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

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A Thesis Submitted to the Graduate School in Partial Fulfilment of the Requirement for the Doctor of Philosophy Degree in Agricultural Extension of Egerton University

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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 modernized and commercial agriculture through the dissemination of agricultural information to farmers. Despite this, extension services are still limited in most parts of 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 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

World's population is projected to surpass the 9 billion mark by 2050. Agriculture sector must boost its production to meet the high demand for food to guarantee sustained food security. Food production has to be increased in developing countries because it's the most hit by food insecurity (Food and Agriculture Organization [FAO], 2017a). Agricultural sector is the mainstay of African economies that contribute to economic growth, employment 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 workforce in rural areas, accounts for 40 percent of the total earnings from export as well as providing over 50 percent of household needs (World Bank, 2017a). About 80 percent of food consumed in most of the developing countries is contributed by 1.5 billion smallholders' farmers. Smallholder farmers are therefore important in enhancing food and nutrition security and poverty reduction but are underprivileged in accessing quality extension services (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 was responsible for poverty reduction between 2005 and 2015. As envisaged in the Kenyan vision 2030, agriculture sector continues to face several constraints at the global to the national level that require special attention in order to meet sustainable economic growth and improve livelihoods for the poor in rural areas (Koome & Wanjohi, 2017). The sector is majorly dominated by smallholder farmers who accounts for over 70 percent of total agricultural production marketed produce in the country (Birch, 2018). These farmers are constrained by among others, poor access to markets 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 percent. 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 conventional to participatory, from top down to bottom up 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 extension system over the years due to reduced funding 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. Extension agent to farmer ratio in Kenya is reported to be 1:1,500 against 1:400 recommended ratio by FAO which indicates that the effectiveness of delivering extension services in terms of reaching many and diverse farmers when and where they require the services is constrained (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). These demands call for innovative approaches in the delivery of extension services.

One of the innovative and cost-effective ways of bridging the gap of reaching more farmers with agricultural information is by integrating Information Communication Technologies (ICTs) in the delivery of extension services. 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 growth in most economies (FAO, 2017b). For instance, increasing use of mobile phones for information exchange is now a common practice. Therefore, ICTs can bridge the information gaps faced by farmers. 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 can reduce the cost of sharing and disseminating information to smallholder farmers by facilitating the availability and accessibility of information (Okello et al., 2014). ICTs unlike the

conventional methods of disseminating information to farmers offers cost-effective way of sharing knowledge and information faster, delivers education and training modules to farmers as well as improving access to markets and credit (Barguma & Ndaghu, 2014. In addition, ICTs also empowers farmers to negotiate for better prices as well as strengthening farmer networks (Barghuma & Ndaghu, 2014). Furthermore, Okello et al. (2014) also asserts that farmers can enhance access to information through use of ICTs across all the agricultural food systems to enable them use inputs appropriately, match cropping practices to climate trends, use improved breeds and better manage their farms and feeds.

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, video, television and radio, mobile phones in combination with radio, web portals among others (Asenso-Okyere & Mekonnen, 2012). e-Extension brings robust opportunities and has the potential of enabling the empowerment of farming communities.. According to Gichamba et al. (2017), e-Extension system enable extension agents to contact farmers using more efficient ICT platforms such as mobile phone calls, Interactive Voice Response (IVR) WhatsApp and Short Messaging Service (SMS) as compared to traditional extension methods thus, enabling reach of larger clientele as the services can be duplicated in different ICT technologies. This helps to increase productivity, profitability and global competitiveness. Some approaches enable farmers to make requests from or respond to the provider which supports two-way interactions (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). Qianget et al. (2011) further argues that, SMS services and websites have the potential to increase smallholder farmers' access to extension services , links to markets distribution channels and finance 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 became 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 platform opportunities and agriculture analytics which is envisioned under the Agricultural Sector Transformation and Growth Strategy (ASTGS) 2019-2029. ASTGS targets included creation of digital products such as ICT-enabled extension agents, digitally trained 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 Kenyan government introduced the programme nationally in 2014 in order to ensure efficient extension service delivery across the country. The government targeted training of 654 e-Extension agents nationally and they were equipped with laptops, modems and smart phones to enable them to reach farmers effectively. The approach was innovative through use of push and pull technique were SMS farmer training, WhatsApp messaging tools and farm visits were to be used by extension agents at the county and ward levels to disseminate agricultural information to farmers (Rono, 2013). It was cost sharing approach where farmers would incur a 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 approaches used by extension agents 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.

Despite rapid spread of ICTs, their use still faces challenges such as inaccessibility, lack of relevant local content in suitable languages, ease of use, affordability and scalability,

(Saravanan, 2010). Social interactions still dominate the agricultural information systems in most rural areas of developing world Kenya included, where farmers rely on their social networks to obtain crucial agricultural information (Centre for Agriculture and Biosciences International, 2014; Nain et al., 2015). The factors that have been found to influence the level of ICT utilization in Kenya include low digital literacy, inaccessibility of ICT's, lack of benefit awareness, lack of ICT training, lack of technological infrastructure, high cost of technology, lack of trust in the ICTs among others (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 led to the reduction of costs of extension in the 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). ICT use in accessing agricultural information among farmers is influenced by socio-economic, cultural or technological factors (Jose & Lokeswari, 2018). Most studies that have been done to explain the low ICT adoption 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 the influence of technology-related factors on the use of ICT, 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 extension services

can improve access to agricultural information by farmers. The Kenyan government has facilitated the integration of ICTs into agricultural extension service delivery in the country 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 by farmers in accessing agricultural extension services 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 would lead 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 ensuring accessibility of to agricultural information by smallholder farmers. It may also assist the extension agents to utilize the available ICTs to facilitate access to technologies, information and knowledge required by farmer 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) showed 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 right, ability and unrestricted permission to put into use information and communication technology devices such as mobile phones, computers, and the internet to create, process, store, retrieve, consume, and disseminate 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 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 CD-ROMs ,downloaded documents, 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 extension services delivered through web tools that allow online sharing, networking and collaboration to enhance face-face and paper-based services that are efficient compared to the traditional extension system of agriculture (Renwick, 2013). In this study, e-Extension services would mean use of ICT tools such as mobile phones through calls, SMS and internet, computers through emails, websites and internet, social media platforms such as WhatsApp, Facebook and Twitter to access agricultural information by smallholder farmers.

Information Communication Technologies – Refers to any device, tool or application that are used to transmit, store, create, share or exchange information. They include mobile phones, computers, internet, live broadcasting technologies (radio, television) recorded broadcasting technologies (videos and audio, podcasting and storage devices) and telephony (satellite, vision/video-conferencing and fixed (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 competently use the basic functions of Information and Communication Technologies to create process, retrieve, store, assess and exchange information, and to communicate using the collaborative networks through 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, learning and communication (Hall et al., 2012). In this study, ICT use refer to the use of the following ICTs (mobile phones, computer, radio, television and the internet) to access e-Extension services by smallholder farmers such as production and market information, connecting to customers and service providers, coordinating agricultural activities among others. 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 1 to 5 respectively.

Influence - Defined as a force a person exerts to the target to bring about changes in behavior, opinion, attitudes, goals, needs and values in order to affect the behavior of others in a particular direction (Hall, 2007). In this study, influence referred to the technology-related factors and its influence on usage of e-Extension services by smallholder farmers

Smallholder Farmers - Republic of South Africa (2012) defined smallholders as farmers who own small parcels of land, less than 2.0 hectares where they either practice subsistence farming or grow cash crops and majorly rely entirely on family labor. This study adopted the same definition.

Social Media –These are web based electronic communication tools that allows users to create, retrieve, interact and exchange information and ideas of any form and on social networks (Suchiradipta & Saravanan, 2016). This study adopted the same definition.

Technology-related Factors – a technology is defined as a tool, device, media as well as a 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 location that is centralized 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 looked 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

Agriculture worldwide is considered as an enabler to economic growth and development. Most economies in Africa depend on the agricultural sector for its economic growth job creation and foreign exchange earnings. The sector employs 90 percent of the rural labor force; accounts for approximately 32 percent of the GDP in the continent and 60 percent of the total workforce both in rural and urban areas (Mckinsy, 2011; Oluoch-Kosura, 2013). The GDP share in most African countries however, is often less that 30 percent which shows that the sector still experiences low productivity (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, inadequate financing, inequitable market environment, high production and transport 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. Globally, studies have shown that levels of returns from 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 entrepreneurism 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). About 90 percent of extension staff in the world are found in developing countries (Anderson, 2007). Similarly, Danso-Abbeam et al. (2018) asserts that agricultural extension in Africa and Asia is one of the major enablers of rural development,achieving food security and reducing poverty. This is by ensuring access to agricultural inputs, access to markets information, credit services, 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 (Aker, 2010; Cook, 2021; FAO, 2017). Agricultural dissemination methods and approaches that include field days, mass media, Farmer Field Schools, demonstration, Training and Visit, Common Interest Groups, agricultural shows and exhibitions have been widely used to widen accessibility to agricultural technologies and information and technologies among farmers. However, there has been limited achievement of reaching large number of farmers and achieving high adoption of technologies (Dixon, 2010). This has been attributed to low number of public extension agents compared to increasing number of farmers and poor infrastructural support.

Extension systems in Kenya for example, are faced with the challenge of declining human and other supportive resources (Birch, 2018). The ratio extension agent to farmers in Kenya is 1:1,500 against the1: 400 ratio recommended by FAO, while in Nakuru County the ratio is 1:779 (Manfre & Nordehn, 2013; World Bank, 2019). The extension officers also have to cover a wide area with farmers also sometimes being dispersed. Furthermore, the Kenyan government has devolved its functions from a national to county government were funding is vested on the county governments and sometimes rely also on project funding for their operations (Tata & McNamata, 2018). Given the challenges of managing a large area and to make sure that farmers receive effective extension services, the Kenyan government transitioned to an e-Extension system in 2014. The Ministry introduced the system in order to support extension system and to offer timely advisory services to the farmers. 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 increase

extension service delivery and facilitate extension agents to provide better services to farmers (Gichamba et al., 2017). However, the extent to which technology-related factor influences usage of e-Extension services among smallholder farmers has 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 approaches used to deliver of extension services. The first one is the provision of the services to the farmers through government led extension system whereby the Ministry in charge of agriculture takes the lead and focuses on food crops and livestock. The second system is commodity based extension system focusing on commercial crops such as tea, coffee, sisal and pyrethrum and is run by government parastatals, cooperatives and out grower companies and are mainly profit oriented. The third system is private led extension system made up of private companies, Faith Based Organizations (FBO's), Non- Community Based Organizations (CBO's) and Governmental Organizations (NGO's) (Kingiri, 2020). The public led extension system availed through 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 began with the Transfer of Technologies Approach (TOT) where emphasis was mainly on the adoption of agricultural technologies with no consideration on the acquisition of knowledge and skills by farmers regarding the technologies. These led to the introduction of Farming Systems Approach (FSR) in 1970's due to non-adoption of technologies by farmers and mainly focused on refining of the technologies through on-farm testing. Mukembo and Edwards (2016) however, reported that this approach was found to be inadequate in addressing the varied farmers' needs. This led to the Training and Visit (T&V) approach promoted by the World Bank in 1980's which was adopted by the Kenya's Agricultural Extension System. This approach aimed at transferring agricultural information and technologies to the farming communities through contract farmers and extension agents. It however, did not meet the need of farmers because of low coverage and high cost 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 is composed of people with common interest of getting together on a regular basis to discuss topics in agriculture, observe, understand, and practice. 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 NALEP was characterized by participatory and gender inclusive approaches that led to demand driven extension service delivery made up of development partners and policy makers and targeted marginalized groups and poor farmers (Manfre et al., 2013; Kiara 2011, citied in Kingiri, 2020). The Kenyan extension system has not only been privatized but has also implemented demand driven pluralistic extension policy for farmers to not only demand but also pay for the services they need (Ongayo et al., 2016). This has led to increase in the number of stakeholders providing extension services including private sector and has resulted in commercialization of 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. The Ministry of Agriculture in 2012 issued a National Agricultural Sector Extension Policy (NASEP) which outlined how extension advisory services in Kenya could meet future challenges of enabling farmers to receive the services they require to become more productive agricultural actors (GOK, 2012). The extension system in the country is majorly dominated by the public sector even though the government is using hybrid approaches of service delivery that involves farmer to farmer extension and entities from private sector. Similar to many extension systems in developing countries, the

Kenyan extension system is constrained by declining human and financial resources (Tata & McNamata, 2018).

Extension service delivery in Kenya 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 ensure locally relevant governance its consequences led to lack of central authority in extension system (Mwololo et al., 2019). Farmers have continually reported lack of access to extension services in the country. Word Bank, 2018 report shows that 21 percent of 38 out of the 47 counties in Kenya accessed extension services between 2013 and 2014, where 19 percent were female headed households and 81 percent were male headed households. A major drawback has been scarcity of qualified personnel with the ratio of extension officers to farmers in Kenya still not meeting the ratio recommended by FAO of one officer for every 400 farmers as it still stands at 1:1,500 (Wanyama et al., 2016). In Nakuru County for example, extension services have been reported to be available but are not able 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 through electronic based extension have been perceived to be transformative having 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 faced by majority of extension systems as their use is inhibited by inaccessible ICT tools and 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

Large scale and smallholder farmers characterizes agricultural sector in Kenya. About 75 percent of the total agricultural production in the country is attributed to smallholder farmers (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 adopted 2 hectares threshold size as a 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 percent (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 in their production activities due to lack of agricultural information, low output and productivity, weak institutional capacity and coordination and 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 susceptible group to climate change impacts 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 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 key in enhancing agricultural productivity.

Studies have shown that the information needs of farmers vary significantly among farmers producing different produce. The differences when seeking for information occurs due to the priorities and their perceptions of the information they require. According to World Bank (2011) the disparities occur due to changes in priorities of farmers all through the production cycle. 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 information, agricultural technologies among others. Information therefore, is seen to be the fundamental factor for growth 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 have continually lacked information and knowledge about best practices in agriculture leading to misuse of inputs and other resources at heavy cost resulting to great losses. The barriers to extension services delivery continue to pose great challenges ranging from few extension agents, farmers growing different crop varieties and speaking several languages for service providers to develop and apply a standard methodology, inadequate transport infrastructure, making it difficult for extension agents to reach rural communities (Gandhi, 2016). Limited access to extension services, technical knowledge, market information, training and quality inputs are among the major challenges to smallholder farmers in SSA towards improving their productivity, increasing their income and food security (Elliot, 2015). Studies have shown that smallholder farmers face numerous information gaps in the agricultural value chain. For example, they may lack access to information on ways of responding to pests and diseases which are associated with changes in climate or access to markets that offer best prices 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 opportunities through which farmers can be able to access agricultural information that they require for their production needs.

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 tools could make a significant towards bridging the gaps of information needs of farmers and meeting the need of increasing productivity and food security. This can be achieved by using ICTs to collect and share relevant, timely and accurate information on inputs, weather forecast, market information and prices, disseminating knowledge to farmers and linking consumers to producers (Barber et al., 2016). FAO, 2017 reports ICT as a significant contributor to development and growth of economies in countries and sectors where they have been effectively deployed. The widespread adoption of various ICT's in the agricultural sector is necessitated by the need of farmers for timely, relevant, accurate, and up to date agricultural information (Thiga & Ndungu, 2015). A significant amount of ICT investments suitable for the agricultural sector have been developed in Africa (ITU, 2015). Initiatives using mobile, voice, radio, and video in the provision of extension services and knowledge sharing in Africa has increased exponentially over the years (Thiga & Ndungu, 2015).

Agricultural extension has been acknowledged as vital means for disseminating information geared towards modernizing agriculture. The conventional extension methods entails visits by extension agents to farmers 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 possibility to address challenges facing public extension systems ranging from being underfunded, unskilled labor and lack of infrastructure , 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 disrupted the provision of extension services making it difficult for extension agents to meet farmers physically. This has also been further worsened by the fact that farmers are densely populated

and sometimes isolated. A well-structured extension system have been reported to be able to reach only 10 percent of the farmer population or less particularly were funding is limited. Market oriented nature of farming also poses another challenge were farmers request for specified and varied information. In cases where there is homogeneity in farming systems the agricultural areas tend to differ in the crops grown, farm inputs, labor and machinery. Information and knowledge has therefore to be tailored in order to be effective in meeting individual needs of farmers.

ICTs application in the delivery of extension services has led to the emergence of the electronic agricultural extension services (e-Extension). e-Extension depends on ICT's such as radio, TV, mobile phones, combination of mass media and mobile phones, farmer call centers, web portals, video shows and video-conference among others (Asenso-Okyere & Mekonnen, 2012).Presently, diverse ICT applications have been developed and tried to enhance extension service delivery. These approaches use different formats and means by which the information is transferred such as sending queries through text messaging, voice calls, voice and picture (Bell, 2015). In some cases the applications enables direct communication between the service provider and the farmer. In other instances, information is disseminated through contact person such as extension agent or local facilitator who has access to ICTs. Some ICT applications support two-way communication hence enhancing interactions and timely sharing of information between farmers, extension agents and researchers (Barber et al., 2016; FAO, 2017). ICT-based extension methods are applied in areas such as gathering and distributing of data, production, marketing, financial services and post-harvest with different tools and applications being suitable for the various uses (Saravanan et al., 2015).

The e-Extension system can also be in the form of information repositories which provides a database of specific information for example information on input retailers and prices best practices for different crops suited for different agro ecological conditions among others. It could also be in form of participatory training videos to be disseminated to farmer groups and cooperatives .These enables sending real time updates and pictures such as those of damaged crops in order to be diagnosed and advice for treatment provided. In rural areas, e-Extension could add value to many sub-Saharan African countries where the extension to farmer ratios stands at 1:1000 by allowing communication through ICT tools such as mobile phones where the extension officers can reach out many farmers than exclusively relying on field visits (Diechmann et al., 2016). Findings from research show that ICTs can improve agricultural

productivity and livelihoods of smallholder 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. Positive results of application of ICTs in agricultural extension service delivery have been reported in India where rural farmers are trained to produce videos through the use of digital green video technologies and are able to share good practices leading to improved agricultural productivity and nutrition. The African Farm Radio Research Initiative (AFRRI) also uses radio for educating rural farmers in Africa (FAO, 2017).

A study by Wamwea and Mutiga, 2013 on the Kenya Seed maize variety SMS system on the other hand revealed that extension officers were largely unaware of the system while those that were aware did not use it. Low utilization of ICT's among extension agents and farmers has been cited to be influenced by a number of factors. These include, lack of government support, low digital literacy, lack of access to ICT's, lack of ICT training, lack of benefit awareness, difficulty in use, the lack of ICT proficiency, lack of appropriate technological infrastructure, the cost of technology, lack of trust in the ICT and lack of training and system complexity (Thiga, 2013). According to Wanyama et al. (2016) they 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. This study is therefore, sought to establish 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 revolutionized the use of technology in agricultural production and the provision of market information for maximizing returns in 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 of limited extension agents and large number of farming communities that require diverse information. Furthermore, the use of ICTs to connect people in rural areas to access agricultural information has shown that even the illiteracy of farming communities may not act as a barrier to 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 prospective benefits of utilizing ICTs. These include access to ICTs, available ICT services and ICT skills. 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 is 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 gender and social differences and their ability to use ICTs to access information for farming activities (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 include lack of women involvement, lack of local content, inadequate collaboration and awareness of existing ICT resources and poor information sharing culture. 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

The major sectors of the economy in the world for instance agriculture have been revolutionized by use of ICT applications and services. ICT integration in the agricultural sector enables access to market and technical information contributing to effective and efficient improvement of productivity of the agricultural value chains (Mwantimwa, 2019). ICT based applications and services in extension service delivery have also provided an enabling tool targeting poor rural farmers particularly smallholder women and youth farmers' (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 methods enable extension agents to get in touch with farmers using efficient alternatives to conventional extension methods. Examples include using platforms such as Short Messaging Service (SMS), Unstructured Supplementary Service Data (USSD), mobile phones and Interactive Voice Response (IVR) where most services can be replicated in other platforms in order to serve more farmers given they have access to different mobile devices. This helps to increase productivity, profitability and global competitiveness. Some approaches support two-way communication enabling the farmer to make request and respond to the information from the provider (Barber et. al., 2016). e-Extension services can speed up agricultural technology transfer process 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 tools such as computers internet, radio, television and mobile phones all having varied impacts depending on the technology applied and farmers' literacy level. Applications such as social media platforms, Short Message Services (SMS), voice messages, videos, audio, and social media platforms can help farmer learning and improve information sharing with experts for example, voice and video based services help in sharing information that that are difficult to be shared through text messaging. Text messages on the other hand could can be effectively in sharing weather information and facilitate and improve learning particularly for adaptation of agriculture to climate change.

Research by Heeks (2018) on the impact of e-Extension on rural resilience in developing countries 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 and techniques of farming and livestock management. ICTs can also enhance 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 platforms and services are the major ICT applications for most developing countries. In addition, they have been acknowledged as a tool for transforming major economic sectors 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 moved from 52.2 million subscribers by 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 was above 100 percent as a result of multiple SIM (Subscriber Identification Module) ownership users of cellular services (CA, 2019)

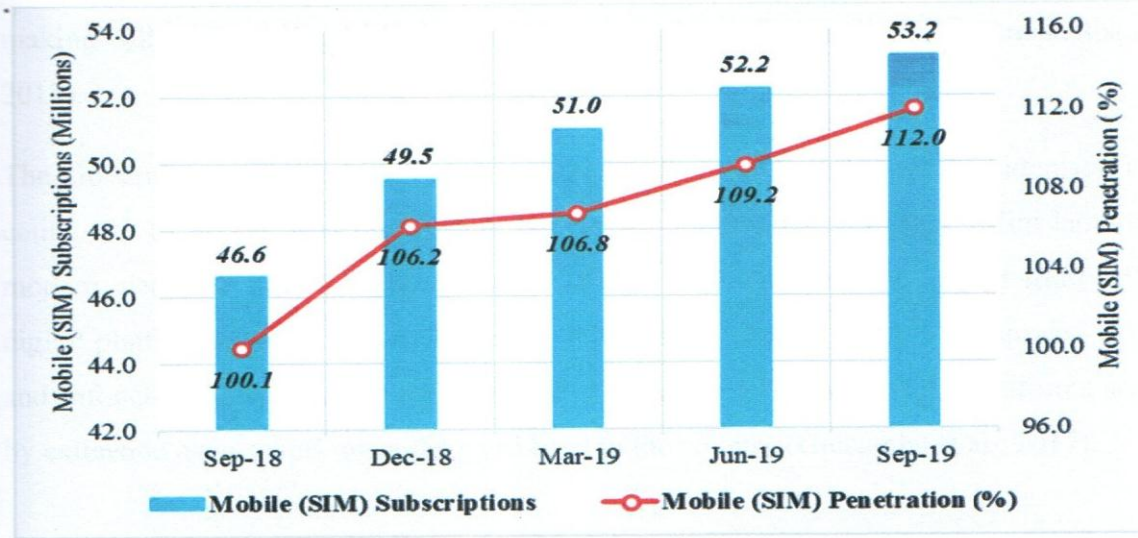

Figure 1: *Growth in Mobile Subscriptions Reported in Kenya in the Last Quarter Of 2019*
Source: (CA, 2019)

The report further indicated that the 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 indicates an opportunity for 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 taken up the opportunity by introducing e-Extension programme which was initiated in 2014, to provide support to agricultural extension service delivery. Through the programme a total of 654 Extension agents were trained and provided with smartphones, laptop and modem. The extension agents were expected to disseminate information to farmers through SMS, farmer training, WhatsApp messaging and social networking at the county level while farmers met the cost through purchase of airtime making calls and sending SMS inquiries to access the information online (Gichamba et al., 2017).

The Government provided platforms based on online and mobile that the extension agents could use to access agricultural information for their extension work. Mini-laptops and modem were also issued to the officers and were trained to obtain content from different digital platforms such as National Farmers Information Service (NAFIS), Plantwise , ikilimo and Infonet-Biovision Platform to pass the information to farmers. These platforms are used by extension agents working at the ward level in the country (Gichamba et al., 2017).

2.7.1 Mobile Phone Based e-Extension Model

The increasing penetration of mobile phones particularly in rural areas makes it a great potential tool to overcome barriers such as illiteracy and gender bias that has led to the digital

divide and inequalities (FAO, 2019.The fast penetration of mobile phones as a communication tool has transformed many sectors including agriculture (Asongu & Asongu, 2018). In developing countries information asymmetry still exists between different actors as a result of poor infrastructure and lack of resources. Consequently, ICTs especially mobile phone has displayed the potential to facilitate exchange of knowledge among stakeholders in agriculture (Aker, 2011). Mobile phones empower farmers to communicate various aspects of farming activities ranging from marketing to buying inputs and selling of 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 phones enable farmers to connect directly with researchers and other critical information service providers hence disrupting the conventional agriculture extension system and creating a new order of farm advisors with different skills and work processes (FAO, 2019). The extension system in Kenya like majority of developing countries is not able to meet the farmers' information needs due to inadequate resources (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). Electronic content delivered through mobile phones and termed as m-services include services such as m-payment, m-commerce, m-agri, and m-banking. The services are delivered in form of SMS, Unstructured Supplementary Service Data (USSD), mobile calls and help lines. The difference between SMS and USSD protocol is that SMS uses texting of messages, whereas USSD uses 'Quick Codes' protocols. Depending on the electronic media that contain m-services, it is possible to access them on phones with and without internet access.

According to Baumüller (2016) m-services are grouped as follows; financial services; information and learning; agricultural inputs and access to markets. m-services can be used to disseminate general information about farming and livestock, send alerts on pest and disease threats, connect buyers to sellers and access market information on prices (Baumüller, 2018). Some m-services offer free services to users while others proprietary in nature and require a cost to use advanced features. *Ujuzi Kilimo* (meaning skillful farming) is a good

example of a service available to Kenyan farmers and offers recommendations for action through SMS subscriptions and USSD services in order to receive highly localized real time diagnostic soil analysis (Krell, 2020). 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) in the Caribbean and Latin America shows that ICTs support adaptation to climate change through increased communal capital, access to climate information services for decision making as well as organization of actors. Ogelleh at al. (2012) also reported that adaptive capacity was limited by inaccessibility to agro-meteorological information.

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). The benefits of these technologies have been further experienced due to increased mobile phone ownership and internet access by rural population in the continent's lowest-income areas as a result of widespread internet connectivity and reduced cost of mobile phones (Wyche & Olson, 2018). The uptake of mobile phones by large number of users can enable subscription to mobile based 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 help reduce poverty in sub-Saharan Africa by strengthening social networks, reducing the costs of travelling, controlling human-wildlife conflict, performing business and financial transactions, and increasing the efficiency of livelihood activities (Lewis Baird & Sorice, 2016). In Kenya, money transfer mobile services have been reported to have positive impact on agricultural household income and reducing poverty by 22 percent among female headed households (Kikulwe et al., 2016; Suri & Jack, 2016).

Mobile phones can provide opportunities to strengthen and complement existing methods of agricultural extension. Many agricultural extension workers already have access to smart phones that can be used to download information on pests and diseases, available technologies, or other issues related to extension work, as well as responding to farmer questions (Lewis et al., 2016). Mobile phones could also be used for purposes of accountability among extension workers which can be achieved by setting of goals, keeping

track of performance, collecting feedback from farmers automatically and confirming farm visits by extension agents by their supervisors (Nakasone et al., 2014). An example of this is a mobile based application called e-diary in Uganda that is meant to reinforce accountability in the delivery of agricultural extension service. 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 prospective to support accountability of extension services through access to distant reporting in real time 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 difference 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 users can exchange messages between a mobile phone and an application 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.

2.7.1.1. 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 farmers. 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).

2.7.1.2. icow

icow is a mobile based application developed by Green Dreams limited and dispersed in partnership with Safaricom mobile telecom provider in Kenya. The application is available to Kenyan farmers and provides them with extension services using the web, USSD and 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 the cows are registered with their insemination date through SMS and receives alerts during the days that are vital in the gestation period. The subscribers also can send SMS messages on breeding, nutrition and other dairy practices on a weekly basis. 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 on icow services accessed by smallholder farmers in three counties in Kenya showed that milk production and income increased significantly due to its use (Marwa et al., 2020). Similarly, it has also been reported that the icow platform when used by dairy farmers they are able to increase milk yields by three litres for each cow hence resulting to high income (Gichamba et al., 2017).

2.7.1.3. M-farm

M-Farm platform was initiated in Kenya in 2010 with the purpose of enabling smallholder farmers' participation in the market through improved bargaining power and linking them to buyers. The service avails both market information and crop prices for 42 crops in Eldoret, Kitale Kisumu, Mombasa, and Nairobi markets in Kenya. The mobile and web based platform purposed to improve the agricultural sector by linking farmers together through collaboration and accessing market information (Baumüller, 2015). The farmer is empowered through availability of the price of agricultural inputs as well as where and when to buy

agricultural inputs. The farmers can either collectively sell their produce to buyers through contracts or are connected to buyers and sellers on the internet and mobile phone platforms (Wyche & Steinfield, 2016). It groups farmers' orders, provides 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 wish to sell their produce and buyers can contact the supplier directly and place an offer on the website when expressing interest for 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. Wyche and Steinfield (2016) in a study on adoption of M-Farm services in western Kenya 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.

2.7.1.4 NAFIS (National Farmers Information Service)

The National Farmers Information Service (NAFIS) through the National Agricultural and Livestock Extension Programme (NALEP) was established in 2008 in Kenya. 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 English, Kiswahili as well as local languages which are distributed to farmers through mobile phones, internet and the website. The information is always updated by officers and farmers can be able to access it in their mobile phones. The services includes electronic trading platforms and market information traders where farmers have access to prices of agricultural produce in form of text, graphics, audio and video for improved accessibility and format (Odinga, 2018; Waruingi & Muriithi, 2016). Although various m-services are 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 has also been reported that though NAFIS provides input price information the extent to which the function is operational remains unclear (Baumüller 2016).

2.7.1.5 KACE (Kenya Agricultural Commodity Exchange)

Kenya Agricultural Commodity Exchange was established in Kenya in 1997. It is a platform 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 market intelligence information on a wide range of crop and livestock products and alerts from government targeting smallholder farmers and small agribusinesses (KACE, 2011). The information is then transmitted to the headquarters in Nairobi, Kenya where it is processed and published on their website and also on the notice boards used by field officers at the Market Information Centers who act as a link between market information points and KACE (Karagu, 2011).

KACE's services include live radio auction service, daily radio bulletins, online computer services, SMS and Interactive Voice Response services. All these applications help in accessing information on daily wholesale buying prices in relation to 20 commodities, bids to buy and offers to sell (KACE, 2011).Trading is done on competitive offers and bids where trading is done between a buyer and a seller and when they agree KACE arranges the logistical and financial aspects of the sale at a fee but gives the farmers bargaining power options (Karoney, 2016). It has been reported that in areas where the services are operational

over 80 percent of farmers use them and have been able to sell their commodities at higher prices (KACE, 2019). It has also been reported that since its inception 1997 KACE has enabled farmers to access markets and receive fair prices 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).

2.7.2 Video Based e-Extension Model

The world's population is growing exponentially and feeding them requires that productivity in agriculture needs to be increase significantly. Availability of agricultural information through public extension system has generally been limited 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 counter the challenges of disseminating information to farmers by reaching the poor, women, marginalized and the youth. According to Bentley et al. (2015) videos in agriculture can be used to request for support, raise awareness, farmer to farmer extension, as a tool for monitoring and evaluation, to stimulate creativity and for training on agricultural innovations. 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 recall the contents of the videos 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 Ghana, video viewing clubs that trained cocoa farmers had significantly improved technical knowledge among the farmers that were trained as opposed to control groups (Bentley et al., 2014). According to Ongachi et al. (2017) video mediated learning had enhanced 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 provides 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).

2.7.3 Social Media Based e-Extension Model

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

Social media enable content sharing and participation in social networking. Similarly, users are able to access services using web based technologies such as computers or download services to mobile devices which provide the functionality of social media. Electronic services create interactive platforms for individuals and communities to share, create, discuss and modify content generated by users (FAO, 2019). As noted by Gonte (2018), there has been a significant improvement in the development of social media that has created opportunities for farmers to access agricultural information. Social media has also improved the reach, frequency, interactivity, quality, usability and performance (Barber et al., 2016) .The strength of social media is that it operates in a dialogue transmission system involving

various sources targeting several users as opposed to traditional monologue transmission model (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 enable them to access agricultural information include Facebook, Twitter, WhatsApp, and YouTube among others. The platforms are cost effective tools in communicating to farmers and stakeholders in the agriculture sector (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 the most used social media platforms by agriculturists are WhatsApp and Facebook. Social media has also been shown to provide an avenue that could improve the distribution and sharing new knowledge and agricultural technologies (Chisenga et al., 2014). Emerging issues and activities such as innovations, conferences, trainings, workshops, publications and reports are tweeted, hash tagged and streamed live on regularly basis. Furthermore, agricultural organizations and researchers have created agricultural platforms where farmers and extension agents can access new practices online to enable interactions between advisory service providers and agricultural experts (Jijina & Raju, 2016).

Mobile phone penetration in Kenya is approximately 100 percent, with 83 percent of its users having a smartphones (Communications Authrority of Kenya [CCK], 2018; Nguniri, 2018). Smartphone accessibility and internet connectivity has led to the increase in the use of social networking platforms such as Facebook, Twitter and WhatsApp were people regardless of the distance can interact through tablets, mobile phones, tablets, computers and the internet (Chesoli et al., 2020). Social networking has also been used for data collection to promote products and services and 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 as well as 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. Evidently also, there is a convergence between traditional media and social media in providing and shaping agricultural digital content. Examples of these are agricultural programs aired on Kenyan television such as *"Shamba shape up"* aired by Citizen TV and *"Seeds of Gold"* a pull out in the Saturday Nation Newspaper which also integrates the use of social media platforms. Other agricultural programs on local radio stations also have social media platforms for receiving feedback from farmers. Low usage social media by farmers to access information has been attributed to poor internet connectivity and lack of data bundles, lack of awareness and costs associated with using gadgets in accessing social media sites and lack of requisite skills (Kuria, 2014).

2.7.4 Mass Media Combined with Mobile phone e-Extension Model

Radio has been used expansively to disseminate agricultural information to majority of the rural farmer in 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 decreasing the barriers associated with 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 extensive 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 a vital tool in networking and exchange of information among communities.

Studies that have assessed the impact of the using radio and mobile phone to deliver agricultural information to farmers have shown that these tools increases awareness of agricultural technologies as well as the uptake of the technologies (Aker, 2011; Baumüller, 2018; Hampson et al., 2016; Hudson et al., 2017; Kaskekacharo, 2016). Participatory radio campaigns have also been shown to lead to increased adoption of agricultural practices that are promoted in African countries (Hudson et al. (2017). Limited and contrasting evidence on the impact of mobile phone based services for farmers in developing countries were however presented by Baumüller et al. (2018). Fafchamps and Minten (2012) on the other hand found that SMS based services used among Indian farmers did impact their likelihood to change crop varieties and agronomic practices and. Other studies however, reports that mobile-based services paired with radio improved household welfare and gender equalities (Sebakira & Qaim, 2017), is linked to 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 has been widely used in rural areas because of its portability nature, availability of frequencies with several vernacular 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 WhatsApp, Facebook and Twitter to interact with 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 continues to play an important role of getting farmers to access 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 in the evening hours and radio in the morning hours. In addition, their study also established that the effects of complementarities in using mobile phones for accessing information and mobile money services to be positive.

2.7.5 Farmer Call Center e-Extension Model

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 curbed 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 as limited resources has led to a shift to provision of extension services through ICTs to help disseminate agricultural information (Aker & Mbiti, 2014).These 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 bring together stakeholders in agriculture enabling them to access relevant and timely information as well as enabling exchange of ideas, experiences, opinions and best practices related to agriculture (Bore et al., 2015).

The proliferation of mobile phones particularly in developing countries is providing new opportunities for delivering timely and relevant agricultural 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 affordable 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 through their phones that include, input information, climate information and market information improved agricultural production. In an event that the farmers' questions cannot be answered by the expert, the second line consultant is consulted and the farmer can get feedback within 24 hours .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 is 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 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.

2.8 Theoretical Framework

The Diffusion of Innovations (DOI) Theory by Rogers and Technology Acceptance Model (TAM) theory was adopted for this study. Diffusion has been defined by Rogers (2010) as the process in which an innovation moves within a social system over time. Innovations can include physical objects, ideas, practices or behaviors that are new to people within a social system. Rogers' DOI theory takes into consideration the characteristics of the innovation to explain the diffusion process. The characteristics include; perceived cost of the innovation and its benefits, testability, familiarity of a person to the innovation, difficulty of use and compatibility with the socio-economic and environmental systems (Elia et al., 2014). The enormous data and information needed and applied in agriculture shows that ICTs can play a crucial role in the exchange, management and flow of agricultural information (Nwagwu & Famiyesin, 2016). The compatibility of a technology into the existing system include effective training, infrastructure and trust is necessary for innovation diffusion (Aubert et al., 2012; Nwagwu & Famiyesin 2016; Taragola Van Lierde & Gelb, 2009).

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 extension 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 traditional communication channels to disseminate agricultural information to farmers and other stakeholders. These channels however, have not allowed for much interaction. Communication of agricultural information using ICTs such as the internet, mobile phones, videos and other digital platforms 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 embrace and accept technology. The model suggests that the factors that influence

consumers' decision about how and when to use a new technology are perceived usefulness and perceived ease of use. Perceived ease of use is the degree one believes that using a certain system would increase their performance and thus, believe that using it would not require any 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 perceived usefulness as well as perceived ease of use only. 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.

2.9 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 variable was 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.

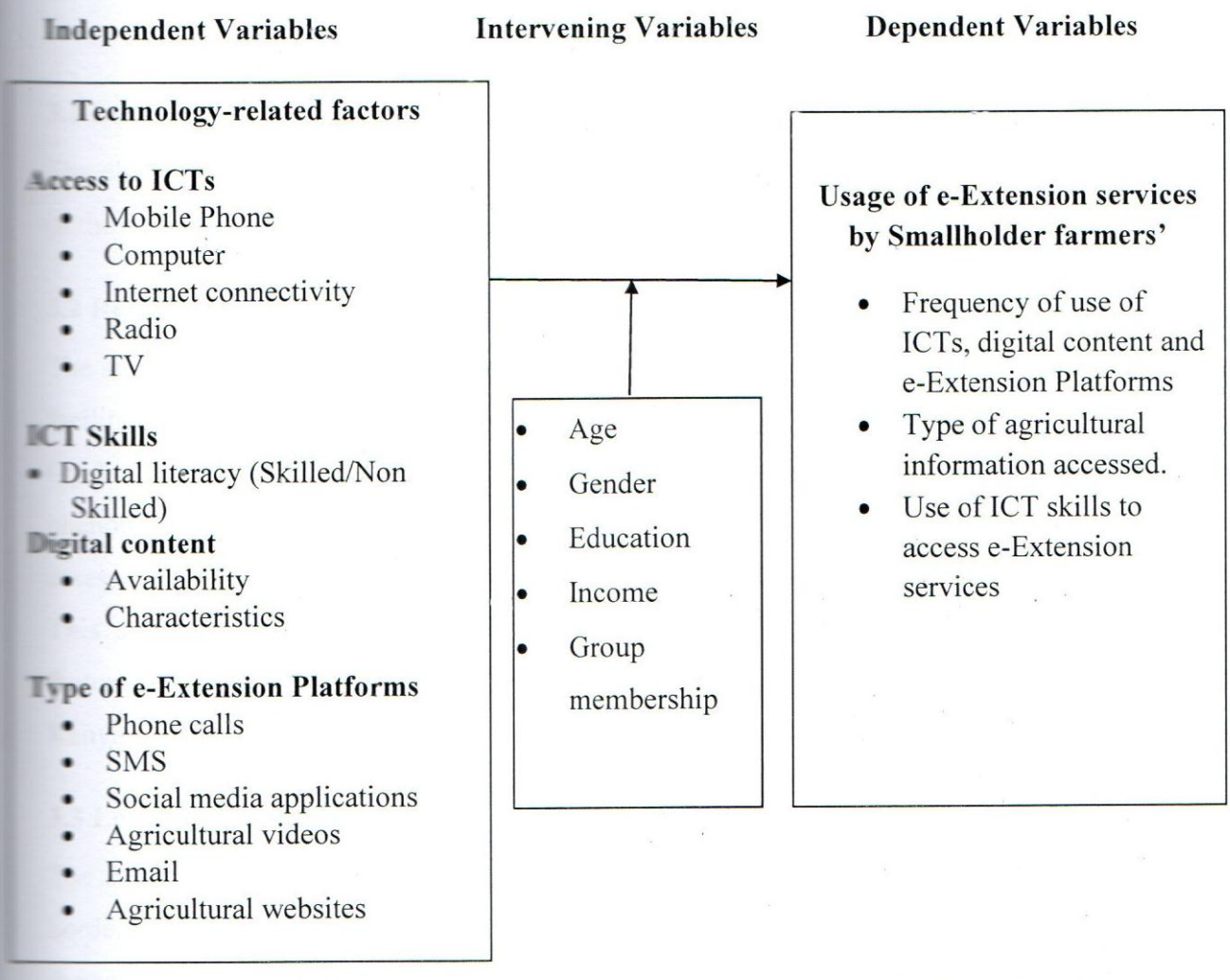

Figure 2: *Conceptual Framework Showing the Interactions between the Variables of the Study*

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 facilitate the collection of data by making observations and direct enquiries. According to Ogula, (1998) descriptive survey is used to collect data that describe characteristics of a phenomenon and reporting the way they are. Survey design entails making precise assessment of the distribution, relationship and influence of a 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 ° East or 35 ° 24' 36" East and 36.6 ° East or 36 °36' 0" East and Latitude 0.23 ° North or 0°13' 48" North and 1.16 ° South or 1° 9`36" South.

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 an average annual rainfall of approximately 800mm with two rainy seasons; long rains that runs between April and August and short rains between October and 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 is the most critical for production of food and as a source 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 credit facilities for farmers and costly farm inputs (GOK, 2018).

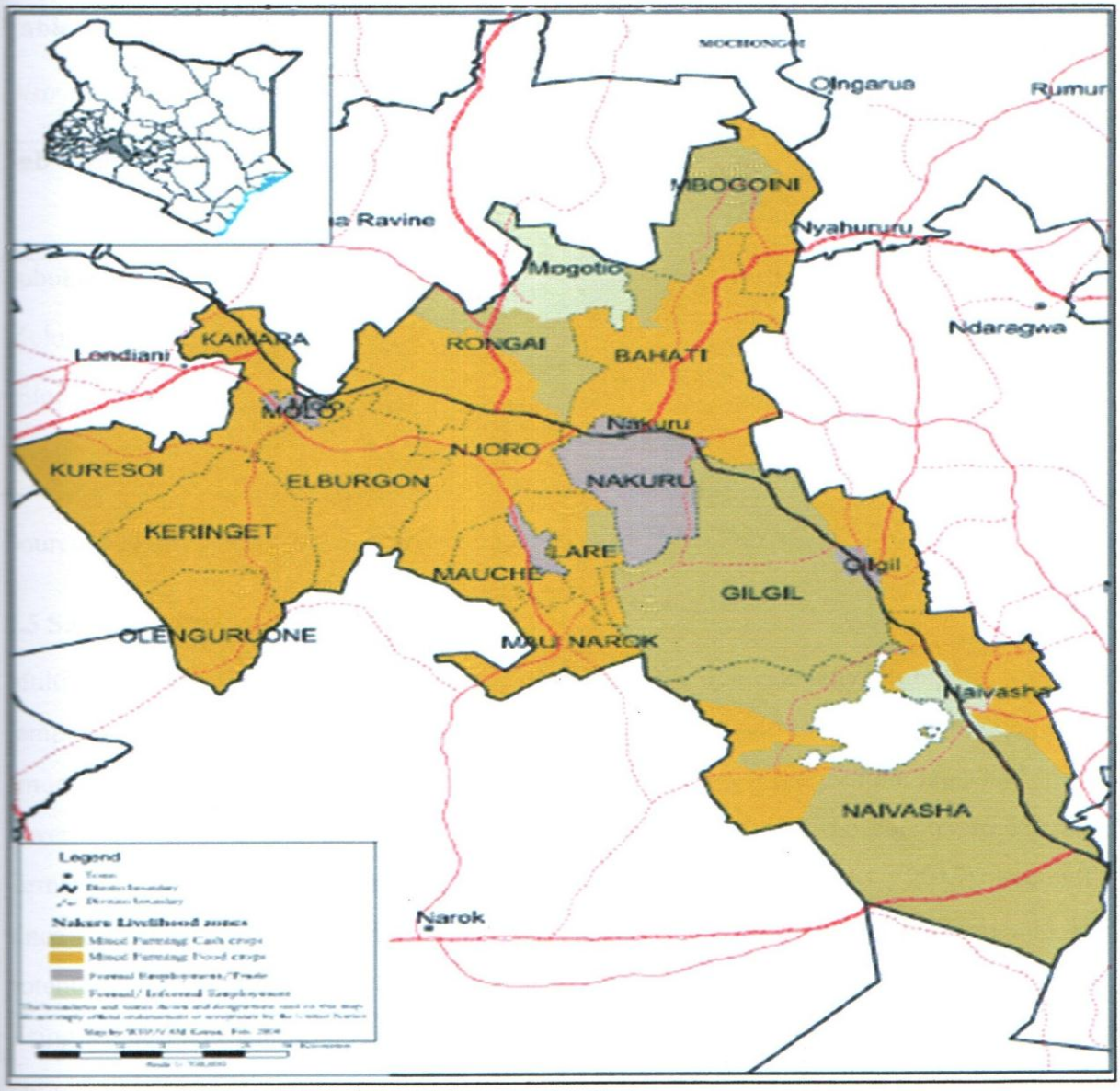

Figure 3: *Map of the Study Area*

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 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

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 is suitable for collecting basic descriptive information and allows the researcher to reach a larger sample of population within a limited time (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 percent response rate. The agriculture extension staff questionnaire targeted 34 respondents and 25 were returned, giving a return rate of 91.7 percent.

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 on 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 the 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 between 10 to 30 participants for pilot-testing in a survey research while Baker (1994) suggested a sample of 10 to 20 percent of the sample size from the actual study as an appropriate 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. 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' questionnaire 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

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

β_{j0} = 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

$j = 1, \ldots, J\text{-}1$

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).

β_{j0} = 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).

β_{j0} = 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)

β_{j0} = 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)

β_{j0} = 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 ofICT 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 evidence that it has attributes of the population and for better understanding of the respondents.

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.

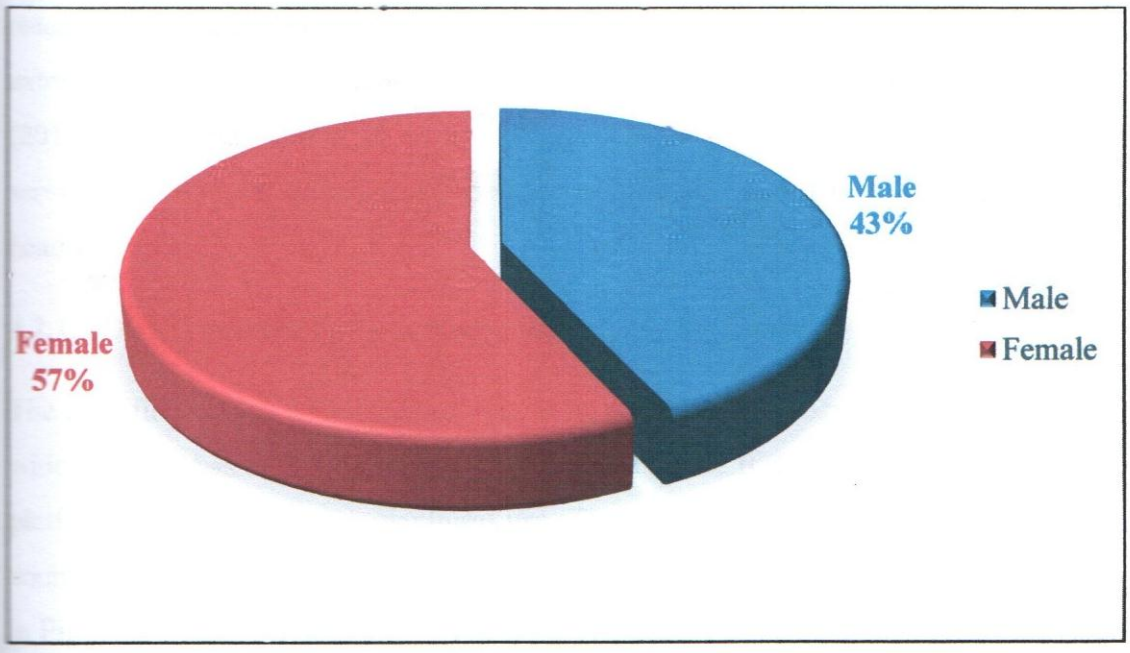

Figure 4: *Distribution of Farmer Respondents by Gender*

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.

Gaps due to gender differences in the adoption of ICTs have been used in past studies. 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 access to mobile money services was found to have a positive impact on the income of the household and to reduce extreme poverty among female-headed households by 22 percent ((Kikulwe et al., 2016; 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 chances of using ICTs for farming activities due to access to productive

resources and information. 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 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.

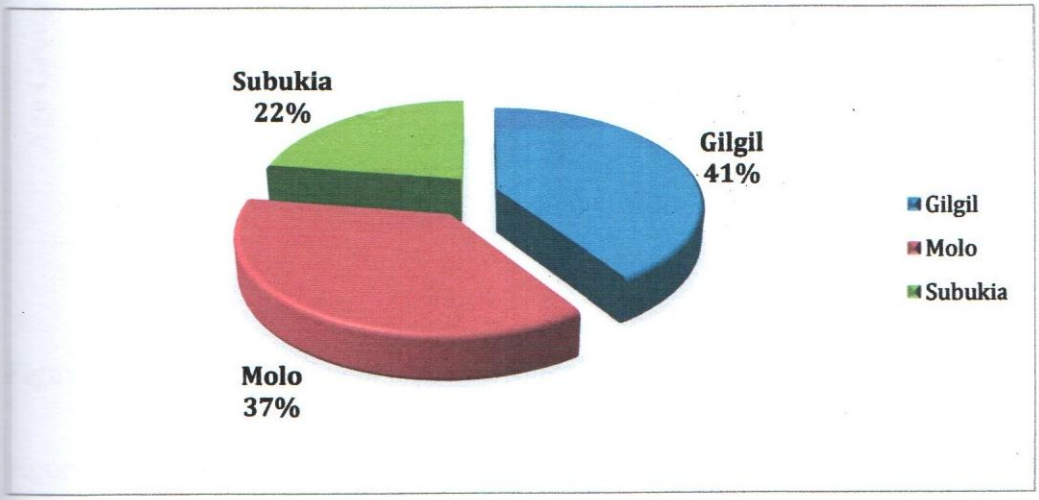

Figure 5: *Distribution of Respondents per Sub County*

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.

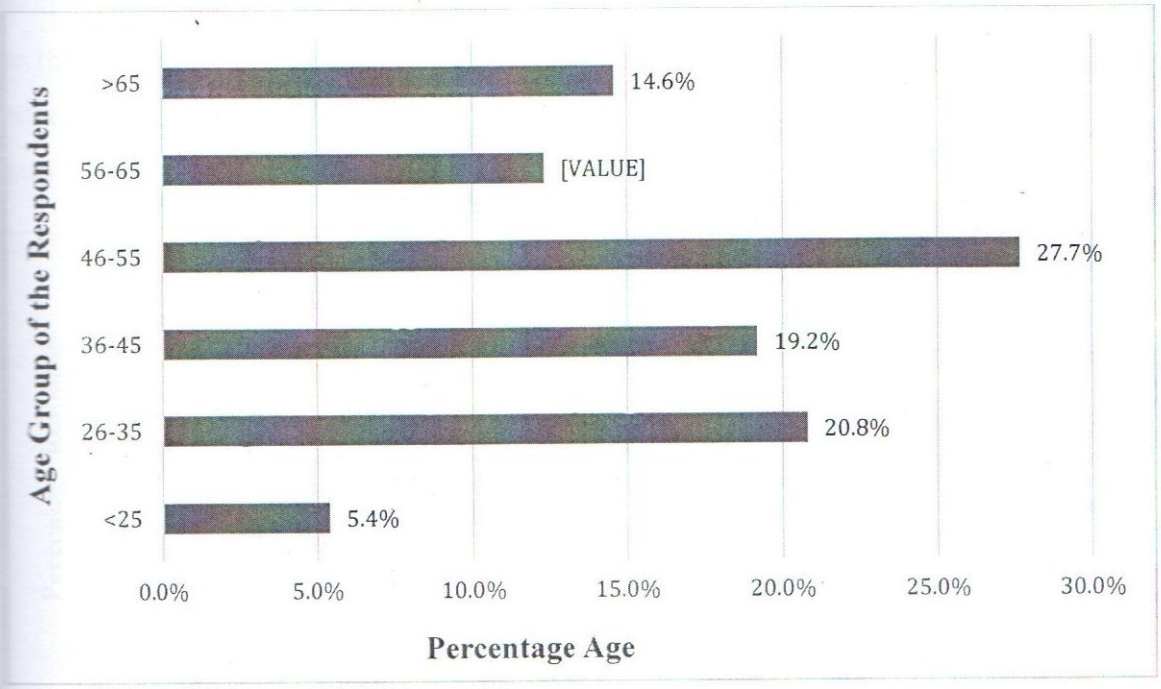

Figure 6: *Age Distribution of the Respondents*

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. According to Wawire et al. (2017) 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 use of ICT tools as an agricultural information source 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.

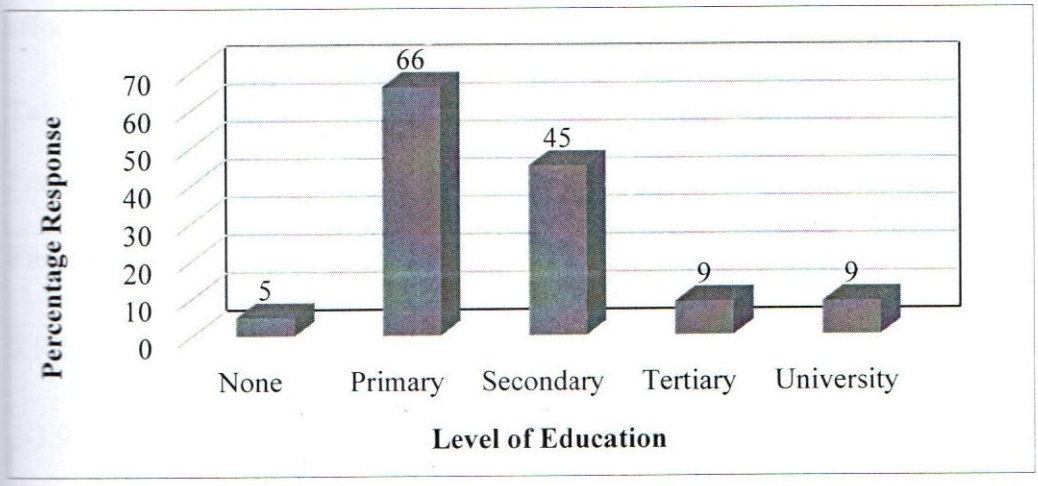

Figure 7: *Level of Education of the Farmer Respondents*

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 one's ability to operate ICT tools easily for example computers, mobile phones, the internet and social media. Krell (2020) reported that farmers who have primary school level of education are more likely 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 a key factor in adoption of ICT technologies for agricultural activities. The size of the farm for example 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 is 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) reported 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 each 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 association existed between increased income and use of ICT information sources. The study reports that income increases the ability to pay for possible cost involved in utilizing ICTs such as purchasing of airtime, payment for electricity and batteries for radio among others. Also According to Wanyama et al. (2016) extension service providers both public and private 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.

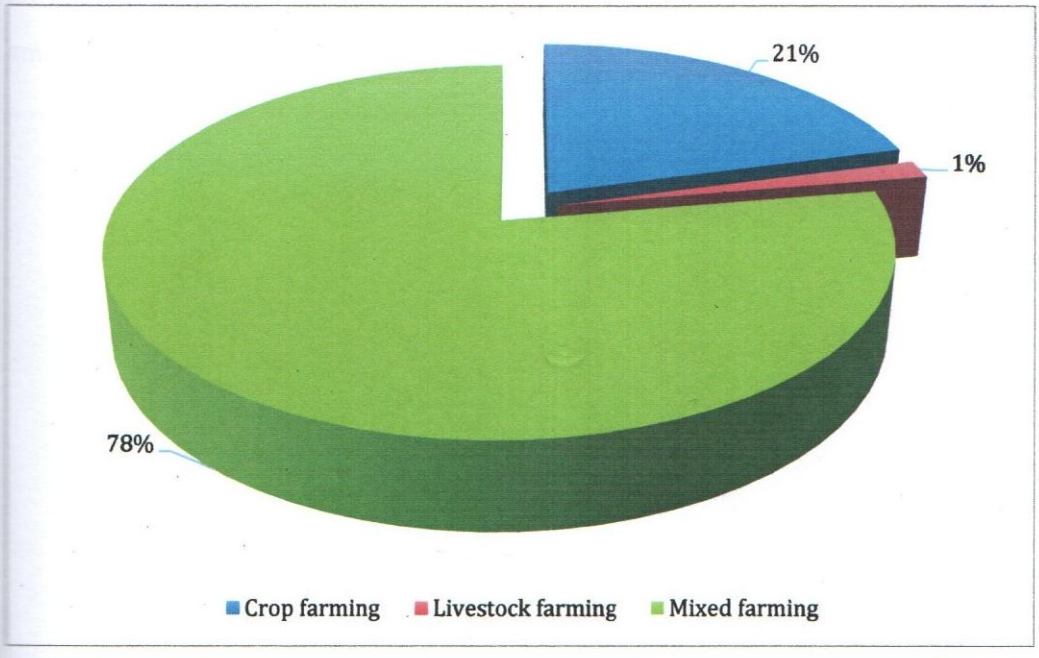

Figure 8: *Farming Activities of the Respondents*

The results in Figure 8 depicts that a great number of the respondents, 77.7 percent were involved in mixed farming involving both crops and livestock. 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 target some specific crops in order to improve farmers livelihoods while others offer multiple functionalities. Examples include m-services in Kenya such as *icow* that purely serves livestock farmers, M-farm which helps farmers to make informed decisions about when to harvest and sell their produce as well as prices for farm produce and Agri-Wallet which is a financial service that offers services to farmers by allowing them to borrow money for agricultural inputs and pay back 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.

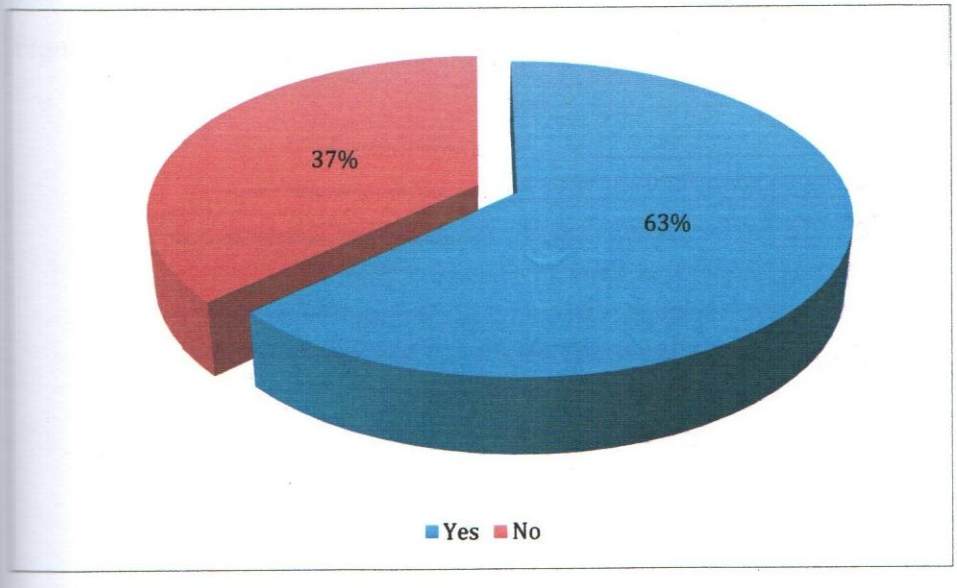

Figure 9: *Farmer Group Membership*

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 likelihood of farmers to use ICTs increased by 23.6 percent for those that belonged to a farmer group. According to the authors, farmer groups enable dissemination of information because farmers are able to obtain knowledge about the existence of agricultural services as compared to non members. Okello (2017) also found a positive significant effect of group membership on use of mobile phones to access agricultural information among smallholder farmers while Krell (2020) posits that farmer groups can serve as an avenue for creating awareness to promote 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.

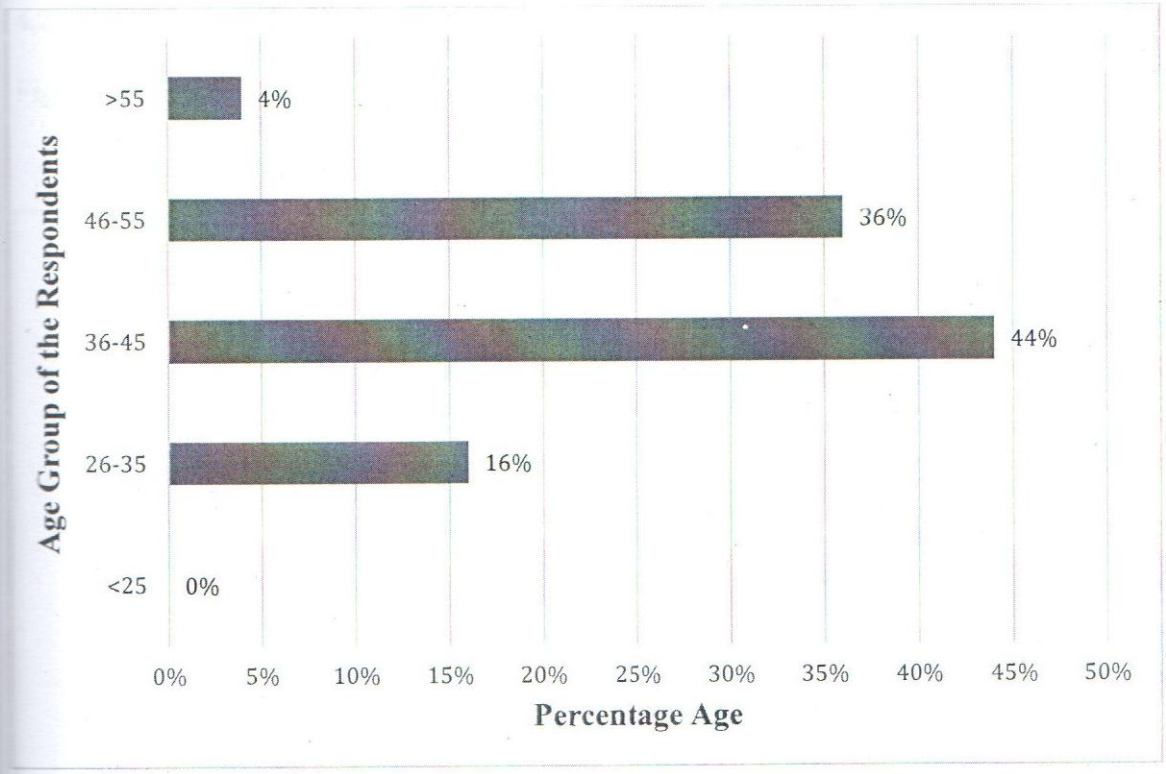

Figure 10: *Age Distribution of Extension Agents*

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.

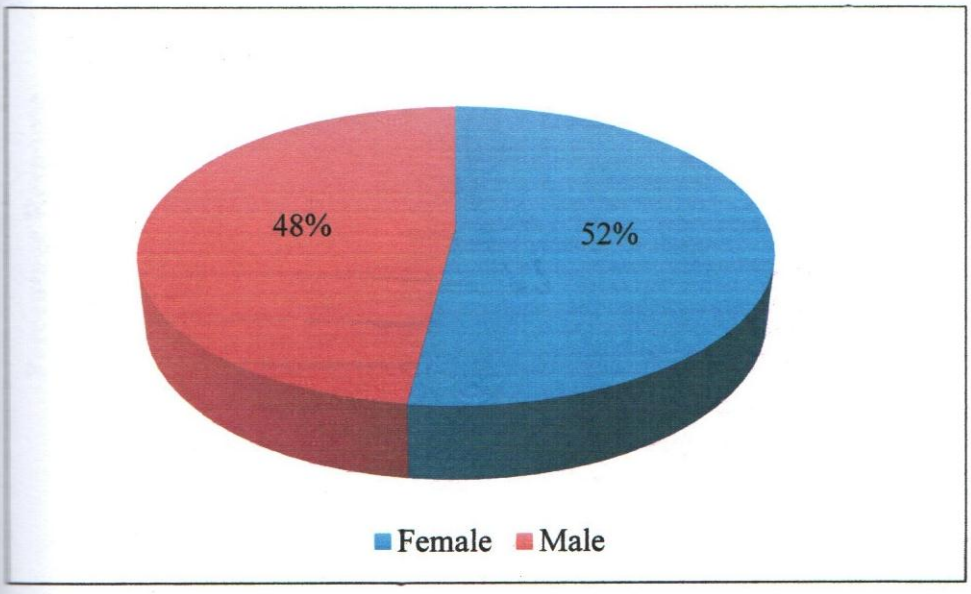

Figure 11: *Gender Distribution of the Extension Agents*

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 a slightly high number of female extension agents in the study area compared to their male counterparts. The results are contrary to the finding by McNamara et al. (2012) who indicated 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.

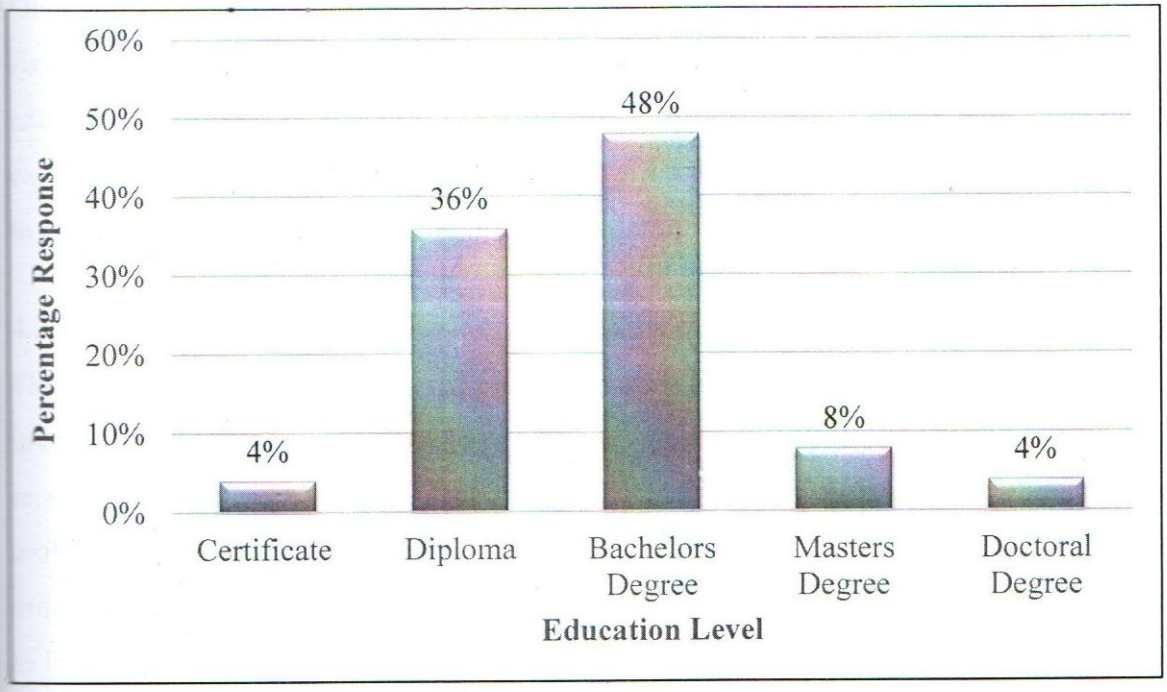

Figure 12: *Education Level of Extension Agents*

The study established that over 90 percent of the extension agent 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 who had advanced their education up to Masters Degree 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 Caribbean. On the other hand, Doss and Morris (2018) also indicated that technology acceptance was influenced positively by higher levels of education. Contrary to these studies however, Mwansa (2004) reported that the attitude of agricultural extension officers 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 was 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) asserts that, mobile phones, radio, television and the internet enhance farmers' access to relevant agricultural information. O'Dea (2020) further indicated that mobile phones that have internet connectivity are the most widely used ICT tool in the world. 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. Household survey done by the Kenya National Bureau of Statistics revealed that in Kenya about 8.4 percent of the adult population have access to computer with its use increasing and reaching the peak between 20 to 24 years then declining gradually with age (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.

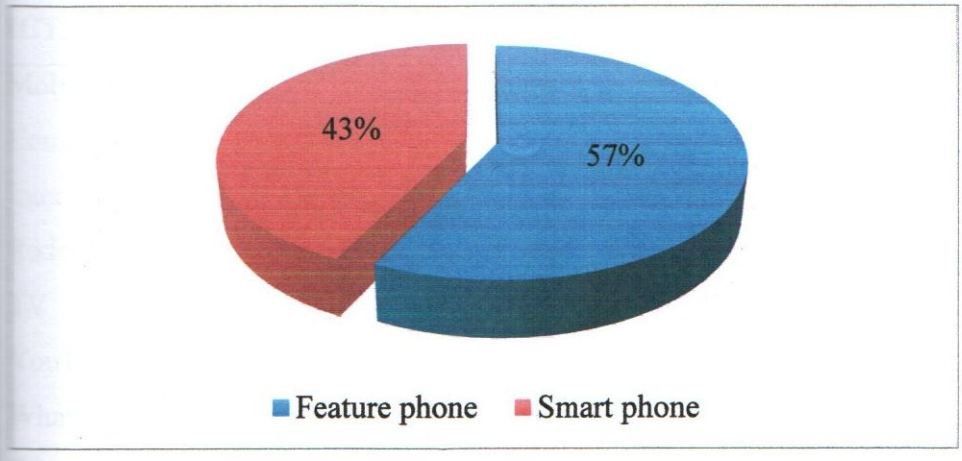

Figure 13: *Type of Mobile Phones Owned by Farmer Respondents*

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 Mercy Corps in (2016) ownership of smartphones was shown to be increasingly becoming widespread among farmers in Kenya. This as reported by the study had been due to increased network coverage in Kenya with of 85 percent 3G population coverage and 25 percent 4 G penetration 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 established 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 ICTs tools mostly used in accessing agricultural information by 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 studies by Mtega and Msungu (2013), Norberth et al. (2018), World Bank (2017b) who established that the leading ICTs among smallholder farmers were radio, mobile phone and television. Findings by Krell et al. (2020) however, indicated that the level of usage of mobile phone in accessing agricultural was determined by the type of mobile phone. According to their study, Smartphone ownership in Kenya was not widespread and that its ownership was positively significant to usage of m-services.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 handling

post-harvest losses, market information, weather information, pest and disease control and fertilizer application.

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.

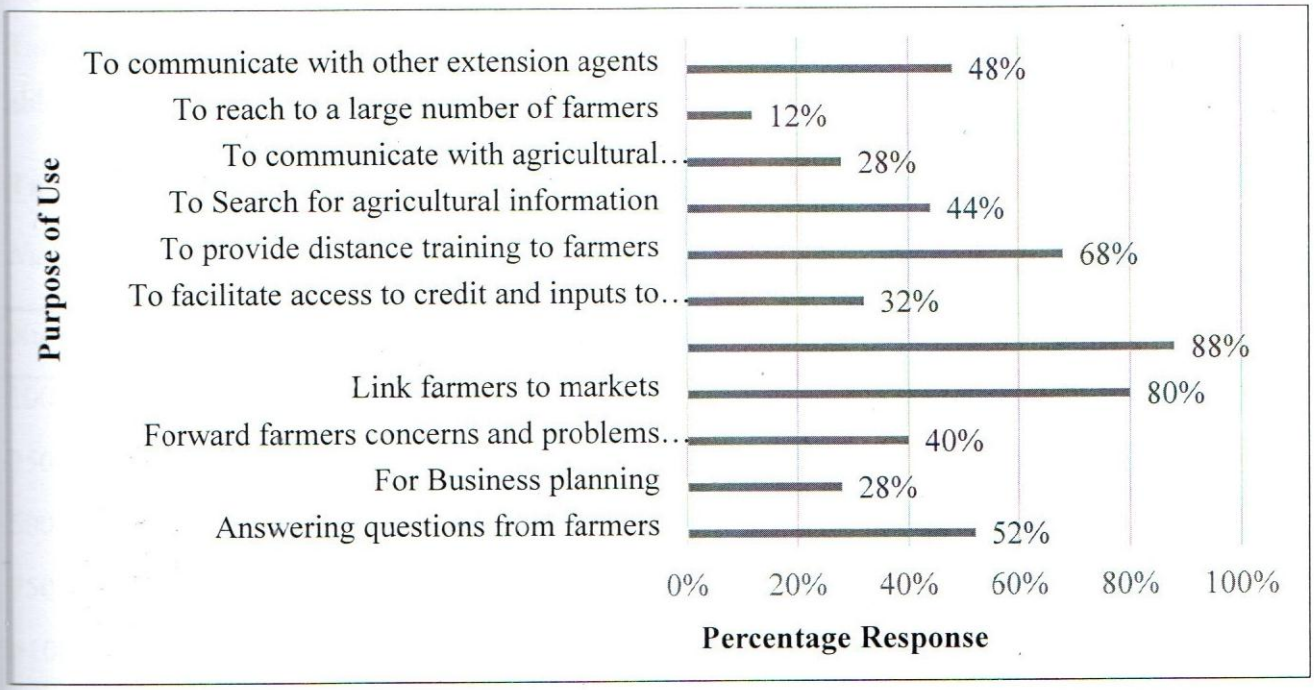

Figure 14: *Purpose of Using ICTs Among Extension Agents*

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 accessing inputs and credit. The usage of ICTs among the extension agents to help in accessing 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 to farmers which indicate that other extension methods are still also used among the extension agents. Ali et al. (2018)

suggests that ICTs can improve extension service delivery 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 delivering agricultural extension services which could help in reducing information asymmetries among farmer, cost and time as well facilitating information dissemination and uptake of agricultural technologies.

4.3.9 Test of Hypothesis One

Objective one of the study determined 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 in accessing agricultural information, within respondents.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 the most inaccessible ICT tool among 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

Objective two of the established 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 having would improve 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 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 leads to digital divide which in turn increases 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 would significantly affect ICTs adoption 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 established whether the respondents had received some 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.

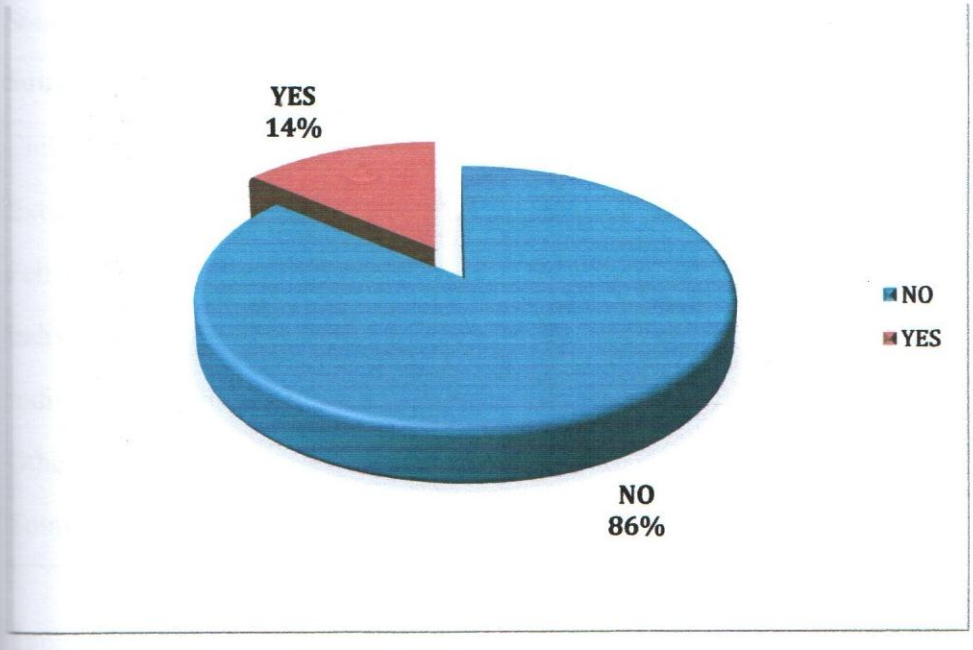

Figure 15: *ICT Training of the Farmer Respondents*

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 proportional to the level of use of 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 had not undergone any formal ICT training 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 to indicate the form of ICT training that they had undergone.. The results are presented in Figure 16.

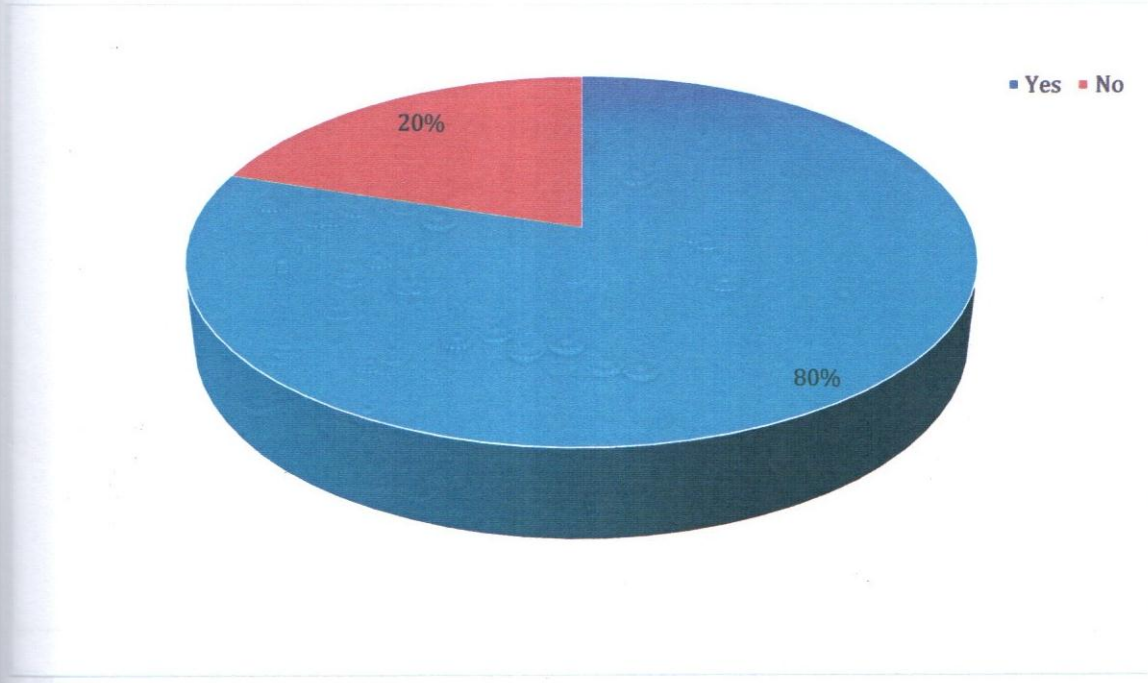

Figure 16: *ICT Training of Extension Agents*

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.

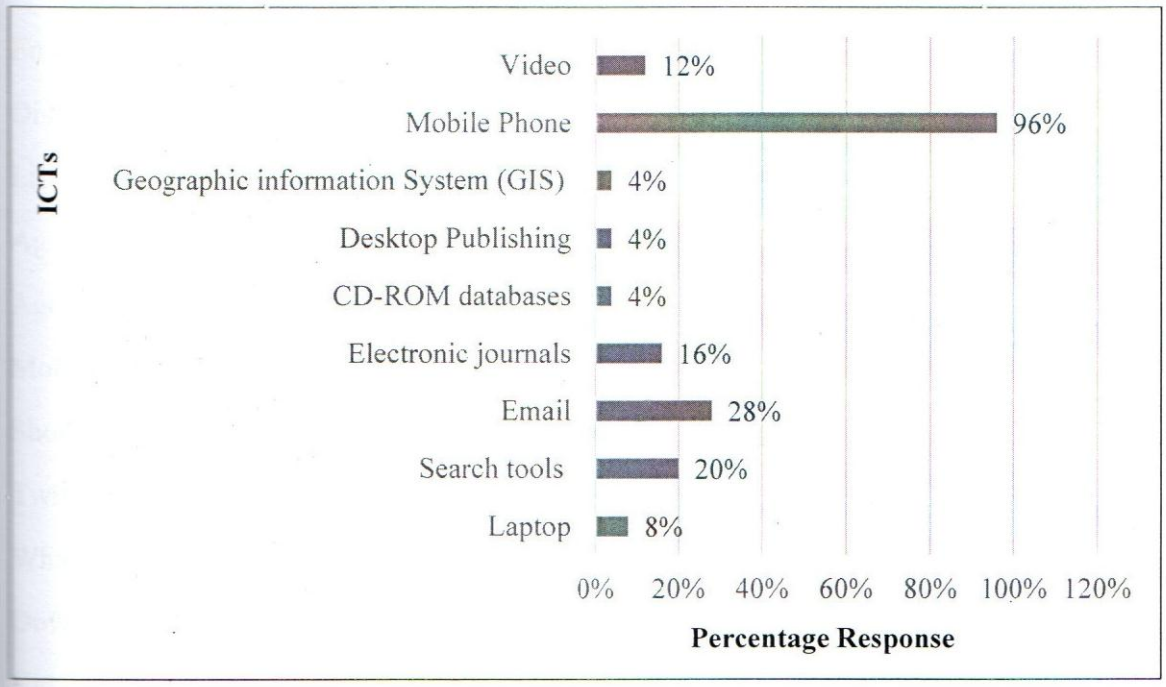

Figure 17: *ICTs Used by Extension Agents in Accessing Agricultural information*

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 established 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 of ICT 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 $\alpha = 0.05$ 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 ($\alpha = 0.05$ $p<0.05$).

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 $\alpha = 0.01$ 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 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 established 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 relevant and well targeted which in turn would affect farmers' decisions and production level. Content therefore is crucial and for it to have impact should it should be localized, relevant and specific to the needs of farmers. 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 level of preference to the available digital content among the respondents was also established in the study.

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 them 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 content development involved experts and local people. Examples of content as aired ranged from crop and livestock production weather forecasting, post-harvest handling and storage, marketing as well as home nutrition.

These corresponds to findings by Okello et al. (2017) who found that agricultural information such as best practices and agricultural technologies can help farmers improve agricultural production when effectively communicated through radio.

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 which enabled farmers 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 country where 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 can reach a large number of the smallholder farmers with price information and are cost effective. 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 show 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 to buy airtime, data bundles and charge their phones, buying batteries for the radio, paying for electricity charges and subscribing to TV channels in order to access get agricultural extension services. 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. Naruka et al. (2017) reported in their study that timeliness of available agricultural information is very essential for farmers to access up to date information. 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 reported that radio and mobile phones were most preferred by farmers because they gave relevant and efficient information on agricultural information and financial services. Nakasone and Torero (2016) also in their findings reports that relevant agricultural information particularly provided through mobile phones are very critical in agricultural extension. Fafchamps and Minten (2012) 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. 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 the most preferred ICT channels among farmers were radio and mobile phones. 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)

4.5.7.1 Digital 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 $\alpha = 0.01$ 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 this 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 these findings Kante (2016) reported that the high cost of mobile phones and services in Tanzania barred poor 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 for servicing mobile phones and to pay for extension services available through 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 $\alpha = 0.05$ 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 $\alpha = 0.01$ 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 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 established 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 to findings by Gichamba et al. (2017), who indicated that 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 adapt to farming practices for improved agricultural productivity. These results correspond to findings by Krone et al. (2020) who found that mobile phones enabled farmers to access both simple knowledge and also complex knowledge that is possible to be shared through calls. Fabregas et al. (2019) also indicated 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 = *Never* 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.

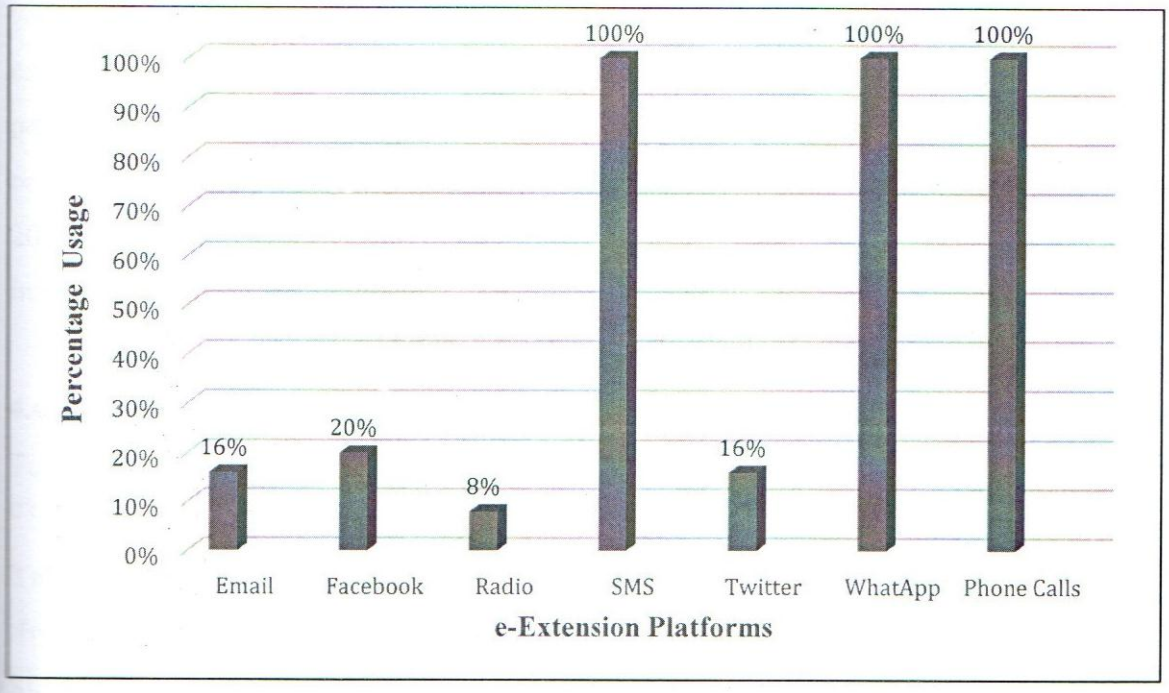

Figure 18: *e-Extension Platforms Used by Extension Agents*

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 technologies and support services.

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 36was 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 the impact of mobile phones on household income was a positively significant being attributed to reduced transaction costs, and aiding in social networks as well as connecting to agricultural players. The studies further reports that the mobile phone is used to avoid travelling by farmers because they are able to make calls for example to someone in the market and obtain accurate and timely information about the market prices and rates. This thus shows that mobile phones can be used to increase social networks by connecting to family and friends and also to collect 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) whose findings indicated that extension agents in Saudi Arabia had generally embraced the 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. High costs of ICT tools and services, lack of ICT skills, poor network coverage, power shortage, language barrier, irrelevant content available online are some of the challenges that farmers face when using ICTs to access agricultural information (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.

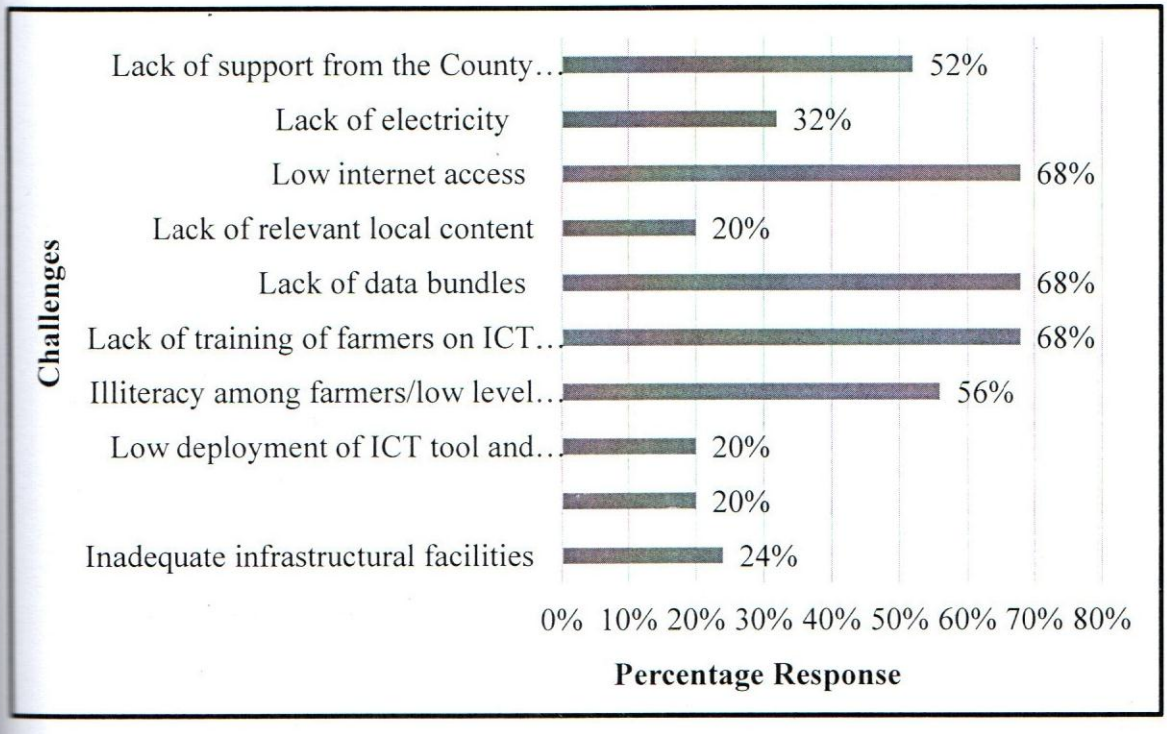

Figure 19: *Challenges of Using ICTs among Extension Agents*

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. Other challenges faced by extension agents when using ICTs include lack of relevant local content, low deployment of ICT tools and lack of ICT skills and infrastructural facilities. This finding corresponds to other studies by Deichmann et al. (2016), Madan and Maredia (2021), Nakasone and Torero (2016) who reports that utilization of ICTs in agricultural extension 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. This 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 Cooperatives and 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.

REFERENCES

Abebe, A., & Mammo Cherinet, Y. (2018). Factors affecting the use of information and communication technologies for cereal marketing in Ethiopia. *Journal of Agricultural & Food Information, 20*(1), 59–70. https://doi.org/10.1080/10496505.2018.1438290

Adejo, P. E., Okwu, O. J., & Ibrahim, M. K. (2012). Challenges and Prospects of Privatization of Agricultural Extension Service Delivery in Nigeria. *Journal of Agricultural Extension and Rural Development, 4* (3), 6-68.

Afzal, A., Al-Subaiee F.S. & Mirza A. A.The Attitudes of Agricultural Extension Workers towards the Use of E-Extension for Ensuring Sustainability in the Kingdom of Saudi Arabia.*Sustainability* 2016, 8, 980.http:// doi:10.3390/su8100980

Agili, G., & Rono, S. K. (2015). *Government supported e-Extension.* ICT update Newsletter. Technical Center for Agriculture and rural Cooperation ACP-EU (CTA). https://ictupdate.cta.int/en/article/government-supported-e-Extension-sid0acc28b12-01be-4ed1-bb37-6a55742cf260.

Agwu, E. A., & Nwokorie, U. M. (2019). Challenges and Opportunities for ICT adoption in Agricultural Extension. *ICT updates*, Technical Center for Agricultural and Rural cooperation (CTA)

Ajzen, I. (1991). *The theory of planned behavior organization behavior and human decision processes,* Academic Press, Inc. 179-211.

Aker, J.C. & Mbiti, I.M. (2014). *Mobile Phones and Economic Development in Africa.* Working Paper 211. Center for Global Development Publication: Washington, D.C. http://www.cgdev.org/files/1424175_file_Aker_Mobile_wp211_FINAL.pdf.

Aker, J.C. & Fafchamps, M. (2014).*Mobile Phone Coverage and Producer Markets: Evidence from West Africa.* World Bank Policy Research Working Paper No. 6986.

http://elibrary.worldbank.org/doi/pdf/10.1596/1813-9450-6986

Aker, J. C., & Mbiti, I. M. (2010), "Mobile Phones and Economic Development in Africa." *Journal of Economic Perspectives, 24* (3), 207-232

Akpalu, D.A. (2013). Agriculture Extension Services Delivery in a Semi-Arid Rural area in South Africa: The Case Study of Thorndale in the Limpopo Province. *African Journal of Food Nutrition and Development. (13)* 8058–8076.

Alavion, S. J., Allahyari, M. S., Al-Rimawi, A. S., & Surujlal, J. (2017). Adoption of agricultural E-marketing: Application of the theory of planned behavior. *Journal of International Food & Agribusiness Marketing, 29*(1), 1–15. https://doi.org/10.1080/08974438.2016.1229242

Ali, M., & Man, N. (2017).Reaching the Millions: Accelerating Agricultural Extension Services Through Information and Communication Technologies (ICTS).*World Applied Sciences Journal 35*(3), 352-355.

Ali, M., Man, N., Abd Latif, I., Muharam, F.M., Omar, S.Z., (2018). The use of information and communication technologies in agricultural risk management by the agricultural extension services in Malaysia. International. *Journal of Agricultural, Environment and Food Science.* 2 (1), 29–35. https://doi.org/10.31015/jaefs.18005.

Ali, S., Afshan, U., & Nikhitha, M. (2016). Impact of ICTs on Agricultural Productivity. *European Journal of Business, Economics and Accountancy 4* (5), 82-92.

American Psychological Association (2003). *Ethical Principles of Psychologist and code of Conduct*

Anderson, J. & Feder, G. (2007). *Agricultural Extension Handbook of Agricultural Economics,* Vol. 3 Everson R.E., Pinyali, P. (eds), Elsevier Science, Amsterdam, The Neitherlands 2343-2378.

Anderson, J. R. (2008). *Agricultural Advisory Services.* Background Paper for the World Development Report, 2008. World Bank, Washington D.C.

Angello, C. (2015). Exploring the use of ICTs in learning and disseminating livestock husbandry knowledge to urban and peri-urban communities in Tanzania. *International Journal of Education and Development. using Information Communication Technologies 11* (2), 5–22.

Asongu, S., & Asongu, N. (2018). The comparative exploration of mobile money services in inclusive development. *International Journal of Social Economics 45*(1),124-139. https://www.econstor.eu/bitstream/10419/173617/1/agdi-wp-17-011.pdf. Accessed: Apr. 26, 2020.

Asenso-Okyere, K., & Mekonnon D. A. (2012). *The Importance of ICTs in the provision of Information for Improving Agricultural Productivity and Rural Incomes in Africa.* Working Paper 2012-015. United Nations Development Programme, New York, NY, USA. Retrieved from http://web.undp.org/africa/knowledge/WP-2012-015-okyere-mekonnen-ict-productivity.pdf. Accessed on 20th April 2016

Aubert, B. A., Andreas S, & Jonathan G. (2012). *IT as Enabler of Sustainable Farming: An Empirical Analysis of Farmers' Adoption of Precision Agriculture Technology.* Decision Support Systems, *54* (1), 510–20.

Awuor, F., Raburu G., Onditi A., & Rambim D. (2016). Building E-agriculture framework in Kenya.*Journal of agricultural informatics,* 7(1), 75-93

Ballantyne, P. G. (2009). Accessing, sharing and communicating agricultural information for development: emerging trends and issues. Information Development, 25, 260 –271.

Baker, T. L. (1994). *Doing Social Research* (2nd Edn.). New York McGraw-Hill Inc.

Barber, J., Mangnus, E., & Bitzer, V. (2016). *Harnessing ICT in Agricultural Extension.* Working paper 2016: 4. Sustainable Development & Gender Special series on Agricultural Advisory Services. Retrieved from https://pdfs.semanticscholar.org/947b/0adb90350157c2daeda00f5cdce8fbfc0744.pdf

Barguma K. A., & Ndaghu A. A. (2014). Information accessibility among fish farmers in Girei, Yola-North and Yola-South local government areas, Adamawa State, Nigeria. *Journal of Science and Technology, 4* (8), 503-507.

Barakabitze, A.A., Fue, K.G., & Sanga, C.A. (2017). The use of participatory approaches in developing ICT-based systems for disseminating agricultural knowledge and information for farmers in developing countries: The case of Tanzania. *Electronic Journal of Information Systems in Developing Countries 78* (8),1-23.

Barakabitze, A.A., Kitindi, E.J., Sanga, C., Shabani, A., Philipo, J., & Kibirige, G. (2015). New technologies for disseminating and communicating agriculture knowledge and information: Challenges for agricultural research institutes in Tanzania. *Electronic Journal of Information Systems in Developing Countries, 70* (2), 1-22.

Baumüller, H. (2018). The little we know: An exploratory literature review on the utility of mobile phone-enabled services for smallholder farmers. *Journal of International Development, 30*(1), 134–154. https://doi.org/ 10.1002/jid. v30.1

Benard, R., Dulle, F., & Lamtane, H. (2019). Challenges associated with the use of information and communication technologies in information sharing by fish farmers in the Southern highlands of Tanzania. *Journal of Information, Communication and Ethics in Society, 18*(1), 44–61. https://doi.org/10.1108/JICES11-2018-0085

Bentley, J., Chowdhury, A. &Soniia, D. (2015). *Videos for Agricultural Extension.* Note 6. GFRAS Good Practice Notes for Extension and Advisory Services. GFRAS: Lindau, Switzerland.

Bentley, J., Van Mele, P., Okry, F. & Zossou, E. (2014). *Videos that speak for themselves: When non-extensionists show agricultural videos to large audiences*. Development in Practice *24* (7),921–929.

Bell, M. (2015). Powering Behaviour Change for a Brighter Agricultural Future. MEAS Discussion Paper, University of California, Davis.

Bell, M., Judith P., & Andrea B. (2011). ICT Options in Relation to Extension Functions. MEAS. Available at www.meas-extension.org/resources/ict

Bhattacharyya, T., Patil, V. K., Bhave, S. G., & Haldankar, P. M. (2018). E-Extension Services of SAUs in Indian Agriculture: Challenges and Management Strategies. *Advanced Agricultural Research & Technology Journal*, *2*(2), 119-25.

Bhattacherjee, A. (2012). *Social science research: Principles, methods and practice. Text books collection.3.* http://scholarcommons.usf.ed/oa_textbooks/3 . Accessed on 20th September 2017

Birch, I. (2018). *Agricultural Productivity in Kenya: Barriers and Opportunities.* K4D Helpdesk Report. Brighton, UK: Institute of Development Studies.

Bore M.C., Owouche, J., & Mutai, J. K. (2015). Assessing benefits and challenges smallholder dairy farmers" experience in using ICTs tools to source information on insemination services and breeding stock in Western Kenya. *Journal of Agriculture and Veterinary Science. 8* (7), 6-10.

Borg, W.R., & Gall, M.D. (1989). *Educational Research: An Introduction* (5th Ed). Longman White Plains, New York.

Brown, L. (2014). *Introducing icow: The virtual mobile midwife for cows*. available at http://voices.nationalgeographic.com.

Casaburi, L., Kremer, M., Mullainathan, S., Ramrattan, R., (2014). *Harnessing ICT to Increase Agricultural Productivity: Evidence from India*. Unpublished Manuscript. Harvard University, Cambridge, MA.

Centre for Agriculture and Bioscience International (2014). mFarmer: Providing Kenya's farmers with agricultural information via mobile.

Centre for the Development of Vocational Training(2014). Terminology of European education and training policy: A selection of 130 key terms.http://www.cedefop.europa.eu/EN/publications/24020.aspx

Chesoli R.N., Mutiso J.M., & Wamalwa M. (2020).Monitoring with social media: Experiences from "integrating" WhatsApp in the M&E system under sweet potato value chain.*Open Agriculture* 2020; 5: 395–403, De Gruyter.

Chikaire, J.U., Anyoha, N.O., Anaeto, F.C., Orusha, J.O., (2017). Effects of use of information and communication technologies (ICTs) on farmers' agricultural practices and welfare in Orlu agricultural zone of Imo State, Nigeria. *International Journal of Research in Agriculture and Forestry 4* (3), 6–15.

Chisango, G., Lesame, Z., (2014). Twenty years of democracy and digital poverty: technology challenges experienced by women in the Chris Hani Municipality of the Eastern Cape province of South Africa. *Mediterranean Journal of Social Sciences 5* (27), 1553–1571.

Chisita, C. T. (2013). *Knotting and networking agricultural information services through web 2.0 to create an informed farming community: a case of Zimbabwe.* http://comference.ifla.org/ifla78.

Christoplos, I. (2010). *Mobilizing the potential of rural and agricultural extension.* Rome, Italy: Food and Agriculture Organization (FAO) of the United Nations and the Global Forum for Rural Advisory Services.

County Government of Nakuru, (2020). Agriculture, Livestock and Fisheries Subsector Report, MTEF 2020/2021 -2022/2023.

CoLab, C. (2018). Exploring synergistic solutions for sustainable development 2018. MIT Center for Collective Intelligence Https://Www. Climatecolab. Org/Contests/2017/Exploring-Synergisticsolutions-for-Sustainable-Development (Accessed: October 2020).

Chavula, H. K. (2014). *The role of ICT in Agricultural Production in Africa.* Economic Commission for Africa (ECA), Addis Ababa, Ethiopia 6 (7), 279-289

Communications Authority of Kenya, (2019). *First Quarter Sector Statistics Report for the financial year 2019/20.*

Communications Commission of Kenya, (2012) Quarterly Sector Statistics Report: 3nd Quarter.January-March 2011/2012.

Communications Commission of Kenya, (2011). *Quarterly Sector Statistics Report April June 2010/2011.*

Davis K. & Franzel S. (2018). *Extension and Advisory Services in 10 developing Countries: A cross-county Analysis*. Developing Local Extension Capacity (DLEC) Project September 2018

Davis, K.E. & Terblanche, S.E. (2016). Challenges Facing the Agricultural Extension Landscape in South Africa, Quo Vadis? *South African Journal of Agricultural Extension (44)* 231–247. Available athttp://www.scielo.org.za/pdf/sajae/v44n2/20.pdf

Dannenberg, P. & Nduru G. M (2013). Practices in international value chains: The case of the Kenyan fruit and vegetable chain beyond the exclusion debate. *Journal of Economic &Social Geography, 104* (1): 41–56.

Davis, K., & Heemskerk, W. (2012). *Investment in extension and advisory services as part of agricultural innovation systems. Module 3 of agricultural innovation systems: an investment sourcebook.* Washington, DC, USA: The World Bank.

Davis, K. E., & K. Asenso-Okyere. (2010). *Innovative models of agricultural extension: Global perspectives and implications for Indian system.* Paper presented at the NAARMIFPRI Workshop on Redesigning Agricultural Extension in India: Challenges and Opportunities, August 20-21

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). *User acceptance of computer technology: A comparison of two theoretical models. Management Science.*

Deichmann, U., Goyal A., & Mishra, D. (2016): *Will digital Technologies Transform Agriculture in Developing Countries.* World Development report 2016, Policy Research Working Paper 7669

Department of Agriculture, Forestry and Fisheries, Republic of South Africa (2012). *A framework for the development of smallholder farmers through cooperative development*. Accessed April 2018, Retrieved fromhttp://www.nda.agric.za/doaDev/sideMenu/cooperativeandenterprisedevelopment/docs/FRAMEWORK-%20OF%20SMALL%20FARMERS%20(2).pdf.

Deininger, K. & L. Squire (1998). *New ways of looking at old issues: Inequality and growth.* Journal of Development Economics.

Dixon. J (2010). *Operationalizing participatory research and farmer-to-farmer extension*: *The Kamayoq in Peru*: RoutledgeInforma Ltd, London, UK.

Dishant J.J. & Lakshminarayan M.T. (2018).Factors influencing the utilization of information and communication technology tools by agricultural extension functionaries.*Agriculture Update Hind Agricultural Research and Training Institute, 13* (2): 228-232.

Eakin, H., Wightman, P. M., Hsu, D., Gil Ramón, V. R., Fuentes-Contreras, E., Cox, M. P., Hyman, T.-A. N., Pacas, C., Borraz, F., GonzálezBrambila, C., Ponce de León Barido, D., & Kammen, D. M. (2017). Information and communication technologies and climate change adaptation in Latin America and the Caribbean: A framework for action. *Climate and Development, 7(3)*, 208–222. https://doi.org/10. 1080/17565529.2014.951021.

Economic Survey, (2015). *Ministry of Devolution and Planning.* Republic of Kenya.

Edwards, A. W. (2006). *Non Experimental Quantitative Research*: Columbus Ohio, USA. http/www.karen.com. Accessed on 12th April 2017.

Elliott, M. (2015). *Sustainable and scalable business models*. ICT Update Bulletin, Issue no. 80. Retrieved from http://ictupdate.cta.int/Regulars/Q-A/Sustainable-and-scalable-business-models/%2880%29/1439915106.

Elia, E. F., Mutula S. & Stilwell C. (2014). *"Indigenous Knowledge Use in Seasonal Weather Forecasting in Tanzania: The Case of Semi-arid Central Tanzania." South African Journal of Libraries and Information Science 80* (1):18–27. doi:10.7553/80-1-180.

East Africa Ecomomic Outlook, (2021).Debt Dynamics: The Path to Post-COVID Recovery.African Development Bank Group.Retrieved from https://www.afdb.org/en/documents/east-africa-economic-outlook-2021

Fabregas, R. Kremer M. Lowes M. On, R., & Zane G. (2019). "Can SMS-Extension Increase Farmer Experimentation? Evidence from Six RCTs in East `Africa." Unpublished paper.

Fahad, A., Mohamed, S., Al, S., Muhammad, A., Ullah, M., & Ali, N. (2017). Farmers' perceptions regarding the use of information and communication technology (ICT) in Khyber Pakhtunkhwa, Northern Pakistan. *Journal of the Saudi Society of Agricultural Sciences, 3* (1), 124–137. https://doi.org/10.1016/j.jssas.2017.05.004

Farm Radio International, (2019). Interventions Research: An Assessment of ICT strategies that are most effective and efficient in scaling agricultural solutions in Malawi. *Canada international Development research Centre* (IDRC).

Food & Agriculture Organization, (2019). *Digital Technologies an Agriculture and Rural Areas. Briefing Paper*. Rome. Retrieved from http://www.fao.org/3/ca4887en/ca4887en.pdf

Food & Agriculture Organization, (2018). Smallholder data-portrait. Available at http://www.fao.org/family-farming/data-sources/dataportrait/farm-size/en/

Food & Agriculture Organization, (2017). *The state of Food and Agriculture: Leveraging Food Systems for Inclusive Rural Transformation*. Rome. Retrieved from http://www.fao.org/3/a-i7658e.pdf.ISBN 978-92-5-109873-8.

Food & Agriculture Organization, (2017a). *The future of food and agriculture – Trends and challenges*. Rome.

Food & Agriculture Organization, (2017b). *Information and Communication Technologies for Agricultural and Rural Development: Success Stories on Information and Communication Technologies for agriculture and rural development. second edition.* Rome.

Food & Agriculture Organization& ITU. (2016). *E-Agriculture Strategy Guide*: Piloted in Asia-Pacific Countries. Bangkok: FAO & International Telecommunication Union (ITU).

Food & Agriculture Organization, (2015). *Information and Communication Technologies for Agricultural and Rural Development.* Rome.

Food & Agriculture Organization, (2013): *ICT uses for inclusive agricultural value chains.* Rome: FAO.

Food & Agriculture Organization, (2006). *Framework on effective rural communication for development* Rome: FAO.

Food & Agriculture Organization, (2005): *Enhancing coordination among AKIS/RD actors: An analytical and comparative review of country studies on agricultural knowledge and information systems for rural development (AKIS/RD).* Rivera, W.M., M.K. Qamar and H.K. Mwandemere (eds.) FAO, Rome.

Fu, X. & Akter, A. (2012). *Impact of Mobile Telephone on the Quality and Speed of Agricultural Extension Services Delivery: Evidence from the Rural e-services Project in India.* Poster presentation at the International Association of Agricultural Economists (IAAE) 2012.Triennial Conference, Foz do Iguaçu, Brazil 18- 24 August 2012.

Gandhi, R. (2016). *Building Community at a Global Scale; Using Video to Improve Extension and Create Farmer Networks. African Farmers in the Digital Age Report. How Digital Solutions Can Enable Rural Development.* Foreign Affairs. Digital Thinking Initiative.

Gakuru, M., Winters, K., & Stepman, F. (2009*). Inventory of Farmers Advisory Services Using ICT.* Forum for Agricultural Research in Africa.

Gichamba, A., Wagacha, P.W., & Ochieng, D.O. (2017). An Assessment of e-Extension Platforms in Kenya. *International Journal of Innovative Studies in Sciences and Engineering Technology* (IJISSET) 3 (7): 36-40.

Global System for Mobile Communications (2018).*The mobile economy: sub-Saharan Africa 2018.* London: GSMA Intelligence.

Global Forum for Rural Advisory Services, (2010). *GFRAS: Making a difference by improving rural advisory services.* Lindau, Switzerland: GFRAS.

Glendenning, C., Babu, S. C. & Asenso-Okyere, K. (2010). *Review of Agricultural Extension in India: Are Farmers' Information Needs Being Met?* IFPRI Discussion Paper 01048. Washington, DC: IFPRI.

Government of Kenya, (2018). *Nakuru County Integrated Development Plan 2018-2022*Retrieved from https://cog.go.ke

Government of Kenya, (2015). *Nakuru Countystatistical abstract 2015*. Kenya National Bureau of Statistics: Nairobi, Kenya: Government printer.

Government of Kenya, (2013). *Nakuru County Integrated Development Plan 2013-2017.*

Government of Kenya, (2012). *National Agriculture Sector Extension Policy (NASEP).* Nairobi, Kenya: Agricultural Sector Coordination Unit.2010. Agricultural Sector Development Strategy 2010-2020. Nairobi, Kenya: Ministry of Agriculture. Retrieved from http:// www.kilimo.go.ke/kilimo_docs/pdf/ASDS_Final.pdf.

Government of Kenya, (2010) *Kenya Agricultural Sector Development Strategy 2010–2020.*

Grain, (2014), Hungry for land: small farmers feed the world with less than a quarter of all farmland. GRAIN. https://www.grain.org/article/entries/4929

Gwademba, G.K., Muthee, D.W. & Masinde, J.M. (2019). Application of ICTs in Transforming Agricultural Extension. *Regional Journal of Information and Knowledge Management, 4* (2),12-21.

Haruna, A., & Baba, D. (2017). *An appraisal of farmer's internet use for sourcing agricultural information in North –Western Nigeria.* SHS Web of Conference,33, DOI:10.1051/shsconf20173300051.

Hao, H. (2013). *Quantifying social influence on IT adoption in health care: A Heirarchichal Bayesian learning model analysis.*

Hall, M., Nix, I. & Baker K (2012). *"Are learner perceptions of digital literacy skills teaching affected by demographic factors?".* The Seventh International Blended Learning Conference, pp. 12-20.

Hall, A. (2007). *Influence: The Essence of Leadership.* Nebraska University-Lincoln Extension. USA

Heeks, R. (2018). Information and communication technology for development (ICT4D). Taylor and Francis*: London.*

Heili, J., & Assar, S. (2009). An empirical enquiry into the adoption of open sources software by users in France.

Hudson, H.E., Leclair, M., Pelletier, B., & Sullivan, B. (2017). Using radio and interactive ICTs to improve food security among smallholder farmers in Sub-Saharan Africa. Telecommunications Policy, 4, 670-684.

International Telecommunication Union, (2015). *The world in 2015. MDG's 2000-2015: ICT revolution and remaining gaps. ICT facts and figures.* San Jose, CA: International Telecommunication Union (ITU).

International Fund for Agriculture and Development, (2013). Smallholders, Food Security, and the Environment, IFAD and UNEP, Rome. https://www.ifad.org/documents/10180/666cac24-14b6-43c2-876d9c2d1f01d5dd. Jayne.

International Fund for Agriculture and Development, (2012). *The future of world food and nutrition security: investing in smallholder Agriculture - an international priority.* Retrieved from https://maintenance.ifad.org/documents/10180/5a63638b-2285-4b8e 8cc2bd6f31dadcbc.

International Telecommunication Union, (2008). Measuring Information Communication and Technology availability in Villages and Rural areas.ITU.

International Food Policy Research Institute, (2005). *Agricultural R&D in sub-Saharan Africa: Recent country briefs and datasets.* IFPRI, Washington, DC, USA.

Jere, N. (2015), the Role of Information and Communications Technology in Improving Food Security in Kwazulu-Natal, South Africa.

Jose, A. M., & Lokeswari, K. (2018). A study on users and non-users of ICT among farming community. *Global Media Journal, 16,*(31:124). ISSN 1550-7521.

Jijina C. K., & Raju G. (2016). *Social Media and Farmers'. International Journal of research in Engineering and Technology.*eISSN:2319-1163/PISSN:2321-7308.

Kansiime, M. K., Alawy, A., Allen, C., Subharwal, M., Jadhav, A., Parr M. (2019). Effectiveness of Mobile agri-advisory service extension Model: Evidence from Direct2Farm program in India. Word Development perspectives (13) 25-33.

Katunyo, P. N., Otieno D. J, Oluoch-Kosura, W. & Okello J. J (2017). *Factors influencing the intensity of use of ICT tools by youth along agricultural value chains: Evidence from Busia County Kenya.* Paper presented in the 30th International Conference of Agricultural Economists July 28- 2nd August, 2018, Vancouver.

Kahenya W.K., Sakwa M., & Iravo M. (2014): Assessing use of Information communication Technologies among Agricultural Extension Workers in Kenya using Modified UTAUT Model. *International Journal of Sciences: Basic and Applied Research (IJSBAR) 16,* (2),11-22.

Karoney, B. K. (2016). *A mobile based marketing information system for farmers and buyers in Kenya.* Msc. Thesis, Strathmore University. Retrieved from

http://su-plus.strathmore.edu/handle/11071/4901

Karagu, W.N. (2011). Kenya Agricultural Commodity Exchange: Linking small-scale farmers to national and regional Markets. Growing inclusive Markets. UNDP. Retrieved from https://bestllcservices.co/wp-content/uploads/2021/05/Kenya_KACE_2011.pdf

Kalusopa, T. (2004). *The challenges of utilizing information communication technologies for small-scale farmers in Zambia*. Library Hi Tech 23 (3).

Kathuri, J.N. & Pals, D.A. (1993). *Introduction to Educational Research*. Njoro, Kenya: Egerton University Press.

Kedera, D.M., Omwenga, V., & Orero, J. (2014). *E-Agriculture Prototype for Information Dissemination among Farmers in the Food Crops subsector*. Msc Thesis, Strathmore University Kenya.

Kenya Agricultural Commodity Exchange (KACE). (2011). *KACE Services*: *The KACE Market Information and Linkage System.* Retrieved from http://www.kacekenya.co.ke/section.asp?ID=64Accessed April 11, 2017.

Kent, R. & Poulton C. (2008). *Marginal farmers, a review of the literature.* Centre for Development, Environment and Policy, School of Oriental and African Studies.

Kiambi, D. (2018). The use of Information Communication and Technology in advancement of African agriculture. African Journal of Agricultural Research, 13(39), 2025-2036.

Kiara, J. K. (2011). Focal Area Approach: A Participatory Community Planning Approach to Agricultural Extension and Market Development in Kenya. *International Journal of Agricultural Sustainability 9* (1), 248–257.

Kilima, F.T. M., Sife A., & Sanga.C. (2016). Factors underlying the choice of ICTs among smallholder farmers in Tanzania. *International Journal of computing and ICT research 10,*(2).

Kikulwe E.M, Fischer, E., and Qaim, M. (2014) *Mobile money, smallholder farmers, and household welfare in Kenya*. 9 (10) e109804. Retrieved from https://doi.org/10.1371/journal.pone.0109804 PMID: 25286032

Kipkurgat, T., Onyiego, M., & Chemwaina, S. (2016). Impact of Social Media on Agricultural Extension in Kenya: A Case of Kesses District. *International Journal of Agricultural Extension and Rural Development Studies, 3 (1)*, 30-36.

Kimani, D. (2015). *Ministry of Agriculture.* http://www.nakuru.go.ke/2015/07/03/ministry.

Khamoushi, S. & Gupta, J. (2015). Factors affecting familiarity and usage of information and communication technologies by agricultural extension scientists in north India. *J. Appl. Sci. Res.,11*(5): 50-56.

Krishnan, A., Banga, K. and Mendez-Parra, M. (2020) Disruptive technologies in value chains: Insights from East Africa. London: ODI

Kramer-Leblanc, C., & Greg, C. (2010). *Capacity Building of Farmers through an e-Extension- Model: Challenges and Opportunities. In Multi Stakeholder Dialogue on Implementing Sustainable Development;* USDA: Washington, DC, USA, 2010.

Krell, N. T., Guido, S. A., Z. Hannah, C., Lopus, S. E. K., Caylor, K. & Evans, T. P. (2020). Smallholder farmers' use of mobile phone services in central Kenya, *Climate and Development,* DOI: 10.1080/17565529.2020.1748847

Koome, D.K., & Wanjohi, J. (2017). *Factors Influencing Marketing of Agricultural Produce Among Small-Scale Farmers: A Case of Sorghum in Giaki Location, Meru County Kenya. International Journal of Economics, Commerce and Management, 5* (8).

Kothari, C.R. (2004). *Research Methodology: Methods of Techniques* (2nd ed.). Wishwa Prakashan. New Delhi.

Koshy, S. M., & Kumar, N. K. (2017). Attitude of Farmers towards Kisan Call Centres. *Journal of Extension Education, 28* (4).

Kuria, C.W. (2014).Use of Social Media as a Source of Agricultural Information by Small Holder Farmers: A Case Study of Lower Kabete, Kiambu County. Unpublished Msc. Thesis. University of Nairobi.

Langat., R.J., Ntale, J. F & Litondo, K.O. (2016). *Determinant of usage of social networking information among small scale farmers in Uasin Gishu County, Kenya.* International journal of Economics, Commerce and Management.London.U.K.4 (11): ISSN 2348 0386.

Lekopanye, C.M., Sundaram, M.K., (2017). An investigation on information communication technology awareness and use in improving livestock farming in southern District, Botswana. *Int. J. Adv. Comput. Sci. Appl. 8* (2), 17–23

Lewis., A.L., Baird., T.D, & Sorice., M.G (2016). *Mobile phone use and human-wildlife conflict in northern Tanzania.*58 (1) 117–129. https://doi.org/10.1007/s00267-016-0694-2 PMID: 27017517.

Leeuwis, C. (2006). *Communication for rural innovation: Rethinking agricultural extension.* Blackwell publishing, Netherlands.

Liebenberg, F. (2015). *Agricultural Advisory Services in South Africa; A Discussion Paper; Department of Agricultural Economics, Extension and Rural Development, University of Pretoria*: Pretoria, South Africa.

Lipton, M. (2005). *The family farm in a globalizing world: The role of crop science in alleviating poverty.*IFPRI 2020 Discussion Paper 40. Washington, DC: *International Food Policy Research Institute.*

Lowder, S.K., J. Skoet and T. Raney (2016) 'The Number, Size, and Distribution of Farms, Smallholder Farms, and Family Farms Worldwide', World Development 87: 16-29.

Lwesya, F. & Kibambila, V. (2017*). The Role of ICT in Facilitating Farmers' Accessibility to Extension Services and Marketing of Agricultural Produce: The Case of Maize in Mbozi District, Tanzania. International Journal of Agricultural Marketing 4*(2), 142-151.

Lwoga, E. T, Stilwell, C. & Ngulube, P. (2011). "*Access and use of agricultural information and knowledge in Tanzania." Library Review. 60* (5): 3–3

Madan, S. & Maredia K. (2021*). Global Experiences in Agricultural Extension, Community Outreach and advisory services.* A joint Publication of Michigan State University (MSU) Extension, East Lansing, Michigan, U.S.A., and the National Institute of Agricultural Extension Management (MANAGE), Hyderabad, India.

Magesa, M.M. (2015). *Linking rural farmers to markets using ICTs*. CTA Working. Paper;15/12. Wageningen: CTA. Available at https://hdl.handle.net/10568/89995

Marwa E.M., Mburu, J., Oburu, R. E. J., Mwai, O., & Kabumbu, S. (2020). *The role of ICT based extension services on Dairy Production and household welfare. The case of iCow service in Kenya.* A conference paper presented at International Research on Food Security, Natural Resource Management and Rural Development Conference in Tropentag 2019, Kassel, Germany September 18-20, 2019.

Majani, M. D. (2020). *Strategies for Effective Implementation of ICT in the Dairy Farming Sector in Saboti Constituency, Tranzoia County*. Unpublished MBA Thesis. United States International University – Africa.

Matto, G. (2018), Agricultural Information Access and the Use of ICTs among Smallholder Farmers. A Case of Bembeke EPA in Dedza District, Malawi.*Research Report Series 2* (1), 59-72.

Manfre, C., & Nordehn, C. (2013). *Exploring the promise of information and communication technologies for women farmers in Kenya.* Cultural practices, LLC, MEAS Case study # 4. urbana, USA: Modernizing Extension and Advisory Services (MEAS)

Mansour, A. M (2013) *Diffusion and adoption of e-Extension technology among extension agents in extension work in Sohag Governorate, Egypt. African Journal of Agricultural Education (1)* 44-99.

McGuire, M., Bell, M. & Crump, A. (2015). Agricultural Call Centers - An Infrastructure and demand audit. Modernizing Extension and Advisory Services project (MEAS). USAID.

Mckinsy, (2011): *Sizing Africa's Agricultural Opportunity. In four Lessons for transforming African Agriculture* Mckinsy Quarterly, April, 2011

Mercy Corps (2016): *Second Benchmark Study of Smallholder Farmers of Kenya, 2016*: Insight on Baseline Changes from 2015. http://mercycorpsafa.org/wpcontent/uploads/2017/02/AFA_Second_Second Benchmark Study_Kenya.pdf

Michura, G.E., (2016). *Impacts of Extension Methods on Women Small Scale Farmers Adoption of Conservation Agricultural in Nakuru County, Kenya.Merit Research Journal of Agricultural Sciences and Soil Sciences 4 (10)*131-138. Retrieved from http:// meritresearchjournals.org/asss/index.html

Ministry of Agriculture (2012). *National Agriculture Extension Policy.*

Mittal, S. (2015). Modern ICT for agricultural development and risk management in smallholder agriculture in India (Working Paper No. 3. Socioeconomics). CIMMYT.

Mittal, S., & Mehar M. (2013). *Agricultural information networks, information needs and risk management strategies: a survey of farmers in Indo-Gangetic plains of India.* socioeconomics working paper 10. Mexico, D.F.: CIMMYT.

Mittal, S. (2012). *Modern ICT for Agricultural Development and Risk Management in Smallholder Agriculture in India.* CIMMYT. Socioeconomics Working Paper 3. Mexico, D.F.: CIMMYT.

Mittal, S., Sanjay G., & Gaurav T. (2010). "*Socio-Economic Impact of Mobile Phones on Indian Agriculture.*" Working Paper No. 246. *Indian Council for Research on International Economic Relations* (ICRIER). New Delhi, India.

Misaki, E., Apiola, M., Gaiani, S. (2016). Technology for small scale farmers in Tanzania: A design science research approach. *Electronic Journal of Information Systems in Developing Countries, 74*(4), 1-15.

Ministry of Agriculture Livestock Fisheries & Irrigation, (2019). *Agricultural Sector Transformation and Growth Strategy 2019 – 2029.* Towards Sustainable Agricultural Transformation and Food Security in Kenya." Abridged Version. Ministry of

Agriculture, Livestock, Fisheries and Irrigation (MOALF & I). Retrieved from http://www.kilimo. go.ke/wp-content/uploads/2019/01/Download-here.pdf.

Munyua, H., Adera, E., & Jensen, M. (2009). *Emerging ICTs and their potential in revitalizing.*

Mojaki R. A, & Kerogoro K.J.B. (2019). Turning Challenges into Opportunity: Potential for Adoption of e-Extension in Lesotho. *Journal of Agricultural Extension and Rural Development.11(11)*,184-191. Retrieved from https://academicjournals.org/journal/JAERD/article-full-text-pdf/EA797A962148

Moore, H. L. (2018). Prosperity in crisis and the longue durée in Africa. *The Journal of Peasant Studies.* Available at https://doi.org/10.1080/03066150.2018.1446001.Accessed on April 2020.

Mtega, W. P., & Msungu, A. C. (2013). Using Information and Communication Technologies for enhancing the accessibility of Agricultural Information for Improved agricultural production in Tanzania. *Electronic Journal of Information Systems in Developing Countries 56,* (1), 1-14 *smallholder agriculture in Africa.* Agric. Inf. Worldw. 2009, 2, pp 3–9.

Muthoni, K. N. (2018). Enhancement of Agricultural Extension Services in Kenya: A Case of Embu County. *Journal of Agriculture and Environmental Sciences, 7*(2), 32-44. Access at http://jaesnet.com/journals/jaes/Vol_7_No_2_December_2018/4.pdf

Mukembo, S., & Edwards, M. C. (2016). Agricultural Extension in Sub-Saharan Africa During and After Its Colonial Era: The Case of Zimbabwe, Uganda, and Kenya. *Journal of International Agricultural and Extension Education, 22* (3), 50-68. https://doi.org/10.5191/jiaee.2015.22304

Mutunga, I.M. & Waema T.M (2016). Context of mobile phone use and its effects on smallholder farmer's livelihood outcomes in Kenya. *International Journal of Scientific Research and Innovative Technology(3)* 4 ISSN: 2313-3759.

Mugwisi, T., Mostert J., & Ocholla, D.N. (2015). Access to and Utilization of Information and Communication Technologies by Agricultural Researchers and Extension Workers in Zimbabwe. *Information Technology for Development, 21*(1), 67-84.

Munyua, H. (2008). *ICTs and smallholder agriculture in Africa: a scoping study.* International Development Research Centre (IDRC)

Muyang, M. & Jayne, T. (2006). *Agricultural Extension in Kenya: Practice and Policy lesson 1* Retrieved from http://watermon.tamu.edu/, Accessed April 12, 2018.

Mugenda, O. M., & Mugenda, A. G. (1999). *Research methods*: Quantitative and Qualitative approaches. Nairobi, Kenya: ACTS press.

Mwantimwa, K. (2019). ICT usage to enhance firms' business processes in Tanzania. *Journal of Global Entrepreneurship Research, 9* (46), 1–23. https://doi. org/10.1186/s40497-019-0170-6

Mwalupaso, G. E. Wang, S. Xu, Z. Xu, I. (2019). Towards Auspicious Agricultural Informatization- Implication of Farmers' Behavioral Intention Apropos of Mobile Phone Use in Agriculture. Sustainability Article

Mwololo, H. M., Nzuma, J. M., Ritho, C. N., & Aseta, A. (2019). Is the type of agricultural extension services a determinant of farm diversity? *Evidence from Kenya, Development Studies Research, 6* (1), 40-46. doi.org/10.1080/21665095.2019.1580596

Myeni, L. Moeletsi, M. Thavhana, M. Randela, M. Mokoena, L. (2019). *Barriers Affecting Sustainable Agricultural Productivity of Smallholder Farmers in the Eastern Free State of South Africa. Sustainability 2019*, 11, 3003.

Namyenya, A., Daum T., Rwamigisa P. B. & Birner R. (2021). E-diary: a digital tool for strengthening accountability in agricultural extension. *Journal of Information Technology for Development*. DOI: 10.1080/02681102.2021.1875186

Narine, L. K., Harder, A., & Roberts, T. G. (2019). Extension Officers' Adoption of Modern Information Communication Technologies to Interact with Farmers of Trinidad. *Journal of International Agricultural and Extension Education,26* (1), 17-34.

Naruka, P. S., Verma, S, Sarangdevot, S. S., Pachauri, C. P., Kerketta, S. & Singh, J.P. (2017). A Study on the role of WhatsApp in Agriculture Value Chains. *Asian Journal of Agricultural Extension, Economics & Sociology, 20* (1), 1-11.

Nakasone, E., & Torero M. (2016). "A Text Message Away: ICTs as a Tool to Improve Food Security." *Agricultural Economics 47* (1), 49–59.

Nain, M.S., Ravi K. K., Singh R., Chahal, V.P. & Bana R.S. (2015). Analysis of farmers' communication network and factors of Knowledge regarding agro metrological parameters. *Indian Journal of Agricultural Sciences, 85* (12),159296.

Nakasone, E., Torero, M., & Minten, B. (2014). The power of information: The ICT revolution in agricultural development. Annual Review of Resource Economics, 6(1), 533–550. https://doi.org/10.1146/annurev-resource-100913-012714

Narayanan, S. & Gulati A. (2002). *Globalization and the Smallholders; A Review of Issues, Approaches and Implications*. World Bank Report

Nassiuma, D. K. (2000). *Survey Sampling: Theory and Methods*. Njoro, Kenya: Egerton University Press.

Norberth, U., C., Adesina T., K., & Mercy O., C. (2018). Utilisation of Agricultural Information sources and adoption of animal and crop technologies among farming households in Imo State, Nigeria. *Journal of Agricultural Extension, 22* (1), 143-155.

Nwafor, C. U., & Abiodun O. (2020). Rural Smallholder Farmers' Awareness and Use of ICT-based Market Information Sources in South Africa.

Nwagwu, W. E., & Famiyesin, B. (2016). Acceptance of Mobile Advertising by Consumers in Public Service Institutions in Lagos, Nigeria. *The Electronic Library, 34* (2), 265–88.

Nyirenda, J. T. (2010). *Unlocking the Promise of ICTs for Transforming Agriculture in Africa.* NEPAD, e-Africa Commissions, Pretoria, South Africa.

Nzonzo, D., & Mogambi, H., (2016). An analysis of Communication and Information Communication Technologies adoption in irrigated rice production in Kenya. *International Journal of Educational Research, 4* (12),295–316.

Odinga, G.A. (2018).*Assessing County Government Modalities for Disseminating Agricultural Information to Farmers in Alego Usonga Ward, Siaya County, Kenya.* Msc. Thesis, Kenyatta University.

Ogutu, S. O., Okello, J.J & Otieno D.J (2014). Impact of information and communication technology-based market information services on smallholder farm input use and productivity: The case of Kenya. *World Development Vol 64*: pp 311-321. Available at https://doi.org/10.1016/j.worlddev.2014.06.011

Ogula, A. (1998). A Handbook on educational research. Nairobi: New Permit Publishers.

Ogalleh, S., Vogl, C., Eitzinger, J., & Hauser, M. (2012). Local perceptions and responses to climate change and variability: The case of Laikipia district, Kenya. *Sustainability, 4*(12), 3302–3325. https://doi.org/10. 3390/su4123302

Okello D.O (2017). *Effect of ICT Use on Performance of Agrienterprises. A case of Smallholder Pineapple farmers in Kiambu County, Kenya.* Master's Thesis Egerton University.

Okello, J. J., Kirui, O. K., Gitonga Z. M., Njiraini, W. G., & Nzuma, J. M. (2014). Determinants of Awareness and Use ICT-Based Market Information Services in Developing Country Agriculture: The Case of Smallholder Farmers in Kenya. *Journal of International Agriculture, 53* (3), 263-282.

Okello, J. J. (2010, May). *Does use of ICT-based market information services (MIS) improve welfare of smallholder farmers? Evidence from Kenya.* A conference paper presented at the 4th Acorn-Redecom Conference Brasilia, DF, May 14-15.

Ongachi, W., Onwonga, R., Nyanganga, H., & Okry, F. (2017). Comparative Analysis of Video Mediated Learning and Farmer Field School Approach On Adoption of Striga Control Technologies in Western Kenya. *International Journal of Agricultural Extension* .2311-8547 ISSN: 2311-6110 (Print). Retrieved from http://www.escijournals.net/IJAE

Otene, V.A., Ezihe, J.A.C., & Torgenga, F. S. (2018). Assessment of Mobile Phone Usage Among Farmers in Keana Local Government Area of Nasarawa State, Nigeria. *Journal of Agricultural & Food Information, 19*(2), 141-148.

Otieno, D. (2018). *Transforming the structure of agricultural information systems using mobile technology.* Tegemeo Institute blog. available at http://www.tegemeo.org/index.php/resources/blog/entry/transforming-the-structure-of-agricultural-information-systems-using-mobile-phone-technology.html

Otaala, S. (2016).An Assessment of the Extent of ICT Use Along the Dairy Value Chain in Western Uganda. Msc. Thesis, Haramaya University.

Osabutey, E. L. & Jin. Z (2016). Factors influencing technology and knowledge transfer: Configurational recipes for Sub-Saharan Africa. *Journal of Business Research, Vol 69*(11), *5390-5395*. Available athttps://www.sciencedirect.com/science/article/pii/S0148296316303472 Accessed: April 28, 2019.

Rono, S. K. (2013). *Adoption of Web24Dev tools in e-Extension project in Kenya.* Paper Presented at the Regional 2013 ICT aAg conference on 4th-5th November 2013. Available at https://www.slideshare.net/ctaspace/adoption-of-web24dev-tools-in-eextension-project-in-kenya

Oluoch-Kosura, W. (2013). *Introduction-Africa Agriculture Status Report.* AGRA 2013.

Ospina, A.V., & Heeks, R. (2010). *Linking ICTs and Climate Change Adaptation: e-Resilience and e-Adaptation.*

Oxfam International, (2009) 'Harnessing Agriculture for Development', Oxfam Research Report, Oxfam International. pp.13–16.

Qiang C. Z., Kuek S.C., Dymond A, & Esselaar S (2012). *Mobile Applications for Agriculture and Rural Development.* World Bank, Washington, DC.

Qiang C. Z., Kuek S.C., Dymond A, Esselaar S & Unit IS (2011). *Mobile Applications for Agriculture and Rural Development*. World Bank, Washington, DC.

Rahman, A. M. A. & Bashir, H. E. E. (2020). *Use of ICT in agricultural extension services, Gedarif State, Sudan*. IOP Conference Series: Earth and Environmental Science. Available at https://iopscience.iop.org/article/10.1088/1755-1315/458/1/012029/pdf Accessed on May 2021.

Rapsomanikis G., (2015), The economic lives of smallholder farmers. An analysis based on household data from nine countries, FAO, Rome, retrieved at: http://www.fao.org/3/a-i5251e.pdf Accessed on April 2021.

Renwick, S. (2013) *Potential for Use of Information Communication Technologies (ICT) Agricultural Extension.* Retrieved from http://uwispace.sta.uwi.edu/dspace/bitstream/handle/2139/12632/icts%20and%20extension%20final%20paper.pdf. Accessed on 10 July 2016.

Rhoades, E., & Aue, K. (2010). *Social agriculture: Adoption of social media by agricultural editors and broadcasters.* Paper presented at 107 th Annual Meeting and Conference of Southern Association of Agricultural Scientists. Orlando, Florida.

Richardson, D. (2009). *How Can Agricultural Extension Best Harness ICTs to Improve Rural Livelihoods in Developing Countries?* Issue 49, ICT update, CTA. http://ictupdate.cta.int/en/Links/Documents/How-Can-Agricultural-Extension-Best-Harness-ICTs-to-Improve-Rural-Livelihoods

Ronald, B. (2019).Using Information and Communication Technologies to Enhance Information Sharing For Improved Fish Farming Productivity In Tanzania. Phd. Thesis, Sokoine University Tanzania.

Rogers, E.M. (1995). *Diffusion of Innovations*. 4th ed. New York. Free Press.

Rogers, E. M. (2010). *Diffusion of Innovations*. Simon and Schuster

Sam, S. (2016). Towards an empowerment framework for evaluating mobile phone use and impact in developing countries. *Telematics and Informatics, 34*(1), 359-369. https://doi.org/http://dx.doi.10.1016/j.tele. 2016.06.003

Saravanan, R., Sulaiman, R., Davis, K. & Suchiradipta, B. (2015). *Navigating ICTs for Extension and Advisory Services.* GFRAS Good Practice Note for Extension and Advisory services.

Saravanan, R. (2010). *ICTs for Agricultural Extension. Global Experiments, Innovations and Experiences*, New Delhi: New India Publishing Agency.

Saxena, A. (2011): *Pedagogical Designs for Generation of Contents for Community, Community Development Theme*, Indira Gandhi National Open University Publications, New Delhi. pp 1-3.

Simar, L. & Wilson, P.W. (2015). Statistical approaches for non-parametric frontier models: A guided tour. *Int. Stat. Rev. 2015, 83*, 77–110.

Singh, R.K.P. and K.M. Singh. (2009). Climate Change, Agriculture and ICT: An Exploratory Analysis.

Stringfellow, R., Coulter, J., Lucey, T., McKone, C. & Hussain, A. (1997). *Improving the access of smallholders to agricultural services in sub-Saharan Africa: Farmer cooperation and the role of the donor community. Natural Resource Perspectives.* Overseas Development Institute.

Strong, R., Ganpat, W., Harder. A., Irby, T. L. & Lindner J. R. (2014). Exploring the Use of Information Communication Technologies by Selected Caribbean Extension Officers. *Journal of Agricultural Education and Extension 20* (5): 485-95.

Suchiradipta, B. & Saravanan, R. (2016) Social media: Shaping the future of agricultural extension and advisory services. GFRAS Good Practice Note for Extension and Advisory services.

Suri., T, Jack., W. (2016). *The long-run poverty and gender impacts of mobile money.* 354 (6317) 1288–1292. Retrieved from https://doi.org/10.1126/science.aah5309 PMID: 27940873 9.

Sulaiman, U., Michael, W. M., Yetunde, T. O. & Rabiu S. (2015). Awareness and use of information and communication technologies among extension agents in Kaduna state of Nigeria. *Journal of Agricultural Extension, 19* (1): 66-77.

Swanson, B.E. & Rajalahti, R (2010). Strengthening Agricultural Extension and Advisory Systems: Procedures for Assessing, Transforming, and Evaluating Extension Systems; World Bank: Washington, DC, USA.

Tata, J. S., & McNamara P. E. (2018). *Impact of ICT on agricultural extension services delivery: evidence from the Catholic Relief Services SMART skills and Farm book project in Kenya, The Journal of Agricultural Education and Extension, 24*(1), 89-110, DOI: 10.1080/1389224X.2017.1387160

Tata, J. S., & McNamara P. E. (2016). "Social Factors that Influence Use of ICT in Agricultural Extension in Southern Africa." *Agriculture, 6* (2), 15.

Tadesse, G. & Bahiigwa, G (2015). Mobile phones and farmers' marketing decisions in Ethiopia. World Dev. 68, 296–307. Available at https://reader.elsevier.com/reader/sd/pii/S0305750X14004082?token=BD080092564

Taragola, N., D. Lierde V., & Gelb E.. (2009). Information and Communication Technology (ICT) Adoption in Horticulture: Comparison of the EFITA, ISHS and ILVO Questionnaires.*Acta Horticulture 831*:73–82.

Thiga M.M., & Ndungu S. (2015). *Utilization of ICT for Agriculture: A case study of Kakamega County, Kenya*. Proceedings of the IST-Africa 2015 Conference.

Thiga, M.M., (2013). *Failing to scale up in ICT for agriculture projects: A Case Study of the NALEP Monitoring and Evaluation System, Kenya.* Technical Center for Agriculture and Rural Cooperation (CTA).

Tsan, M., Totapally S.D., Hailu, D.M & Addom, B.K (2019). *The Digitalisation of African Agriculture Report 2018-2019*.CTA 2019.

United Nations Conference on Trade and Development, (2017). *East African Community Regional Integration: Trade and Gender Implications*.Geneva: UNCTAD

United Nations Economic Commission for Africa, (2012). *Economic report on Africa 2007:Unleashing Africa's Potential as a pole for global growth.* UNECA, Addis Ababa, Ethiopia.

Van Campenhout, B., Lecoutere, E., & Spielman, D.J. (2017). ICT-mediated agricultural knowledge transfer in Uganda: What works? American Economic Association RCT Registry. https://www.socialscienceregistry.org/trials/2153/history/18586.

Wawire, W.A., Wangia M.S & Okello J.J. (2017) Determinants of Use of Information Communication Technologies in Agriculture: A Case of Kenya Agricultural Commodity Exchange in Bungoma County, Kenya. *Journal of Agricultural Sciences, (9)*128-137. Canadian Center of Science and Education.

Wanyama, R., Mathenge M.W. K., & Mbaka Z. S (2016). *Agricultural Information Sources and their effect on farm productivity in Kenya*. Tegemeo Institute of agricultural policy and development. WPS 62/2016.

Waruingi, J. & Muriithi E. (2016). How to Grow and Sustain the Digital Harvest? Deep dive into Business models of 15 ICT4Ag solution providers across Ghana, Kenya and Tanzania. Alliance for a Green Revolution in Africa (AGRA)

Wamwea, J.W. & Mutiga M.W. (2013). *Government ICTs for Agriculture: Lessons from the failed Maize Seed SMS Information Services in Kenya, in Failed ICT's for Agriculture.* Technical Center for Agriculture and Rural Cooperation (CTA).

Welch., V. Petkovic J., Simeon R., Presseau J., Gagnon D., & Hossain A. (2018). Interactive social media interventions for health behaviour change, health outcomes, and health equity in the adult population. Cochrane Database Syst Rev.

World Bank. (2019). *Independent Evaluation Group Project Assessment Report: Kenya Agricultural Productivity Program (KAPP I & II)*; Washington D.C: World Bank Group. Accessed April 2019 available at https://reliefweb.int/sites/reliefweb.int/files/resources/ppar_kenyaagriculture.pdf

World Bank Group (2018). *Kenya Economic Update, April 2018, No. 17: Policy options to advance the Big 4*. World Bank, Nairobi. Retrieved from: https://openknowledge.worldbank.org/handle/10986/29676

World Bank (2017a). ICT in Agriculture: Connecting Smallholders to Knowledge, Networks, and Institutions. Updated Edition. Washington, DC: World Bank. doi:10.1596/978-1-46481002-2.

World Bank. (2017b). *Employment in agriculture (% of total employment) (modeled ILO estimate)*. Accessed April 2018, retrieved from: https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS

World Bank. (2016). *World Development Report 2016: Digital Dividends; Creative Commons Attribution CC BY 3.0 IGO;* World Bank: Washington, DC, USA, 2016. Accessed April 2018, retrieved from: http://documents.worldbank.org/curated/en/896971468194972881/pdf/102725-PUB-Replacement-PUBLIC.pdf.

World Bank. (2011). *World Development Report. Growth and poverty reduction in agriculture's three worlds*. Pages: 26 – 44. Accessed April 2018, available at https://doi.org/10.1596/9780821368077.

Wyche, S., & Steinfield, C. (2016). Why Don't farmers use cell phones to access market prices? Technology affordances and barriers to market information services adoption in rural Kenya. *Information Technology for Development, 22*(2), 320–333. https://doi.org/10.1080/02681102. 2015.1048184

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**	**Timelines s**	**Detailed**	**Reliabilit y**	**Languag e**	**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	☐	e) Twitter	☐
b) SMS	☐	f) WhatsApp	☐
c) Email	☐	g) Facebook	☐
d) Interactive voice Response	☐	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	☐	e) Twitter	☐
b) SMS	☐	f) WhatsApp	☐
c) Email	☐	g) Facebook	☐
d) Interactive voice Response	☐	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 ☐
SMS ☐
Email ☐
Interactive voice Response ☐
Twitter ☐
WhatsApp ☐
Facebook ☐
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
Tel: Pilot: 254-51-2217620
254-51-2217877
254-51-2217631
Dir.line/Fax: 254-51-2217847
Cell Phone

UNIVERSITY
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

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Appendix G: Journal Publications

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Journal Homepage: -www.journalijar.com

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RESEARCH ARTICLE

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

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

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Authors' contributions

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

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Original Research Article

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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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