RELATIONSHIP BETWEEN SELECTED FACTORS AND USE OF INFORMATION AND COMMUNICATION TECHNOLOGY TOOLS AMONG CASSAVA SMALLHOLDER FARMERS IN RANGWE SUB-COUNTY, KENYA

DIMO CALEB JOHN

A Thesis Submitted to the Graduate School in Partial Fulfilment of the Requirements for the Master of Science Degree in Agricultural Extension of Egerton University

EGERTON UNIVERSITY

NOVEMBER 2022

DECLARATION AND RECOMMENDATIONS

Declaration

This thesis is my original work and has not been presented in this University or any other for the award of a degree.

Signature...  Date...16/10/2022...

Dimo Caleb John

EM12/13617/19

Recommendations

This thesis has been submitted with my approval as University supervisors

Signature...  ... Date…27/10/2022...

Dr. Stephen Wambugu Maina, PhD,

Department of Agricultural Education and Extension,

Egerton University,Njoro, Kenya.

Signature...  Date…20/10/2022…

Prof. Alice Ndiema Chesambu, PhD,

Department of Agribusiness Management and Extension,

Masinde Muliro University of Science and Technology,

Kakamega, Kenya.

COPY RIGHT

DEDICATION

This thesis is dedicated to the MasterCard Foundation through RUFORUM at TAGDev Egerton and my beloved family.

ACKNOWLEDGEMENTS

I would like to thank God for providing good health and ability throughout the study. My gratitude goes to MasterCard Foundation through Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) at TAGDev Egerton for giving me the scholarship to further my study. I appreciate the guidance of my supervisors Dr. Stephen Wambugu Maina of Egerton University and Prof. Alice Ndiema of Masinde Muliro University of Science and Technology. I extend my gratitude to the best support offered by all lecturers in the Department of Agricultural Education and Extension as well as the Faculty of Education and Community Studies. Thanks to the entire Egerton University and Masinde Muliro University of Science and Technology for their assistance. Am also grateful for the support given by the sampled smallholder cassava farmers and Agricultural extension officers in Rangwe Sub-County. Lastly, I acknowledge the unfettered support and encouragement given by my family and everyone of goodwill.

ABSTRACT

The use of mobile phones, televisions, computers, and radios in agricultural extension enhances the efficient sharing of agricultural information and improves the link among farmers, researchers, and agricultural extension officers in Kenya. Nevertheless, the use of these Information and Communication Technology (ICT) tools to access production inputs, management practices, post-harvest practices, and marketing was underutilized among smallholder farmers (SHFs). The purpose of this study was to determine the relationship between selected factors (socio-economic status, access to credit, and training) and the use of ICT tools among cassava smallholder farmers in Rangwe Sub-County, Kenya. The study adopted a correlation research design and targeted 3808 SHFs growing cassava in Rangwe Sub-County, Kenya. The accessible population was 3025 members of cassava farming groups in the Sub-County. Simple random sampling techniques were used to select a total sample size of 106 SHFs from four wards of the Sub-County. Pretested semi-structured questionnaire was used to collect data. Validity was determined by the experts in the departments. Reliability of 0.756 α Cronbach alpha was attained through a pilot test with 30 SHFs in Homa-Bay Town Sub-County. Descriptive data analysis was done using frequency, percentage, and cross-tabulation while hypotheses were tested at a 0.05 level of significance using linear regression with the aid of Statistical Package for Social Science (SPSS) Version 25. The majority of the SHFs were female, middle age (36-50 years), attained primary education and earned the lowest average annual income ($X \leq$ KES160, 000). Selected socio-economic factors had very high correlation with ICT adoption (R=0.912, P=0.004, R^2=0.832, Adj. R^2= 0.825) while Access to training and access to credit had a moderate correlation with the adoption (R = +.778, P = .004, R^2 =0.602) and (R = +.654, P = .003, R^2 =0.427, adj. R^2=0.422) respectively. The three null hypotheses were rejected. In conclusion, a unit change in the selected factors results in a significant change in ICT adoption. The study recommends the empowerment of women, adults, and those with low education. Credit subsidies and training should also be enhanced.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS AND ACRONYMS

CBSD: Cassava Brown Streak Diseases.

CIDP: County Integrated Development Plan.

CMD: Cassava Mosaic Disease.

DAE: Department of Agricultural Extension.

FAO: Food and Agriculture Organization.

FAOSTAT: Food and Agriculture Organization Statistics.

ICT: Information and Communication Technology.

IFPRI: International Food Policy Research Institute.

IITA: International Institute of Tropical Agriculture.

KALRO: Kenya Agricultural and Livestock Research Organization.

KES: Kenyan Shillings.

MoALFI: Ministry of Agriculture, Livestock, Fisheries and Irrigation.

NACOSTI: National Commission for Science, Technology and Innovation.

NAFIS: National Farmers Innovation services.

NGOs: Non-Governmental Organizations.

RUTAM: Rural Technology Acceptance Model.

SACCOs: Saving and Credit Co-Operative

SHFs: Small Holder Farmers.

SPSS: Statistical Package for Social Science.

WAOs: Ward Agricultural Officers.

CHAPTER ONE
INTRODUCTION

1.1 Background Information

Agriculture is the central point where economy of most countries turn aroud. It is a system that involve many sub-sectors. The sub-sectors include irrigation, mechanization, extension, education and training, marketing, researcher and processors (Kundiri *et al.*, 2022). Agriculture provide food to many households through crop production and livestocks enterprise in various countries. It is a significant sector that should be given priority in food security improvement campaign (Hussain *et al*., 2022). Agriculture has been considered as the main source of income and employment for many people and enhancer in rural development (Beckman, *et al*., 2021). The sector contributes largely to the grows domestic products in many countries since it is a source of raw materials for foregn exchange (Mizik, 2021).

Production and yield of agriculture is low in some countries as a result of production challenges among smallholder farmers in the sector. The constraints may include planting time, climate change, poor soil nutrients, pests and diseases infestation, inadequate reliable market information and postharvest handling techniques among other problems (Bielski *et al.,* 2021). The smallholder farmers may solve these problems through various technologies develop by researchers and communicated by agricultural extension officers (Were *et al.,* 2022). It is necessary to have a close link among the farmers, researchers and extension officers to ensure timely communication of the agricultural information for quick adoption. However, efficient communication is difficult to achieve with traditional extension method; where agricultural extension agents must physically travel to meet the farmers and train them on the innovations (Parlasca *et al.,* (2022).

Globally, traditional agricultural extension face significant challenges in meeting farmers' diverse information needs and demands because the number of the farmers are higher than the number of the extension officers. This makes adoption of agricultural technology difficult among the farmers (Karanja *et al.,* 2022). The successful adoption of agricultural technology and providing necessary information is essential to achieving the rural development goals (Zulqarnain *et al.*, 2020). Parlasca *et al.,* (2022) noted that actively performing agricultural extension system is a crucial mechanism for sharing knowledge and encouraging adoption of a novel agrarian technology among rural SmallHolder Farmers (SHFs). According to Sa'adu *et al.* (2022), a thriving agricultural extension

program depends on disseminating agrarian information, knowledge exchange, effective communication and interaction among stakeholders who include researchers, agricultural extension staffs and farmers. Wan-Mohd *et al.* (2020) noted that agricultural extension should embrace modern technology and Information and Communication Technology (ICT), which can facilitate knowledge management process to achieve sustainable development and improve production of food security crops, which include cassava (*Manihot esculenta*).

Cassava is a root tuber food security crop that has the potential to perform well unger extreme environmental condition. It can provive food security especially now that the change in climate has caused failure of many crops in Africa leading to increase in hunger (Ouma *et al.*, 2021). Cassava is a staple food for Africa, Latin America and Caribbean cuisines (Kundiri *et al.*, 2022). The crop can provide food to many household for long period of time. The crop is a good source of vitamin C, riboflavin, niacin and resistant starch that assist in blood sugar management and health of gut (Obong'o *et al*., 2020). Therefore more effort should be channeled to its production and yield. The crop was chosen for this study because there was a campaign on improving its production and yield to help in food security.

In Africa, cassava smallholder farmers need agricultural information that include adequate cassava inputs, management practice and marketing, among other extension services (Were *et al.*, 2022). In addition, there are infestations of crop pests and diseases such as cassava whitefly, cassava green spider mite, cassava bacterial blight, Cassava Brown Streak Diseases (CBSD) and Cassava Mosaic Disease (CMD) (Okuku, 2018). The diseases affect the plants' growth and production of tubers depending on the infection level of the plant. Cassava that is severely affected by the illnesses shows poor growth with no tubers, while cassava moderately affected produces few tubers with intermediate development compared to a healthy plant. The pests cause chlorosis, shriveled leaves and yellow speckles (Wagaba *et al*., 2021). Kabir *et al.* (2022) noted that the use of ICT tools in sharing agricultural extension services has a potential to solve the farm problems.

In Kenya, the Government and other organizations like the International Institute of Tropical Agriculture (IITA) and Kenya Agricultural and Livestock Research Organization (KALRO) introduced some clean cassava seeds. The seeds were believed to be early maturing and disease resistant. The varieties include mijera, shibe, karembo, karibuni, nzalauka, tajirika, Siri, TMS30572, MH95/0183, TM/14 and MH93/OVA (Cheboi *et al.*, 2021). Agricultural extension

officers from Green Shamba, One Acre Fund and the Ministry of Agriculture, Livestock, Fisheries, and Co-operatives (MoALFC) disseminated the information about the new varieties. However, the extension staffs were limited by the large number of the farmers widely distributed in the region and this necessitated the use of ICT tools in agricultural extension to reach many farmers at the same time.

In Rangwe Sub-County, the agricultural extension agents resorted into the use of mobile phones, radios, televisions and computers to access the farmers easily as oppose to the traditional method, where agricultural extension officers had to travel and physically serve the farmers (Samwel *et al.*, 2021). The sectors providing services through ICT tools in the Sub-County include the Sub-County Agricultural Extension Officers, Green Shamba, One Acre Fund, Shamba Shape-Up, National Farmers Innovation services (NAFIS), Mfarm and M-farmer. The platforms provided good agricultural services that covered farm inputs supply, agrarian credits, harvesting, storage, marketing, value addition and post-harvest management (Gaol & Gustira , 2020).

Martinez-Gomez *et al.* (2022) reported that capacity of ICT to improve agricultural extension service delivery still possess challenges that caused its low adoption. The use of ICT tools in agriculture among SHFs can be influenced by various factors that include infrastructural, institutional and socio-economic factors, among others (Ulhaq *et al.*, 2022). Rogers (2003), in the diffusion of innovation study, suggested socio-economic factors, personalities variables and communication behavior as characteristics of decision-making units in the process of technology adoption. The rural technology acceptance model (RUTAM) noted that some external and socio-economic factors influence the use of a technology (Lazim *et al.*, 2021).

Some research findings have highlighted that a few socio-economic factors (household size, head of household, exposure to internet) and institutional factors (cybercrime, awareness, availability, power source) determine the application of ICT in agriculture among smallholder farmers (Gupta *et al*, 2021; Pinto *et al*., 2021). Identifying the relationship between technology adoption and the driving factors is necessary in the agenda to promote the adoption of technologies in agricultural extension (Dhehibi *et al.,* 2020). This study selected a few factors that include age, gender, income level, education level, access to credit and access to training on the matters of using the ICT tools in agricultural extension. The chosen factors were considered for this study because there is limited

information on whether they have a relationship with the adoption of ICT tools in agricultural extension among smallholder farmers.

The study was conducted at Rangwe Sub-County, which is loacated in Homa-bay County, Kenya, Africa. It aimed at determining whether the selected factors have a relationship with the application of ICT tools among cassava smallholder farmers in the Sub-County. Rangwe Sub-County was chosen for this study because the MoALFC in the Sub-County promotes cassava production among the smallholder farmers since the crop can perform well in that area and provide food security throughout the year (Samwel *et al.*, 2021). Agricultural extension officers used ICT tools such as mobile phones, televisions, computers, and radios to disseminate information on input supply, cassava management practices, and marketing services. However, the use of the ICT tools among cassava smallholder farmers was inadequate.

1.2 Statement of the Problem

The majority of cassava smallholder farmers in Rangwe Sub-County, Kenya required efficient access to agricultural extension information that include reliable cassava marketing, agricultural credit and cassava production inputs among other services. The use of ICT tools such as mobile phones, smartphones, computers, televisions and radios in agricultural extension has the potential to improve access to the information timely and efficiently among the farmers. The ICT tools can help the farmers receive the agricultural extension services faster without physical interaction. However, the use of the tools among cassava SHFs in the Sub-County was observed to be low. This led to delay in access to the information and poor linkage among the smallholder farmers, extension officers and researchers.

Factors that may determine technology adoption in agricultural extension include institutional, socio-economic and infrastructural. Some research studies have reported on these factors except a few that this study selected. There is a gap in knowledge whether age, gender, income level, education level, access to credit and access to training have relationship with the use of ICT tools among cassava smallholder farmers in Rangwe Sub-County, Kenya. Bridging this gap might improve the adopt of ICT tools among the farmers.

1.3 Purpose of the Study

This study sought to increase the adoption of ICT tools in agricultural extension through determining relationship that age, education level, income level, gender, access to training, and access to credit have with the use of ICT tools among cassava smallholder farmers in Rangwe Sub-County, Kenya.

1.4 Objectives of the Study

The objectives of this study were to:

(i) Determine the relationship between selected socioeconomic factors and the use of ICT tools among cassava smallholder farmers in Rangwe Sub-County, Kenya.

(ii) Determine the relationship between access to training and the use of ICT tools among cassava smallholder farmers in Rangwe Sub-County, Kenya.

(iii) Determine the relationship between access to credit and the use of ICT tools among cassava smallholder farmers in Rangwe Sub-County, Kenya.

1.5 Research Hypotheses

The following null hypotheses derived from the objectives of this study guided the study:

H01: The selected socioeconomic have no statistically significant relationship with the use of ICT tools among cassava smallholder farmers in Rangwe Sub-County, Kenya.

H02: Access to training has no statistically significant relationship with the use of ICT tools among cassava smallholder farmers in Rangwe Sub-County, Kenya.

H03: Access to credit has no statistically significant relationship with the use of ICT tools among cassava smallholder farmers in Rangwe Sub-County, Kenya.

1.6 Significance of the Study

The study was significant because its findings brought the understand that access to credit, access to training, age range, education level, income level and gender have relationship with the adoption of ICT tools in agricultural extension. This knowledge might give the farmers direction on where to improve in order to increase the adoption. The results pointed out that there is need to improve training of the farmers about ICT tools and a subsidized credit interest. Other researchers may also use the results from this study as a source of knowledge for reference.

1.7 Scope of the Study

The respondents in this study were SHFs who grew cassava in Gem East, Gem West, Kochia and Kagan administrative wards of Rangwe Sub-County in Homa-bay County, Kenya. The research focused on the relationship that age, gender, education level, income level, access to credit and access to training have with the use of ICT tools in agricultural extension among cassava smallholder farmers in Rangwe Sub-County, Kenya. The ICT tools that the study focused on included televisions, mobile phones, radios and computers.

1.8 Assumptions of the Study

The following were the assumptions of the study:

(i) The sampled responses were a true reflection of the situation in the entire Rangwe Sub-County.

(ii) The respondents participated in the study willingly.

1.9 Limitation of the Study

The following was the limitation of this study:

Rangwe Sub-County had inadequate current literature addressing the research topic.

1.10 Definition of Terms

The following terms used in this study have the following meanings;

Access to credit: To be able to get money, services or goods from lenders (Mushtaq *et al*., 2022). In this study, access to credit was used to mean the ability of the SHFs to obtain loan or agricultural production inputs for a promised future payment with interest. The variable was measured by whether a farmer received agricultural credit, if yes then credit sources and amount received per year.

Access to training: The opportunity to get teaching on a particular skills or information (Chohan & Hu, 2022). In this study, access to training was used to mean liberty to obtain learning activities conducted to equipt the SHFs with knowledge on how to use ICT tools in agricultural extension. It was measured by whether a farmer attended the training or not, if yes then the number of training, training sources and information involved.

Age: The length of time that someone has lived or something has existed (Kundiri *et al*., 2022). In this study it means the number of years that the SHFs have lived since birth. It was

measured by the number of years a farmer had lived. The ages were categorized and coded as: 1= 18-32 (youths), 2=33-47 (middle age), 3= 48-62 (early old) and 4= above 62 (late old).

Income: Money received, especially on a regular basis for work or through investment (Oyekola, 2021). It was used in this study to mean amount of money a farmer obtained from salary and/ or sales of agricultural products. It was measured by the amount of money that each farmer received from sales of agricultural products, investments or business within a year. The income was categorized and coded as: 1=below 160, 2=161-270 and 3= 271-380 and 4=above 380.

Education: The process of giving or gaining systematic knowledge (Krell *et al*., 2020). In this study it means formal knowledge that one acquires from learning institutions. It was measured by the level of formal knowledge that a farmer had attained from schools. The levels were categorized and coded as: none = 1, primary = 2, secondary = 3, post-secondary = 4 and any other = 5.

Gender: The state of being female, male or both with reference to cultural and social responsibility (Huijsmans *et al*., 2021). In this study, it refers to male or female in relation to the cultural and social roles that the societies consider appropriate for a specific gender. It was measured by whether the farmer was male or female. It was categorized and coded as 1= male and 2= female.

Selected factors: The chosen elements that contribute to the observed results (Vilhanová *et al*., 2020). In this study, selected factors refer to specified circumstances that can cause change in behave of the SHFs. The factors selected in the study included socioeconomic status, access to credit and access to training on ICT tools.

Smallholder farmers: Farmers who produce cassava with less advanced and cheap technologies on a relatively small piece of land approximately 2-3 hectares (Dhehibi *et al.,* 2020). In this study it refers to farmers who produce cassava using cheaper technology on a small piece of land approximately 2-3 hectares.

Socioeconomic factors: Refers to personal characteristics related to one's society and economy that influence one's perception, lifestyle and personalities (Diaz *et al*., 2022). In this study it refers to the personal characteristics related to economy, development and society of the SHFs who produce cassava. The socioeconomic factors in this study included education, age, gender and income of the SHFs.

Information and Communication Technology tools: Electronic communication devices (Jablanovic, 2021). In this study it refers to communication gadgets such as radios, televisions, mobile phones and computers used to access agricultural extension information among SHFs in Rangwe Sub-County. This variable was measured by whether a farmer used the tools in agricultural extension or not, types of the types information involved, opportunities and challenges in the use.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

Chapter two contains review of selected relevant theoretical, conceptual and empirical literature to identify the existing gap that the study sought to address. The chapter begins by agricultural extension, the use of ICT tools in extension, overview of cassava production and its economic value, selected socio-economic factors, access to training and access to credit. Lastly, it gives the theoretical framework and a conceptual framework of this study.

2.2 Use of Information and Communication Technology Tools in Extension

The modern world has many technologies that provide a base for social transformation. One of the most important technologies used in various sectors globally is ICT, which is the most advanced technology in the past three decades (Spielman *et al*., 2021). Agriculture sectors in America, Europe and Asia have adopted ICT tools in farm operations, access to credit and marketing of the products. This has enabled smallholder farmers to advance their access to the ICT tools used in agriculture (Jat *et al*., 2021). According to Baruah and Mohan (2021), some smallholder farmers across the globe have benefited from the use of televisions, mobile phones, radios and computers in agriculture.

Use of ICT tools in agricultural extension focuses on the adoption of the tools in disseminating agricultural information among the farming stakeholders (Al-Mamary, 2022). Dissemination of quality agricultural extension services promotes the use of new agricultural technologies which in turn improve farm productivity (Kassem *et al.,* 2021). One of the major solutions for the agricultural extension challenges is the use of ICT in the sharing of agricultural extension services (Ohlan *et l*., 2021). The ICT is electronic tool use to enter data, store, process and share information. Common ICT tools among smallholder farmers include mobile phones, televisions, computer and radios (Mishra *et al*., 2020).

These tools have the potential to improve diffusion of agrarian technologies and connect rural smallholder farmers with agricultural extension officers easily. Farm digitalization and promoting data-based agrarian tools are essential in fostering farming innovation. Raza *et al.* (2020) noted that digitalized farm innovations are modern farm inputs to solve agricultural extension problems.

Numerous ICT-based development initiatives around the world have beneficial impacts, starting from Information Technology application in Europe, the IKisan portal in India, mobile phone-based animated videos in Burkina Faso, the Agriculture portal in Bangladesh (Sa'adu *et al.*, 2022).

Studies revealed that the effective use of ICT tools in agricultural extension depends greatly on institutional and socio-economic factors among the smallholder farmers. The ability of the smallholder farmers to use various ICT tools depends on continued training and funding from organizations. It also based on their age, income, education and gender (Gupta *et al.*, 2021). Lazim *et al.* (2021) noted that promoting farm technologies instead of addressing communication constraints of smallholder farmers is one of the reasons for agricultural extension failures in in the adoption of ICT tools.

The current world greatly depends on ICT tools for accessing agricultural information, which are increasingly becoming the fundamental drivers of social and economic development in agriculture across the globe (Abdul-Rahaman & Abdulai, 2021). Episodic evidence of research results showed that radios, mobile phones, smartphones and televisions are the essential communication tools that are readily available to smallholder farmers and agricultural extension agents for sharing agricultural related information and knowledge globally (United Nations, 2020). A few agricultural extension agents and smallholder farmers in India, Brazil and Vietnam have successfully used ICT tools such as radios, televisions, computers and mobile phones in agriculture. However, some farmers do not use the ICT tools in agriculture (Mishra *et al*., 2020).

In Africa, agricultural extension agents and researchers have succeeded in using ICT tools to share agrarian information services easily to smallholder farmers (Bhusal *et al.*, 2021). However, the farmers' turn-out to use the ICT tools in agriculture is not optimum. Khidir (2020) reported that some of the smallholder farmers in Nigeria used various ICT tools in agriculture. Similarly, Getahun (2020) found that ICT tools have been used successfully in agriculture among smallholder farmers in Ethiopia. However, the ICT tools utilization in agriculture is not optimum. Nyarko and Kozári (2021) conducted a study in Nigeria on e-resources in agricultural extension among public agricultural extension agents. They found that most of them prioritize the use of ICT tools because it is a faster and easier method of disseminating agricultural information to smallholder farmers. The majority of agricultural extension agents use mobile phones, televisions and smartphones to

share information on marketing, credits, fertilizers, on-farm management practices, pests and diseases control mechanisms among smallholder farmers.

In Kenya, a lower percentage of smallholder farmers have used ICT tools such as mobile phones to share agricultural information. A few smallholder farmers who use the ICT tools have realized a significant increase in farm yields and income due to quick access to inputs, credits and marketing, among other services (Githinji, 2022). However, the potential of using the ICT tools in accessing agricultural information is still underutilized. Some of the smallholder farmers and agricultural extension agents in Kenya used radios, televisions, mobile phones, cameras and computers in agriculture (Awuor & Rambim, 2022). However, the use of the ICT tools in agriculture is still recording low.

In Rangwe Sub-County, Agricultural extension officers use ICT tools such as radios, mobile phones, televisions and computers to disseminate agricultural information to SHFs and others. Some households in the Sub-County have at least one of the ICT tools, though; they used them for various intended purposes. Some of the farming households use them for entertainment, while others use them to access marketing, management practices and input supply (County Integrated Development Plan [CIDP], 2021). Despite the effort of the agricultural extension officers to share agricultural information through the ICT tools, the use of the tools in agriculture among SHFs in Rangwe Sub-County is still low. In addition, there is inadequate information on whether education level, age range, gender, income level, access to credit, awareness and agricultural knowledge needed influence the use of the ICT tools in cassava production among the smallholder farmers in the Sub-County.

2.3 Overview of Cassava Production and its Economic Value

Cassava (*Manihot esculenta Crantz*) originated from Latin America and managed to spread across many countries globally with the help of Portuguese traders (Krishna *et al.*, 2020). The young leaves and mature tubers of cassava possess many end-uses, including human consumption of fresh tubers, boiled leaves, commercial production of starch or starch derivatives, animal feed and ethanol used as automotive fuel or liquor (Adiele, 2020). Smallholder farmers are the majority of cassava producers in the top country producers of cassava globally, such as Nigeria, Indonesia, Brazil, Vietnam, China, India and Thailand (Szyniszewska, 2020).

Globally, the average yield of cassava is about 13 tons per hectare against the expected average output of about 24 tons per hectare (Krishna *et al.,* 2020). In India, Thailand, China, and Vietnam, cassava is mostly grown for local consumption and exported to other countries (Bukar *et al*., 2022). In China, Guangxi province is responsible for about 60% of the cassava production in the country (Adiele, 2020). It is reported that India cultivates cassava on about 0.20 million hectares and gets an average production of 8.13 million tons and 22.3 metric tons per hectare, which is both consumed locally and exported to other countries to help in food security (Lekshmanan *et al*., 2022).

In Africa, cassava was originally considered inferior food however, the current advancement in processing technologies and climate change have increased its economic value. There is an increased demand for fresh cassava and processed products such as starch, dried cassava and flour (Amelework & Bairu, 2022). The governments and various development donors are investing in considerable programs, which include providing access to agricultural extension services, cassava marketing and cassava inputs among other services to promote and improve the average cassava yield and livelihood of the smallholder farmers (Ekpunobi *et al*., 2020).

African countries heavily depend on root-tuber crops like cassava, potatoes and yam. Smallholder farmers in Africa mostly grow cassava as a staple or sub-staple food (Uzochukwu *et al.,* 2021). Cassava is the third-highest source of carbohydrates in Sub-Saharan Africa, providing daily nutrition for over 800 million people (Sunday, 2020). The topmost African countries in cassava production include Nigeria with the highest yield of about 20.4%, followed by the Democratic Republic of Congo with 10.83%, Ghana with 6.32% and Angola with 4.02% (FAOSTAT, 2020). The average yield of cassava in Africa is the lowest, with about 10 tons per hectare against the expected average output of about 25 tons per hectare compared to other continents of the world that actively produce cassava (Otun *et al*., 2022).

In Kenya, cassava is produced in Western, Coastal, Central and Eastern regions by majority of smallholder farmers, who mostly intercrop it with maize, beans and banana (Simiyu *et al*., 2022). The smallholder farmers need agricultural information that include access to cassava inputs, credit and cassava marketing among other services (Mutoni *et al.,* 2022). These services can be accessed timely when the smallholder farmers use ICT tools to share the information about them. The ICTs tools that agricultural extension officers commonly use to disseminate the agricultural information

in Kenya include e-mail, internet, mobile phones, smart phones, radios, televisions and computers (Ouma & Ngala, 2021).

Cassava is one of the strategic crops that can tolerate adverse climatic patterns in some parts of Kenya. It performs better in areas with limited rainfall (Ouma *et al.,* 2021). Figure 1 shows the trend in cassava yield. It revealed how the yield of cassava has been fluctuating from the year 2011 to 2020. It revealed a decline in the current yield. The average cassava yield has been fluctuating between 5 to 15 tons per hectare against the expected average output of 40 to 50 tons per hectare. The majority of cassava growers in Kenya are smallholder farmers, who produce it as the second most crucial root tuber crop (FAOSTAT, 2021).

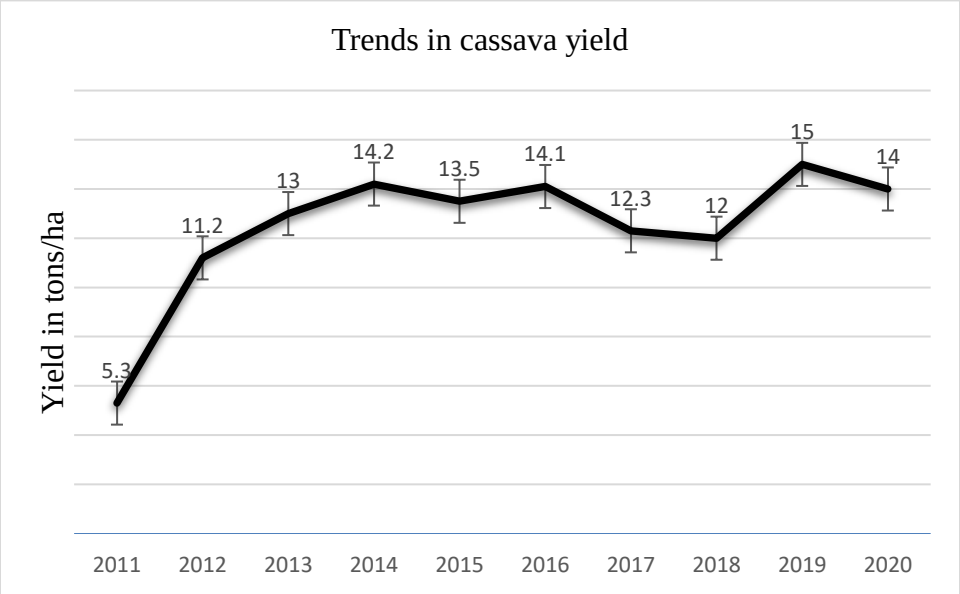


Figure 1: Trends in cassava yield (FAOSTAT, 2021).

Kenya is one of the leading African countries in cassava export with about 0.0052% share globally and earns the country about 114,000 United States Dollars of total export value per annum (Mutoni *et al.,* 2022). The smallholder farmers produce the crop in an average land size of about 90 000 hectares per year. The western part of Kenya grows and consumes about 60% of the national cassava production, which was 946,076 tons as of the year 2018 (FAOSTAT, 2020).

In Rangwe Sub-County, cassava remains the most important food security crop for the rural people. It is mainly grown by the smallholder farmers in the rural parts of Kochia, Kagan, Gem West and Gem East (CIDP, 2021). The sub-county is one of the significant producers of cassava

in Homa-Bay County. The farmers make use of manure, insecticides and other on-farm management practices to increase yield and control pests and diseases (Were *et al.,* 2022). The average cassava yield in the sub-county is about 5.2 tons per hectare against the expected average output of 20 tons per hectare (Mutoni *et al.,* 2022). The majority use and consume cassava, especially when the stocks of maize and millet are depleted or during drought. Some also mix cassava with millet, make flour, boil the tuber and consume it. Cassava tuber is processed at the household level into flour. The tuber can be processed into sun-dried chips locally named *Abeta* or dried fermented locally referred to as *Akuoga.* These products are sold to consumers, retailers and wholesalers (Obong'o *et al.,* 2020).

2.4 Selected Socio-economic factors

Socio-economic factors play a vital role in the rate of agricultural technology adoption, such as ICT tools among smallholder farmers across the globe (Dutta & Hazarika, 2020). This study considered a few socio-economic factors that were found to be significant in technology adoption among smallholder farmers across various. These include gender, age, income level and education level.

2.4.1 Education Level of Smallholder Farmers

Smallholder farmers have different demographic statuses, which may or may not influence their day-to-day decision-making in the society (United Nations, 2020). A few studies have shown that education level plays an essential role in the rate of technology adoption globally. It is reported that smallholder farmers who attained higher education are majority in agricultural technology adoption due to their better understanding on the operation language and skills (Ayim *et al*., 2022). This was in contrast with the results from other studies who found that majority of smallholder farmers using new agricultural technologies in rural part of Punjab, Pakistan attained primary education level and that education level do not influence the use of any agricultural technology, ICT tools included.

In Africa, demographic status is one of the major determinants of technology adoption among smallholder farmers. Although mobile phones, televisions, internet, radios, and web-based applications have become important in sharing agricultural information, there is little uptake in the use of the ICTs tools among smallholder farmers due to various socioeconomic factors among others that affect the decision-making unit (Chilundo *et al.,* 2020). A study that was conducted in

Ghana revealed that smallholder farmers who attained post-secondary education level were the majority in the use of television, computer, mobile phone and radio to access marketing information, credits and farm inputs (Nyarko & Kozari, 2021). On the contrary, Sennuga (2019) conducted a study in Nigeria and reported that the majority of smallholder farmers using ICT services in agriculture attained primary level and below. The report summarized that education level does not determine the capacity to use ICT tools in agricultural extension among smallholder farmers.

In Kenya, a few smallholder farmers use ICT tools and programs like National Farmers Innovation services (NAFIS), Mfarm and mFarmer to access agricultural input information through mobile phones, computers, radios and televisions (Wens *et al*., 2022). A research study conducted about the factors influencing the use of ICT tools in agriculture reported that institutional and infrastructural factors influence the rate of technology adoption among smallholder farmers (Chia *et al.,* 2020). However, the information on whether socioeconomic factors especially, education level influence the use of ICT tools in agriculture is limited.

Ulhaq *et al.* (2022) conducted a study on factors influencing intention to adopt ICT among smallholder farmers in Kenya and found that majority of the smallholder farmers using mobile phones in agriculture, attained primary education level. On the same note, Okello *et al*. (2021) conducted a study on the use of modern ICT in stallholder farming in Kenya and found that the majority of the smallholder farmers using radios, mobile phones and computers in agriculture, attended primary school as the highest level of education. This indicates that their low education level did not limit them from accessing agricultural information through the ICT tools. On the contrary, Akintelu *et al.* (2021) stated that the majority of smallholder farmers who use ICT tools in agriculture in Kenya are at least the holders of secondary school certificate holders, diploma and above. The literatures show contradiction on the relationship between education and the use of ICT tools in various localities. This indicates the gap that this study sought to bridge among smallholder cassava farmers in Rangwe Sub-County, Kenya.

2.4.2 Age of Smallholder Farmers

Globally, age is considered as a socioeconomic factor that plays a significant role in the decision-making unit of technology adoption. Al-Mamary (2022) conducted a study on social demographic factors in the use of ICT in agriculture in Yemen. They found that older smallholder farmers with an average age of 50 years use mobile phones to access agricultural extension services than younger smallholder farmers. This was in contrast with Khan *et al.* (2020) who found that majority of smallholder farmers in rural part of Punjab, Pakistan using mobile phones and computers in agriculture were young farmers within the age range of 20 to 40 years old.

In Africa, the use of mobile phone, television, internet, radio, and web-based applications have become important in sharing agricultural information (Kabir *et al.,* 2022). For instance, Nyarko and Kozari (2021) conducted a study on socioeconomic characteristics of smallholder cassava farmers in the use of e-agriculture in Ghana. They found that young smallholder farmers dominated the use of the ICT tools in the production. Similarly, Abdul-Rahaman and Abdulai (2021) also reported that youths are the majority of the ICT services users in agriculture. On the contrary, Mwenda *et al.* (2022) conducted a study on the factors that determine the adoption of ICT-based pest information services among tomato growers. They concluded that the majority of smallholder farmers who used the ICT tools in agriculture were older people.

In Kenya, smallholder cassava farmers belong to different ages that might determine use of technologies among them. Wang *et al.* (2021) conducted a study on the use of modern ICT in smallholder farming and found that young smallholder farmers dominated the use of ICT tools to access agricultural information. On the other hand, Bhusal *et al*. (2021) conducted a review on determinants of ICT in agricultural extension. They found that the majority of agricultural extension agents using ICT tools to deliver agricultural input services were older. The literatures show different results on age and use of ICT tools in agriculture across different localities. This indicates a gap in knowledge whether there is a relationship between age and use of ICT tools among smallholder cassava farmers in Rangwe Sub-County.

2.4.3 Income Level of Smallholder Farmers

Income level is the amount of money the smallholder farmers earn from farm sales, investments and employment. This might vary among various households of the farmers. The amount of money available to each farmer may determine whether she or he adopt a technology; especially if some funds are involved in the use of the technology (Mhlanga & Dunga, 2020). Higher amount of money may facilitate technology adoption or not depending on the level of finance needed to be used. The use of mobile phone and computer might require some money to buy the gadget, charge its battery and buy airtime for data bundles to browse internet or recharge credit for communication. Televisions and radios might involve money in buying the gadget, power source and subscribing to the farmers' channels (Asravor *et al*., 2022).

Globally, financial stability is expected to give the smallholder farmers ability to adopt new agricultural technologies (Getahun, 2020). In Myanmar Asia, smallholder farmers with higher income level use mobile phones to access cassava marketing, inputs and credit among other services (Baruah & Mohan, 2021). Similarly, in Italy it was reported that the smallholder farmers with higher household income levels formed the majority of those who were subscribing and using e-mails, radios, computers, smartphones and mobile phones in agriculture (Bucci *et al.,* 2019). This was not the same case in Bangladesh, where Asif *et al*. (2019) reported that majority of the smallholder farmers who use ICT tools in agriculture have lower household income.

In Africa, smallholder farmers have different amounts of income level depending on their various income sources. For example, in Ghana, smallholder farmers with more resources and household income level formed the majority in the use of computers, mobile phones and radios to access agricultural information (Akintelu *et al.,* 2021). Similarly, Ogutu *et al*. (2020) conducted a study in Nigeria and reported that smallholder farmers with lower income levels do not prefer the use of ICT tools in agriculture. On the contrary, Quaye *et al.* (2019) carried out a research study on the the socioeconomic factors and technology adoption in Nigeria and reported that the majority of smallholder cassava farmers who had low-income level used mobile phones, radios and smart phones to access agricultural information.

In Kenya, some studies showed that smallholder farmers with higher income level are the majority in the adoption of agricultural technology (Wichean & Sungsanit, 2022). The others showed that majority of ICT tools users in agriculture are the smallholder farmers with lower- or middle-

income level (Mushtaq *et al.,* 2022). Hartmann, *et al.* (2021) conducted a study on the digital connectivity at the upstream end of value chains; A dynamic perspective on smartphone adoption amongst horticultural smallholders in Kenya and found that the majority of the smallholder farmers who use ICT tools in agriculture have a higher income level. The inconsistence in the results showed a gap showed on whether income level correlate with the use of ICT tools among smallholder cassava farmers in Rangwe Sub-County, Kenya.

2.5.4 Gender of Smallholder Farmers

Globally, gender of smallholder farmers plays a significant role in determining their responsibilities in the society, which may also influence technology adoption in agriculture. Moreover, preference of agricultural technology differs across genders of smallholder farmers (Huijsmans *et al.,* 2022). For example, a study conducted by Kassem *et al*. (2021) in some parts of America reported that more female SHFs use ICT tools than male SHFs do. The results contradicted the report by Mdoda and Mdiya (2022) who conducted a study on factors that affecting adoption of ICT among smallholder farmers and found that male farmers formed majority of those who use ICT tools in agriculture at Eastern Cape Province.

In Africa, there are contested claim statements over the concern of gender gap in the use of ICT tools in agriculture. Gender equality has been a key discussion and the policies supporting the same have been formulated in many sectors include agriculture. Gender play a key role in the characteristics of decision-making units (United Nation, 2020). For example, Nyarko and Kozari (2021) conducted a study on socioeconomic characteristics of smallholder farmers in the use of electronic-agriculture. They concluded that male smallholder farmers were majority in the use of ICT tools in agriculture. On the other hand, Quaye *et al*. (2019) carried out a research study on analysis of gender of smallholder farmers in the use of ICT in agricultural extension in Nigeria and reported that majority of smallholder farmers using ICT tools to access agricultural information were female farmers.

In Kenya, gender has been given a priority in the development of economy. It plays a significant role in the use of technologies in various sectors including agriculture. The rate of technology adoption differs along the gender divide of smallholder farmers (Khan *et al.,* 2020). For instance, Awuor and Rambim (2022) conducted a study on the a doption of ICT in agriculture innovation

among smallholder farmers and reported that the majority of the farmers who used ICT tools in agriculture were male. On the contrary, Wong (2022) conducted a study and found that more female smallholder farmers use ICT tools in agricultural production than their male counterparts. This contrast in the results do not justify whether there exists a relationship between gender and the use ICT tools in agriculture. Hence, it indicates the gap in knowledge that this study sought to bridge in Rangwe Sub-County, Kenya.

2.6 Access to Training and Use of ICT Tools

Globally, training smallholder farmers on how to access agricultural information such as input supply, management practices and reliable marketing services through ICT tools play a crucial role in the decision making to adopt or reject such tools. The same training may become more useful when agricultural extension officers are also included (Kabir *et al.*, 2022). According to Ulhaq *et al.* (2022), numerous and repeated training to smallholder farmers increases the extent of agricultural technology adoption. Lack of knowledge, skills and awareness are some of the most suggested barrier that block smallholder farmers from adopting some of the agricultural technologies (Çetin *et al.*, 2021).

In Africa, it is reported that the effectiveness of smallholder farmers' training on the use of new agricultural technologies depend more on the number of times an individual receives the training. The training programmes that are well strategized and focused might increase the use of ICT tools in cassava production (Sa'adu *et al.,* 2022). According to Parvand and Rasiah (2022), training on the use of ICT tools is a very important and effective factor in adoption of ICT tools in agriculture among smallholder farmers. It is well noted that a well-trained and skilled workforce is crucial in work progress and project performance. Training of farmers to use mobile phones in sharing agricultural information increases the frequency of ICT adoption among the farmers (Kemhe *et al.*, 2022).

In Kenya, Training smallholder farmers on the knowledge and skills of the use of technologies as well as why they should be used through training play a role as an incentive for their adoption (Kabir *et al.,* 2022). Similarly, access to training on ICT tools might enable smallholder farmers to familiarize themselves with the use of ICT tools in agriculture. This might translate into the adoption; nevertheless, there is no information on the number of times smallholder farmers should be trained to improve their skills effectively. In addition, smallholder it was found that farmers can

use mobile phones and radios in sharing agricultural information without attending any training on how tho operate the tools (Githinji, 2022). This revealed inconsistence on whether there is a relationship between access to training and use of ICT tools that this study sought to determine among smallholder cassava farmers in Rangwe Sub-County, Kenya is limited.

2.6.1 Sources of Training

Agricultural extension systems play key roles in the training of smallholder farmers to adopt new agricultural technologies. The systems involved the institutions or organizations that provide extension services (Yang & Wang, 2021). The systems include public extension system; which is mostly organized by the Ministry of Agriculture or its equivalent. Another system is privatized extension service; in which the extension services are provided by private extension companies on commercial basis. The third system is farmers' organization based such as Community-Based Organization and farmers cooperatives; where the farmers team up to provide extension services. Another system is educational or institutional; where the services are provided through the schools, colleges and universities (Kabir *et al.,* 2022).

The systems organized training to equipt farmers with the useful knowledge needed to improve agricultural production and yield. Luo *et al*. (2022) conducted a study on the farmers' training cooperatives and reported that private extension system reached many smallholder farmers with the training on the use of new technology in agriculture. On the same note, Benson *et al*. (2022) carried out a study on postharvest training and found that privatized extension system had more training among smallholder farmers. This could mean that private extension system formed the majority in the training of smallholder farmers. However, Yang and Wang (2021) studied relationship between training and use of drip fertigation system among banana smallholder farmers and recorded that public extension managed to train many smallholder farmers. The inconsistence in the sources of training indicate a gap in knowledge.

2.6.2 Number of Training Received among Smallholder Farmers

The number of training refers to the frequency of agricultural extension training a farmer is able to attend in a given period of time. The number of training attended may vary from one farmer to another base of perceptions, awareness and interest (Li *et al.*, 2022). The training frequency attained by a farmer may influence the use of a technology or fail to determine. The number of training received depends on both agricultural extension providers and the farmers who receive

the training. The smallholder farmers may attend the training when they are sensitized and made aware of the training available and their values. That would change the perception and interest about the training and enhance the frequency of attendance (Onuwa & Folorunsho, 2022). Alternatively, the smallholder farmers may choose not to attend training even if they are organized and the awareness created due to other reasons (Alemu, 2021).

Alemu (2021) conducted a study on factors determining how farmers participate in agricultural training organized by the extension agents and reported that majority of smallholder farmers have low frequency of agricultural training. This could be contributed by the failure of agricultural system to organize many trainings for the farmers or the interest of the farmers to attend the organized training. Similarly, Akinmolafe (2022) carried out a study on the training schedule preferred by smallholder farmers on good agricultural operations and reported that majority of the smallholder farmers attended between one to two training per year. On the other hand, Christian *et al*. (2022) studied the training of smallholder farmers on forestry and reported that the smallholder farmers showed high interest and attended many agricultural trainings organized by various agricultural extension agents. Similarly, Dongmei and Mingzhong (2021) conducted a research on the impact of agricultural training on adoption of novel technologies among smallholder farmers and recorded that the majority of smallholder managed to attend many agricultural trainings that were organized by the government.

2.7 Access to Credits and Use of ICT Tools

Globally, agriculture is a sector that has been negatively affected by low productivity despite the fact that it is a basic instrument for the reduction of poverty, food security increment, and enhancement of sustainable development (Tanti *et al*., 2022). Efficacious dissemination of agricultural information among the farming stakeholders is one of the major contributions to increasing agrarian productivity (Kamal *et al.*, 2022). It has been observed that the use of ICT tools in sharing agricultural information is one of the major ways to connect farmers and sources of information easily and faster (Birke & Knierim, 2020). The information may entail tillage and sowing practices, soil and water conservation techniques, improved seeds, fertilizer application, appropriate methods of pesticides, and fungicide application to crops. It may also include harvesting and post-harvesting operations (Ahmadi *et al*., 2022).

Across the world, smallholder farmers require funds to buy ICT tools and maintain them in good condition as well as subscription for the agricultural services. However, majority of smallholder farmers in the rural localities have low-income level. Access to credit has the potential to increase the financial ability of smallholder farmers to use ICT tools in agriculture (Hoang *et al.*, 2022). Access to credit among smallholder farmers is reported to be one of the great pillars that improve adoption of agricultural technologies including the e-extension (Hartmann *et al.*, 2021). Technology have developed a number of digital financial services that smallholder farmers can be accessed through mobile phones. Examples of the mobile financial services include mobile loans, mobile payments, mobile money, mobile banking and mobile savings (Parlasca *et al.,* 2022).

In Kenya, according to the report by the Kenya National Bureau of Statistics [KNBS], (2020), the agricultural sector contributes about 11% of her labour force and about 34% of her Gross Domestic Product (GDP). This could mean that agriculture is a basic sector in the Kenyan economy. Most of the farmers practice farming on a piece of land of fewer than 3 acres (Odhiambo, 2020). The farmers can easily adopt the novel techniques when they receive the information timely through constructive extension dissemination techniques like ICT tools (Hoang *et al.,* 2022). The tools refer to a set of technological devices and resources used to receive, store and communicate information. The tools are becoming crucial methods for improving agricultural production across the world (Tiwari *et al*., 2022). The ICT tools mostly used in the extension service delivery include radios, televisions, computers, phones, and the internet. These tools are used to communicate agricultural extension services that include improved inputs, on-farm practices, harvesting activities, post-harvest handling, and marketing information (Mallory *et al.*, 2022).

Access to credit from money lending institutions in Kenya is accredited as significant accelerators in the agricultural technology adoption like the use of ICT tools. The smallholder farmers may access credit from public and private institutions such as banks, farmer groups, friends and relatives (Sa'adu *et al.,* 2022). Nevertheless, there is limited information reporting on the challenges that smallholder farmers experience while looking for the credits or during usage. Osabohien *et al.* (2022) conducted a study on access to credit and performance of agriculture and recorded that even those who had not received credit from creditors had good performance in agricultural production. The importance of credits to smallholder farmers were not uniform across the farmers in various localities. The contradictions on the correlation of access to credit and

technology adoption indicate a gap that this study sought to fill by determining whether access to credit correlate with the use of ICT tools among smallholder cassava farmers in Rangwe Sub-County, Kenya.

In Rangwe Sub-County, adoption of agricultural technology has been encouraged by the government and private organizations as a crucial method to improve agrarian production. Nevertheless, the percentage of adoption of most of the technologies remains low (Ruzzante *et al.*, 2021). The Sub-County is marked by the low adoption of ICT tools in agricultural extension services delivery among peasants. The limited use of ICT tools in agricultural information sharing could be one of the major causes of low crop productivity like cassava, mainly due to the inadequate access to agricultural extension services and improved inputs (Githinji, 2022). The adoption of the tools in agricultural extension requires capital to buy them and access the extension services. The majority of peasants in the rural localities of the Sub-County have a low-income level, which may translate to inadequate capital and low technology adoption (Rengaraj & Shibu, 2022). This might restrict agricultural sustainable development in Rangwe Sub-County, Kenya (Kamal *et al.*, 2022).

The peasants may require agricultural credit to adopt the modern agricultural technologies used in agricultural extension. Agricultural credit refers to funds borrowed for use in agricultural production, processing, and marketing (Moahid *et al.*, 2021). The provision of agricultural credit may be one of the major means to overcome financial problems for the farmers. Agricultural credit provides enabling environment and ability for the smallholder farmers to purchase and maintain the ICT tools and subscribes to the extension services (Birke & Knierim, 2020). The types of agricultural credit available to the farmers include seasonal credit, development credit, agri-business credit, and loan size (Ullah *et al.*, 2020). This study hence sought to explain the access level of agricultural credit, credit sources, amount of the credit accessed, and the correlation between access to credit and the use of ICT tools in the extension services among the peasants.

2.7.1 Access to Agricultural Credit

Access level to agricultural credit is the percent of smallholder farmers able to receive agricultural credit to be used in farm production (Ankrah *et al.*, 2022). Smallholder farmers require funds to buy ICT tools and maintain them in good working conditions as well as subscribe to agricultural extension services. However, the majority of smallholder farmers in the rural localities have a low-

income level (Ayim *et al.*, 2022). This condition disadvantaged them when it comes to technology adoption (Ullah *et al.*, 2020). Access to agricultural credit could be one of the major contributions to solving farmers' financial problems. Agricultural credit is used as a method to provide short and long-term financial aid for smallholder farmers. However, The access level was low among the farmers while some of the farmers were also reported to get less amount of credit. Hoang *et al.* (2022) conducted a study and reported that access to credit has the potential to increase the financial ability of smallholder farmers to use ICT tools in agriculture. Although a few who accessed the credit got a small amount.

A high rate of access to credit among smallholder farmers is one of the great pillars that improve the adoption of agricultural technologies including the e-extension. The access to the credit was found to be average among the farmers (Osabohien *et al*., 2022). Ruzzante *et al.* (2021) reported that technology has developed a number of digital financial services that smallholder farmers can access through mobile phones. Examples of mobile financial services with low and high adoption rates included mobile loans, mobile payments, mobile money, mobile banking, and mobile savings (Martinez-Gomez *et al*., 2022). The access level was not consistent across the farmers interviewed. This provides the gap for a study to determine access levels in other areas, especially in Rangwe Sub-County.

2.7.2 Sources of Agricultural Credit

The Source of agricultural credit was operationally defined in this study as the providers of the credits to farmers. Various agencies are committed to providing agricultural credit to farmers. The credit is categorized based on the source such as institutional and non-institutional agencies (Bernards, 2022). The major sources of credit for agricultural producers include Commercial Banks, Agricultural Credit Institutions, Farm Service Agencies, and Insurance Companies (Meena *et al.*, 2021). Ullah *et al*. (2020) reported that access to agricultural loans from banks enabled smallholder farmers to adopt and use novel agricultural technologies in farming. Odhiambo (2020) also found that farmers who got flexible loans from government agencies were able to buy and use improved inputs such as seeds, fertilizers, and pesticides.

In Kenya, especially in Rangwe Sub-County, access to credit from money lending institutions is accredited as a significant accelerator in agricultural technology adoption like the use of ICT tools. The smallholder farmers may access credit from public and private institutions such as banks,

farmer groups, friends, and relatives (Sa'adu *et al.,* 2022). Some of the smallholder farmers who had used mobile phones to share agricultural information have not received agricultural credit from any creditors. The effects of credits on smallholder farmers were not uniform across the farmers in various localities (Meressa, 2022). Some literature recorded a positive correlation while others recorded a negative. The contradictions in the correlation between access to credit and technology adoption indicate a gap that this study sought to fill by determining whether access to credit correlates with the use of ICT tools among peasants in Rangwe Sub-County, Kenya.

2.8 Theoretical Framework

Some of the theories that could guide this study included Diffusion of Innovation Theory by Rogers (2003), Rural Household Behavior Under Market Failure by Arora *et al.* (2022) and Rural Technology Acceptance Model by Fussell and Truong, (2022). However, diffusion of innovation theory by Rogers is more relevant to this research study because the theory explains how several factors interact to determine technology adoption and points out socio-economic factors, institutional and communication behavior as one of the characteristics of the decision-making unit (Figure 2).

Diffusion of Innovations theory explains the rate of technology adoption by different categories of farmers (Rogers, 2003). Rogers reported that an innovation diffuses through a social system over a time and rate of the diffusion depends on the perception of potential adopters towards the innovation (Arora *et al.,* 2022). The categories of adopters based on their rate of adoption include innovator, early adopters, early majority, late majority and laggards. The process of innovation diffusion entails the innovation, the person with technical expertise of the innovation, another person without the technical expertise of the innovation and the channels of conveying the knowledge to these people (Goh & Sigala, 2020).

Characteristics of decision-making unit include socioeconomic characteristics, personality variables and communication behavior. Perceived characteristics of innovation include; relative advantage, compatibility, complexity, trialability, and observability (Rogers, 2003). These variables might influence the decision of smallholder cassava farmers to adopt or reject a technology such as use of ICT tools in agriculture (Goh & Sigala, 2020). Nevertheless, the weakness of this theory is in failing to note that communities are discrete and that the effect of these factors may vary from one community to another. Therefore, this study sought to determine

the how the use of ICT tools have been diffused and the relationship between its usage and selected factors among smallholder cassava farmers in Rangwe Sub-County, Kenya.

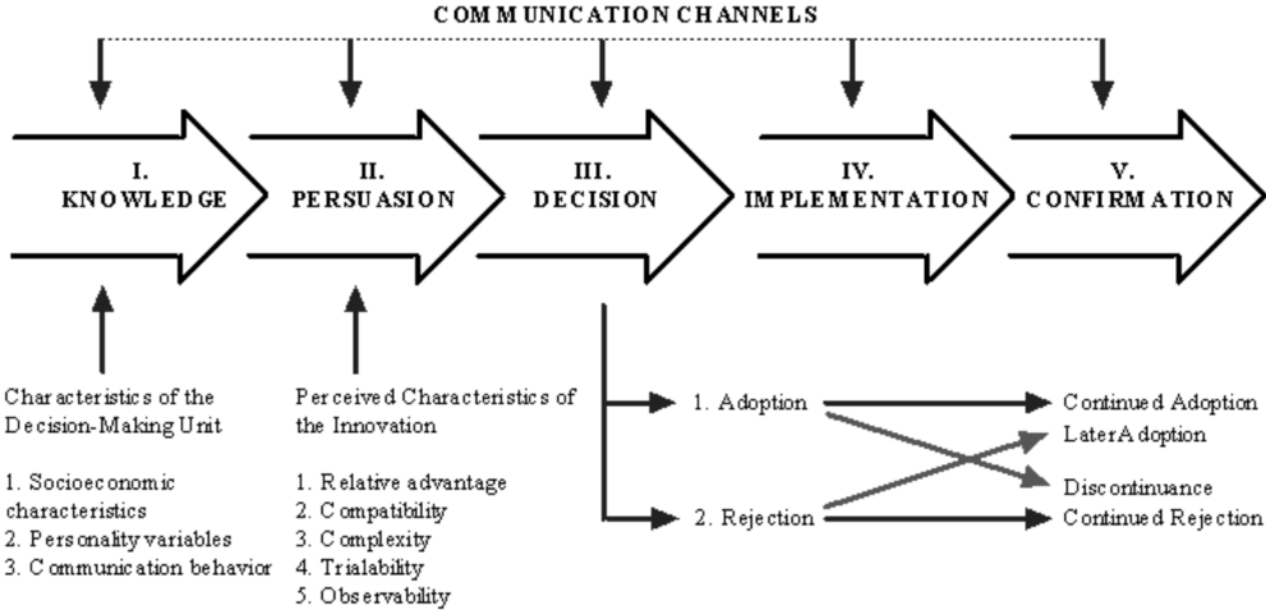


Figure 2: The process of diffusion of innovation theory (Rogers, 2003).

2.9 Conceptual Framework

The conceptual framework constitutes independents, dependent and moderating variables (Figure 3). The three selected independent variables include; (i) Access to credit among cassava smallholder farmers. This was measured by whether a farmer obtain agricultural credit or not, credit sources and amount received per year. (ii) Selected socioeconomic factors such as age range, gender, education level and income level. It was measured by the various categories that a farmer belongs. (iii) Access to training on ICT tools use in agriculture. This was measured by whether a farmer received training or not, training sources, number of times trained and the information involved. The dependent variable was the use of ICT tools in agricultural extension among smallholder cassava farmers. This was measured by whether a farmer used the tools or not, information involved and type of tools mostly used. The moderating variables indicated the variables that may strengthen, diminish or change relationships between the independent variables and dependent variable.

The moderating variables in this study included smallholder cassava farmers' experience and skills. Experience and skills earned from cassava production may determine the extent of

information needed from the ICT tools hence, moderate the use of the ICT tools in the production. In that case, the variables may interfere with the relationship between dependent and independent variables. The moderating variables were controlled by simple random sampling.

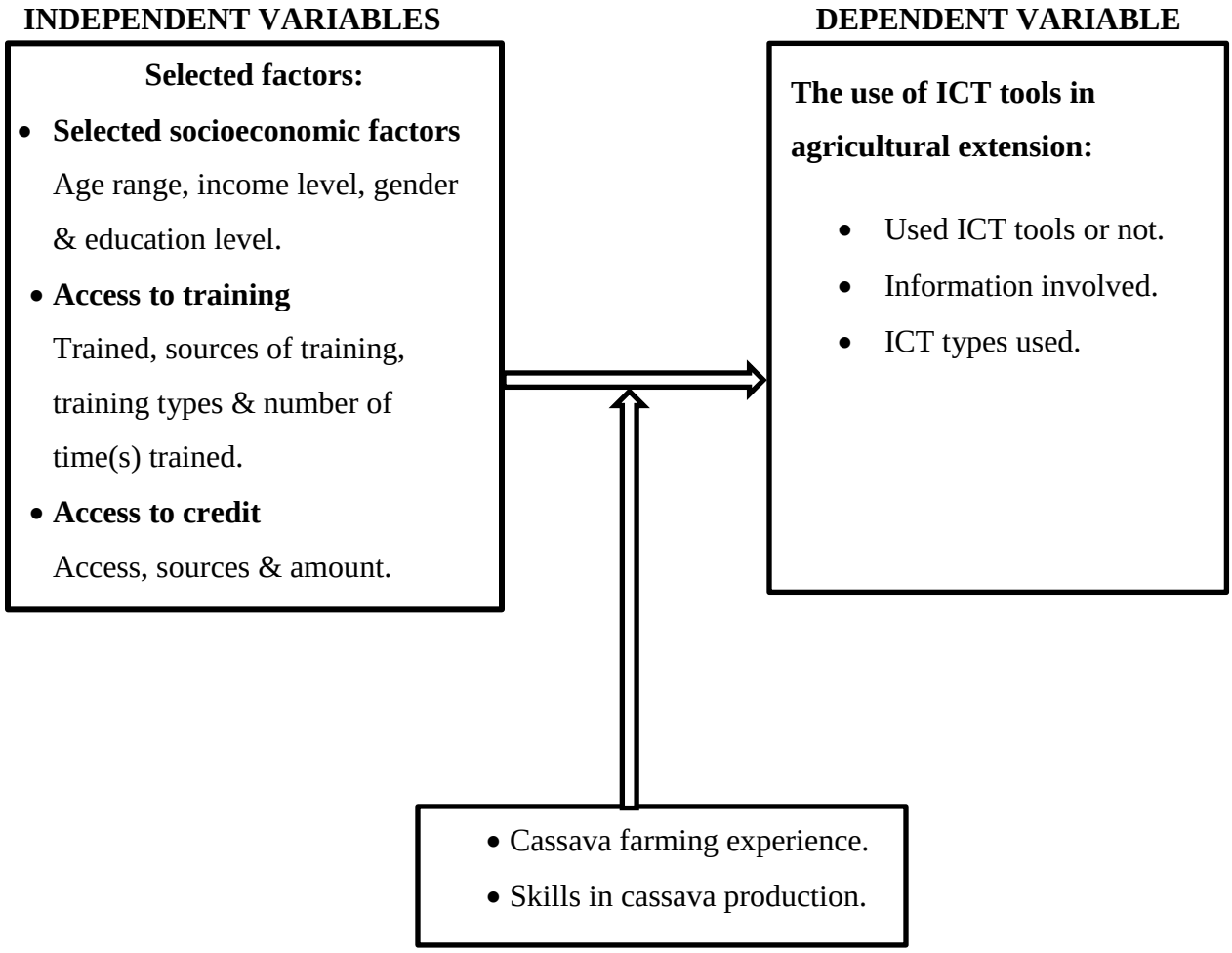


Figure 3: Conceptual framework for interaction of selected factors and use of ICT tools

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

Chapter three deals with the research design, study location, target population, sampling procedure, sample size, instrumentation, validity, reliability, pilot study, data collection, analysis, and ethical considerations.

3.2 Research Design

The study used a correlation research design to determine the relationship between the selected factors and adoption of ICT tools in agricultural extension. The design is a non-experimental research design that focuses on the relationship between two variables with statistical analysis (Li *et al*., 2020). The design assists in isolating and investigating the interaction of the variables of interest without manipulation. It reflects the strength and direction of the relationship between the variables. The design was appropriate because it provided a quick and easy way to determine whether a relationship exists between the independent and dependent variables.

3.3 Location of the Study

This study was conducted in Rangwe Sub-County. The Sub-County is one of the eight Sub-Counties in Homa-Bay County. Rangwe Sub-County is located in Nyanza province, Western region, Kenya, Africa (Appendix B). It is found at a latitude range of 0' 25° 0" S to 0' 42° 0" S and longitude range of 34' 30° 0" E to 34' 40° 0" E. Its area is approximately 273.2 km^2 and has four administrative wards that include Kochia, Kagan, Gem west and Gem east (CIDP, 2021). The Sub-County has an average bimodal rainfall of about 1150 mm. The Sub-County has a population of 3808 cassava smallholder farmers (Rangwe Sub-County Ministry of Agriculture Annual Report, 2021). The residents in Rangwe Sub-County derive their livelihoods from agriculture, formal or informal wage labor, and commerce. Agriculture, which employs about 60% of the residents, is the significant economic activity in the Sub-County. The farmers cultivate about 86% of their lands for subsistence farming practices. The smallholder farmers grow cassava, maize, beans, sorghum, sweet potatoes, kales, millet, and rice for consumption. They also grow pineapple and sugar cane as a cash crop (Cheboi *et al.,* 2021).

3.4 Target Population

The target population was 3808 smallholder cassava farmers distributed in the four administrative wards of Rangwe Sub-County (Rangwe Sub-County Ministry of Agriculture Annual Report, 2021). Out of the 3808 SHFs target population, the accessible population was 3025 SHFs who belong to cassava farming groups. The accessible population was distributed in the four administrative wards of the Sub-County as follow; 760 SHFs were from Kochia, 867 SHFs from Kagan, 740 SHFs from Gem West, and 658 from Gem East (Okoroji *et al.*, 2021).

3.5 Sampling Procedure and Sample Size

Rangwe Sub-County was purposively selected for this study because the County government promote cassava production for food security. The same time, agricultural extension agents use ICT tools in the extension information delivery. However, the use of the ICT tools was limited among cassava smallholder farmers. The appropriate sample size was calculated from the accessible population using the Naissuma formula as shown below:

$$n = \frac{NC^2}{C^2 + (N-1)e^2}$$

Where:

n = the required sample size,

N = the population within the study area,

C= Coefficient of Variation,

e = Standard error.

Appropriate sample size was obtained using the coefficient of variation. The recommended coefficient variation range is 21%≤ C≤ 30% and a standard error range is 2%≤ e ≤ 5% (Nassiuma, 2000). This study, therefore, used the lower limit coefficient variation of 21% and a lower limit standard error of 2% to reduce variability and degree of error in the sample. The study expected 95% confidence (5% sampling error) to obtain an appropriate sample size of SHFs from Rangwe Sub-County.

$$n = \frac{3025x(0.21)^2}{(0.21)^2 + (3025-1)x(0.02)^2} = 106$$

Proportionate was used to established appropriate sampling percentages of cassava smallholder farmers in Kochia, Kagan, Gem West, and Gem East administrative wards. The sampling method was preferred because it enhances equity in the selection percentage. Out of the obtained

proportion from the four wards, a simple random sampling method was used to select 106 SHFs from the four wards of Rangwe Sub-County. The simple random sampling method ensured that every population unit had an equal chance of selection. Table 1 provides Accessible population and sample size distribution.

Table 1

Population Unit, Accessible Population, Proportion and Sample Size Distribution

Population unit	Accessible population	Proportion (%)	Sample size
Kochia	760	25	27
Kagan	867	29	31
Gem West	740	24	25
Gem East	658	22	23
Total	**3025**	**100**	**106**

3.6 Instrumentation

A semi-structured questionnaire was prepared based on the study objectives and used to gather primary data from the SHFs who grow cassava in Rangwe Sub-County. The questionnaire was appropriate in this study because it allowed the practical gathering of data that was easy to analyze. Section A of the questionnaire gathered data on selected socioeconomic status. Section B gathered data on the use of ICT tools in cassava production, while section C gathered on access to ICT tools training and credit.

3.6.1 Validity

Validity is the extent to which an instrument measures what it is supposed to measure (Nanri *et al*., 2022). Before data collection, the questionnaire was prepared and submitted to the experts in the Department of Agricultural Education and Extension of Egerton University and Department of Agribusiness Management and Extension of Masinde Muliro University of Science and Technology to help in the validation. The comments and recommendations from the experts were used to improve the questionnaire.

3.6.2 Reliability

Reliability is the consistency with which an instrument measures what it is supposed to measure (Schrepp, 2020). In this study, the reliability of the questionnaire was ensured using a pilot study with randomly selected 30 SHFs who grow cassava in Homa-bay Town Sub-County. The Sub-County was the most appropriate because it has similar characteristics as those in Rangwe Sub-County. The reliability coefficient was estimated using Cronbach Alpha Scale to being 0.756α (Appendix D). The questionnaire was considered reliable after attaining the alpha coefficient above the threshold (0.70α) for acceptable reliability (Cronbach, 1975).

3.7 Data Collection Procedure

Ward Agricultural Officer from each of the four wards helped in organizing farmer group meetings in the various chief camps and primary school compounds. As each farmer was arriving at the meeting location, an introduction was done, purpose of the study explained, consent was sought and the questionnaire served to each farmer in order of the arrival. The majority of them could not fill the questionnaire by themselves and they were assisted in reading, translation and filling. The response rate per meeting was changing from low (8 SHFs) to average (15 SHFs). In order to attain the sample size (106 SHFs), two meetings were organized per day; one in the morning hours and the other in the afternoon.

3.8 Data Analysis

The raw data obtained were organized systematically through coding into Statistical Package for Social Sciences (SPSS) Version 25 to enhance analysis. Percentage and frequency were used to describe the data and study population meaningfully. Cross-tabulation used to compare the selected factors and the use of ICT tools. Linear regressions were used to test the relationship between selected factors and the use of ICT tools in agricultural extension at 5% significance level. The regression was necessary because it helps to determine the magnitude of relationship between two or more variables. A typical regression model is written is as follows:

$y= b_0+ b_1x_1 + b_2x_2 +\ldots+ b_nx_n + €$

Where;

Y= dependent variable.

b_0 = intercept, which is also known as constant.

b = regression coefficient, it shows the amount of change in dependent variable, corresponding to the change in independent variable.

X=independent variable.

€= error term, the difference between actual and predicted values in regression model.

Table 2 illustrates summary of the data analysis.

Table 2

Summary of data analysis

Hypothèses	**Independent Variables**	**Dependent Variable**	**Statistical Analyses**
H01: The elected socioeconomic factors have no statistically significant relationship with the use of ICT tools among cassava smallholder farmers in Rangwe Sub-County, Kenya.	selected socioeconomic factors	The use of ICT tools in agricultural extension.	Percentage, Frequency, Cross-tabulation & multiple Regression.
H02: Access to training has no statistically significant relationship with the use of ICT tools among cassava smallholder farmers in Rangwe Sub-County, Kenya	Access to training	The use of ICT tools in agricultural extension.	Percentage, Frequency, Cross-tabulation & simple regression.
H03: Access to credit has no statistically significant relationship with the use of ICT tools among cassava smallholder farmers in Rangwe Sub-County, Kenya	Access to credit	The use of ICT tools in agricultural extension.	Percentage, Frequency, Cross-tabulation& simple regression.

3.9 Ethical Considerations

Ethical considerations are the set standards and values for conducting research (Husband, 2020). In this study, Egerton University Board of Post-Graduate Studies issued an introduction letter to facilitate obtaining a research permit from the National Commission for Science, Technology, and

Innovation (NACOSTI) (Appendix C). The permit was obtained and used to seek data collection permission from Rangwe Sub-County Agricultural Office. Proper introduction and explanation of the real purpose of the study were done. The consent to collect data was obtained. Their cultural values, privacy, confidentiality, an anonymity and dignity were ensured during the data collection process.

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Introduction

This chapter shows the results and discusses the data analyzed based on the objectives and hypotheses in chapter one. The aspects analyzed and discussed included the use of ICT tools, types of the tools used, information involved, opportunities in the tools, challenges in the tools, the relationship that the use of ICT tools has with the selected socio-economic factors, access to training, and access to credit among cassava smallholder farmers.

4.2 Use of Information and Communication Technology Tools and Information involved

The smallholder farmers were asked to indicate whether they used ICT tools to access agricultural extension information or not. It was established that the majority (62%) of them did not use any of the ICT tools. Nevertheless, the minority (38%) had used various ICT tools to access the information. The majority (53%) of smallholder farmers who used the ICT tools received information on production inputs, on-farm management practices, processing and marketing. This was followed by (27%) those who received information on processing, post-harvest practices and marketing. The least (20%) percentage received the information on production inputs, on-farm management and processing. (Table 3). These results indicated that there is inadequate use of the tools among the farmers. The reason could be challenging that the farmers experience in farming (Karanja *et al.,* 2022). The results agreed with the findings of Awuor and Rambim (2022) who conducted a study on the adoption of ICT in agriculture innovation among smallholder farmers and noted that there was limited adoption of ICT in agriculture. However, it contradicted Gaol and Gustira (2020) who conducted a study on utilization of ICT in agriculture and noted that many farmers have embraced the use of ICT tools in farming activities.

Table 3

Use of ICT tools

Usage ICT tools	Frequency	Percentage
Use	40	38
No use	66	62
Total	**106**	**100**
Information involved		
production inputs, on-farm management practices, processing, marketing.	21	53
processing, post-harvest practices, marketing.	11	27
production inputs, on-farm management, processing.	8	20
Total	**40**	**100**

4.2.1 Types of Information and Communication Technology Tools Used

The farmers who had used the ICT tools in agricultural extension were asked to name one type of the ICT tools they mostly used in agricultural extension. The majority (58%) said that they had used mobile phones. This was followed by 27% who used radios, 10% used televisions and 5% used computers (Table 4). This could mean that mobile phones were cheaper to use and readily available compared to other types among the farmers (Gaol & Gustira, 2020). These results supported report by Pal *et al.* (2020) who studied identification and assessment of ICT tools in agriculture and noted that mobile phones were the most used ICT tools in agriculture. On the other hand, it contradicted Sethy and Mukhopadhyay (2020) who researched on the use of ICT by farmers in Odisa and found that many farmers listened to agricultural shows on radio programs. The program acts as their reliable source of agricultural information.

Table 4

Types of ICT tools used

ICT Tools Used	Frequency	Percentage
Mobile phones	23	58
Radios	11	27
Television	4	10
Computers	2	5
Total	**40**	**100**

4.2.2 Opportunities in the Use of Information and Communication Technology Tools

The farmers were asked to state opportunities that exist in the use of the ICT tools. The majority (43%) of the farmers who used the ICT tools in the extension and those who did not were of the opinion that the availability of ICT tools, efficiency, convergence and subsidized services were some of the main opportunities that exist in the use of the tools in agricultural extension. About 24% mentioned efficiency, availability and convergence as the opportunities in the tools. Around 20% talked of convergence and efficiency as the opportunities, while 13% said that the opportunities included subsidized services and convergence (Table 5). This indicated that the use of the tools in agriculture had high potential of an adoption due to many opportunities available (Karanja *et al*., 2022). The result agreed with Githinji (2022) who conducted a study on the application of ICT in Kenya and reported that the use of ICT in agriculture provide numerous opportunities that can facilitate its use in farming. Nevertheless, this finding contradicted Chiazoka *et al.* (2021) who studied awareness and use of ICT among farmers and recorded that farmers had inadequate opportunities that can encourage them to use ICT in farming.

Table 5

Opportunities in the use of ICT tools

Opportunities in ICT tools Used	Frequency	Percentage
Available, efficient, convergent, subsidized services	46	43
Efficient, available, convergent	25	24
Convergent, efficient	21	20
Subsidized services, convergent	14	13
Total	**106**	**100**

4.2.3 Challenges in the Use of Information and Communication Technology Tools

The farmers were asked to mention some of the challenges that made the use of the ICT tools in agriculture unachievable. The majority (57%) noted that the tools were expensive, there were inadequate operation skills, power source not reliable and poor network connectivity in the areas. About 33% recorded inadequate skills and unreliable power source. The 10% mentioned unawareness and language barrier (Table 6). This could mean that the farmers had problems that might slow down the adoption rate of the tools in agriculture (Getahun, 2020). The finding was in line with Karanja *et al.* (2020) who researched on impact and challenges of ICT and noted that use of ICT in agriculture faces many challenges that call for urgent address. The results contradicted Pal *et al.* (2020) who studied identification and assessment of ICT tools in agriculture and found that constraints of ICT in farming have been reduced through various subsidies. This enable the farmers to use the tools in receiving farming information.

Table 6

Challenges in the use of ICT tools

Challenges in ICT tools Used	Frequency	Percentage
Expensive, inadequate skills, unreliable power source, poor network.	60	57
Inadequate skills, unreliable power source.	35	33
Unaware, language barrier.	11	10
Total	**106**	**100**

4.3 Selected Socioeconomic Factors and Use of ICT Tools

The respondents were asked to indicate their socioeconomic status. Based on the education level, the majority (49%) of cassava smallholder farmers in the study area attained primary education and only 4% in this level used ICT tools in agricultural extension. This was followed by 30% who attained secondary and 72% of them used the tools in farming. About 15% attained post-secondary and had 81% use of the tools. About 6% did not attain formal education and none of them used the tools in agriculture (Table 7). This indicated that high education level increase adoption of ICT tools in agriculture (Pogorelskaia & Várallyai, 2020). The results concurred with Naqvi *et al.* (2021) who studied factors influencing adoption of mobile phone among farmers in Punjab and reported that the majority of the smallholder farmers had low education level. However, it contradicted Pajk (2020) who researched on education in eco-farming supported by ICT and found that a higher percentage of farmers had attained secondary level.

Based on age range, the majority (43%) were in the middle age (33-47 years) and had 35% ICT tools 'usage. This was followed by 26% in the age range of 48-62 years with 7% use of the tools, 25% were youths (18-32 years) with 80% use of the tools and 7% were above 62 years with no use of the tools in agriculture (Table 7). This could mean that increase in age post challenges in the use of ICT tools in agriculture (Hoang *et al*., 2022). The results agreed with Oyekola *et al.* (2021) who studied socioeconomic factors influencing cassava production in Rural part of Nigeria and reported that majority of farmers are in their middle age. On the other hand, it contradicted the

findings of Mwenda *et al*. (2022) who conducted a study on the factors determining the use of ICT-based pest information services among smallholder farmers and noted that the majority of the farmers who used ICT tools in the farming activities were youths.

Based on income level, the majority (58%) recorded a lower income level of KES 160,000 and below and had 6% use of the tools. This was followed by 24% with between KES 161,000 to 270,000, and 72% ICT usage, and 16% had KES 271,000 to 38,00 with 84% use of the tools (Table 7). This might show that increase in the income provide financial muscles to the farmers to increase ICT adoption in the farm. The results supported the findings of Wichean and Sungsanit (2022) who studied factors influencing intension to adopt a technology in Thailand and reported that the majority of the farmers in had lower income levels which give them great challenge in the use of technology. However, the results contradicted the findings of Hartmann *et al.* (2021) who studied a dynamic perspective of mobile phone adoption in Kenya and found that most farmers had a middle-income level.

Based on gender, the majority (62%) were female with 27% ICT tools usage while 38% were male with 50% use of the tools (Table 7). It could indicate that male farmers used the tools compared to the female (Gaol & Gustira, 2020). These results supported the findings of Oyekola *et al.* (2020) who studied socioeconomic factors influencing cassava farming in Nigeria and reported that most smallholder farmers in are female. On the other hand, it contradicted the finding of Mdoda and Mdiya (2022) who conducted a study on the factors that affect the used of ICT tools in farming in Eastern Cape and noted that more males farmers used the tools than the female farmers.

Table 7

Descriptive on the selected socioeconomic factors

Socioeconomic factors	Total Respondents		Respondents Used ICT	
	F	%	F	%
Education level				
None	6	6	0	0
Primary	52	49	2	4
Secondary	32	30	23	72
Postsecondary	16	15	13	81
Total	**106**	**100**	**38**	
Age range				
18-32	25	24	20	80
33-47	45	43	16	35
48-62	28	26	2	7
Above 62	8	7	0	0
Total	**106**	**100**	**38**	
Income level (1000/=)				
X≤160	62	58	4	6
161-270	25	24	18	72
271-380	19	18	16	84
Total	**106**	**100**	**38**	
Gender				
Female	66	62	18	27
Male	40	38	23	50
Total	106	**100**	**38**	

4.3.1 Relationship between Socio-economic Factors and Use of ICT Tools

The first objective of this study was to:

Determine the relationship between selected socioeconomic factors and the use of ICT tools among cassava smallholder farmers in Rangwe Sub-County, Kenya.

The study collected data on selected socio-economic factors of smallholder cassava farmers in Rangwe Sub-County, Kenya. The socio-economic factors included education level, age, average annual income level, and gender. These factors were important because they could help one understand the nature of cassava farming among the smallholder farmers in the Sub-County. The results were analyzed and discussed.

Objective one was translated into the following null hypothesis as follow;

H01: *The selected socioeconomic factors have no statistically significant relationship with the use of ICT tools among cassava smallholder farmers in Rangwe Sub-County, Kenya.*

The hypothesis H01 was tested using multiple linear regression, and the results discussed below.

Multiple linear regression was used to test the hypothesis at 0.05 significance level. It found a very high correlation between the selected factors and use of ICT tools in agricultural extension among the farmers (R=0.912, P=0.004, R^2=0.832, Adj. R^2= 0.825) (Table 8). The selected socioeconomic factors explain 83% in the use of ICT tools in agricultural extension. A unit change in the socioeconomic factors leads a significant change in the adoption tools. This concurred with the findings of Naqvi *et al.* (2021) who researched on factors influencing adoption of mobile phone in Punjab and reported that socioeconomic factors have impact on the use of mobile phone among farmers. However, it opposes (Kemhe *et al.* (2022) who studied the application of mobile phones in sharing research knowledge among the smallholder farmers and noted that socioeconomic status of the smallholder farmers influence the use of ICT in farmers.

Table 8

Hypothesis one test

Independent variable	R	R^2	Adj. R^2	Sig.	Hypothesis test	Interpretation
Socioeconomic factors (age, education, gender, income).	0.912	0.832	0.825	0.004	Null hypothesis rejected (0.004<0.05)	Very high correlation exists. There is significant change in ICT tools' adoption due to a unit change in age, education, gender and income.

4.4 Training and Use of Information and Communication Technology Tools

The second objective of this study was to:

Determine the relationship between access to training and the use of ICT tools among cassava smallholder cassava farmers in Rangwe Sub-County, Kenya.

The study focused on access to training on ICT tools, sources of the training, and the number of the training obtained. These were discussed below (Table 9). The cassava smallholder farmers were asked to indicate whether they received training or not. If they receive, they state sources, number of times received and training types. It revealed that out of the smallholder farmers interviewed, 63% had no access to training on the use of ICT tools in agricultural extension and had 9% ICT usage, while 37% had access with 87% use of the tools. The majority (54%) of those who had access to training received from private extension systems and had 90% tools' usage, followed by 38% received from the ministry of agriculture with 87% usage and 8% received from universities with 67% usage. The majority (46%) of them had attended the training once a year and had 83% usage, while 39% had attended 2 to 3 times with 87% and 15% had attended more than 4 times in a year with 100% use of the tools. The majority (49%) of those who had access received training services such as ICT importance, operation, opportunities, and programs available with 84% usage. This was followed by 36% received on ICT tools' importance and

operation with 86% usage and 15% received on ICT available programs, opportunities and opportunities with 100% usage.

The relatively low percentage of smallholder cassava farmers trained on the use of ICT tools may contribute to the low use of the tools since training exposes the smallholder farmers to agricultural institutions that support the use of ICT tools in agriculture (Fathi & Azizpanah, 2021). The results concurred with Kumar *et al.* (2021) who researched on effective utilization of ICT and noted that ICT training provide the skills and knowledge they require to adopt ICT effectively. However, it opposes Ohlan *et al.* (2021) who assessed international training program on ICT application and found a higher percentage of farmers trained on ICT tools usage. The fact that the majority of the smallholder farmers had less training with low usage might mean that the smallholder farmers did not have adequate knowledge and skills that may enable them to optimize the benefit of ICT tools in agriculture since the farmers require many repetitions of training to master the concept effectively (Laureti *et al*., 2022).

Table 9

Training and use of ICT tools

Factor	Total respondents		Respondents Used ICT	
	F	%	F	%
Training				
No access	67	63	6	9
Access	39	37	34	87
Total	**106**	**100**	**40**	
Sources				
Agriculture Ministry	15	38	13	87
Private sector	21	54	19	90
Universities	3	8	2	67
Total	**39**	**100**	**34**	
Numbers				
Once	18	46	15	83
2-3 times	15	39	13	87
More than 4	6	15	6	100
Total	**39**	**100**	**34**	
Types				
ICT operation & importance.	14	36	12	86
Available program., operation & opportunities.	6	15	6	100
Importance, operation, opportunities & program available.	19	49	16	84
Total	**39**	**100**	**34**	

4.4.1 Relationship between Access to Training and Use of ICT Tools

Objective two was translated into the following null hypothesis;

H02: *Access to training has no statistically significant relationship with the use of ICT tools among cassava smallholder farmers in Rangwe Sub-County, Kenya.*

Simple linear correlation was used to determine the relationship between smallholder farmers' access to training and the use of ICT tools in agricultural extension at 0.05 level of significance (Table 10). There was a moderate correlation between access to training and the use of ICT tools (R = +.778, P = .004, R^2 =0.602). Access to training appears to provide a substantial guide to the use of the ICT tools as it predicts at 60% of the use of ICT tools among cassava smallholder farmers. The remainder (40%) of the unexplained variance may involve other variables. This qualified rejection of the null hypothesis. The results concurred with the findings of Al-Mamary *et al.* (2022) who examined the factors affecting the use of ICT among farmers and reported that access to training increase adoption through awareness and knowledge provision on the technology. On the other hand, it opposes Chohan and Hu (2022) who conducted a study on cohesive ICT training programs and reported that access to training did not correlate with the use of improved crops.

Table 10

Hypothesis two test

Independent variable	***R***	***R^2***	**Adj. *R^2***	**Sig.**	**Hypothesis test**	**Interpretation**
Access to training.	0.778	0.606	0.602	0.004	Null hypothesis rejected (0.004<0.05)	There is a moderate correlation. A unit increase in access to training leads to a significant increase in ICT tools' adoption

4.5 Credit and Use of Information and Communication Technology Tools

The third objective of this study was to:

Determine the relationship between access to credit and the use of ICT tools among cassava smallholder farmers in Rangwe Sub-County, Kenya.

The farmers were asked to indicate whether they accessed credit or not, if they do they indicate sources and amount. The results revealed that 67% of the smallholder farmers interviewed had no access to credit and 15% of them (who had no access to credit) use of ICT tools in farming, while 33% had access with 83% ICT usage. The majority (77%) of those who had access to credit received from SACCOs and friends with81% the tool usage, followed by 23% who received it from banks and had 88% use of the tools. The majority (63%) of those accessed received the credit amounts between KES 10,000 to 20,000 yearly and had 95% ICT usage, followed by 26% who had received less than KES 10,000 with 56% tools usage, and lastly, 11% had received between KES 20,001 to 30,000 and had 100% use of the tools (Table 11).

A relatively low percentage of smallholder cassava farmers who accessed credit with the most significant percentage who had received the low amount from locally saving and credit institutions might mean that the smallholder farmers experienced significant challenges accessing credit and using ICT tools (Karanja *et al.,* 2020). The use of ICT tools requires funds to buy and subscribe to the services. The finding agreed with previous report in which access to credit was appreciated to assist in ICT and innovation adoption (Mushtaq *et al*., 2022). Nevertheless, it contradicted Nagar *et al.* (2021) who researched on determinants of access to extension services and adoption of technical inputs in India and noted that most smallholder farmers had access to credits.

Table 11

Credit and use of ICT tools

Factor	Total respondents		Respondents Used ICT	
	F	**%**	**F**	**%**
Credit				
No access	71	67	11	15
Access	35	33	29	83
Total	**106**	**100**	**40**	
Sources				
SACCOs & friends	27	77	22	81
Banks	8	23	7	88
Total	**35**	**100**	**29**	
Amount				
X<KES 10,000	9	26	5	56
KES 10,000-20,000	22	63	20	95
KES 20,001-30,000	4	11	4	100
Total	**35**	**100**	**29**	

4.5.1 Relationship between Access to Credit and Use of ICT Tools

Objective three was translated into the following null hypothesis;

H03: *Access to credit has no statistically significant relationship with the use of ICT tools among cassava smallholder farmers in Rangwe Sub-County, Kenya.*

Simple linear regression was run to determine the relationship between smallholder farmers' access to credit and the use of ICT tools in cassava production at 0.05 level of significance (Table 12). There was a moderate, positive correlation between access to credit and the use of the ICT tools (R = +.654, P = .003, R^2 =0.427, adj. R^2=0.422). Access to credit appears to provide a moderate guide to the use of the ICT tools as it 42% of the use of the ICT tools in agricultural extension. A unit increase in access to credit cause a significant increase in the use of ICT tools in agricultural extension. The remaining (58%) unexplained variance may involve other variables. This qualified rejection of the null hypothesis. The results concurred with the findings of Oyelami *et al*. (2022)

who researched on ICT adoption and agricultural performance on access to credit among smallholder farmers and reported that access to adequate finance provides an ability to subscribe and utilize ICT services. They can easily acquire the tools and maintain in service. However, it contradicted the findings of Lazaro and Alexis (2021) who researched on the factors that determine how smallholder farmers receive agricultural credit in Tanzania and stated that access to loans burden farmers with payment stress and divert attention from the adoption to loan issues. Some farmers acquire loans to use in farming but do not manage to adopt ICT tools in agricultural extension.

Table 12

Hypothesis three test

Independent variable	***R***	***R^2***	**Adj. *R^2***	**Sig.**	**Hypothesis test**	**Interpretation**
Access to credit.	0.654	0.427	0.422	0.003	Null hypothesis rejected (0.003<0.05)	Moderate correlation exists. A unit increase in access to credit results to a significant increase in ICT tools' adoption

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter entails a summary, conclusions, recommendations and suggestions for future study based on the findings of this research study.

5.2 Summary of the Study

The majority of cassava smallholder farmer in Rangwe Sub-County, Kenya were not using ICT tools to acquire agricultural extension information. The few who adopted the tools benefited by getting efficient information on production inputs, on-farm operation, harvesting, processing and marketing of cassava products. The tools used included mobile phones, radios, televisions and computers. The main opportunities that existed in the use of the tools included availability of ICT tools, efficiency, convergence and subsidized services. The major constraints farmers faced in the used included tools expensive, inadequate operation skills, power source not reliable and poor network connectivity.

The majority of the farmers were female, primary education level attainers, low income earners and middle age individuals. The selected socioeconomic factors were found to have very high correlation with the use of ICT tools in agricultural extension. Increase in income level, education level lead to increase in the adoption. However, increase in age results to decease in the use of the tools. More males used the tools than the females.

Minority of the farmers had access to training organized to equip the farmers with ICT skills. The major source of the training was private sectors followed by public and the universities. The types of training received included operations skills, programs available and opportunities in the use. The majority of those who accessed the training had attended once followed by those who attended 2-3 times and lastly those attended 4 times. Increase in access to training appeared to increase the adoption of the tools in farming.

A few of the farmers had access to agricultural credit. The major sources of the credit were SACCOs and friends followed by banks. Many of those who received credit got little amount ranging from kes 10,000 to 20, 000. Increase in access to the agricultural credit proved to increase the use of ICT tools in agriculture.

5.3 Conclusions

The following conclusions were arrived at base on the study findings:

(i) Very high relationship exists between the selected socio-economic factors (income level, education level, age and gender) and the use of ICT tools among cassava smallholder farmers in Rangwe Sub-County, Kenya.

(ii) Moderate relationship exists between access to training and the use of ICT tools among smallholder cassava farmers in Rangwe Sub-County, Kenya.

(iii) Access to credit and the use of ICT tools had a moderate relationship among cassava smallholder farmers in Rangwe Sub-County, Kenya.

5.4 Recommendations

Based on the findings of this study, the following recommendations were made:

(i) Low education attainers, female farmers and those with little income level should be empowered through providing free ICT tools, teaching them and subsidizing the services to improve the adoption.

(ii) Training programs should be organized for smallholder farmers on the use of ICT tools in agriculture to equipt them with knowledge and improve the adoption.

(iii) Enabling environment should be provided for creditors to thrive.

5.5 Suggestions for Further Research Studies

The following suggestion for further research was arrived at based on the results of this study:

Research study should be conducted to determine the use of the ICT tools among the agricultural extension officers in Homa-bay County, Kenya. This might provide knowledge on the future of ICT in agricultural extension.

REFERENCES

Agyekum, F. K., Reddy, K., Wallace, D., & Wellalage, N. H. (2022). Does technological inclusion promote financial inclusion among SMEs? Evidence from South-East Asian (SEA) countries. *Global Finance Journal*,*53*(10)6-18.

Akintelu, S. O., Awojide, S., Akinbola, A. O., & Adegbite, W. M. (2021). Social Demographic Factors and Information and Communication Technology (ICT) Adoption Constrains Amongst Small and Medium Scale Farmers in Nigeria. *International Journal of ICT Research in Africa and the Middle East (IJICTRAME),10(1)33-41. 6042-6046. doi: 10.4018/ijictrame.2021010103.*

Alemu, A. (2021). Determinants of Participation in Farmers Training Centre Based Extension Training in Ethiopia. *Journal of Agricultural Extension*,*25*(2)86-95.

Al-Mamary, Y. H. S. (2022). Examining the factors affecting the use of ICT in teaching in Yemeni schools. *Journal of Public Affairs*,*22*(1)23-30.

Amelework, A. B., & Bairu, M. W. (2022). Advances in Genetic Analysis and Breeding of Cassava (Manihot esculenta Crantz): A Review. *Plants*,*11*(12)16-17.

Ankrah Twumasi, M., Jiang, Y., Ntiamoah, E. B., Akaba, S., Darfor, K. N., & Boateng, L. K. (2022, February). Access to credit and farmland abandonment nexus: The case of rural Ghana. *Resources Forum Natural Blackwell Publishing*,46(1)3-20).

Arora, S. C., Sharma, M., & Singh, V. K. (2022). Using diffusion of innovation framework with attitudinal factor to predict the future of mobility in the Indian market. *Environmental Science and Pollution Research*,12(7)1-16.

Asif, M. S. U., Farouque, M. G., Rahman, M. H., & Rana, M. M. (2019). Constraints of Using Information and Communication Technologies by Young Entrepreneurs for Farm Management. *Bangladesh Journal of Extension Education,3(2)29-37 ISSN*,1011-3916. http://bjee.com.bd/public/articles/Constraints-of-Using-ICTs-by-Young-Entrepreneurs.pdf

Asravor, R. K., Boakye, A. N., & Essuman, J. (2022). Adoption and intensity of use of mobile money among smallholder farmers in rural Ghana. *Information Development*,*38*(2)204-217.

Baruah, A., & Mohan, G. M. (2021). Exploring the ICT preferences of personnel from agricultural extension organizations in the northeastern region of India. *Asian Journal of Agriculture and Development*,*18*(13)106-120.

Beckman, J., & Countryman, A. M. (2021). The importance of agriculture in the economy: impacts from COVID-19. *American Journal of Agricultural Economics*,*103*(5)1595-1611.

Benard, R., Dulle, F., & Lamtane, H. (2021). Determinants of Information and Communication Technology Use in sharing Information by Fish Farmers in the Southern Highlands of Tanzania. *The Sub Saharan Journal of Social Sciences and Humanities (SJSSH),1(1)8-17. http://eajssh.sua.ac.tz:9093/index.php/EAJSSH/article/view/39.*

Benson, O. B., Olatilewa, O. M., Anifowoshe, A. O., & Sanusi, R. O. (2022). Exploring the Effectiveness of Selected Postharvest Training Information on Improved Maize Crib Utilization by Maize Farmers in Southwest Nigeria. *European Journal of Training and Development Studies*,*9*(1)20-31.

Bhusal, A., Sagar, G. C., & Khatri, L. (2021). A review article on role of information and communication technology in agriculture and factors affecting its dissemination in Nepal. *J. Appl. Biotechnol*,8(5)81-85.

Bielski, S., Marks-Bielska, R., Zielińska-Chmielewska, A., Romaneckas, K., & Šarauskis, E. (2021). Importance of agriculture in creating energy security—a case study of Poland. *Energies*,*14*(9)24-31.

Bucci, G., Bentivoglio, D., & Finco, A. (2019). Factors affecting ICT adoption in agriculture: A case study in Italy. *Calitatea*,*20*(2)122-129.

Cheboi, P. K., Siddiqui, S. A., Onyando, J., Kiptum, C. K., & Heinz, V. (2021). Effect of Ploughing Techniques on Water Use and Yield of Rice in Maugo Small-Holder Irrigation Scheme, Kenya. *AgriEngineering, 3(1)110-117.* https://doi.org/10.3390/agriengineering3010007

Chia, S. Y., Macharia, J., Diiro, G. M., Kassie, M., Ekesi, S., van Loon, J. J., ... & Tanga, C. M. (2020). Smallholder farmers' knowledge and willingness to pay for insect-based feeds in Kenya. *PloS one*,*15*(3)021-34.

Chiazoka, E., Oduntan, F. T., & Olayemi, S. S. (2021). Awareness and Usage of Information and Communication Technologies (ICTs) among Farmers in Federal Capital Territory, Nigeria. *Cur Tre Agri Envi Sust*,*2*(1)1-4.

Chilundo, A. G., Mukaratirwa, S., Pondja, A., Afonso, S., Alfredo, Z., Chato, E., & Johansen, M. V. (2020). Smallholder pig farming education improved community knowledge and pig management in Angónia district, Mozambique. *Tropical Animal Health and Production*,*52*(3)1447-1457.

Chohan, S. R., & Hu, G. (2022). Strengthening digital inclusion through e-government: cohesive ICT training programs to intensify digital competency. *Information Technology for Development*,*28*(1)16-38.

Christian, C. S., Fraser, R., Herbert, B. S., & Scott, C. (2022). Training of Small Farmers and Minority Agroforestry Landowners in Southeastern US–an Evolving Model. *Advances in Social Sciences Research Journal*,*9*(1)2-9.

County Integrated Development Plan. (2021). Homa-Bay, *Nairobi. Kenya.*

Cronbach, L. J. (1975). Beyond the two disciplines of scientific psychology. *American Psychologist, 30*(2)116–127. https://doi.org/10.1037/h0076829

Dhehibi, B., Rudiger, U., Moyo, H. P., & Dhraief, M. Z. (2020). Agricultural technology transfer preferences of smallholder farmers in Tunisia's arid regions. *Sustainability*,*12*(1)4-21. https://doi.org/10.3390/su12010421

Diaz, R. T., Osorio, D. P., Hernández, E. M., Pallares, M. M., Canales, F. A., Paternina, A. C., & Echeverría-González, A. (2022). Socioeconomic determinants that influence the agricultural practices of small farm families in northern Colombia. *Journal of the Saudi Society of Agricultural Sciences*,*21*(7)440-451.

Dongmei, Y., & Mingzhong, L. (2021). Study on the impact of training onthe agricultural operating income of novel professional farmers. *Journal of Chinese Agricultural Mechanization*,*42*(9)2-22.

Dutta, H., & Hazarika, A. (2020). Assessment of Different Aspects of Elephant Depredation at a Rural Society-Protected Area Interface in Northeast India Based on Public Estimation. *Strategies for Sustainability*,*6(2)*249–263. https://doi.org/10.1007/978-3-030-32463-6_12.

Ekpunobi, C. E., Nwigwe, A. C., & Nkamigbo, D. C. (2020). Socioeconomic determinants of Yellow Cassava production in Anambra State, Nigeria, West Africa. *International Journal of Applied Science And Research*,*3*(2)90-100.

Fathi, R., & Azizpanah, A. (2021). Investigating the effective factors on the use of training based on information and communication technology in agriculture of North Khuzestan. *Journal of Rural Development Strategies*,*8*(1)55-69.

Food and Agriculture Organization Statistics (FAOSTAT). (2020). United Nations of the Statistical Database, Statistical Division, *Rome*.

Fussell, S. G., & Truong, D. (2022). Using virtual reality for dynamic learning: an extended technology acceptance model. *Virtual Reality*,*26*(1)249-267.

Gaol, T. V. L., & Gustira, M. R. (2020). Utilization of Information and Communication Technology in Agriculture. In *IOP Conference Series:Materials Science and Engineering*,879(1)234-242.

Getahun, A. A. (2020). Challenges and opportunities of information and communication technologies for dissemination of agricultural information in Ethiopia. *International Journal of Agricultural Extension*,*8*(1)57-65.

Getahun, A. A. (2020). Challenges and opportunities of information and communication technologies for dissemination of agricultural information in Ethiopia. *International Journal of Agricultural Extension*,*8*(1)57-65.

Goh, E., & Sigala, M. (2020). Integrating Information & Communication Technologies (ICT) into classroom instruction: teaching tips for hospitality educators from a diffusion of innovation approach. *Journal of Teaching in Travel & Tourism*,*20(2)156-165*.

Gupta, Y., Khan, F. M., & Agarwal, S. (2021). Exploring Factors Influencing Mobile Learning in Higher Education-A Systematic Review. *International Journal of Interactive Mobile Technologies*,*15*(12)18-29.

Hartmann, G., Nduru, G., & Dannenberg, P. (2021). Digital connectivity at the upstream end of value chains: A dynamic perspective on smartphone adoption amongst horticultural smallholders in Kenya. *Competition & Change*,*25(2)167-189.*

Huijsmans, R., Ambarwati, A., Chazali, C., & Vijayabaskar, M. (2021). Farming, gender and aspirations across young people's life course: Attempting to keep things open while becoming a farmer. *The European Journal of Development Research*,33(1)71-88.

Husband, G. (2020). Ethical data collection and recognizing the impact of semi-structured interviews on research respondents. *Education Sciences*,10(8)206-207.

Jablanovic, V. (2021). Investment in Information and Communication Technology in Agriculture and Soybean Production Stability: The Case of China. *Engineering Proceedings*,*9*(1)34-35.

Jat, J. R., Punjabi, N. K., & Bhinda, R. (2021). Use of ICTs by tribal farmers for obtaining agricultural information in southern Rajasthan. *Indian Journal of Extension Education*,*57*(3)16-19.

Kabir, K. H., Hassan, F., Mukta, M. Z. N., Roy, D., Darr, D., Leggette, H., & Ullah, S. A. (2022). Application of the technology acceptance model to assess the use and preferences of ICTs among field-level extension officers in Bangladesh. *Digital Geography and Society*, 3(20)10-22. https://doi.org/10.1016/j.diggeo.2022.100027

Karanja, L., Gakuo, S., Kansiime, M., Romney, D., Mibei, H., Watiti, J., ... & Karanja, D. (2020). Impacts and challenges of ICT based scale-up campaigns: Lessons learnt from the use of SMS to support maize farmers in the UPTAKE project, Tanzania. *Data Science Journal*,*19*(1)34-42.

Kassem, H. S., Alotaibi, B. A., Muddassir, M., & Herab, A. (2021). Factors influencing farmers' satisfaction with the quality of agricultural extension services. *Evaluation and Program Planning*,*85*(10)19-25.

Khan, N. A., Qijie, G., Sertse, S. F., Nabi, M. N., & Khan, P. (2020). Farmers' use of mobile phone-based farm advisory services in Punjab, Pakistan. *Information Development*,*36*(3)390-402.

Krell, N. T., Giroux, S. A., Guido, Z., Hannah, C., Lopus, S. E., Caylor, K. K., & Evans, T. P. (2020). Smallholder farmers' use of mobile phone services in central Kenya. *Climate and Development*,13(3)1-13.

Krishna T., Sajeev MS, Raju S., Giri N., Pradeepika C., Bansode V. (2020). Studies on the development of cassava based reconstituted dry starch sago with modified starch as binder and characterization of its physico-functional properties. *Journal of Environmental Biology*,41(1)29-34.

Kumar, V., Khan, I. M., Sisodia, S. S., Sharma, R. N., & Sharma, K. C. (2021). Training Needs of Agriculture University Teachers Regarding Effective Utilization of ICT Tools. *Journal of Agricultural Resources*,16(2)30-43.

Kundiri, M. M., Bello, O. G., Mamman, B. Y., Makinta, U., Chamo, A. M., & Kenneth, A. I. (2022). Socio-economic Determinants of Adoption of Improved Cassava Varieties among Crop Farmers in ADP Zone I, Jigawa State, Nigeria. *Journal of Agricultural Economics, Environment and Social Sciences,8*(1)20-32.

Laureti, L., Costantiello, A., Matarrese, M., & Leogrande, A. (2022). Enterprises Providing ICT Training in Europe. *East African Agricultural and Forestry Journal,75*(3)9-15

Lazaro, A. M., & Alexis, N. (2021). Determinants of credit demand by smallholder farmers in Morogoro, Tanzania. *African Journal of Agricultural Research,17*(8)1068-1080.

Lazim, C. S. L. M., Ismail, N. D. B., & Tazilah, M. D. A. K. (2021). Application of technology acceptance model (TAM) towards online learning during covid-19 pandemic: Accounting students perspective. *International. Journal Business. Economic and Law,24*(1)13-20.

Li, Q., Wang, J., Wang, X., & Wang, Y. (2022). The Impact of Training on Beef Cattle Farmers' Installation of Biogas Digesters. *Energies,15*(9)30-39.

Li, W., Ji, L., Shi, W., Yang, Y., Awais, M., Wang, Y., & Xu, X. (2020). Correlation research of rotor–stator interaction and shafting vibration in a mixed-flow pump. *Journal of Low Frequency Noise, Vibration and Active Control,39*(1)72-83.

Luo, L., Qiao, D., Tang, J., Wan, A., Qiu, L., Liu, X., ... & Fu, X. (2022). Training of Farmers' Cooperatives, Value Perception and Members' Willingness of Green Production. *Agriculture,12*(8)11-45.

Mhlanga, D., & Dunga, S. H. (2020). Measuring financial inclusion and its determinants among the smallholder farmers in Zimbabwe: An empirical study. *Eurasian Journal of Business and Management,8*(3)266-281.

Mishra, A., Yadav, O. P., Dubey, S. K., Kumar, N., & Mishra, S. (2020). Extent of use of ICT Tools for Accessing the Agricultural Information in Lucknow District of Uttar Pradesh. *Journal of Community Mobilization and Sustainable Development*,15(3)759-763.

Mizik, T. (2021). Climate-smart agriculture on small-scale farms: a systematic literature review. *Agronomy,11*(6)10-26.

Mushtaq, R., Gull, A. A., & Usman, M. (2022). ICT adoption, innovation, and SMEs' access to finance. *Telecommunications Policy,46*(3)61-75.

Mutoni, C. K., Nzuve, F. M., Miano, D. W., Kivuva, B. M., Ferguson, M. E., & Kipkoech, Y. H. (2022). Prevalence of cassava brown streak and cassava mosaic diseases in Lamu County Kenya. *East African Agricultural and Forestry Journal,85*(3 & 4)8-8.

Nagar, A., Nauriyal, D. K., & Singh, S. P. (2021). Determinants of farmers access to extension services and adoption of technical inputs: Evidence from India. *University. Journal of Agricultural Resources,9*(4)127-137.

Naqvi, S. M. H., Siddiqui, B. N., & Haider, M. Z. Y. (2021). Factors Influencing Adoption of Mobile hPone among Vegetable Growers: A study of Dera Dhazi Khan, Punjab. *J. Agric. Res,59*(2)229-234.

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

Nyarko, D. A., & Kozári, J. (2021). Information and Communication Technologies (ICTs) Usage among Agricultural Extension officers and its Impact on Extension Delivery in Ghana. *Journal of the Saudi Society of Agricultural Sciences*,20(1)1-66.

Obong'o, B. O., Ayodo, G., Kawaka, F., & Adalla, M. K. (2020). Fungi and Aflatoxin Levels in Traditionally Processed Cassava (Manihot esculenta Crantz) Products in Homa Bay County, Kenya. *International Journal of Microbiology*,20(1)126-154.

Ogenga, J. O., Mugalavai, E. M., & Nyandiko, N. O. (2018). Impact of Rainfall Variability on Food production under Rain-fed Agriculture in Homa Bay County, Kenya. *International Journal of Research and Scientific Publications,8(8),849-861*.

Ogutu, S. O., Gödecke, T., & Qaim, M. (2020). Agricultural commercialisation and nutrition in smallholder farm households. *Journal of Agricultural Economics,71*(2)534-555.

Ohlan, M., Shirur, M., & Dharmaraj, B. M. (2021). Assessment of International Training Program on ICT Applications in Agricultural Extension Management for Officials from Africa and Asia. *Journal of Agricultural Extension Management,22*(1)71-84.

Okello, D., Owuor, G., Larochelle, C., Gathungu, E., & Mshenga, P. (2021). Determinants of utilization of agricultural technologies among smallholder dairy farmers in Kenya. *Journal of Agriculture and Food Research,6*(10)2-13.

Okoroji, V., Lees, N. J., & Lucock, X. (2021). Factors affecting the adoption of mobile applications by farmers: An empirical investigation. *African Journal of Agricultural Research,17*(1)19-29.

Onuwa, G., & Folorunsho, S. (2022). Determinants of Tomato Farmers Participation in Agricultural Services and Training Centre (ASTC) Activities. *Turkish Journal of Agriculture-Food Science and Technology*,*10*(8)1369-1376.

Otun, S., Escrich, A., Achilonu, I., Rauwane, M., Lerma-Escalera, J. A., Morones-Ramírez, J. R., & Rios-Solis, L. (2022). The future of cassava in the era of biotechnology in Southern Africa. *Critical Reviews in Biotechnology*,8(3)1-19.

Ouma, J. O., & Ngala, S. (2021). Contribution of cassava and cassava-based products to food and nutrition security in Migori County, Kenya. *African Journal of Food, Agriculture, Nutrition and Development*,*21*(1)17379-17414.

Oyekola, I. A., Oye, A. J., Samuel, F., OYEYIPO, E. J., Arisukwu, O. C., Iwelumor, O. S., & Rasak, B. (2021). Social, Economic and Ecological Factors Influencing Cassava Farming in Nigerian Rural Context. *International Journal of Social Sciences*,*10*(4)295-303.

Pajk, T., Van Isacker, K., Aberšek, B., & Flogie, A. (2021). STEM Education in Eco-Farming Supported by ICT and Mobile Applications. *Journal of Baltic Science Education*,*20*(2), 277-288.

Pal, A., Singh, D., & Dhaliwal, R. K. (2020). Identification and relevance of e-readiness assessment tools for ICT use in agriculture. *Current Journal of Applied Science and Technology*,*39*(16)93-102.

Parlasca, M. C., Johnen, C., & Qaim, M. (2022). Use of mobile financial services among farmers in Africa: Insights from Kenya. *Global Food Security*,*32(10)*50-62.

Parvand, S., & Rasiah, R. (2022). Adoption of Advanced Technologies in Palm Oil Milling Firms in Malaysia: The Role of Technology Attributes, and Environmental and Organizational Factors. *Sustainability*,*14(1)26-32*.

Pinto, L., Ferreira, C. S., & Pereira, P. (2021). Environmental and socioeconomic factors influencing the use of urban green spaces in Coimbra (Portugal). *Science of The Total Environment*,*792*,(14)82-93.

Pogorelskaia, I., & Várallyai, L. (2020). Agriculture 4.0 and the role of education. *Journal of Agricultural Information*,*11(8)*45-51.

Quaye, W., Fuseini, M., Boadu, P., & Asafu-Adjaye, N. Y. (2019). Bridging the gender gap in agricultural development through gender responsive extension and rural advisory services delivery in Ghana. *Journal of Gender Studies*,*28(2)185-203.*

Raza, M. H., Khan, G. A., Shahbaz, B., & Saleem, M. F. (2020). Effectiveness of information and communication technologies as information source among farmers in Pakistan. *Pakistan Journal of Agricultural Sciences*,57(1)281-288. DOI: 10.21162/PAKJAS/19.8292

Sa'adu, M., Man, N., Kamarulzaman, N. H., Shah, J. A., & Tafida, A. A. (2022). Factors Affecting use of Information Communication Technologies among Extension Agents in North-East, Nigeria. *Journal of Agricultural Extension*,*26*(1)36-43.

Samwel, S. M., Paul, K., & Joshua, O. (2021). Effectiveness of Imazapyr Coated Hybrids and Selected Striga-tolerant Varieties on S. hermonthica Management and Maize Yield Performance in Western Part of Kenya. *Advances in Applied Physiology*,*6(1)1-13.*

Schrepp, M. (2020). On the Usage of Cronbach's Alpha to Measure Reliability of UX Scales. *Journal of Usability Studies*,*15*(4)56-67.

Sel Pilar Ríos-León, R., Salas-Huallparimache, J. M., Díaz-Pizán, M. E., & Blanco-Victorio, D. J. (2022). Validity and Reliability of questionnaires measuring attitudes to oral health: A review of the literature. *Journal of Clinical and Experimental Dentistry*,*14*(9)7-18.

Sethy, S., & Mukhopadhyay, S. D. (2020). Use of ICTs by Farmers: A Study in Odisha. *Asian Journal of Agricultural Extension, Economics & Sociology*,*38*(5)74-86.

Simiyu, E., Cheboi, J., Miano, D., & Kuria, P. (2022). Evaluation of selected cassava germplasm for tolerance to cassava bacterial blight disease in Kenya. *East African Agricultural and Forestry Journal*,*85*(3 & 4)7-16.

Spielman, D., Lecoutere, E., Makhija, S., & Van Campenhout, B. (2021). Information and communications technology (ICT) and agricultural extension in developing countries. *Annual Review of Resource Economics*,*13(4)*177-201.

Sunday, F. X., Niyitanga, F., Mbarushimana, V., Nyandwi, T., Hakizimana, I., & Njunwa, K. J. (2020). Does contract farming improve Cassava production, price determination and farmer's income in Ruhango district in Rwanda? *Rwanda Journal of Agricultural Sciences*,*2*(1)15-19.

Szyniszewska, A. M. (2020). Cassava Map, a fine-resolution disaggregation of cassava production and harvested area in Africa in 2014. *Scientific Data*,*7*(1)1-5.

United Nations (2020). Teaching material on Trade and Gender Linkages: Gender Impact of Technological Upgrading in Agriculture. *United Nations Publications 405 East 42nd Street New York.*

Uzochukwu, U. V., Mgbedike, N. G., & Chukwujekwu, O. A. (2021). Adoption of Improved Cassava Production Technologies among small-scale Farmers in Anambra State, Nigeria. *Journal of Plant Sciences,9(4)119-127.*

Vilhanová, A., Langová, N., Kłos, R., & Máchová, E. (2022). The Effect of Selected Factors on the Strength of Stitches of Upholstery Faux Leather. *Materials*,15(19)65-85.

Wagaba, H., Kuria, P., Wangari, P., Aleu, J., Obiero, H., Beyene, G., ... & MacKenzie, D. J. (2021). Comparative Compositional Analysis of Cassava Brown Streak Disease Resistant 4046 Cassava and its Non-transgenic Parental Cultivar. *GM Crops & Food*,*12*(1)158-169.

Wan Mohd, R. W. I. Norzaidi, M. D. and Roshidi, H. (2020). The Roles of ICT for Knowledge Management In Agriculture. *Journal of Technology Management and Information System*, 2(2)1-12. http://myjms.moe.gov.my/index.php/ijtmis.

Wang, D., Zhou, T., Lan, F., & Wang, M. (2021). ICT and socio-economic development: Evidence from a spatial panel data analysis in China. *Telecommunications Policy,45(7)102-123*.

Wens, M. L., Van Loon, A. F., Veldkamp, T. I., & Aerts, J. C. (2022). Education, financial aid, and awareness can reduce smallholder farmers' vulnerability to drought under climate change. *Natural Hazards and Earth System Sciences*, *22*(4)1201-1232.

Were, M. N., Ndong'a, M., Ogema, V., Mabele, A. S., & Were, H. K. (2022). Diversity of cassava mosaic disease causal viruses in Kenya. *East African Agricultural and Forestry Journal*,*85*(1 & 2)8-8.

Wichean, A., & Sungsanit, M. (2022). Factors Influencing the Intentions to Adopt Technology of the Broiler Farmer in Livestock Region 3, Thailand. *Trends in Sciences,19(1)1707-1707. https://doi.org/10.48048/tis.2022.1707*

Wong, S. (2022). Gendering Information and Communication Technologies in Climate Change. In *Research Anthology on Environmental and Societal Impacts of Climate Change* 1(2)764-779. IGI Global. doi: 10.4018/978-1-6684-3686-8.ch037.

Yang, Q., Zhu, Y., & Wang, F. (2021). Exploring mediating factors between agricultural training and farmers' adoption of drip fertigation system: Evidence from banana farmers in China. *Water*,*13*(10)1364.

Zulqarnain, Norsida Man, Juwaidah Sharifuddin, Muhammad Roslan and Salim Hassan (2020). A Factors Influencing Attitude towards Technology Adoption among Permanent Food

Production Park (PFPP) Program Participants in West Malaysia. *Journal of Agricultural Science and Technology,10(20)89-97. doi: 10.17265/2161-6264/2020.02.004.*

APPENDICES

Appendix A: Questionnaire for Smallholder Cassava Farmers

I am a second-year student at Egerton University, pursuing Master of Science in Agricultural Extension. Am conducting a study on the '*The Relationship between Selected Factors and the Use of ICT Tools in Cassava Production among Smallholder Farmers in Rangwe Sub-County Kenya*.' The research study is a requirement for partial fulfillments of the master's degree in Agricultural extension of Egerton University. Kindly respond to the following questions. Your responses will be treated with confidentiality and for academic purposes only. Thank you.

Section A: Socio-economic Status

Kindly fill/tick where necessary.

1. What is the highest level of education you attained?

Education level	*None (1)*	*Primary (2)*	*Secondary (3)*	*Post-secondary (4)*
Tick				

2. What is your age range in years?

Age group	*18 to 32 (1)*	*33 to 47 (2)*	*48 to 62(3)*	*Above 62 (4)*
Tick				

3. What is your average annual income level in terms of thousands of Kenyan shillings?

Income level	*160 and Below (1)*	*161 to 270 (2)*	*271 to 380 (3)*	*Above 380 (4)*
Tick				

4. What is your gender?

Gender	*Male(1)*	*Female(2)*
Tick		

Section B: Use of ICT tools in Cassava Production

5. What is your source of cassava value chain information? *Tick all that applied.*

Source of cassava value chain information	ICT	Farmer groups	Extensionists	Farmer field school	Plant clinics	Neighbors
Use						

6. (a) Do you use ICT tools in cassava production?

ICT tools usage	Use (1)	No use (0)
Tick		

6 (b) If yes, which of the following ICT tools do you use mostly in the production?

Tick all that applies.

Types of ICT tools used	Mobile phones	Radios	Television	Computer
Usage				

6 (c) What are the challenges in the use of the ICT tools in cassava production?

.....

.....

6 (d) What are the opportunities in the use of ICT tools?

.....

.....

6 (e) What agricultural information's do you receive through the use of ICT tools?

.....

.....

Section C: Access to ICT tools Training and Credit

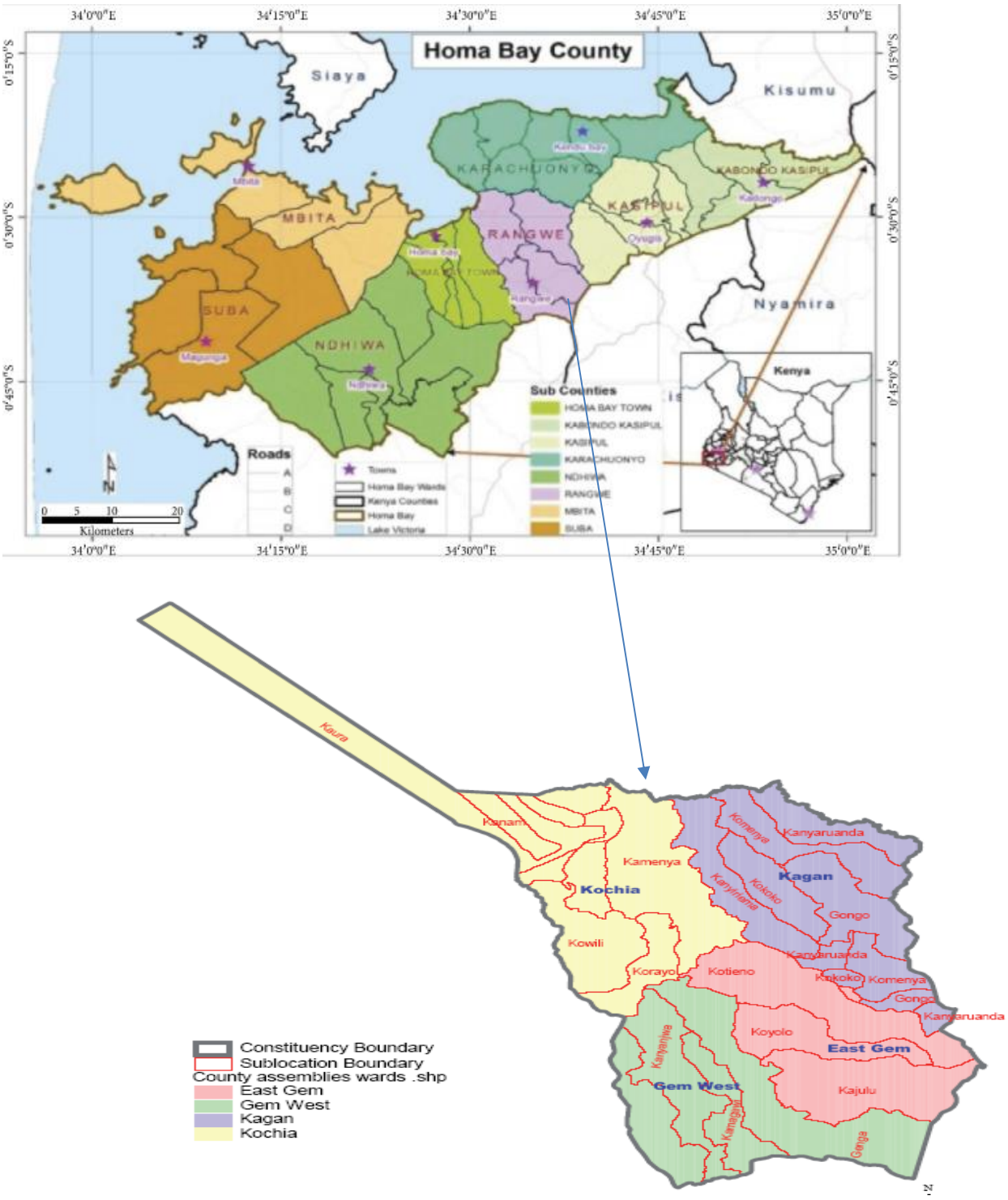
10. Access to training. *Tick all that applies.*

Access to training	*Tick*
Access	
No access	
Sources of training received	
Ministry of Agriculture	
Private systems	
Universities	
Any other	
Training type	
ICT importance	
ICT operation	
ICT programmes available	
Any other	
Number of training received	
Once	
2 to 3 times	
More than 4 times	

11. Access to credit. *Tick all that applies.*

Access to credit	*Tick*
Access	
No access	
Sources of credit received	
SACCOs	
Banks	
Friends	
Any other	
Amount of credit received yearly	
Less than KES 10,000	
KES 10,000 to 20,000	
KES 20,001 to 30,000	
Above KES 30,000	

Appendix B: Location of Rangwe Sub-County in Homa Bay, Kenya



Location of Rangwe Sub-County in Homa-Bay County, Kenya.

Source: CIDP (2017).

Appendix C: Research License

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **686754**

Date of Issue: **06/December/2021**

RESEARCH LICENSE

This is to Certify that Mr.. JOHN CALEB DIMO of Egerton University, has been licensed to conduct research in Homabay on the topic: Socioeconomic factors Influencing the use of Information and Communication and Technology Tools in Cassava Production among Smallholder Farmers in Rangwe Sub-County Kenya for the period ending : 06/December/2022.

License No: **NACOSTI/P/21/14779**

686754

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

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

THE SCIENCE, TECHNOLOGY AND INNOVATION ACT, 2013

The Grant of Research Licenses is Guided by the Science, Technology and Innovation (Research Licensing) Regulations, 2014

CONDITIONS

1. The License is valid for the proposed research, location and specified period
2. The License any rights thereunder are non-transferable
3. The Licensee shall inform the relevant County Director of Education, County Commissioner and County Governor before commencement of the research
4. Excavation, filming and collection of specimens are subject to further necessary clearence from relevant Government Agencies
5. The License does not give authority to tranfer research materials
6. NACOSTI may monitor and evaluate the licensed research project
7. The Licensee shall submit one hard copy and upload a soft copy of their final report (thesis) within one year of completion of the research
8. NACOSTI reserves the right to modify the conditions of the License including cancellation without prior notice

National Commission for Science, Technology and Innovation
off Waiyaki Way, Upper Kabete,
P. O. Box 30623, 00100 Nairobi, KENYA
Land line: 020 4007000, 020 2241349, 020 3310571, 020 8001077
Mobile: 0713 788 787 / 0735 404 245
E-mail: dg@nacosti.go.ke / registry@nacosti.go.ke
Website: www.nacosti.go.ke

Appendix D: Reliability Test Results

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	29	96.7
	Excluded[a]	1	3.3
	Total	30	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.756	.387	108

Item Statistics

	Mean	Std. Deviation	N
Education level	2.4828	.91107	29
Age group	2.7586	.98761	29
Income level	1.1724	.38443	29
Gender	1.6552	.48373	29
Total land size owned	3.0345	.97221	29
Size of land under cassava	1.0690	.51277	29

Appendix E: Key Data Analysis Output

Regression

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Income level in kes 1000, Gender, Age range, Education level[b]	.	Enter

a. Dependent Variable: Use of ICT tools

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.912[a]	.832	.825	.20355

a. Predictors: (Constant), Income level in kes 1000, Gender, Age range, Education level

Regression

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Access to training[b]	.	Enter

a. Dependent Variable: Use of ICT tools

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.778[a]	.606	.602	.30731

a. Predictors: (Constant), Access to training

Regression

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Access to credit[b]	.	Enter

a. Dependent Variable: Use of ICT tools

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.654[a]	.427	.422	.37038

a. Predictors: (Constant), Access to credit

Appendix F: Abstracts' Page of the First Publication

Asian Journal of Agricultural Extension, Economics & Sociology

40(7): 86-95, 2022; Article no.AJAEES.84270
ISSN: 2320-7027

Assessment of Information and Communication Technology Tools' Usage in Agricultural Extension among Cassava Peasants in Rangwe Sub-County, Kenya

John Caleb Dimo [a*], Maina Stephen Wambugu [a] and Alice Chesambu Ndiema [b]

[a] Department of Agricultural Education and Extension, Egerton University, Kenya.
[b] Department of Agribusiness Management and Extension, Masinde Muliro University of Science and Technology, Kenya.

Authors' contributions

This work was carried out in collaboration among all authors. Author JCD designed the study, reviewed literature, collected data, analyzed the data and drafted the first manuscript. Authors MSW and ACN supervised the whole study process and edited the first draft. All authors scrutinized and consent to the manuscript.

Article Information

DOI: 10.9734/AJAEES/2022/v40i730621

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/84270

Original Research Article

Received 02 January 2022
Accepted 11 March 2022
Published 16 April 2022

ABSTRACT

Aims: This study sought to determine selected demographic characteristics, the extent of information and Communication Technology (ICT) tools' usage, opportunities in ICT, challenges in the use, strategies to improve the use, and the correlation between the selected demographic factors and ICT tools' usage among peasants who produce cassava in Rangwe Sub-County, Kenya.
Study Design: A correlation research design was used in this study conducted at Rangwe Sub-County, Kenya from 8th December 2021 to 14th January 2022.
Methodology: The study gathered data with the aid of pretested structured questionnaire from 106 Cassava Peasants (CPs) who used or not used ICT tools in agricultural extension.
Results: The response rate achieved was 100%. The majority of the CPs were female (62%), middle-aged (36-50 years), attained primary education (52%), and earned the lowest average annual income (X ≤ KES160, 000). The majority of ICT tools users in extension were males, elite, higher-income earners, and youths. The largest percentage of ICT tools users mentioned, ICT tools availability as one of the opportunities in ICT, expensiveness as the main challenge in the use, ICT services subsidies as one of the improvement strategies. Spearman's correlation analysis showed that a correlation between the selected demographic factors and ICT tools' usage was statistically significant at a 1% level of significance (P=.000).
Conclusion: Adoption of ICT tools in agricultural extension services is directly proportional to income, gender equality, and education, while it is inversely proportional to age. The provision of supporting policies for the selected demographic factors, availability of training centers, and subsidized credit interest rate would increase ICT tools usage in extension.

Keywords: Information and communication technology tools; peasant farmers; demographic factors; agricultural information; agricultural extension.

Appendix G: Abstracts' Page of the Second Publication

Asian Journal of Agricultural Extension, Economics & Sociology

40(10): 97-105, 2022; Article no.AJAEES.87762
ISSN: 2320-7027

Access to Credit and Its Relationship with Information and Communication Technology Tools' Adoption in Agricultural Extension among Peasants in Rangwe Sub-County, Kenya

J. C. Dimo [a*], S. W. Maina [a] and A. C. Ndiema [b]

[a] Department of Agricultural Education and Extension, Egerton University, Kenya.
[b] Department of Agribusiness and Extension Management, Masinde Muliro University of Science and Technology, Kakamega, Kenya.

Authors' contributions

This work was carried out in collaboration among all authors. Author JCD conducted the literature review, designed the study, collected data, analyzed the data and prepared the first draft of the manuscript. Authors SWM and ACN helped with data analysis, edited the manuscript and supervised the study process. All authors consented and approved the manuscript for publication.

Article Information

DOI: 10.9734/AJAEES/2022/v40i1031047

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/87762

Original Research Article

Received 01 April 2022
Accepted 02 June 2022
Published 15 July 2022

ABSTRACT

Access to agricultural credit is one of the key factors that boost the adoption of technologies to improve agricultural production. Information and Communication Technology (ICT) tools have been referred to as essential channels in the dissemination of agricultural extension information. However, it has been observed that the majority of peasants were not using them to access the information. The aim of this study was to delineate the level of agricultural credit access, sources of the credit, amount of the credit accessed, and the correlation between access to the credit and the use of ICT tools in the extension services among peasants. A correlation research design was utilized in this study at Rangwe Sub-County, Kenya. Data were collected with the help of pretested structured questionnaire from 106 peasants who grow cassava in the Sub-County. The data obtained were analyzed using Spearman's correlation and descriptive statistics with the aid of Statistical Package for Social Science (SPSS) Version 25. Descriptive results revealed that 68% of the peasants interviewed had no access to the credit, while 32% had access. The majority (70%) of those who had the access received it from Saving and Credit Co-Operative (SACCOs). The majority (68%) received the lowest amount of credit. Spearman's correlation revealed that there was a moderate, positive correlation between access to credit and the use of the ICT tools. The correlation was statistically significant at 1% level of significance ($R = +.646^{**}$, $P = .000$, $R^2 = 0.417$). Access to credit appears to provide a positive and moderate correlation with the use of the ICT tools as it predicts 42% of the use of the tools in cassava production. The positive correlation coefficient indicates that an increase in access to agricultural credits among the peasants translates to an increase in the adoption of ICT tools in agricultural extension.

Keywords: Agricultural credit; ICT tools; agricultural technology; post-harvest handling; marketing information.

Appendix H: Abstracts' Page of the Third Publication

Asian Journal of Agricultural Extension, Economics & Sociology

40(9): 22-32, 2022; Article no.AJAEES.86456
ISSN: 2320-7027

Impact of Training on Adoption of Information and Communication Technology Tools in Agricultural Extension among Smallholder Cassava Farmers in Rangwe Sub-County, Kenya

John Caleb Dimo [a*], Maina Stephen Wambugu [a] and Alice Chesambu Ndiema [b]

[a] Department of Agricultural Education and Extension, Egerton University, Kenya.
[b] Department of Agribusiness and Extension Management, Masinde Muliro University of Science and Technology, Kakamega, Kenya.

Authors' contributions

Author JCD conducted the literature review, designed the study, gathered data, analyzed the data, and prepared the first draft of the manuscript. Authors MSW and ACN helped with data analysis, edited the manuscript, and supervised the study process. The authors consented and approved the manuscript.

Article Information

DOI: 10.9734/AJAEES/2022/v40i930671

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/86456

Original Research Article

Received 12 February 2022
Accepted 24 April 2022
Published 21 May 2022

ABSTRACT

The use of Information and Communication Technology (ICT) tools in Agricultural extension in Kenya is key to providing farm families with appropriate technical information and helping them develop skills for improved resource use in their agricultural activities to improve the efficiency of their value chains. The latent perk of ICT tools in the dissemination of agricultural information is not well exploited. Studies to assess the determinants of ICT tools adoption among smallholder cassava farmers in Kenya are limited. The aim of this study was to describe the level of access to training on ICT tools, the level of ICT tools' adoption, and to determine the correlation between access to training and the use of ICT tools among the Small Holder Farmers. A correlation research design was employed in this study at Rangwe Sub-County. The study used pretested structured questionnaire to collect data from 106 SHFs who grow cassava in the Sub-County. Data were analyzed using Statistical Package for Social Science Version 25 to run Spearman's correlation and descriptive statistics. From the results 36% of the respondents had used ICT tools in agricultural extension; only 37% had access to ICT training and a majority had received training once from a private extension system. Spearman's correlation analysis showed that a correlation between access to training and the use of ICT tools among the SHFs was statistically significant at a 1% level of significance ($R = +.776^{**}$, $P = .000$, $R^2 = 0.602$). Training on ICT tools explained about 60% of the use of the tools among the SHFs. An increase in access to the training enhances the use of ICT tools in agricultural extension. The availability of training centers was recommended to increase the use of ICT tools.

Keywords: Access to training; agricultural extension; information and communication technology tools; agriculture.