Table 17 present percentage of agricultural digital content available to smallholder farmers in Nakuru County, Kenya.

Table 17

Sources of Agricultural Digital Content Among Farmer Respondents

Sources of Agricultural Digital content	Received (%)	Not Received (%)
SMS	46.9	53.1
Phone calls	60.8	39.2
Radio Content	79.2	20.8
TV Content	67.7	32.3
Pictures (Accessed from ICTs)	18.5	81.5
e-books/journal/blogs/websites	3.8	96.2

As shown in Table 17, 79.2 percent of farmers received agricultural digital content through listening to the local radio stations that aired agricultural programmes aimed at improving farming activities among local communities. Focus group discussions indicated that farmers received agricultural content through local radio agricultural talk shows that were majorly aired at a particular time depending on the radio station. It was indicated in the discussions that agricultural information is usually aired in local languages that is understood by the respondents and are interactive in nature hence provides two-way communication. As indicated in the discussions most of the local radio stations have different mechanisms to interact with their listeners such as call-in with mobile phones, SMS as well as social media platforms e.g Facebook and Twitter. These platforms provide one on one interaction where, listeners ask questions and get immediate response from expert interviews in real time. Some farmers also indicated that in some cases they could record the talk shows on their mobile phones and this enabled then to be able to listen to them later when required. Respondents gave examples of local radio stations such as Inooro FM a program called '*Mugambo Wa Murimii'* and Chamgei FM a program called "*Tugetab Temiik*" aired in Gikuyu and Kalenjin languages respectively, and involved experts and local people in development of content. Examples of content as aired ranged from crop and livestock production weather forecasting, post-harvest handling and storage, marketing as well as home nutrition.

The corresponds to findings by Okello et al. (2017) who found that radio was the most effective ICT tool for used to communicate agricultural messages such as best practices and agricultural technologies that can help farmers improve agricultural production.

TV also was highly used with 67.7 percent of famers indicating to use the digital content from TV to access agricultural information. The respondents pointed out that a number of TV channels aired agricultural TV shows that were very educative and captivative because they are visual, provides peer to peer practical learning and are also entertaining in nature. A number of examples were cited by the farmers during focus groups discussions such as "Shamba Shape-up" aired by Citizen TV, Seeds of gold aired by NTV and "*Mugambo wa Muriimi*" aired by Inooro TV. The TV show such as "Shamba Shape-up as indicated during the discussions involved farmers that cut across East Africa and therefore, farmers were able to share best practices with the help of a range of experts invited to the show.

A local agricultural TV show "*Mugambo wa Muriimi*" aired by Inooro TV in Kenya was also indicated to be complementary in nature with the same show aired on local radio (*Inooro FM*) where farmers indicated that they could listen to the programme on radio and later watch the same show on TV. According to the farmers this was very important in case you missed the programme or part of the content that was aired. The content was also shared to the farmers where they could make a request through and SMS to receive leaflets of the different series aired, for example for the case of "Shamba Shape-up". For the case of "Seeds of gold" farmers also indicated that content could be accessed through daily magazine pull out every Saturday.

Studies have shown that radio and TV still dominate as a source of agricultural information among farmers compared to other ICTs due to their ability to reach households at the comfort of their homes and also due to the wider geographical coverage, diverse local languages and dialects that are used by abundant local radio and TV stations (Hailu et al., 2017).

Mobile phones were also found to be frequently used mode of receiving agricultural content with 60.8 percent of famers making phone calls, while texting was used by 46.9 percent. During the focus group discussions, the respondents indicated that it was more convenient for them to make a phone call and write a text message to receive agricultural content because its two-way communication reduces time taken to access the information and is cheap. Phone

calls for example were made by farmers to extension officers, agro dealers, buyers of agricultural products, neighbors, friend & fellow farmers, farm laborers among others where, different services were requested and negotiated for.

SMS based services was also as cited by farmers to be used to request and receive different services.An example of this as indicated by farmers during focus group discussions was *"iShamba"* which is an SMS based service available to Kenyan farmers across the countrywhere they can subscribe to it at a fee. In return they are able to receive local weekly weather forecast and market prices for two crops, two nearby markets and two agronomic tips related to their region. Another example is *icow* which is an SMS service for dairy farmers where they subscribe to receive regular SMS on breeding and production patterns of their cows. These two examples are those that farmers subscribe to and are able to get daily SMS based content. Farmers also were able to get other forms of SMS based content that were generated on request from other service providers such as agro-dealers, veterinary service providers or extension agents. As indicated from focus group discussions farmers noted that SMS services were more cost effective and could be referred to later particularly, where complex information and steps to be followed were shared compared to phone calls. On the other hand, SMSs was indicated to take more time to write and be responded to compared to phone calls and could only be utilized by those who could to read and write.

Phone calls on the other hand, as indicated by farmers was good in getting quick response, could be used to get instructions and follow-ups though they were more expensive according to them when compared to SMS. The findings correspond to findings by Okello et al. (2017) reports that farmers used phones calls and text messages to access market information because texting a low-cost means for disseminating price information to reach a significant portion of the smallholder farmers. Mutunga and Waema (2016) however, found that phone calls were more convenient to farmers with low level of education. The finding of this study further shows that, pictures accessed from ICTs and e-books were used by 18.5 percent and 3.8 percent of farmers respectively. Interactive Voice Response was not used by any respondents to receive information. This means that few farmers only used these ICTs to access agricultural digital content.

4.5.2. Level of Accessibility of Agricultural Digital Content among Farmer Respondents

Table 18 presents the scores ofthe level of accessibility of agricultural digital content that was available among respondents through the different ICTs. This included actual agricultural digital content that was accessed by respondents through different ICTs. This was scored at a 5 point Likert scale of 1= *No Access* 2 = *Low access* 3 = *Moderate access* 4 = *High access* 5 = *Very high access.*

Table 18

Central Tendencies of Level of Availability of Agricultural Digital Content Among Smallholder Farmers

Agricultural digital content	Mode	Median	Lower bound	Higher Bound
SMS	4	4.00	1	5
Phone call	4	4.00	1	5
Radio broadcast	4	4.00	1	5
TV Content	4	4.00	1	5
Pictures (Accessed from ICTs)	3	2.00	1	5
e-books/journal/blogs/websites	2	2.00	1	5

(n=130)

The results in Table 18 shows that accessibility to texting, phone calls, radio broadcast, and TV content among the farmers was very high with all of them having a median and mode of 4. Pictures had a poor to moderate availability with a median and mode of 2 and 3 respectively while e-books/journal/blogs/websites had a poor usage level with both median and mode of 2.

4.5.3. Agricultural Digital Content Usage among Farmer Respondents

The researcher sought to establish whether the information accessed by respondents through various ICT platforms was agricultural related and would enable them to use in their agricultural activities. The results are presented in Table 19.

Table 19

Central Tendencies for Agricultural Digital Content Usage for Agriculture

Digital content	Mode	Median	Lower bound	Higher Bound
SMS	3	3.00	1	5
Phone call	5	4.00	1	5
Radio broadcast	4	4.00	1	5
TV Content	4	4.00	1	5
Pictures (Accessed from ICTs)	3	3.00	1	5
e-books/journal/blogs/websites	1	2.00	1	5

(n=130)

Table 19 indicates that phone calls are often and always used by the farmers to access agricultural information as it had a mode of 5 and a median of 4. Radio and TV were often used for agriculture-related information with both having a mode and median of 4. Texting and pictures obtained from ICTs sometimes contained agricultural information with a mode and median of 3 for both these digital contents. E-books had a mode of 1 and a median of 2 shows that they were rarely used while no farmer recorded to have ever used Interactive Voice Response. This shows that the respondents received agricultural digital content in form of text, making calls for enquires and also listening to agricultural radio and TV programmes. These was confirmed through focus group discussion where the discussants indicated that they would subscribe to mobile text to receive alerts on agricultural information such as variety of seeds to plant in a particular region, availability of inputs and new products in the market such as agro-chemical. They further indicated that they listened to farmers' radio and TV programmes that helped them to learn and improve their agricultural practices.

4.5.4 Farmer Respondents' Perception on the Characteristics of Agricultural Digital Content

Table 20 presents the scores of smallholder farmers in relation to the various characteristics of agricultural digital content which included cost, timeliness, detail, reliability, language,

and relevance. The scores were rated at a five point Likert scale of 1= *Very poor*2 = Poor 3 = Good 4 = Very Good to 5 = *Excellent*.

Table 20

The Average Scores of Farmers' Perceptions of Characteristics of Agricultural Digital Content

Digital content characteristics	**SMS**	**Phone Calls**	**Radio Content**	**TV Content**	**Pictures**	**e-book /journals**
Cost	3.1	3.4	3.2	3.2	2.9	2.8
Timeliness	3.1	3.4	3.5	3.6	2.8	2.4
Detailed	3.1	3.4	3.5	3.7	3.2	2.4
Reliability	3.1	3.5	3.6	3.5	3.3	2.6
Language	3.5	3.9	3.8	3.7	3.4	2.8
Relevance	3.5	3.7	3.8	3.6	3.4	3.4

The data in Table 20 shows that the cost of the of receiving agricultural content through various ICTs was relatively fair, with farmers indicating that the cost for texting, phone calls, radio and TV programmes having an average mean 3.1 to 3.4. The costs associated with use of ICTs included costs that a farmer incurs in buying airtime, data bundles and charging the phone, buying batteries for the radio, paying for electricity charges and subscribing to TV channels in order to access agricultural information. The results indicate that the cost of receiving agricultural digital content through various ICT tools is average for texting making phone calls, listening to agricultural radio programmes and watching agricultural TV programmes. Discussions from focus groups indicated that farmers found ICTs to convenient because it provided them with real time agricultural information and saved them the cost of travelling to access the information. They indicated that they could make calls for example, to public extension agents to find out availability of government subsidized fertilizer and only travel when the fertilizer was in stock.

Pictures and e-books /journals/ blogs/ websites were also fairly scored though as indicated by the results over 90 percent of the respondents did not have access. The timeliness of receiving agricultural information though the various ICTs was indicated to be good except for pictures and e-books/ journal/ blogs/ websites. As indicated by the results the timeliness of receiving

information from radio (3.5) and TV (3.6) was relatively good as farmers indicated from focus group discussion that most of the programmes were based on seasons and were tailored to their needs. According to Naruka et al. (2017) timeliness of agricultural information is very crucial for farmers' access. Regarding the amount of details of information provided by the specific ICTs resources information received by farmers though radio was scored 3.5 and TV 3.7 tending towards very good. Discussions from focus groups indicated that the information aired through the programmes they listened to was very informative to the farmers. As indicated by farmers the information from TV in particular was very educative because they could follow the agricultural practices being done practically. They also suggested that some programmes were aired on both radio and TV and one could listen to the radio while in the farm and also follow the same programme later on TV after work hence, the two complementing each other. A good example of this was "*Mugambo wa Muriimi*" aired by Inooro Citizen Radio and TV stations.

In relation to reliability, radio, phone calls and TV were scored to be good with a mean average of 3.5 and above meaning that farmers relied on these tools majorly as their information source. They indicated that they relied on these sources because they trusted them as a source of agricultural information and was believed by farmers to be credible. The language used in receiving agricultural information through phone calls radio and TV had the highest score of 3.9, 3.8 and 3.7 respectively majorly because the language used was their local language. The farmers who had access to e-books/journals/websites scoring them to be fair in the language used which they indicated to be majorly in English. In terms of relevance of information all the ICTs were rated fairly above 3.4. Texting, phone calls, radio and TV were the most highly rated at a mean of 3.5 and above in terms of relevance of content. In particular radio and TV programmes are aired in local languages which make the content very relevant to the farmer. This agrees with the finding by Kante et al. (2018) who found that farmers preferred radio and mobile phones because they gave relevant and efficient information on agricultural information and financial services. Nakasone and Torero (2016) also in their findings reportsmobile phones are very critical in agricultural extensionin providing relevant agricultural information particularly. However, found out that there was no impact of agricultural information that was based on "push scheme" (push messages are those that are sent out to a persons' mobile phone without them initiating a request for the information) thorough texting (Fafchamps & Minten, 2012). The possible reasons according to them were due to push contents not being specific to farmers' concerns and the content

being complex. This could be an indication that when the content provided does not meet the information needs of the farmers they might not likely utilize the content provided to them. Mittal and Mehar (2013) posits that access to reliable, timely, and relevant information can help significantly and, in many ways, to reduce farmer's risks and uncertainty, empowering than to make good decisions.

4.5.5. Preference for Agricultural Digital Content Among Farmer Respondents

Smallholder farmers were asked to score their level of preference to the agricultural digital content that they were able to access at a five point Likert scale of = *Never preferred* to 5 = *Most preferred*. The results are presented in Table 21.

Table 21

Central Tendencies for Preference for Agricultural digital content among farmer respondents

Digital content	N	Mode	Median	Lower bound	Higher Bound
SMS	130	3	3.00	1	5
Phone calls	130	5	4.00	1	5
Radio Content	130	4	4.00	1	5
TV Content	130	4	4.00	1	5
Pictures (Accessed from ICTs)	130	1	1.00	1	5
e-books/journal/blogs/websites	130	1	1.00	1	5

Phone calls, radio content and TV content as shown in Table 21 is the most preferred among farmers all having a with median of 4. Discussions from the Focus Groups suggested that radio followed by mobile phones and TV were the most preferred channels in receiving agricultural digital content aired through local radio and TV stations. The discussions further revealed that a combination of radio and mobile calls complemented one another were there were feedback needed or clarifications from experts. The content that were aired cut across various agricultural practices and farmers indicated that it was even possible to listen to a

programme on radio and later on watch the same on TV. The radio and TV content was also preferred due to the involvement of experts that were invited to the shows.

The results also revealed that texting was sometimes preferred with a mode and median of 3 with farmers indicating that they preferred making phone calls over texting. These correspond to findings by Farm Radio International [FRI] 2019, who found that radio and mobile phones were the most preferred ICT channels among farmers. Pictures, Interactive Voice Response, e-books/journal/blogs/websites were never preferred as a source of digital content for the farmers. This could be attributed to the fact that they were inaccessible to most of the farmers.

4.5.6 Level of Availability of Agricultural Digital Content Among Extension Agents

Table 22 presents the level of availability of agricultural digital content according to extension agents that were involved in the study.

Table 22

Availability of Agricultural Digital Content Among Extension Agents

Agricultural Digital content	Available (%)	Not available (%)
Graphics (Images, Photos, Pictures)	100	0
Radio Content	96	4
TV Content	88	12
Agricultural Blogs	44	56
Agricultural e-books	84	4
Agricultural Websites (e.g. NAFIS,KACE,)	96	16
Agricultural e-journal	72	28
Agricultural forums	60	40

(n=25)

Table 22 presents the results of the level of availability of digital content among extension agents. All the extension agents (100 %) indicated to have access to graphics such as images, photos and pictures. Radio, TV Agricultural blogs, e-books, websites and e-journals and agricultural forums also showed to be highly available to the respondents. This indicates that these are very valuable ICTs that could benefit farmers. The result however, shows that to 56 percent of the respondent did not access agricultural blogs and 40 percent did not access agricultural forums.

4.5.7 Test of Hypothesis Three

The third objective of the study was to establish the influence of agricultural digital content on usage of e-Extension services among smallholder farmers in Nakuru county, Kenya**.** Based on the objective the following hypothesis was generated:

$H0_3$: There is no statistically significant influence of agricultural digital content on usage of e-Extension services among smallholder farmers' in Nakuru county, Kenya.

To determine the influence of digital content on usage of e-Extension services among the respondents the researcher focused on; digital content which was categorized into two sections, availability of digital content and characteristics of the digital content. The selected characteristics of the digital content were; cost, timeliness, detail, reliability language, and relevance. The test on both, availability and characteristics of digital content was done through administering questions to all the respondents. availability of digital content was measured at a 5 point Likert scale ranging from 1= *No access* 5 = *Very high access* while the characteristics of digital content were also measured at a 5 point Likert scale ranging from 1 = *Very poor* to, 5 = *Excellent.* The level of usage of the digital content to access agricultural information was also measured at a 5 point Likert scale ranging from 1 = *Never*to, 5 = *Always*. The data was then analyzed using ordinal regression model to test on the influence of availability of digital content on usage of e-Extension services and then the influence of digital content characteristics on usage to access e-Extension services.

4.5.7.1Digital content Availability and its Influence on Usage of e-Extension Services Among Farmer Respondents

Ordinal regression model was used to test the level of influence of digital content availability on usage of e-Extension services among smallholder farmers. The results are presented in Table 23.

Table 23

Model Summary of Ordinal Regression Between Availability of Digital Content and Usage of Digital Content for e-Extension Services

Agricultural Digital content	N	Sig value	Goodness-of-Fit sig value	R value	R^2 Value
SMS	61	.000	.200	.673*	.453
Phone calls	78	.000	.616	.538*	.289
Radio Content	102	.005	.277	.387*	.150
TV Content	88	.050	.091	.336*	.113
Pictures	23	.315	.545	$.443^{NS}$	.196
ebooks/journal/blogs/websites	5	.578	.225	$.461^{NS}$	.212

NS=Non-significant and * indicate significance of values at P=0.05 and 0.01goodness of Fit

The ordinal regression test results in Table 23 shows a positive relationship (r = 0.336 - 0.673) between availability of digital content on the usage of e-Extension services by smallholder farmers which were statistically significant for all the digital content at $\alpha = 0.05$ significance level except for pictures and ebooks/journal/websites.Pictures and ebooks/journal/websites had a p-value of .315 and .578 respectively, which is greater than the chosen level of significance of 0.05 under which the hypotheses of this study were investigated. A decision of not rejecting the null hypotheses for this digital content was therefore made, since there was no statistically significant influence between their availability and usage for e-Extension services among smallholder farmers in Nakuru County, Kenya. The P-values for texting, phone calls, radio, and TV were all less than the selected 0.05 significance level consequently, rejecting the null hypothesis as the p-value is significant at ($\alpha = 0.05$ $p<0.05$).

The results further revealed that the predictor variables accounted for different variations for availability of digital content on usage of e-Extension services using Pearson's goodness of fit of $\alpha = 0.01$ to test whether the observed data were consistent with the fitted model. The

goodness of fit for all the ICTs under study had a significance value which was greater than α = 0.01 as seen in Table 23, hence the null hypothesis was accepted indicating goodness-of-fit to the fitted model except for pictures and ebooks /journal/websites. The results also revealed that the predictor variables accounted for different variations in usage of e-Extension services with R^2 ranging from 0.113 to 0.453 for the available digital content. This implies that that the variations accounted for 11.3 to 45.3 percent in usage of different available digital content among the respondents as shown in Table 23.

The finding therefore suggests that availability of digital content has an influence on usage of e-Extension services among smallholder farmers. These imply that farmers use the available digital content to access agricultural information for various farming activities. The results further suggest that pictures and e-books/journals/websites did not influence usage and this could be due to the low level of accessibility to these types of digital content. Therefore, the null hypothesis was rejected for the alternate hypothesis meaning that the study concludes that there is an influence of availability of digital content on usage of e-Extension services except for pictures and e-books/journals/websites.

4.5.7.2 Characteristics of digital content and their influence on usage of e-Extension services

The characteristics of digital content will determine its accessibility and utilization among smallholder farmers for decision making in their farming activities. The researcher sought to determine the characteristic of digital content as perceived by smallholder farmers'. The characteristics under study included cost, timeliness, detail, reliability, relevance and language. The findings on each of the characteristics were then used to test its influence on usage of e-Extension services among smallholder farmers. The results are presented in Tables 24 – 29.

a) Cost of Digital Content

Table 24 presents the regression results between the of cost of digital content on usage of e-Extension services among smallholder farmers.

Table 24

Model Summary of Ordinal Regression Between the Cost of Digital Contents and Usage of Digital Content for e-Extension Services

Digital content	N	Sig value	Goodness-of-Fit sig value	R value	R^2 Value
SMS	61	.020	.316	.378*	.143
Phone calls	78	.035	.670	.224*	.150
Radio content	102	.000	.001	.439*	.193
TV Content	88	.016	.007	.316*	.100
Pictures	23	.016	.821	.556*	.309
ebooks/journal/blogs/websites	5	.469	.307	$.654^{NS}$	.428

NS=Non-significant and * indicate significance of values at P=0.05 and 0.01goodness of Fit

The finding as indicated in Table 24 shows a positive relationship (r = 0.224-0.654) that between the cost of digital content on usage of e-Extension services among smallholder farmers was evident. The results further show that the influence was statistically significant for texting, phone calls radio and TV and pictures at $\alpha = 0.05$ significance level. The influence of receiving digital content ebook/journals/websites/had was not significant with a p-value of 0 .469 which is larger than the chosen level of significance of 0.05 under which the hypotheses of this study were investigated. A conclusion of not rejecting the null hypotheses for the digital content was therefore made, since there was no statistically significant influence between the cost of digital content and usage for e-Extension services among smallholder farmers in Nakuru County, Kenya. The P-values for texting, phone calls, radio, pictures and TV were all less than the selected 0.05 significance level consequently, rejecting the null hypothesis as the p-value is significant at ($\alpha = 0.05$ $p<0.05$).

The results further revealed that the predictor variables accounted for different variations for availability of digital content on usage of e-Extension services using Pearson's goodness of fit of $\alpha = 0.01$ to test whether the observed data were consistent with the fitted model. The goodness of fit for all the digital content under study had a significance value which was

greater than $\alpha = 0.01$ as seen in Table 24, hence the null hypothesis was accepted indicating goodness-of-fit to the fitted model except for phone calls and ebooks/journal/websites. The results also revealed that the predictor variables accounted for different variations in usage of e-Extension services with R^2 ranging from 0.100 to 0.428 for the available digital contents. The variations therefore accounted for 10.0 to 42.8 percent in the cost of using different available digital content among the respondents as shown in Table 24.

The finding therefore suggests the cost of digital content except for ebooks/journal/websites an influence on usage of e-Extension services among smallholder farmers. These implies that farmers attributed the cost of accessing digital content influenced their use to access agricultural information. The results further suggest that the cost of e-books/journals/websites did not influence usage for extension services and this could be due to the low level of accessibility to these type of digital content which was only accessed by 5 respondents in the study. The findings revealed that the cost of receiving digital content through different ICTs influenced the usage of extension services among farmers except for ebooks/journal/websites implying that it could act as a barrier to usage of ICTs. In line with this findings Kante (2016) reported that the cost of mobile handsets and services in Tanzania excluded poor rural farmers from accessing mobile based agricultural value added services called "*Tigokilimo"*. Other studies by Barakabitze et al. (2017), Mugwisi et al. (2015), Kiambi (2018) and Otene (2018) indicate that farmers are unable to afford the costs associated with servicing mobile phones and to pay for extension and advisory services rendered thorough ICTs due to farmers' low standard of living.

b) Timeliness of Digital Contents

Table 25 presents the regression results between the timeliness of digital content on usage of e-Extension services among smallholder farmers.

Table 25

Model Summary of Ordinal Regression between the Timeliness of Digital Contents and Usage of Digital Content for e-Extension Services

Digital content	N	Sig value	Goodness-of-Fit sig value	R value	R^2 Value
SMS	61	.079	.720	.370 ^{NS}	.137
Phone calls	78	.042	.689	.231*	.103
Radio Content	102	.096	.021	.259^{NS}	.067
TV Content	88	.057	.032	.332^{NS}	.110
Pictures	23	.097	.887	.503 ^{NS}	.253
ebooks/journal/blogs/websites	5	.008	.999	.810*	.656

NS=Non-significant and * indicate significance of values at P=0.05 and 0.01goodness of Fit

Table 25 shows the results for ordinal regression which indicate that though there was a positive relationship (r = 0.231- 0.810) between timeliness of digital content on usage of e-Extension services among respondents they were not statistically significant at α = 0.05 significance level except for phone calls and ebooks/journal/blogs/websites. The study therefore, fails to reject the null hypothesis for texting, radio, TV and accepts the null hypothesis for phone calls and ebooks/journal/blogs/websites based on the study finding.

The results further revealed that the predictor variables accounted for different variations for timeliness of digital content on usage of e-Extension services using Pearson's goodness of fit of α = 0.01 to test whether the observed data were consistent with the fitted model. The goodness of fit for all the ICTs under study had a significance value which was greater than α = 0.01 as seen in Table 27 except for phone calls and e-book/journal/websites, hence the null hypothesis was accepted indicating goodness-of-fit to the fitted model. The results also revealed that the predictor variables accounted for different variations in usage of e-Extension services with R^2 ranging from 0.103 to 0.656 for the timeliness of available digital contents. This implies that that the variations accounted for 10.3 to 65.3 percent in usage of different available digital content among the respondents as shown in Table 25.

The finding therefore suggests that the timeliness of agricultural information disseminated through texting, radio, TV and pictures do not have an influence on usage of e-Extension services among smallholder farmers while phone calls and ebooks/websites/ had an influence on usage of e-Extension services. These implies for digital content to be used by farmers has to be provided in a timely manner. Casaburi et al. (2014) in their study notes that the timing of information provided is very crucial in the delivery of agricultural information using ICTs.

c) Details of Digital Content

Table 26 presents the regression results between the details of digital content on usage of e-Extension services among smallholder farmers. The details of the content entailed the information contained in a particular ICT tool provided enough information to enable the user to be able to make decision.

Table 26

Model Summary of Ordinal Regression Between the Details of Digital Contents and Usage of Digital Content for e-Extension Services

Digital content	N	Sig value	Goodness-of-Fit sig value	R value	R^2 Value
SMS	61	.028	.723	.417*	.174
Phone calls	78	.032	.780	.257*	.066
Radio Content	102	.018	.011	.283*	.080
TV Content	88	.008	.003	.399*	.159
Pictures	23	.019	.903	.649*	.422
ebooks/journal/blogs/websites	5	.0291	.452	.647*	.418

* indicate significance of values at P=0.05 and 0.01goodness of Fit

The ordinal regression test results in Table 26 shows a positive relationship (r =0.257-0.649) between the details of digital content on the usage of e-Extension services by smallholder farmers which were statistically significant for all the digital contents at $\alpha = 0.05$ significance level. The study null hypothesis is therefore rejected based on the findings.

The results further revealed that the predictor variables accounted for different variations for availability of digital content on usage of e-Extension services using Pearson's goodness of fit of $\alpha = 0.01$ to test whether the observed data were consistent with the fitted model. The goodness of fit for all the digital contents under study had a significance value which was greater than $\alpha = 0.01$ as seen in Table 26, hence the null hypothesis was accepted indicating goodness-of-fit to the fitted model. The results also revealed that the predictor variables accounted for variations in usage of e-Extension services with R^2 ranging from 0.066 to 0.422 for the available digital content. This implies that that the variations accounted for 6.6 percent to 42.3 percent in usage of different available digital content among the respondents as shown in Table 27.

The finding therefore suggests that the details of digital content have an influence on usage of e-Extension services among smallholder farmers. These imply that the details provided by the type of digital content will influence the use of e-Extension service for farming activities by farmers. The results further suggest that pictures and e-books/journals/websites had a high variation which is indicated to contribute 42.2 percent and 41.8 percent respectively, but this could be attributed to the low number of respondents that had access to these types of digital content and therefore the results might not be generalized.

d) Reliability of digital content

Table 27 presents the regression results between the reliability of digital content on usage of e-Extension services among smallholder farmers. The reliability of the agricultural digital content entailed the consistency of obtaining information from the different ICTs and the users also could trust the source.

Table 27

Model Summary of Ordinal Regression Between the Reliability of Digital Contents and Usage of Digital content for e-Extension Services

Digital content	N	Sig value	Goodness-of-Fit sig value	R value	R^2 Value
SMS	61	.060	.591	.383^{NS}	.147
Phone calls	78	.008	.317	.333*	.510
Radio Content	102	.000	.039	.447*	.200
TV Content	88	.002	.004	.738*	.545
Pictures	23	.005	.314	.707*	.500
ebooks/journal/blogs/websites	5	.008	.809	.674*	.454

NS = Non-significant and* indicate significance of values at P=0.05 and 0.01goodness of Fit

The ordinal regression test results in Table 27 shows a positive relationship (r = 0.333 -0.707) between reliability of digital content on the usage of e-Extension services by smallholder farmers which were statistically significant for all the digital contents at $\alpha = 0.05$ significance level except for texting where significance value was 0.60. A conclusion to reject the null hypotheses is made. The P-values all the digital contents were all less than the selected 0.05 significance level consequently rejecting the null hypothesis as the p-value is significant at ($\alpha = 0.05$ $p<0.05$).

The results further revealed that the predictor variables accounted for different variations in relevance of digital contents on usage of e-Extension services using Pearson's goodness of fit of $\alpha = 0.01$ to test whether the observed data were consistent with the fitted model. The goodness of fit for all the digital contents under study had a significance value which was greater than $\alpha = 0.01$ as seen in Table 28, hence the null hypothesis was rejected indicating goodness-of-fit. The results also revealed that the predictor variables accounted for different variations in usage of e-Extension services with R^2 ranging from 0.147 to 0.545 for the available digital content. This implies that that the variations accounted for 14.7 percent to

54.5 percent in reliability of digital content on usage of e-Extension services among the respondents as shown in Table 27.

The finding therefore suggests that reliability of digital content has an influence on usage of e-Extension services among smallholder farmers except for texting which did not influence usage and this could be due to the type of digital content shared through texting. The participants in the focus group discussion indicated that some texts could be sent to their phones without subscription to the alerts through text and therefore were treated as spam and they could not trust the source.

e) Language of Digital Content

Table 28 presents the regression results between the language of digital content on usage of e-Extension services among smallholder farmers.

Table 28

Model Summary of Ordinal Regression between the Language of Digital content and Usage of Digital Content for e-Extension Services

Digital content	N	Sig value	Goodness-of-Fit sig value	R value	R^2 Value
SMS	61	.012	.787	.449*	.202
Phone calls	78	.001	.733	.487*	.237
Radio Content	102	.000	.189	.535*	.286
Video/TV Content	88	.005	.002	.418*	.175
Pictures	23	.006	.235	.704*	.495
ebooks/journal/blogs/websites	5	.008	.999	.738*	.545

NS=Non-significant and * indicate significance of values at P=0.05 and 0.01goodness of Fit

Table 28 presents the ordinal regression results and shows a positive relationship (r = 0.418-0.738) between the language of digital content on the usage of e-Extension services by smallholder farmers which were statistically significant for all the digital contents at $\alpha = 0.05$

significance level for all the digital content types. The null hypothesis was therefore rejected since there was no statistically significant influence.

The results further revealed that the predictor variables accounted for different variations for availability of digital content on usage of e-Extension services using Pearson's goodness of fit of $\alpha = 0.01$ to test whether the observed data were consistent with the fitted model. The goodness of fit for all the digital contents under study had a significance value which was greater than $\alpha = 0.01$ as seen in Table 28, hence the null hypothesis was rejected. The results also revealed that the predictor variables accounted for different variations in usage of e-Extension services with R^2 ranging from 0.175 to 0.545 for the available digital contents. This implies that that the variations accounted for 17.5 percent to 54.5 percent in usage of different available digital content among the respondents. The findings therefore show that language has an influence on usage of e-Extension services among smallholder farmers. The alternative hypothesis was therefore accepted based on the findings accepted implying that language of digital content influences the usage of e-Extension services among farmers.

f) Relevance of Digital Content

Table 29 presents the regression results between the relevance of digital content on usage of e-Extension services among smallholder farmers.

Table 29

Model Summary of Ordinal Regression Between the Relevance of Digital Contents and Usage of Digital Content for e-Extension Services.

Digital content	N	Sig value	Goodness-of-Fit sig value	R value	R^2 Value
SMS	61	.000	.971	.631*	.398
Phone calls	78	.001	.300	.476*	.227
Radio Content	102	.002	.002	.389*	.151
TV Content	88	.003	.003	.431*	.186
Pictures	23	.010	.368	.681*	.463
ebooks/journal/blogs/websites	5	.008	.809	.459*	.211

NS=Non-significant and * indicate significance of values at P=0.05 and 0.01goodness of Fit

The results presented in Table 29 shows the that there is a positive relationship (r = 0.431-0.681) between relevance of digital contents on the usage of e-Extension services by smallholder farmers which were statistically significant for all the digital contents at $\alpha = 0.05$ significance level.it was therefore, concluded that since the P-values for are less than the selected 0.05 ($\alpha = 0.05$ $p<0.05$) significance level consequently, the null hypothesis is therefore rejected.

The results further reveals that the predictor variables accounted for different variations for availability of digital content on usage of e-Extension services using Pearson's goodness of fit of $\alpha = 0.01$ to test whether the observed data were consistent with the fitted model. The goodness of fit for all the ICTs under study had a significance value which was greater than $\alpha = 0.01$ as seen in Table 30, hence the null hypothesis was rejected indicating goodness-of-fit to the fitted model. The results also revealed that the predictor variables accounted for different variations in usage of e-Extension services with R^2 ranging from 0.151 to 0.463 for the available digital contents. This implies that that the variations accounted for 15.1 to 46.3 percent for the contribution of relevance of digital content on usage of e-Extension services among the respondents as shown in Table 29. The finding therefore suggests that the relevance of digital content has an influence on usage of e-Extension services among smallholder farmers.

4.6. Type of e-Extension Platform and Usage of e-Extension Services Among Smallholder Farmers

Objective four of the study sought to establish the influence of type of e-Extension platform on usage of e-Extension services among smallholder farmers among smallholder farmers in Nakuru County, Kenya. E-Extension platforms were selected by the researcher one of the most significant technological factors in the study. It serves to point out different usage and preference levels for all the e-Extension platforms. The researcher sought to establish the e-Extension platforms available to farmers, the e-Extension platforms used to access e-Extension services, level of usage of e-Extension platforms, the skill level in using the e-Extension platforms and the preference to the e-Extension platforms among smallholder farmers.

4.6.1 Level of Availability of e-Extension Platforms Among Farmer Respondents

Table 30 presents the results of the respondents' level of availability of e-Extension platforms.

Table 30

Availability of e-Extension Platforms Among Smallholder Farmers

e-Extension platforms	Available (%)	Not Available (%)
Phone calls	69.2	30.8
SMS	56.9	43.1
Facebook	23.8	76.2
WhatsApp	27.7	72.3
Twitter	3.1	96.9
YouTube	16.2	83.8
Email	13.8	86.2
Farmer Call Centre	10	90.0
e-Plant Clinic	9.2	90.7

Results in Table 30 shows that phones calls were the most widely available e-Extension platform with 69.2 percent of the farmers having access. Texting was also extensively available to 56 percent of farmers, while WhatsApp 27.7 percent of farmers had access. Facebook was accessed by 23.8 percent and YouTube was only available 16.2 percent of the farmers. A low availability was recorded for Twitter, emails, farmer call center and plant clinics each accounting to over 80 percent non-availability among the respondents. These corresponds findings by Gichamba et al. (2017), who indicated there is low adoption of modern ICTs by farmers in accessing agricultural information.

4.6.2. Usage of e-Extension Platforms among Farmer Respondents

The level of usage of e-Extension platform among farmers in accessing agricultural information is presented in Table 31.

Table 31

Usage of e-Extension Platforms Among Farmer Respondents

e-Extension platforms	Used (%)	Not Used (%)
Phone calls	62.3	37.7
Texting	56.2	43.8
Facebook	22.3	77.7
WhatsApp	24.6	75.4
Twitter	2.3	97.7
YouTube	13.8	86.2
Email	5.4	194.6
Farmer Call Centre	5.4	94.6
e-Plant Clinic	4.6	95.4

The respondents that used phone calls as an e-Extension platform to access agricultural information, as seen on the Table 31, were the most widely with 62.3 percent of respondents stating that they used it. The results further revealing that 56.2 percent used texting, Facebook 22.3 percent, WhatsApp 24.6 percent and YouTube 13.8 percent. Email, Framer Call Centres, Plant Clinic, and Twitter had the least number of farmers using them with 5.4, 5.4, 4.6 percent of farmers using them respectively. The results reveal that phone calls and texting was mostly used by famers to access agricultural information. Focus group discussions revealed that farmers could access information such as application rates for agro-chemicals where they could make phone calls and receive instructions from an extension agent or input dealers. This shows that mobile calls and texting is being used widely by farmers to receive e-Extension services. The implication of this results indicating that ICT tools such as mobile phones could be greatly utilized to provide avenues for customized agricultural information for farmers which can empower them to adopt to farming practices for improved agricultural productivity. These results correspond to findings by Krone et al. (2020) who found that mobile phones provided farmers with the opportunity to access not only simple knowledge but also complex knowledge that is possible to be exchanged through calls. Fabregas et al. (2019) also reported positive results in the use of SMS messages in

randomized controlled trials in Kenya and Rwanda to increase the use of agricultural lime to reduce soil acidity and increase yields.

4.6.3. Extent of Usage of e-Extension Platforms among Farmer Respondents

Farmer were asked to score the frequency of usage of the e-Extension platforms which was at done at a five-point Likert scale of 1 = *Neve*r to 5 = *Daily*. Table 32 presents the average scores of the extent of usage.

Table 32

Average Scores of Farmers' Extent of Usage of e-Extension Platforms

e-Extension Platforms	N	Mean	Std. Dev.
Phone calls	90	4.2	0.957
Texting	74	3.3	1.16
Facebook	31	3.2	1.07
WhatsApp	36	3.6	1.11
Twitter	4	3.3	1.71
YouTube	21	3.1	1.30
Email	18	2.0	1.28
Farmer Call Centre	7	2.9	1.07
e-Plant Clinic	6	2.2	0.753

Conferring to Table 32, phone calls are always used as platform by farmers to access agricultural information with a mean of 4.2 with 69.2 percent of the respondents using the platform. Texting, WhatsApp, YouTube and Facebook were also used on average by the respondents with all having a mean average above 3, showing they were sometimes used by the farmers as e-Extension platforms among 56.9, 27.6, 16.1 and 23.8 percent of the respondents using them respectively. Twitter though it had a mean of 3.3 indicating that it was used sometimes by farmers only 4 farmers were using it. Email, Farmer Call Centre and Plant Clinic were rarely used by the farmers with a mean of 2.0, 2.9 and 2.2 respectively. The

results generally show that the percentage of farmers using e-Extension platforms are still low with only texting and phone calls having over 50 percent of the farmers using them.

4.6.4 Extent of Usage of e-Extension Platforms among Extension Agents

The extension agents were asked to indicate the extent to which they used e-Extension platforms in their extension work. The results are shown in Figure 18.

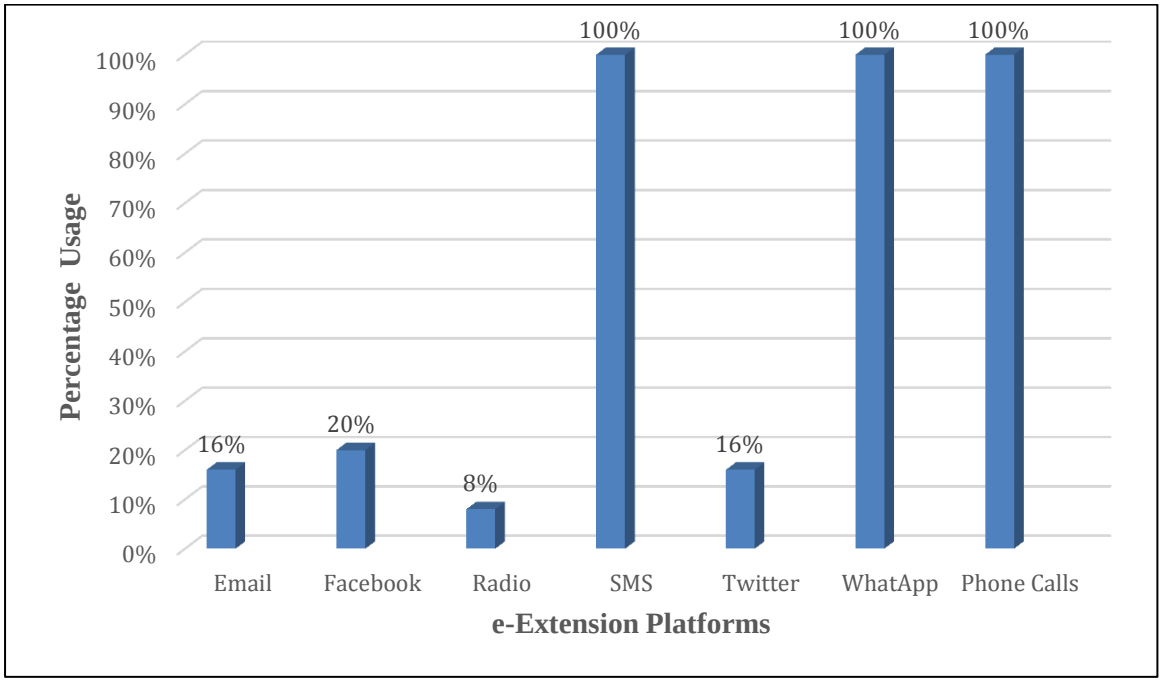

Figure 18: *e-Extension Platforms Used by Extension Agents*

The results of the study show that all the respondents in the study used SMS, WhatsApp, and phone calls as an e-Extension platform for providing extension services to farmers. These shows that these platforms are the most popular among the respondents and could provide a good opportunity to be utilized to provide e-Extension services. Radio was only used by 8 percent of the respondents although this was the most popular ICT among the farmers in accessing agricultural information. Email and Facebook and Twitter were only used by 20 percent, and 16 percent of the respondents respectively. Focus group discussions indicated that these platforms were used to provide agricultural information and advisory services to farmers such as access to inputs, financial and credit services, crop and livestock husbandry practices, market information, record keeping as well as weather forecasting, post-harvest handling and food nutrition. According to extension agents these messages were customized

and disseminated through the e-Extension platforms depending on farmer requests or generally to create awareness about available agricultural information and technologies.

According to the discussions it was indicated that the platforms were majorly used differently to provide agricultural information to farmers. For example, SMS was cited to be used majorly to provide information to farmers such as availability of inputs, procedures for farming activities, responding to farmers' questions and invitations for meetings. WhatsApp was also cited to be used to provide a learning platform for farmers due to its capability of exchanging videos and photos. It was indicated that farmers could send for example photos of pests and diseases affecting their crops and livestock, get diagnosed by extension agents and provide appropriate control measures. These corresponds with findings by Gichamba et al. 2017 who found mobile based platforms could be best used in providing agricultural information to farmers.

4.6.5 e-Extension Platforms Skill Level of Farmer Respondents

Table 33 present the results on the level of skill among the extension agents in using different extension platforms.

Table 33

Average Scores of Farmers' e-Extension Platforms Skill Level

Skill level of using e-Extension platform	**N**	**Mean**	**Std. Dev.**
Phone calls	90	3.7	0 .58
Texting	74	3.5	0.75
Facebook	31	3.5	0.85
WhatsApp	36	3.4	0.91
Twitter	4	3.5	0.58
YouTube	21	3.5	0.68
Email	18	2.7	1.18
Farmer Call Centre	7	3.3	0.49
e-Plant Clinic	6	2.2	0.75

Skills in using e-Extension platforms were generally high for a great number of the e-Extension platforms by the farmers. A very high skill level was revealed, as seen on the Table 33, for phone calls, texting, Facebook, WhatsApp, and YouTube with all obtaining a median and mode of 4. The farmers had little skills when it came to using emails, Plant Clinics with both mode and median been 2. Moderate to little skill was revealed for Farmer Call Centre and Twitter with a mode of 2 for both and a median of 3 and 2.5 respectively. As indicated by the results however though high skill level was recorded for Facebook, WhatsApp and YouTube it was only utilized by 27 percent, 23 percent and 16 percent of the respondents respectively. The focus group discussion indicated that majority of farmers that used Facebook, WhatsApp, and YouTube were the youthful farmers as compared to the older farmers. The findings correspond to findings by Katunyo et al. (2019) who found that Facebook and WhatsApp platforms were majorly used by the youths to market and sell their farm produce as compared to other platforms.

4.6.6. Preference for e-Extension Platforms by Farmer Respondents

Farmers were asked to indicate the e-Extension platforms that they preferred and their responses are shown in Table 34.

Table 34

Average Scores for Farmer Respondents Preferences to e-Extension Platforms

Preference to e-Extension platforms	Mean	Standard Deviation
Phone calls	3.8	1.21
Texting	3.2	1.27
Facebook	1.9	1.34
WhatsApp	2.2	1.52
Twitter	1.4	0.95
YouTube	1.9	1.41
Interactive Voice Calls	1.3	0.89
Email	1.3	0.85
Farmer Call Centre	1.8	1.44
e-Plant Clinic	1.2	0.664

(n=130)

The farmers preferred e-Extension platforms as shown in Table 34 indicate that Phone calls radio and TV are the most preferred platforms with a mean of 3.8, 3.9 and 3.6 respectively. Texting was also sometimes preferred by the farmers as a platform for accessing e-Extension services with a mean of 3.2. Facebook, WhatsApp, Twitter, YouTube, email, Farmer Call Centre, and Plant Clinic were all never preferred e-Extension platforms with all having a mean of 1. The findings are similar to the finding by Ronard (2019) who also found that mobile phones radio and TV were the most preferred ICTs among fish farmers in Tanzania.

4.6.7. Preference of e-Extension Platforms by Farmer Respondents According to Extension Agents

The extension agents were asked to score the e-Extension platforms that are preferred by smallholder farmers at a five-point Likert Scale of 1=*Never Preferred to 5= Most Preferred.* The results are presented in Table 35.

Table 35

Preferred e-Extension Platforms by Smallholder Farmers According to Extension Agents

Preferred e-Platforms	N	Mean	Std. Deviation
Phone Calls	25	4.32	0.900
SMS	25	4.20	1.155
Email	25	2.30	0.974
Interactive Voice Response	25	2.27	1.241
Twitter	25	2.14	1.207
WhatsApp	25	3.88	0.833
Facebook	25	2.77	1.378

The researcher categorized the scores between 1- 1.5 as never preferred, 1.6-2.4 as seldom preferred, 2.5-3.3 as moderately preferred and 3.4 – 4.2 as often preferred and 4.3-5.0 Most preferred. According to the results phone calls were the most preferred e-Extension platforms to farmers according to extension agents. WhatsApp, and SMS were often preferred, Facebook moderately preferred while email, Interactive Voice Response and Twitter were

seldom to never preferred by farmers. The results therefore imply that farmers mostly preferred mobile phone calls as compared to SMS and social media platforms.

4.6.8 Test of Hypothesis Four

The fourth objective of the study was to establish the influence of type of e-Extension platform on usage of e-Extension services among smallholder farmers among smallholder farmers in Nakuru County, Kenya.

Based on objective four of the study, the following hypothesis was generated:

Ho_4: There is no statistically significant influence of type of e-Extension Platform on usage of e-Extension services among smallholder farmers' in Nakuru county, Kenya.

The influence of the type e-Extension platform on their usage of e-Extension services was tested using Pearson's Chi-square test. Since the type of e-Extension platform was the subject under study, two types of analysis were conducted, a chi-square test and a central tendency analysis. The Chi-square was used test to check on the presence of a significant relationship between e-Extension platforms and their usage for e-Extension services while the central tendency analysis was used to check on the level of influence. Table 36 presents the Chi-square test results.

Table 36

Chi-square Statistics and Results on Availability of e-Extension Platforms and Usage of e-Extension services

e-Extension platform	N	Sig value	Cramer's V value
Phone calls	90	0.000	0.857
Texting	74	0.000	0.769
Facebook	31	0.000	0.644
WhatsApp	36	0.000	0.712
Twitter	4	0.000	0.411
YouTube	21	0.001	0.594
Email	18	0.000	0.216
Farmer Call Centre	7	0.000	0.497
e-Plant Clinic	6	0.000	0.348

Level of significance $\alpha = 0.05$

A Chi-Square test was done on each separate e-Extension platform in the study using the results obtained from the type of e-Extension platform available and level of usage for e-Extension services to determine whether there was any association. The Cramer's V was also employed to check the strength of the association with values ranging from 0-1. The relationship between the availability of e-Extension platforms and their usage for e-Extension services by smallholder farmers as evident as shown in Table 36 was statistically significant at $\alpha = 0.05$ level of significance for all the e-Extension platforms. The level of influence as seen in the Cramer V section was interpreted as follows; 0 - 0.19 was considered "*very weak",* 0.2 - 0.39 as *"Weak",* 0.40-0.59as *"moderate",* 0.6-0.79 *as "strong",* and 0.8-1 as *"very strong"* association. The results showed that phone calls had a very strong association with Cramer's V value of 0.857. Texting, Facebook and WhatsApp also had a strong association with Cramer's V value above 0.6. The findings are consistent with other findings by Aker and Fatchamps (2014) and Tadesse and Bahiigwa (2015) which indicated that was a positive significant impact of mobile phones on household income being attributed to reduced transaction costs, and aiding in social networks as well as connecting to agricultural players. The studies further reports that the device is used to substitute for travelling as farmers are able to make calls for example to someone in the market thereby having accurate and timely information about the market prices and rates. This thus shows that mobile phones are not only used to enhance social networks by connecting to family and friends but are also used in collecting agricultural information (Mwalupaso et al., 2019).

YouTube, Twitter and Farmer call center had a moderate association of 0.4 and above though as indicated by the results very few farmers had access to these e-Extension platforms. Plant clinics and Emails had a weak association with a Cramer's V value being 0.348 and 0.216 respectively. This shows that though each type of e-Extension platform, had a statistically significant relationship with their usage for e-Extension service, the level of association was different for each platform ranging from strong to weak.From this merit, the null hypothesis of this objective was rejected, and thus showing that the type of e-Extension platforms has a statistically significant influence on the usage of e-Extension services among smallholder farmers' in Nakuru County, Kenya at 0.05 level of significance.

4.7 Findings on Effectiveness and Challenges of e-Extension Services

This section presents the findings on effectiveness and challenges of providing e-Extension services to farmers according to extension agents.

4.7.1 Effectiveness of Using e-Extension Services According to Extension agents

The extension agents were asked to score a range of statements on effectiveness of using ICTs in dissemination agricultural information to farmers at a five point Likert scale of 1= *Not effective* to 5 = *Very effective*. The results are presented in Table 37.

Table 37

Effectiveness of Using e-Extension Services According to Extension Agents

Effectiveness e-Extension services	**Mean**	**Std. Dev**
Mobile phone are effective in reaching famers with agricultural information and SMS is effective	4.4	1.155
Use of e-Extension will improve extension workers' efficiency	4.4	1.118
By using e-Extension methods, the workload of the extension worker will be minimized	4.2	1.044
Using e-Extension to reach farmers is timely and cost effective	4.1	.666
Using websites to provide agriculture information could help farmers to access agricultural information.	3.1	.850
e-Extension if effectively implemented the extension department could achieve its goals easily	4.4	.714
Social media (Facebook & Twitter, WhatsApp) can ensure better communication between extension workers and farmers.	4.3	.945
e-Extension could increase the workers responsibility	3.2	.891
e-Extension could be used to complement traditional extension methods	4.0	.539

Table 37 indicate that the respondents' viewed e-Extension services positively in terms of its effectiveness in the provision of e-Extension services to the farmers. The overall mean for the nine statements that were scored by the respondents towards the effectiveness of e-Extension services was 4.2; SD = 0.666. Most of the respondents highly scored the statements "Mobile phone are effective in reaching famers with agricultural information and SMS is effective"; "Use of e-Extension will improve extension workers' efficiency"; "e-Extension if effectively implemented the extension department could achieve its goals easily" all having a mean of 4.4. The second highest mean that was scored by the respondents was "social media (Facebook & Twitter, WhatsApp) can ensure better communication between extension workers and farmers" with a mean of 4.3. Other statements that were highly scored were "By

using e-Extension methods, the workload of the extension worker will be minimized", "using e-Extension to reach farmers is timely and cost effective", "e-Extension could be used to complement traditional extension methods" each scoring 4.4, 4.1 and 4.0 respectively. The results correspond with findings by Afzal et al. (2016) who reported that extension agents in Saudi Arabia generally had a positive attitude towards implementation of e-Extension services. The lowest mean in this study was attained by the statement "using websites to provide agriculture information could help farmers to access agricultural information" with a mean of 3.1 which could indicate that websites were not the most effective mean of reaching farmers with agricultural information.

4.7.2 Challenges of Using ICTs among Farmer Respondents

Table 38 shows the results on the challenges that farmers experience when using e-Extension services. The challenges were rated at a five point Likert scale of 1 to 5 (*1=Not at all, 2=Low, 3=Moderate, 4=High, 5=Very High).*

Table 38

Average scores of Farmers' Challenges in Using e-Extension Services

Challenges	Mean	Std. Dev.
Lack of ICTs	3.7	1.80
Lack of awareness	3.3	1.10
Inaccessible internet	3.4	1.10
Lack of electricity	3.0	1.41
Lack of relevant information	3.0	1.10
Lack of content in local language	2.7	1.22
High cost of accessing information	3.1	1.18

Table 39 presents the challenges of using ICTs among smallholder farmers. Lack of ICTs and inaccessible internet were the main challenges faced by the farmers as both had a mode and median of 4. Lack of awareness and the generally high cost of accessing information also provided moderate to high levels of challenge with both having a mode of 4 and a median of

3. The absence of electricity was also a challenge faced by the farmers at a moderate to high level with a mode and median of 3 and 4 respectively. Lack of relevant information and lack of content in local language also affected the farmers on a sensible level as both had a mean and mode of 3. During focus group discussions also, the respondents indicated that the content available online difficult to authenticate the source and was generally overloaded. A number of challenges that farmers face when using ICTs to access agricultural information have been cited in other studies and ranges from high costs of ICT tools and services, lack of ICT skills, poor network coverage, power shortage, language barrier, irrelevant content available online (Katunyo et al., 2017; Muhammad et al., 2019).

4.7.3 Challenges of using ICTs Among Extension Agents

The extension agents were asked to indicate some of the challenges they face when using ICTs in their extension work and the finding are presented in Figure 19.

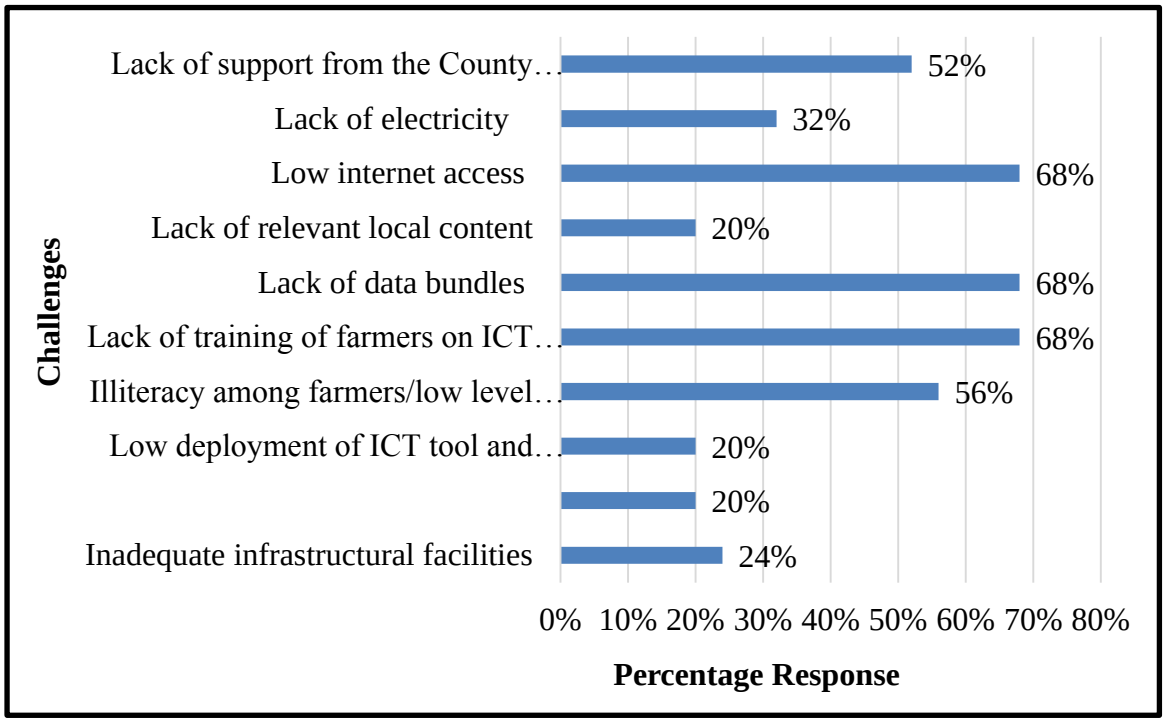

Figure 19: *Challenges of Using ICTs among Extension Agents*

Figure 19 shows that 68 percent of the extension agents indicated low internet access, lack of data bundles and lack of training of farmers on ICT skills as the among most of the challenges being faced in the integration of ICTs in agricultural extension service delivery. Over 50 percent of the respondents also indicated that farmers' illiteracy and lack of support from the county government still remained a challenge in the use of e-Extension services

among the extension agents. Lack of relevant local content, low deployment of ICT tools and lack of ICT skills and infrastructural facilities were indicated to be other challenges faced by extension agents in the use of ICTs in extension service delivery. This finding corresponds to other studies by Deichmann et al. (2016), Madan and Maredia (2021), Nakasone and Torero (2016) who reports that use of ICTs in agricultural extension and advisory services is increasing worldwide but with several challenges such as lack of internet connectivity, lack of relevant content inaccessibility to ICT tools and lack of digital literacy among farmers. Agwu and Nwokorie (2019) also points out other challenges to include unreliable power supplies, high cost of ICT infrastructure and low income of rural farmers.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter outlines a summary of the study including the background, methodology and the key findings. It gives the conclusions and recommendations based on the findings and suggestions for further research.

5.2 Summary of the Study

Access to ICTs among smallholder farmers can provide a great opportunity to increase agricultural production and eradicate poverty through access to relevant timely and cost-effective agricultural information. The use of ICTs in agriculture however, has not been fully exploited among smallholder farmers due to a number of factors ranging from, accessibility to ICTs, poor connectivity, lack of skills, lack of relevant content, lack of infrastructure, lack of policy support among others. Previous studies have centered on the relationship between ICT and agriculture, usage of ICTs in different stages of the agricultural value chain but little is known about the influence of technology factors on usage of e-Extension services among farmer in accessing e-Extension services. This study purposed to establish the influence of technology-related factors on usage of e-Extension services among smallholder farmers in Nakuru county, Kenya. The study specifically aimed at determining the influence of technology-related factors namely: access to ICTs, ICT skills of farmers, digital content availability and characteristics and types of e-Extension platforms on usage of e-Extension services among smallholder farmers.

The study adopted descriptive survey design. Multistage sampling coupled with proportionate purposive and simple random sampling, were used to collect data from a sample of 130 farmers, 34 extension agents and 3 focus group discussions. A total of 130 farmers responded to the questionnaires which equated to 100 percent response rate while 25 extension agents responded equating to 75 percent response rate. Farmer and extension agent's questionnaires were used to collect data from farmers and extension agents while focus group discussion guide was used to collect data from focus group discussions.

The first objective sought to determine the influence of access to ICT resource on usage of e-Extension services among smallholder farmers. Results of the study revealed that over 70 percent of the respondents had access to mobile phones, radio and TV while 27.7 only had

access to the internet. The respondents however, that had access to YouTube, twitter and computers were less than 20 percent. Hypothesis testing revealed a significant influence between access to ICTs and usage of e-Extension services among smallholder farmers. The regression results were statistically significant at ($\alpha = 0.05$ $p < 0.05$) hence the null hypothesis was rejected. This implies that the more access to ICTs the farmers had the higher the level of usage of the ICTs to access e-Extension services.

The second objective sought to determine the influence of ICT skills of farmers on usage of e-Extension services among smallholder farmers. Most respondent indicated that they had average skill level in using mobile phone and TV having a mean of 3.3 while radio had a mean of 3.6 having been scored at a five-point Likert scale of 1= *no skill* and 4 = *advanced skill.* The skill levels were rated depending on the type of ICT tools which requires that one has a set of skills to be able to use it. Low skill level was reported for twitter and YouTube and very little skills for internet and computers. A significant influence was shown to exist between the ICT skills of farmers and usage of e-Extension services among the smallholder farmers. When the hypothesis was tested at 0.05 level of significance the regression results failed to reject the null hypothesis for influence of ICT skills and usage of radio and TV in accessing e-Extension services. This implies that usage of e-Extension services among smallholder farmers is influenced by the ICT skills of the farmers except for radio and TV which were not significant as depicted by the results.

The third objective sought to determine the influence of digital content on usage of e-Extension services among smallholder farmers. The researcher focused on digital content which was categorized into two sections, availability of digital content and characteristics of the digital content. The selected characteristics of the digital content were; cost, timeliness, detail, reliability language, and relevance. Availability and characteristics of digital content was measured at a 5 point Likert scale ranging from 1= *No access* 5 = *Very high access* while the characteristics of digital content were also measured at a 5 point Likert scale ranging from 1 = *Very poor*to, 5 = *Excellent.* The level of usage of the digital content to access agricultural information was also measured at a five-point Likert scale ranging from 1 = *Never* to, 5 = *Always*. Results depict that 79.3 percent of farmers received digital content through listening to radio and 67.7 percent through TV. Other digital content was received by 60.8 percent of farmers though phone calls and 46.9 percent through texting. Pictures and e-books/journal/websites/blogs were the least digital content available to smallholder farmers with 18.5 percent and 3.8 percent of farmers accessing them respectively. Regression test

results showed a positive relationship between availability of digital content on the usage of e-Extension services by smallholder farmers which were statistically significant for all the ICTs at $\alpha = 0.05$ significance level except for pictures and ebooks/journal/websites.Pictures and ebooks/journal/websites had a p-value of .315 and .578 respectively, which was greater than the chosen level of significance of 0.05 under which the hypotheses of this study were investigated. A conclusion of not rejecting the null hypotheses for these digital contents was therefore made, since there was no statistically significant influence between their availability and usage for e-Extension services among smallholder farmers. The P-values for texting, phone calls, radio, and TV were all less than the selected 0.05 significance level consequently, rejecting the null hypothesis for this digital content having the p-value being significant at ($\alpha = 0.05$ $p<0.05$).

The influence of characteristics of digital content on usage of e-Extension services among smallholder farmers was also determined for objective three. The findings showed that the cost of digital content except for ebooks/journal/websites had an influence on usage of e-Extension services among smallholder farmers. This implies that farmers attributed the cost of accessing digital content to influence their use of e-Extension services. The results further suggest that the cost of e-books/journals/websites did not influence usage for e-Extension services and this could be due to the low level of accessibility to these types of digital content which was only accessed by 5 respondents in the study. The timeliness of agricultural information disseminated through texting, radio, TV and pictures was found to have no influence on usage of e-Extension services among smallholder farmers while phone calls and ebooks/websites/ had an influence on usage of e-Extension services. These implies for digital content disseminated through texting, radio, TV and picture to be used by farmers it has to be provided in a timely manner. Details of digital content had an influence on usage of e-Extension services among smallholder farmers. These implies that the details provided by the type of digital content will influence the use of e-Extension service for farming activities by farmers.

The finding further indicated that reliability of digital content had an influence on usage of e-Extension services among smallholder farmers except for texting which did not influence usage and this could be due to the type of digital content shared through texting. The participants in the focus group discussion indicated that some texts could be sent to their

phones without subscription to the alerts through text and therefore were treated as spam and they could not trust the source.

Language was also found to influence usage of e-Extension services among smallholder farmers while for reliability of digital content it was established to have an influence on usage of e-Extension services among smallholder farmers except for texting which did not influence usage and this could be due to the type of digital content shared through texting. The participants in the focus group discussion indicated that some texts could be sent to their phones without subscription to the alerts through text and therefore were treated as spam and they could not trust the source. Lastly, the relevance of digital content was also found to influence usage of e-Extension services among smallholder farmers.

The fourth objective sought to determine the influence of type of e-Extension platform on usage of e-Extension services among smallholder farmers. Among the types of e-Extension platforms that were studied mobile phones provided a platform for farmers with 69.2% and 56.9 percent having phone calls and texting platforms available to them. Over 20 percent of farmers had Facebook and WhatsApp platforms being available to them while 16.2 percent and 13.8 percent of farmers had Facebook and email platforms available respectively. A Chi-Square test was done on each separate e-Extension platform in the study using the results obtained from the type of e-Extension platform available and level of usage for e-Extension services to determine whether there was any association. The Cramer's V was also employed to check the strength of the association with values ranging from 0-1. The relationship between the availability of e-Extension platforms and their usage for e-Extension services by smallholder farmers was evident as it was statistically significant at $\alpha = 0.05$ level of significance for all the e-Extension platforms. The level of influence as shown by Cramer V values showed that phone calls had a very strong association with Cramer's V value of 0.857. Texting, Facebook and WhatsApp also had a strong association with Cramer's V value above 0.6. YouTube, Twitter and Farmer call center had a moderate association of 0.4 and above though as indicated by the results very few farmers had access to these types of e-Extension platforms. Plant clinics and Emails had a weak association with a Cramer's V value being 0.348 and 0.216 respectively. This shows that though each type of e-Extension platform, had a statistically significant influence with their usage for e-Extension service, the level of influence was different for each platform.

5.3 Conclusions

The following conclusions are made based on the findings of the study:

i.) Access of ICTs influences usage of e-Extension services among smallholder farmers in Nakuru County.

ii.) ICT skills play critical role in the usage of e-Extension services, with smallholder farmers that have the skills to use an ICT tool having a greater ability to use them to access e-Extension services. ICT skills for using radio and TV however, do not influence their usage for accessing e-Extension services among smallholder farmers.

iii.) Agricultural digital content availability positively influences usage of e-Extension services among smallholder farmers. Among the digital content characteristics details of digital content, language and relevance of digital content positively influences usage of e-Extension services. The cost of digital content influenced usage of e-Extension services except for eBooks/journal/websites. Reliability was also found to have an influence usage of e-Extension services except for texting. Timeliness of digital content influenced usage of e-Extension services except for digital content disseminated through texting, radio, TV and pictures which did not influence their usage while those from phone calls and eBooks/websites were found to influence their usage.

iv.) The type of e-platform was found to positively influence usage of e-Extension services among smallholder farmers.

5.4 Recommendations

Based on the conclusions of the study, the following recommendations are made:

i.) The findings to be disseminated through conferences, workshops and community meetings that involve small holder farmers, local leaders, county and national government officials of Ministry of Agriculture, Livestock, Fisheries and Cooperatives. These will create forums were farmers can be sensitized to subscribe to e-Extension service platforms using the available ICTs to enhance access to agricultural information access. The county government of Nakuru also needs to create awareness and sensitize farmers on the availability of e-Extension services such as Nakuru Farmers' Call Centre.

ii.) The Kenyan Government through the Ministry of Agriculture, Livestock, Fisheries and Cooperativesand county government need to invest on the development of ICT skills of farmers through digital skilling programmes. The illiterate farmers also still can be reached by use of decentralized outreach systems and peer networks such as farmer

groups in providing e-Extension services which could bridge the digital divide because not all farmers can directly access or use ICTs and prefer to learn from a trusted contact or groups. Agro-dealers can also be used especially if equipped with ICT tools and platforms such as WhatsApp groups that could enable information sharing and exchange and for learning purposes.

iii.) Policy makers need to ensure that agricultural digital content development is well coordinated and regulated and also stakeholders' participation is considered in order to ensure quality agricultural information is disseminated to farmers. The government, mobile and internet service providers could make provisions for subsidies for mobile phone airtime, data bundles and internet subscriptions to increase affordability for farmers at all time when seeking agricultural information through e-Extension services.

iv.) There is need for partnerships between the national government, county governments and other stakeholders in the provision of e-Extension services through different e-Extension platforms. This will also require support from technology partners e.g. mobile network operators, software developers, development partners and agencies, research and content developers such as agricultural research institutes and private sectors that offer most of the agricultural digital content.

5.5 Suggestions for Further Research

Following the findings of the study, the following recommendations were made for further research.

i.) The study focused only on smallholder farmers and therefore, a comparative study could be done to investigate the e-Extension services accessed by large scale farmers and smallholder farmers.

ii.) There is need for an in-depth study on agricultural digital content development process in order to understand who develops and regulates the content that is disseminated to farmers through the various e-Extension services available to the farmers in Kenya.

iii.) The study focused only at examining e-Extension services from the point of view of public extension services. It did not take into consideration the private e-Extension services which have been termed as disruptive agricultural extension services. A study therefore will need to be carried out to examine the comparison between both the public and private e-Extension services in order to get a holistic picture.

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APPENDICES

Appendix A: Questionnaire for Smallholder Farmers

Introduction

My name is Viola Kirui, a PhD student at Egerton University and currently doing research on the influence of technology-related factors on usage of e-Extension services in Nakuru County, Kenya. You have been identified as a useful informant in obtaining the required information for this study. Your participation is voluntary and you are assured that the information you provide will be used solely for research purpose. Kindly respond to all the questions below. Thanks in advance for your kind support.

SECTION 1: Farmer demographic information

1. Gender: Male **[ ]**
   Female **[ ]**

2. Sub County: Rongai **[ ]** Molo **[ ]** Subukia**[ ]**

3. Age 20-30 **[ ]** 31-45 **[ ]** 46-60 **[ ]** Above 61**[ ]**

4. Highest level of education attained:

   None **[ ]** Primary **[ ]** Secondary**[ ]** Tertiary**[ ]** University**[ ]**

5. Type of farming activity: Crop farming**[ ]** Livestock farming**[ ]** Mixed farming**[ ]**

6. Farm Size (in hectares): < 1 ha **[ ]** 1-2 ha**[ ]** Above 2 ha**[ ]**

7. Average income (per month in Kshs.)

<3000**[ ]** 3001 – 5000 **[ ]** 5001 – 8000**[ ]** 8001 – 10000**[ ]** 10001 – 20000 **[ ]**>20000 **[ ]**

8. Membership to a farmer group Yes **[ ]** No**[ ]**

SECTION 2: ACCESS TO ICTS AMONG SMALLHOLDER FARMERS

9. Which of the following ICTs do you have in your household?

Type of ICT	Access (1=no access 2=low access, 3=medium access, 4=high access, 5=ownership)
Mobile phone	
Computer (Desktop/laptop)	
Internet	
Radio	
TV	
Youtube	
Social Media (WhatsApp, Facebook, Twitter	

10. How frequently do you use this ICTs for accessing agricultural information?

11. What type of Agricultural information do you seek for using the above ICTs? (Indicate from the choices given/you can choose more than one)

Type information	Mobile Phone	Computer	Internet	Radio	TV
Production information					
Processing and Value addition					
Weather Information					
Pest and disease Control					
Market Information					

12. Are you aware of e-Extension Services offered by the county government of Nakuru?

Yes **[ ]** No **[ ]**

Type of ICT	Frequency of use (5= Daily 4=Weekly 3= Monthly 2= Occasionally1= Never)
Mobile phone	
Computer (Desktop/laptop)	
Internet	
Radio	
TV	
Youtube	
Social Media	

13. Do you use the e-Extension services? Yes **[ ]** No **[ ]**

14. If Yes, for how long have you been using the e-Extension service

a) 1 Year **[ ]**
b) 2 Years **[ ]**
c) 3 Years **[ ]**
d) >3years **[ ]**

SECTION 3: ICT SKILLS OF SMALLHOLDER FARMERS

17. Do you have the skills for using the ICTs listed in below? (Rate at scale of 1-5, 1 = No skill 2 = Basic ICT skills 3 = Intermediate ICT skills 4= Skilled 5 = Advanced skills)

Mobile phone	Computer	Internet	Radio	TV	YouTube	WhatsApp	Facebook	Twitter

18. Have you ever had any ICT training? Yes **[ ]** No**[ ]**

19. If No how did you acquire the ICT skills? (Circle Appropriately)

a) Individual learning
b) Fellow farmer
c) Extension officers
d) Children
e) Seminars
f) Religious meetings
g) Chiefs Baraza
h) Other Specify……

20. Listed below are e-Extension platforms. Indicate whether you have the skills of using them. (Please tick appropriately)

e-Extension Platforms	Not at All	Low	Moderate	High	Very High
Phone calls					
Texting (SMS)					
Facebook					
WhatApp					
Twitter					

Youtube					
Interactive Voice Call					
Email					
Farmer Call Center					

21. For what purpose do you apply ICT skills for? Social purposes **[ ]** Accessing agricultural information **[ ]**

SECTION 4: SOURCES OF DIGITAL CONTENT AVAILABLE TO SMALLHOLDER FARMERS AND ITS CHARASTERISTICS

22. Is the type of digital content you look for using the ICTs available to you?Yes **[ ]** No **[ ]**
23. At a scale of 1-5 rate the type of agricultural digital content that you are able access (1=no access 2=low access 3=medium access 4=high access 5=very high access)

Digital content	
a) SMS [___]	f) Interactive Voice Response[___]
b) Phone calls [___]	g) agricultural-books/journal/blogs/websites [___]
c) Radio Content [___]	
d) Tv Content [___]	
e) Pictures [___]	

At a scale of 1-5 rate the characteristics of digital content that are accessible to you (1 = Very Poor 2 = Poor 3 = Good 4 = Very Good 5 = Excellent)

Agricultural Digital content	**Cost**	**Timeliness**	**Detailed**	**Reliability**	**Language**	**Relevance**
SMS	[___]	[___]	[___]	[___]	[___]	[___]
Phone calls	[___]	[___]	[___]	[___]	[___]	[___]
Radio Content	[___]	[___]	[___]	[___]	[___]	[___]

TV content	[___]	[___]	[___]	[___]	[___]	[___]
Pictures	[___]	[___]	[___]	[___]	[___]	[___]
Interactive voice response	[___]	[___]	[___]	[___]	[___]	[___]
Agricultural Books/journals//blogs/websites	[___]	[___]	[___]	[___]	[___]	[___]

24. In what form would you prefer that digital content services to be made available to you (Rate at a scale of 1-5) **1=Never preferred 2=Seldom preferred 3=Sometimes preferred 4=Often preferred 5=Most preferred**

digital content	**Preferred Rating**
Phone Calls	
Texting	
Audio	
Video	
Pictures	
Interactive Voice Response	

SECTION 5: E-PLATFORMS USED BY SMALLHOLDER FARMERS

25. What e-Extension platforms are available to you for accessing agricultural information? (Tick Appropriately)

a) Mobile Calls to extension agents ☐
b) SMS ☐
c) Email ☐
d) Interactive voice Response ☐
e) Twitter ☐
f) WhatsApp ☐
g) Facebook ☐
h) Call Center ☐
i) Other specify…….

26. How frequent do you use these platforms? Rate at a scale of 1-5 (5=Daily, 4=Weekly, 3=Monthly, 2=Occasionally, 1= Never)

e- Platforms — Frequency of use

a) Mobile Calls ☐
b) SMS ☐
c) Email ☐
d) Interactive voice Response ☐
e) Twitter ☐
f) WhatsApp ☐
g) Facebook ☐
h) Call Center ☐
i) other…….

34. In what language do you use these platforms? (1=English, 2=Kiswahili, 3=Vernacular

e- Platforms — Language

a) Calls ☐
b) SMS ☐
c) Email ☐
d) Interactive voice Response ☐
e) Twitter ☐
f) WhatsApp ☐
g) Facebook ☐
h) Call center ☐
i) other…….

28. Which e-Platform would you prefer agricultural information to be provided to you? Rate at a scale of 1-5. (5= Most Preferred 4=Often Preferred 3= Sometimes Preferred 2= Seldom Preferred 1= Never Preferred)

e- Platforms

a) Mobile Calls ☐
b) SMS ☐
c) Email ☐
d) Interactive voice Response ☐
e) Twitter ☐
f) WhatsApp ☐
g) Facebook ☐
h) other…….

29. To what extent do you face the following challenges when using the e-Extension service?

Challenges	**1=Not at all**	**2=Low**	**3=Moderate**	**4=High**	**5=Very High**
Lack of ICTs					
Lack of awareness					
Inaccessible Internet					
Lack of electricity					
Lack of relevant information					
Lack of content in local language					
High cost of accessing information					

THANK YOU FOR TAKING THE TIME TO FILL THE QUESTIONNAIRE

Appendix B: Questionnaire for Extension Agents

Introduction

My name is Viola Kirui, a PhD student at Egerton University and currently doing research on the influence of technology-related factors on Usage of e-Extension services among smallholder farmers in Nakuru county, Kenya. You have been identified as a useful informant in obtaining the required information for this study. Your participation is voluntary and you are assured that the information you provide will be used solely for research purpose. Kindly respond to all the questions below. Thanks in advance for your kind support.

SECTION ONE: Respondents Characteristics

1. Sub-County: Rongai ☐ Molo ☐ Subukia ☐

2. Gender: Male ☐ Female ☐

3. Age: 20-29 years ☐
   30-39 years ☐
   40-49 years ☐
   50-59 years ☐
   60 years > ☐

4. Highest education level (Tick)

   Certificate ☐
   Diploma ☐
   Bachelor's degree ☐
   Post-graduate diploma ☐
   Master's degree ☐
   Doctoral degree ☐
   Others please specify.....

5. Key areas of responsibility

Soil conservation ☐

Crop development ☐

Agribusiness ☐

Home Economics ☐

Field Extension Worker ☐

6. Job Title/Designation

……

7. Number of years worked in extension service (Tick where appropriate)

Below 5 years ☐ 5-10 years ☐ Above 10 years ☐

SECTION TWO: SKILLS AND COMPETENCIES IN THE USE OF ICTS

8.

a. What type of skills do you have ? (Tick where appropriate)

ICT Skills	
Basic computer skills	
Ability to use the computers and its peripherals	
Ability to use MS windows (Word processing, spreadsheets, Power Point, Access, Data storage)	
Ability to generate, edit, save and print documents without assistance	
Internet Skills	
Knowledge & use of internet web browsers e,g internet explorer, Mozilla, chrome	
Proper and safe use of the e-mail	
Knowledge of group mails , online file sharing, discussion boards and chat tools	
Working knowledge of video chatting e.g Skype	
Working knowledge of social networking	
Knowledge of online surveys	

Knowledge of online library and other resource databases	
Knowledge on downloading and saving Documents for offline reading	
Knowledge of use of Geographical Information System	
Ability to search for information independently on the internet and CD-ROMs	

a. Have you received any training on ICT the above mentioned skills? Yes No
b. If yes, for how long did you receive the training conducted?…….
c. If no, how did you acquire the skills?.....
d. Which of the following areas do you need more training in? (You may select more than one)

Computer Skills/ Internet Skills	
ICT skills for disseminating agricultural information	
ICT skills for doing research	
ICT skills for educational purposes	
ICT skills for publishing	
ICT skills for packaging Agricultural information	

SECTION THREE: AVAILABILITY AND USE OF ICTS FOR EXTENSION WORK

9.

a) Which of the following ICT tools and services are available or accessible to you? (Rate at a scale of 1-5) **1=Not at All 2=Low 3=Moderate 4=High 5=Very High**

ICTs tools and services	**Available**	**Accessible**
a) Computer(Desktop/Laptop)		
b) Mobile phone		
c) Modem		

d) Data bundles		
e) Email		
f) Agricultural journals		
g) CD-ROM databases		
h) Videos		

b) Which of the following ICTs do you use in Accessing Agricultural Information? (Tick where appropriate).

ICTs Tools and Services	
a) Laptop	
b) Search tools e.g google, askme, yahoo etc	
c) Email	
d) Electronic journals	
e) CD-ROM databases	
f) Desktop Publishing	
g) Geographic information System (GIS)	
h) Mobile Phone	
i) Video	

c) How often do you use the following ICTs in accessing agricultural information? Rate at a scale of 1-5 (**5=daily, 4=weekly, 3=monthly, 2=occasionally, l=never)**

ICT tools and services	**Daily**	**Weekly**	**Monthly**	**Occasionally**	**Never**
a) World Wide Web					
b) Email					
c) Discussion Groups					

d) Library online public access catalog					
e) Agricultural electronic journals					
f) Agricultural on-line databases					
g) Mobile Phone Calls					
h) Short Messaging service(SMS)					
i) Twitter					
j) WhatsApp Messaging					
k) Downloading software					
l) Video Conferencing					
m) Down loading Videos					
n) Downloading Documents					

d) What purpose do you use the above ICT tools and services for? (You may select more than one)

Purpose for use of ICTs	(Tick Where appropriate)
a) To communicate with agricultural researchers	
b) To communicate with other extension agents	
c) To communicate technical and information to farmers	
d) To facilitate access to credit and inputs for farmers	
e) To provide distance training to farmers	
f) Answering questions from farmers	

g) Link farmers to markets	
h) To Search for agricultural information	
i) To reach to a large number of farmers	
j) Forward farmers concerns and problems to decision makers	
k) For Business planning	

Others (Specify)…….

e) How much time do you spend on the Internet for extension work and communication purposes per week? (Tick where appropriate)

< 1hour **[ ]** > 16 hours **[ ]**

1-5 hours **[ ]**

6-10 hours **[ ]**

11-15 hours **[ ]**

f) How often do you get the information you need from the Internet and offline databases? (Rate using the rates provided) **(1=Never, 2=Less often, 3=Sometimes, 4=Often 5=Always**) …….

How many farmers have you been able to reach using the e-Extension services ?(tick were appropriate)

a. <100 **[ ]**
b. 100-250 **[ ]**
c. 250-500 **[ ]**
d. 500-750**[ ]**
e. 750-1000**[ ]**
f. >1000**[ ]**

g) On average how many farmers are you able to reach per week using any of the e-Extension tools/services ……

h) From your observation, has there been an increase or decrease in demand for e-Extension services by farmers? Increase **[ ]** Decrease **[ ]**

i) Rate the following statements in terms of effectiveness of ICTs in disseminating agricultural information to farmers.**1=Not Effective 2= Less Effective 3 = Moderately Effective 4= Effective 5 = Most Effective**

ICT tools and services	

Mobile phone are effective in reaching famers with agricultural information and SMS is effective	
Use of e-Extension will improve extension workers efficiency	
By using e-Extension methods, the workload of the extension worker will be minimized	
Using e-Extension to reach farmers and timely and cost effective	
Using websites to provide agriculture information could help farmers to access agricultural information.	
e-Extension if effectively implemented the extension department could achieve its goals easily	
Social media (Facebook & Twitter, WhatsApp) can ensure better communication between extension workers and farmers.	
e-Extension could increase the extension workers responsibility	
e-Extension could be used to complement traditional extension methods	
e-Extension, in comparison to a traditional extension system, is a better method	
Agricultural blogs and research papers on the Internet are providing sufficient agricultural information.	

Others (Specify)

……

SECTION FOUR: TYPE OF DIGITAL CONTENT AVAILABLE THROUGH DIFFERENT AGRICULTURAL INFORMATION PLATFORMS

10.

a) What type of digital agricultural content is available to you when you access the internet?

1 = Available 2 =Not Available (Tick where appropriate)

Agricultural Digital content	Available	Not available
Graphics (Images, Photos, Pictures)		
Audio		
Videos		

Agricultural Blogs		
Agricultural e-books		
Agricultural Websites (e.g. NAFIS,KACE,M-farm etc)		
Agricultural e-journal		
Agricultural forums		

Others

(specify)……

b) In what format is agricultural information disseminated in your organization? [Tick]

Text ☐ Image ☐ Video ☐ Audio ☐ All the above ☐

c) What format below is most preferred by farmers? [Tick]

Text ☐ Image ☐ Video ☐ Audio ☐

d) Do you provide personalized agro-advice to farmers using ICTs? [Tick]

Yes ☐ No ☐ Don‘t know ☐

e) Do users have a feedback mechanism? (Tick) Yes ☐ No ☐ Don‘t know ☐

f) How often do you give feedback to farmers using ICTs? [Tick all applicable]

Daily ☐ Weekly ☐ Monthly ☐ Quarterly ☐ Annually ☐

Other……

SECTION FIVE: TYPE e-PLATFORMS USED IN DISSEMINATING AGRICULTURAL INFORMATION TO FARMERS

11.

a) What e-Extension platforms do you use in disseminating agricultural information to farmer?

Calls ☐ Twitter ☐

SMS ☐ WhatsApp ☐

Email ☐ Facebook ☐

Interactive voice Response ☐ Radio ☐

TV ☐

Other specify…….

b) How frequently do you use these platforms to disseminate agricultural information to farmers? Rate a scale of 1-5 (1=Daily 2=Weekly 3=Monthly 4=Occasionally 5= Never)

e- Platforms

j) Calls ☐
k) SMS ☐
l) Email ☐
m) Interactive voice Response ☐
n) Twitter ☐
o) WhatsApp ☐
p) Facebook ☐
q) other……

c) Which e-Platform is most preferred by farmers in receiving agricultural information from you? 5= Most Preferred 4=Often Preferred 3= Sometimes Preferred 2= Seldom Preferred 1= Never Preferred)

e- Platforms

a. Mobile Calls ☐
b. SMS ☐
c. Email ☐
d. Interactive voice Response ☐
e. Twitter ☐
f. WhatsApp ☐
g. Facebook ☐
h. Radio ☐
j.TV ☐
i. Other…….

12. What challenges do you face in using ICTs in your work? (You may tick more than one)

Constraints in use of ICTs	
Inadequate infrastructural facilities	
Lack of skills associated with the use of ICTs	
Low deployment of ICT tool and services	
Illiteracy among farmers/low level of education	
Lack of training of farmers on ICT skills	
Lack of data bundles	
Lack of relevant local content	
Low internet access	
Lack of electricity	
Lack of support from the County Government	

Others (specify)……..

THANK YOU FOR TAKING THE TIME TO FILL THE QUESTIONNAIRE

Appendix C: Focus Group Discussion Guide

A. Details of the discussion

1. Location of the discussion ……..
2. Date ……
3. Participants personal details

   ……

   ……

B. Introduction

1. Researcher welcomes the group, introduces herself and explains to participants the purpose of the study
2. The reserchers explains to the participants the discussion process/guidelines

C. ICTS ACCESSIBLE To Farmers

1. What ICTs are
   a) Owned by Farmers……
   b) Accessed by farmers…….
   c) For what purpose (s) are these ICTs used for?.....

D. ICT SKILLS/TRAINING

2. Have the respondents undergone any form of ICT traning?.....
3. How did the farmers acquire the Skills…….....
   a) Through Training
   b) Own Individual learning
   c) Through Friends,neighbours and familiy

4. Are farmers able to use ICTs available to them……
5. Are farmers able to serach for agricultural information using the ICTs

   ……

E. Agricultural digital content Availiability

6. What type of digital content is majorly available to farmers?.....
7. What are the charasteristics of the digital content that is available to farmers?.....

8. In what format is the digital content mainly available?.....
9. What format is mostly preferred by farmers?.....
10. What are the reasons for the preference to the digital content above?.....

F.Type of e-platforms

11. What type of e-platforms are available for farmers to use in accessing agricultural information?.....
12. What type of e-platforms are majorly used to reach farmers with e-Extension Services?.....
13. Which e-platforms are preferred by farmers?.....
14. Are farmers using e-platforms to obtain agricultural information?

……

G. CHALLENGES ON USE OF e-Extension SERVICES

15. What are the challenges that are faced by farmers in using e-Extension services as a means of accessing agricultural information?

NOTE: The discussion should take around 45 minutes and the proceedings be recorded on paper, and using an audio or video recorder.

Appendix D: Letter from the Graduate School

EGERTON UNIVERSITY
Tel: Pilot: 254-51-2217620
254-51-2217877
254-51-2217631
Dir.line/Fax: 254-51-2217847
Cell Phone

P.O. Box 536 - 20115
Egerton, Njoro, Kenya
Email: bpgs@egerton.ac.ke
www.egerton.ac.ke

OFFICE OF THE DIRECTOR GRADUATE SCHOOL

ED12/0478/14 **18th November, 2020**

Ref:..... **Date:.....**

The Director General
National Commission for Science Technology and Innovation,
P. O. Box 30623-00100
NAIROBI.

Dear Sir,

RE: REQUEST FOR RESEARCH PERMIT– MS. VIOLA CHEROTICH KIRUI
REG. NO. ED12/0478/14

This is to introduce and confirm to you that the above named student is in the Department of Agricultural Education & Extension, Faculty of Education and Community Studies, Egerton University.

She is a bona-fide registered PhD student in this University. Her research topic is **"Influence of Technology Related Factors on Usage of e-Extension Services Among Smallholder Farmers in Nakuru County, Kenya."**

She is at the stage of collecting field data. Please issue her with a research permit to enable her undertake the studies.

Your kind assistance to her will be highly appreciated.

Yours faithfully,

20 NOV 2020

Prof. Nzula Kitaka
DIRECTOR, BOARD OF POSTGRADUATE STUDIES

NK/en

Appendix E: Letter of Research Authorization

MINISTRY OF EDUCATION

STATE DEPARTMENT OF EARLY LEARNING OF BASIC EDUCATION

Telegrams: "**EDUCATION**",
Telephone: **051-2216917**
When replying please quote
Email:cdenakurucounty@gmail.com

COUNTY DIRECTOR OF EDUCATION
NAKURU COUNTY
P. O. BOX 259,
NAKURU.

Ref. CDE/NKU/GEN/4/1/21 VOL.II/76

9th December, 2020

TO WHOM IT MAY CONCERN

RE: RESEARCH AUTHORIZATION – VIOLA CHEROTICH KIRUI
PERMIT NO. NACOSTI/P/20/7937

Reference is made to letter NACOSTI/ P/20/7937 dated 2nd December, 2020.

Authority is hereby granted to the above named to carry out research in Nakuru County, Kenya on the topic: "***INFLUENCE OF TECHNOLOGY RELATED FACTORS ON USAGE OF EXTENSION SERVICES AMONG SMALLHOLDER FARMERS OF NAKURU COUNTY*** "for the period ending ***02//12/2021.***

Kindly accord her the necessary assistance.

COUNTY DIRECTOR OF EDUCATION NAKURU COUNTY P. O. Box 259 NAKURU

George M. Ontiri
For: COUNTY DIRECTOR OF EDUCATION
NAKURU

Copy to:

- Egerton University

Appendix F: Research Permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR
SCIENCE,TECHNOLOGY & INNOVATION

Ref No: 221570

Date of Issue: 02/December/2020

RESEARCH LICENSE

This is to Certify that Ms.. VIOLA CHEROTICH KIRUI of Egerton University, has been licensed to conduct research in Nakuru on the topic: INFLUENCE OF TECHNOLOGY RELATED FACTORS ON USAGE OF e-EXTENSION SERVICES AMONG SMALLHOLDER FARMERS IN NAKURU COUNTY for the period ending : 02/December/2021.

License No: NACOSTI/P/20/7937

221570

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR
SCIENCE,TECHNOLOGY &
INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

Appendix G: Journal Publications

ISSN: 2320-5407 Int. J. Adv. Res. 9(12), 38-44

Journal Homepage: -www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI: 10.21474/IJAR01/13873
DOI URL: http://dx.doi.org/10.21474/IJAR01/13873

ISSN NO. 2320-5407

RESEARCH ARTICLE

EVALUATING USE OF ICTS IN ACCESSING e-EXTENSIONSERVICES AMONG SMALLHOLDER FARMERS IN NAKURU COUNTY, KENYA

Viola Kirui, Agnes Nkurumwa and Justus Ombati
Egerton University, Department of Agricultural Education and Extension, Kenya.

Manuscript Info

Manuscript History
Received: 05 October 2021
Final Accepted: 10 November 2021
Published: December 2021

Key words: -
E-Extension Services, ICTs, Agricultural information, Smallholder Farmers

Abstract

Smallholder farmers in Kenya are faced with low agricultural productivity which has been attributed toa number of factors among them being lack of access to agricultural information. This has been further exacerbated by shrinking number of public extension staff and underfunding of the extension system in the country. ICTs can play a crucial role in bridging this gap. This study determined ICTs accessed, and the extent of use of the ICTs to access e-Extension services among smallholder farmers in Nakuru county, Kenya. Data was collected from randomly selected sample of 130 smallholder farmers in a descriptive survey, using structured questionnaires and focus group discussions. Over 70 percent of the respondents had access to mobile phones, radio and TV while only 27.7 percent had access to the internet. The respondents that had access to YouTube, twitter and computers however, were less than 20 percent. The findings of the study revealed that mobile phones, radio and TV were the most accessed and utilized ICT tools in accessing e-Extension services among smallholder farmers.Social media platforms such as WhatsApp and Facebook were on average used by the farmers to access e-Extension services while computers and twitter were the least used.The findings further revealed that e-Extension services that were most sought for by the farmers included production, market, pest and disease information.The major constraints in the use of ICTs tools in accessing e-Extension services were reported to include lack of ICTs such as computers and the internet, lack of awareness of availability of e-Extension services, lack of relevant information and lack of infrastructure such as electricity. The study concludes that accessible ICTs could be used to supplement other extension methods. There is need for improving access to ICTs particularly the internet and computers and creating awareness on use of platforms such as YouTube, Twitter and Farmer Call Centres in accessing agricultultural information among farmers.

Introduction:-

World population is expected to surpass the 9 billion mark by 2050, and agriculture has to increase the production of nutritious food to meet the growing demand and ensure food security for all. Most of the increase in food production will have to take place in developing countries (Food and Agriculture Organization [FAO], 2017a). African

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Asian Journal of Agricultural Extension, Economics & Sociology

40(10): 557-564, 2022; Article no.AJAEES.88409
ISSN: 2320-7027

Sources, Nature and Characteristics of Agricultural Digital Content Accessed by Smallholder Farmers in Nakuru County, Kenya

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[a] Department of Agricultural Education and Extension, Egerton University, Kenya.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJAEES/2022/v40i1031113

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/88409

Original Research Article

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Accepted 05 July 2022
Published 03 August 2022

ABSTRACT

This paper examined the sources, nature and characteristics of agricultural digital content accessed by smallholder farmers in Nakuru County, Kenya. Descriptive survey design was used in the study. A sample of 130 farmers and 12 Agricultural Extension staff were selected using purposive, proportionate and simple random sampling techniques. Questionnaires and focus group discussion guide were used to collect data. The results of the study indicated that 79.2 percent and 67.7 percent of smallholder farmers received agricultural digital content through listening to the local radio and TV stations that aired agricultural programmes respectively. The findings of the study also revealed that 60.8 percent of farmers used mobile phone calls while 46.9 percent used Short Messaging Services (SMS) to access agricultural digital content. e-books, journal, blogs, websites and pictures were the least used in accessing agricultural digital content among the smallholder framers. The findings of the study also indicated that the cost of receiving agricultural digital content was relatively fair for texting, making phone calls, listening to agricultural radio programmes and watching agricultural TV programmes. Agricultural digital content received by farmers through radio, TV and mobile phone calls were indicated to be good in terms of timeliness, reliability and details. The language used in receiving digital content through phone calls radio and TV were also scored highly because local language is used for interaction. Texting, phone calls, radio and TV were also rated highly in terms of relevance of content. The study concluded that there is a high interest for agricultural digital content among the smallholder farmers and that they

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