ASSESSMENT OF GENERATIONAL DIFFERENCES IN AWARENESS, USE AND EFFECTS OF INFORMATION AND COMMUNICATION TECHNOLOGY PLATFORMS AMONG IRISH POTATO FARMERS IN KENYA

BY

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DECLARATION

This thesis is my original work and has not been submitted to any university or institution for any award.

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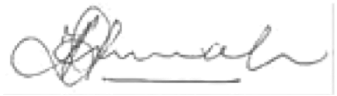

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DEDICATION

I dedicate this work to my late mother, Christine Atieno, whose dream was to see me attain the highest academic goals. I also dedicate it to my uncle Linus and my sister Constand for their constant support and prayers.

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LIST OF ABBREVIATIONS AND ACRONYMS

ATE	Average Treatment Effect
CIDP	County Integrated Development Plan
CIP	International Potato Center (Centro Internacional de la Papa)
DID	Difference-in-Difference
ETE	Endogenous Treatment Effect
ICT	Information and Communication Technology
ISF	Information Security Forum
KACE	Kenya Agricultural Commodity Exchange
KALRO	Kenya Agricultural and Livestock Research Organization
KAOP	Kenya Agricultural Observatory Platform
KNBS	Kenya National Bureau of Statistics
MIS	Market Information Services
MoALD	Ministry of Agriculture, Livestock and Development
MoALF	Ministry of Agriculture, Livestock and Fisheries
NFCC	Nakuru Farmer Call Centre
NPCK	National Potato Council of Kenya
OLS	Ordinary Least Squares
PSM	Propensity Score Matching
RUT	Random Utility Theory
SDGs	Sustainable Development Goals
SMS	Short Message Service
SSA	Sub-Saharan Africa
TC	Transaction Cost

ABSTRACT

Information is a key enabler that updates the use of production resources along agricultural value chains. However, high transaction costs (TCs) remain a challenge to timely and reliable agricultural information. In response to this challenge, information and communication technologies (ICTs) have been developed to facilitate the flow of information along agricultural value chains. The inadequacy of agricultural information has contributed to persistent low potato productivity of 7.9 tons per hectare (t/ha) against the 40 t/ha national threshold. In Kenya, the National Potato Strategy sought to integrate ICT platforms into the potato value chain to support and facilitate farmers' access to real-time data on various information needs. Literature has demonstrated a variation in the adoption stages of ICT. However, the extant literature has focused more on the young users of these technologies than the older ones. Despite their solid contributions to the transformation of the agricultural sector, literature has somewhat ignored the existence of generational differences in ICT. The current study contributes to addressing the aforementioned knowledge gaps by establishing how awareness, use and effects of using ICT platforms vary between the two generations of potato farmers. The study employed a multistage sampling technique in selecting 434 potato farmers from Nakuru County in Kenya. Logit, Heckpoisson and endogenous treatment effect (ETE) models were applied in data analysis. Results showed that access to digital sources of information and use of the internet increased young farmers' awareness of ICT platforms. Additionally, the number of sources of information and access to extension services increased awareness of ICT platforms among older potato farmers. The Heckpoisson results revealed that household income and institutional support services highly determined the use of ICT platforms among young potato farmers. Furthermore, the ETE results indicated a higher and positive effect of using ICT platforms on potato income among older farmers. The study recommends the promotion of diverse interventions targeting improved awareness and use of ICT equally among the youth and older farmers. These include interventions that enhance technical information delivery through extension services, collective action institutions like agricultural groups as well as enhancing online advertisement. Additionally, the study recommends interventions that provide incentives to farmers through increased incomes. These include promoting equal access to physical resources such as land, especially among youth farmers.

Keywords: ICT platforms, potato, awareness, use, intensity of use.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Access to information is critical in boosting agricultural performance to meet the rising demand for food due to rapid population growth in developing countries. According to Das *et al*. (2017) and Kelil *et al*. (2020), reliable agricultural information determines the decisions on the use of factors of production. However, the high cost of searching for information remains a challenge to achieving cost-effective production (Mulbah *et al*., 2020). Additionally, barriers to traditional sources of information like direct extension services (Marwa *et al*., 2019), have hindered farmers' access to timely information (Phiri *et al*., 2017). Such barriers include inadequate extension officers, poor infrastructure, and the recent Covid-19 containment measures against movement and social gatherings (Bright *et al*., 2021).

Consequently, information and communication technologies (ICTs) are emerging to address the aforementioned challenges in access to information (Daum, 2018). Innovations like ICT platforms are being integrated into the agricultural sector to accelerate access to information on various subjects including extension services (Sam and Grobbelaar, 2021). An ICT platform refers to a set of database resources from which multiple users simultaneously draw information on different subject matter (Panos *et al.*, 2018).

The use of ICT as an enabler of agricultural transformation was primarily instituted to enhance access to information in the sector. For instance, it strengthens farmers' access to markets by providing them with timely market information services (MIS) (Okello *et al*., 2020). It also help in reducing transaction costs (TCs) in agriculture by providing symmetric information against opportunistic behaviors like moral hazard and high negotiation costs (Chete *and* Fasoyiro, 2014).

Furthermore, the use of ICT presents an attractive opportunity for the youth to join and upscale agricultural production that has hitherto been characterized by the aging generation of farmers. In Kenya, youth are defined as individuals between the ages of 18 and 35 and account for over 30% of the working age group (Republic of Kenya, 2019). They are energetic individuals who are creative, talented, innovative, easy to train and have high receptors for the use of technologies, such as ICTs. The use of ICT provides a rebranded image, which is useful in enticing youth to

transform the drudgery, rural-based and low-income agricultural image into a 'cool' enterprise (Irungu *et al*., 2015).

In order to enhance information flow among potato value chain actors in Kenya, the Ministry of Agriculture, Livestock and Fisheries (MoALF) ratified the use and integration of ICT in its five-year strategy (Republic of Kenya, 2021). Consequently, various ICT platforms have since been developed to provide information services in the sector. Farmers willingly access information from these platforms through various tools, such as mobile phone applications, short message services (SMSs), websites and social media applications, such as *Facebook* (Ayim *et al*., 2022). These platforms include *DigiFarm* by Safaricom Communication Company, which provides information services on government e-subsidies, inputs, credit, crop insurance and output markets (Iazzolino and Mann, 2019).

The other popular platform is *Viazi Soko* from the National Potato Council of Kenya (NPCK). According to the International Potato Center - CIP (2021), the platform provides access to information on potato quality and certified planting materials, market information, extension and advisory services. Additionally, the Kenya Agricultural and Livestock Research Organization (KALRO) has promoted open information sharing on weather patterns, through the development of the *Kenya Agricultural Observatory Platform (KAOP)* (Osiemo *et al*., 2021). Other ICT platforms in Kenya include *SokoShambani, Mkulima Young, M-Farm, iCow, Kenya Agricultural Commodity Exchange (KACE), M-Kilimo* and *Sokopepe* (Baumüller, 2016).

Since the establishment of these ICT platforms, Nakuru County has been the leading enforcer of their application in agriculture (Maina *et al*., 2023). In conjunction with other strategies, the efforts to promote the use of ICT especially in potato production have enabled the county to maintain high production of potatoes in Kenya (Wakaba *et al*., 2022). In the year 2021, the county contributed about 20% of the national potato output. This is a considerable share of the national output given that currently, the crop is grown in more than 13 counties in Kenya (Republic of Kenya, 2021). Additionally, the county has established various certified seed-producing entities such as Agricultural Development Corporation and Agrico East Africa (CIP, 2021).

The potato sector is among the fastest growing ones, whose contribution to rural economic development through food security and employment is highly appreciated by its producers. The sector recorded an annual production of 2.1 million tonnes in the year 2021 and has employed over

3.3 million people in Kenya (Wakaba *et al.,* 2022). Currently, the crop's productivity is estimated at 7.9 tons per hectare (t/ha) against the national potential of 40t/ha (Republic of Kenya, 2021).

Kenya has consistently recorded low levels of production compared to the leading producers like Egypt and China, at continental and global levels, respectively. Figure 1 shows the latest annual potato production pattern in the world. Kenya has been characterized by a low and fluctuating pattern throughout the past five-year period. For instance, in the year 2021, Kenya produced only two million tonnes compared to Egypt which produced about six million tonnes and China, which produced over 90 million tonnes.

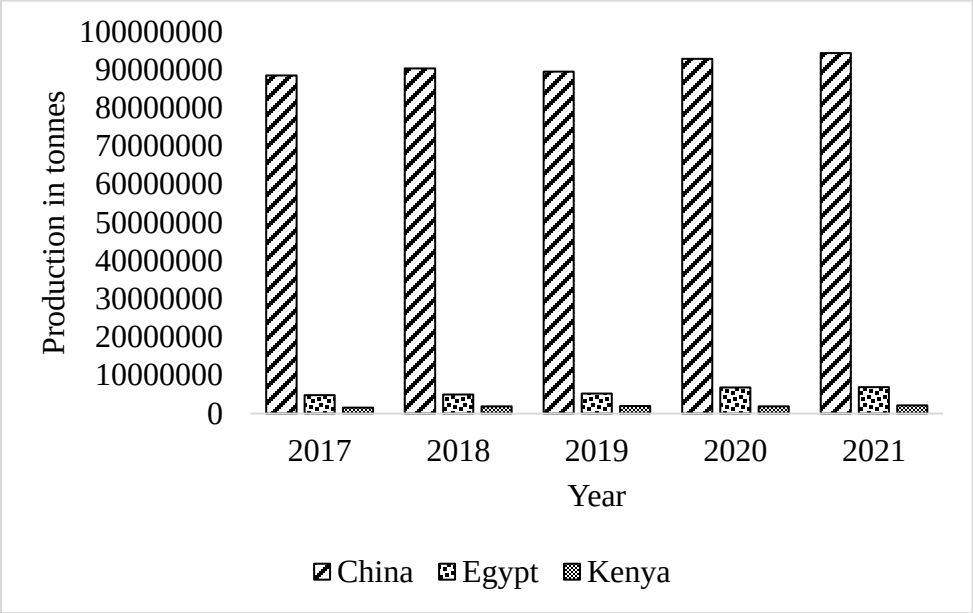

Figure 1: Annual potato production pattern in the world
Source: FAOSTAT (2021).

Several constraints have led to the poor performance of the crop in Kenya. According to Kwambai *et al*. (2022), the lack of clean and certified seeds and planting materials is the most important constraint among potato farmers in Kenya. Subsequently, recycling of old planting materials causes high disease infestation, particularly late blight disease. In addition, high costs of inputs have confined the scale of production to subsistence practice in most rural households. Moreover, the effect of challenges such as high post-harvest losses and inadequate information on standardized market prices has periodically caused spoilage and wastage of this perishable crop. Most of these challenges have been attributed to lack of access to adequate information in the sector (CIP, 2021).

Despite the availability of ICT platforms to enhance potato production through the provision of information solutions to the sectors' challenges, the performance of the crop is still low. The inadequacy of information could be due to low uptake of the ICT platforms among other technologies (Ayim *et al*., 2022). This challenge is mostly common among farmers older than 35 years, who tend to shy away from embracing new technologies by expressing their distrust of them (Rose *et al.*, 2023). Despite their high physical resource endowment, they have low enthusiasm for learning new technologies (Luo *et al.*, 2022). Therefore, even with the ownership of production resources such as land, older farmers tend to have low production efficiency in the phase of technology, leading to low yields (Rigg *et al*., 2020).

The second factor that could lead to low productivity in potato yield is the lack of access to production resources among the farmers, especially the youth (Geza *et al.*, 2021). Potato farming has always been associated with older farmers, who have higher access to land, capital and experience in producing the crop than the younger generation (Ugwu, 2019). According to Ruzzante *et al.* (2021), the poor resource endowment is a disincentive to the youth to use ICT platforms. Consequently, the youth may not produce much even if they have access to ICT (Katunyo *et al.*, 2018).

1.2 Statement of the Research Problem

The existence of generational differences in the use of ICT (see Freeman *et al*., 2020; Guner and Acarturk, 2020; Jolex and Tufa, 2022), and in resource endowment such as land (see Christophers, 2017; Rigg *et al*., 2020; Geza *et al.*, 2021), between the youth and the older farmers has led to a persistent low performance in agriculture (Lindsjö *et al.*, 2020). This has led to a disconnect between the two generations in terms of technical and physical resource ownership. The age gap has greatly hindered the rapid uptake of ICT platforms in potato production (Doss, 2018). Consequently, the productivity of the crop has remained low against the targeted national potential of 40t/ha, which initially informed the integration of ICT in the sector (Republic of Kenya, 2021).

While there is a growing body of literature on youth and their usage of ICT in developing countries like Kenya, research on the links between the youth and older farmers is still scanty. This is despite the latter group dominating and contributing significantly to the rural economy through the production of food crops like potatoes (Mudege *et al*., 2019; Mdoda and Mdiya, 2022). Extant literature has overlooked the significant role of older farmers in rural agriculture, despite them

having vast experience in farming and high resource endowment compared to the youth (Mengui *et al*., 2019).

Subsequently, there is a bias of existing literature as well as the resulting policies towards older farmers. The current study addressed these knowledge gaps by estimating and comparing the determinants of awareness, use, and effects of ICT platforms in potato production in Nakuru County, Kenya from a generational point of view. This is necessary to understand the relative contributions of different generations toward agricultural transformation.

1.3 Objectives of the Study

The purpose of this study was to provide insights that could improve the contribution of ICT platforms to potato production by assessing generational differences in awareness, use and effects of ICT platforms among potato farmers in Nakuru County in Kenya. The specific objectives were:

1. To analyze the differences in determinants of awareness of ICT platforms between the youth and the older potato farmers.
2. To analyze the differences in determinants of use and intensity of use of ICT platforms between the youth and the older potato farmers.
3. To analyze the differences in effects of using ICT platforms on potato income between the youth and the older potato farmers.

1.4 Hypotheses

1. There are no differences in determinants of awareness of ICT platforms between the youth and the older potato farmers.
2. There are no differences in determinants of use and intensity of use of ICT platforms between the youth and the older potato farmers.
3. There are no differences in the effects of using ICT platforms on potato income between the youth and the older potato farmers.

1.5 Justification of the Study

Establishing differences in the factors influencing awareness, use and effects of ICT platforms between youth and older potato farmers, provides policy insights on how to boost potato production in Kenya. The information from this study would help achieve policy targets, such as

the ones documented in the African Agricultural Transformation Strategy of 2016 – 2025. For instance, information on factors affecting awareness of ICT platforms in potato production would help in identifying the causes of digital literacy gaps between the two generations. This would help to fast-track actions that promote equity in the use of ICT infrastructure as an enabler in transforming African agricultural production (African Development Bank, 2016).

Information on factors affecting the use and intensity of use of ICT platforms would inform policy and service providers on the needs of each user group in the design of the platforms. This ensures that digital platforms are made fit to counter the generational inequalities that have led to persistent poverty in sub-Saharan Africa (SSA) (O'Donnell and Sweetman, 2018). Information on the effects of using the platforms on potato income provides insights into the economic importance of these platforms. The results help to determine how the benefits compare between the two groups. Specific policies could be formulated to target the respective groups on the need to encourage them to invest more in the use of these platforms.

At the county level, information on the youth's awareness of ICT platforms is useful in notifying the Nakuru County government of the level of ICT literacy among its farmers. Additionally, information on the use and intensity of use of ICT platforms is useful in enlightening the county government on the degree of the use of ICT in agriculture. This is in line with the Nakuru county integrated development plan (CIDP), which aims to increase youth exposure to ICT by establishing ICT centers in the region. The plan also seeks to improve internet connectivity, integrate the use of ICT in agriculture, and promote online public services and digital literacy (Republic of Kenya, 2018).

Nationally, the study contributes to Kenya's ICT policy, which seeks to improve the livelihood of Kenyans through access to reliable and affordable ICT tools and platforms (Republic of Kenya, 2016). Information from awareness and use of ICT platforms among potato farmers would guide ICT policymakers on the approaches needed to boost the accessibility and use of these platforms. The national ICT policy makers would assess the impact of ICT on livelihoods with the aid of information from the effects of ICT platforms on potato income.

At the continental level, information from this study contributes to aspiration number one of the Africa Agenda 2063 on inclusive growth and sustainable development. The aspiration seeks to increase agricultural production through increasing investments in science and technology and

promoting youth empowerment (DeGhetto *et al*., 2016). Additionally, this study contributes to the fourth Sustainable Development Goal (SDG 4) on inclusivity and equity among the youth and the older population. Achieving inclusivity and equity in technical skills is one of the elements geared towards achieving this goal (United Nations, 2015). The findings from this study are also useful in designing strategies to help achieve the Malabo Declaration, which seeks to end hunger and halve poverty by the year 2025, through empowering the youth (African Union, 2014).

1.6 Study Area

This study was conducted in Nakuru County, Kenya. The county is among the major potato-growing regions besides Nyeri, Kiambu, Taita-Taveta, Trans-Zoia, Nyandarua, Meru, Narok, Bomet, Bungoma, West Pokot, Uasin-Gishu and Elgeyo Marakwet (Republic of Kenya, 2021; Wakaba *et al.*, 2022). The crop production data from the Ministry of Agriculture, Livestock, and Development (MoALD), shows a consistent improvement in potato production in the county from 228,065 tonnes in the year 2018 to 422,207 tonnes in 2021.

The KilimoSTAT (2021) latest data ranked Nakuru County at number two after Elgeyo Marakwet in the year 2021 annual production list, as shown in Figure 2. This justifies the choice of Nakuru County as a suitable study site based on the annual volume of potato production. Due to this high production, the crop has been classified as one of the major cash crops, which is also serving as a major source of livelihood in the region (Republic of Kenya, 2018). Nakuru also hosts various ICT service providers targeting potato production and marketing such as the *Viazi Soko* platform (CIP, 2021).

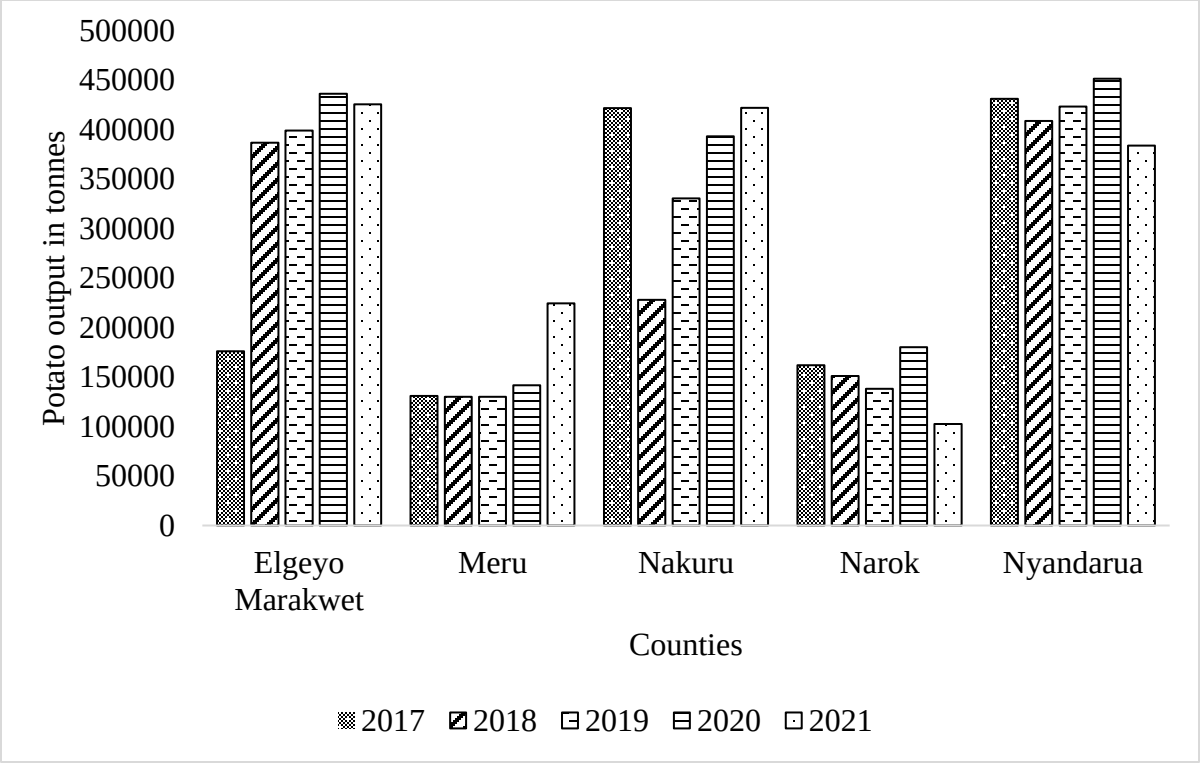

Figure 2: Potato production by counties in Kenya

Source: KilimoSTAT (2021).

Nakuru County is located in the southeastern part of the Rift Valley region and it is bordered by seven counties including Baringo, Nyandarua, Laikipia, Kajiado, Narok, Bomet and Kericho. Further, the county has 11 sub-counties: Kuresoi South, Kuresoi North, Rongai, Subukia, Bahati, Gilgil, Naivasha, Nakuru town West, Nakuru town East, Molo and Njoro. The current study was conducted in Molo and Njoro sub-counties purposely because they host various ICT projects in the county (Maina *et al*., 2023). Figure 3 shows the location of the study sites; Molo and Njoro sub-counties.

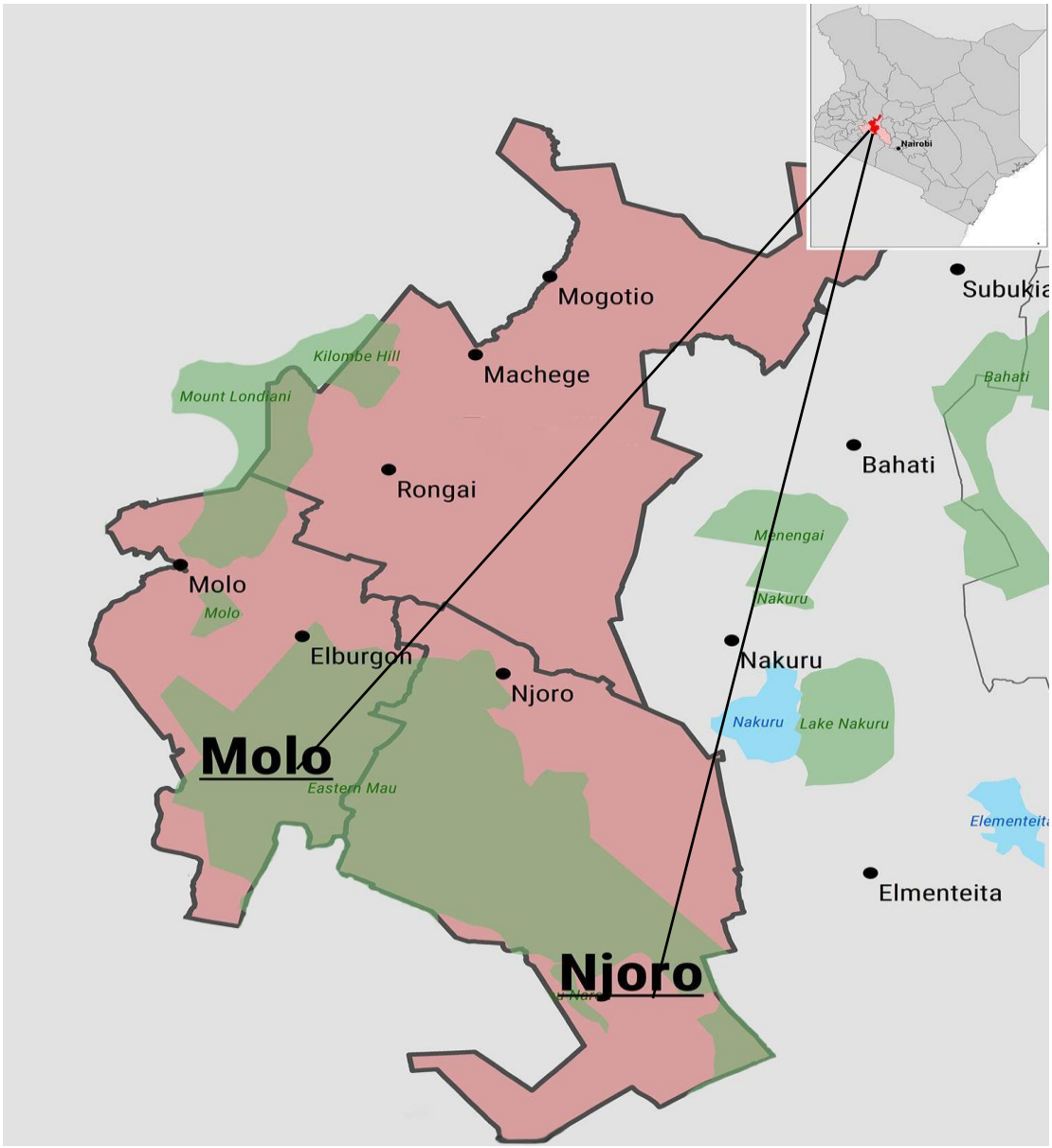

Figure 3: Map of study sites in Nakuru County, Kenya

Source: ARC-GIS explorer (2022).

1.7 Organization of the Thesis

This thesis is structured into six chapters. Chapter one has described the background of the study, statement of the research problem, research objectives, hypotheses, justification of the study and the study area. Chapter two provides a review of the literature. Chapters three, four and five present the methodologies and results in a paper format for each of the three specific objectives. Finally, chapter six offers a summary, conclusion and key recommendations from the study findings.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 The State of ICT Platforms in the World

There are over one million mobile phone applications for agricultural production on the Apple Store and Google Play Store (Kumar and Karthikeyan, 2019). The Information Security Forum (ISF) report of the year 2021 classified the ICT platforms as follows. The digital platforms, which facilitate direct interaction among users, an example is *DigiFarm* in Kenya. The second one is a digital solution provider, such as the Indian *FarmForce*, which provides products to farmers. The third one is the coordination platforms like the *World Cocoa Foundation*, which facilitates systematic knowledge sharing. These platforms are useful in bringing disconnected market actors together, increasing efficiency and transparency in market transactions along agricultural value chains (Shakhovskoy *et al*., 2021).

Globally, China leads in information empowerment through its advanced marketing platforms, such as *WeChat* and *Pinduoduo* (Yang *et al*., 2022). *Pinduoduo* is an internet-based platform that registers over 10 million daily active users. It allows customers to pre-order agricultural products before harvest and enables them to enjoy up to 30% discounts. Elsewhere, *Alibaba's flash sales and marketing platform* are dominantly used by producers and consumers in China and India. The platform enables farmers to access consumers' past purchase data and trends to aid in future planning. It links farmers to cooperatives and enables them to reduce TCs by helping them bypass middlemen.

In Africa, radio has dominated as the main source of 'digital' information, especially in rural agriculture. Other tools like mobile phones have been known for their primary purpose of calling and sending SMS. However, this narrative is gradually changing especially with the introduction of affordable smartphones, which is promoting access and use of mobile phone services (*m-services*) (Krell *et al*., 2021). The establishment of m-services through mobile applications and platforms has become the most predominant innovations from ICT in African agricultural transformation (Ayim *et al*., 2022).

The Kenyan Safaricom-owned *DigiFarm* platform has registered over 1.4 million users since its launch in 2017. The platform offers advisory facilities and provides information on inputs, loans

and credit, off-take services and e-government subsidies. It has enabled farmers to grow their income by up to 40% (Iazzolino and Mann, 2019). Among the cash crop farmers, the *M-Farm* mobile phone application provides information that facilitates collective sales and connects farmers to input dealers and buyers. The platform also enables farmers to access warehouses for storage services and offers them credit services (von Bismarck-Osten, 2021). The other platforms include *Tulaa, Mkulima Young, Twiga Foods and UshauriKilimo* among others in Kenya, *FarmCrowdy* and *Agromall* in Nigeria and *AgroCenta* in Ghana.

2.2 Review of the Use of ICTs in Agriculture

2.2.1 Determinants of Awareness of ICTs in Agriculture

Okello *et al*. (2014), assessed the determinants of awareness of ICT-based market information services in Kenya. The logistic regression results indicated that farmer characteristics, capital endowment variables, and location variables determined awareness. However, the study overlooked infrastructural factors like access and the use of the internet. These factors are useful determinants of the type of platforms used by farmers. It distinguishes the internet-based and SMS-based tools (Okello *et al*., 2020) The current study analyzed how the use of the internet determines the awareness of ICT platforms in potato production between the youth and the older potato farmers.

Mtega *et al*. (2014) conducted a study on awareness and use of web technology in sharing agricultural information in Tanzania. The study showed that 43% of the 255 farmers sampled were aware of these technologies, which included *Facebook* and *Wikipedia*. The study, however, failed to quantitatively analyze the determinants of awareness of these technologies. The current study filled this gap using a binary logit model.

Muatha *et al*. (2017), assessed the determinants of awareness of devolved extension services in Kenya. The logit model deployed on the data collected from 288 farmers in Kenya showed that access to farmer field days increased awareness. Field days are characterized with practical demonstration of the technologies and hence, are regarded high quality in terms of facilitating better understanding among the farmers. This implied that the quality of sources of information a farmer uses increases awareness. In order to improve this finding, the current study determined if the number of such sources of information would result in variation in awareness of ICT platforms

between youth and older potato farmers. This was necessary in informing policy on the need to increase sources of information for farmers.

Furthermore, Joshi *et al*. (2019), found that only education and participation in training increased the awareness of farmers on good agricultural practices among 103 farmers in Nepal. The current study improved the nature of the independent variables used by adding behavioral variables of potato farmers to the analysis. These variables include the number of sources of information and the main type of information. The number and nature of sources of information used by farmers were expected to have different effects on awareness, leading to enhanced quality of the resulting policies for young and older farmers.

2.2.2 Determinants of Use and Intensity of Use of ICT in Agriculture

Okello *et al*. (2014), assessed the determinants of use and intensity of use of ICT-based market information services in Kenya. The three-stage analysis established that farmer characteristics and capital endowment determined the use and intensity of use among the adopters of ICT technology. The study under review used the number of ICT-based market information services to measure the intensity of use. The current study built on this by measuring the intensity of use as the weekly frequency of use of ICT platforms by the farmer. This is in addition to the previous measurement approaches, such as the number of tools used to access information from a platform by Wawire *et al*. (2017).

Enwelu *et al*. (2014) conducted a study on determinants of ICT usage across gender in Nigeria. The study extended its descriptive analysis to compare the use of ICT across men, women and youth. The findings indicated that men led in the use of mobile phones in disseminating agricultural information on input, followed by the youth and then women. The availability of power supply was the main determinant of ICT usage, especially of the radio. However, the study under review did not clearly define how youth differed from men and women. Secondly, the results from the study under review were qualitative. Despite allowing for the detailed and unrestricted explanation of concepts, qualitative analysis generates non-factual and non-evidence-based results and policies. The current study addressed these gaps by quantitatively analyzing the determinants of the use of ICT platforms among youth and older potato farmers. This would help in formulating targeted policy actions for the respective groups concerning their usage of ICT platforms.

Additionally, Wawire *et al*. (2017) analyzed the determinants of use and intensity of use of the *KACE* marketing ICT platform among smallholder farmers in Bungoma County in Kenya. They used logistic and Poisson regression models to analyze the determinants of use and intensity of use, respectively. However, use and intensity of use were analyzed separately despite being dependent decisions. The current study improved these analyses by using a Heckpoisson model. The model estimated these two separate decisions in a single regression, thereby, controlling for sample selection bias, a problem that was overlooked by the study under review.

Okello *et al*. (2021) analyzed determinants of the utilization of agricultural technology among dairy farmers in Kenya. Using multivariate probit and ordered probit models, they established various socioeconomic, institutional, and infrastructural factors on use and intensity of use, respectively. However, the study under review was not specific about the agricultural technologies used by dairy farmers. Apart from providing insights for formulating a diverse potato sector policy, the current study improved on the previous study by focusing precisely on ICT platform technologies in the potato sector.

Ayim *et al.* (2022) conducted a review protocol study on the adoption of ICT innovation in the agricultural sector in Africa. The results from pilot data extracted from 23 papers indicated that radio is still widely used in disseminating agricultural information in most rural households. On the other hand, the reviewed literature showed low usage of ICT innovations like mobile applications and digital platforms. The study underpinned the low uptake of these innovations to poor technological infrastructure, inappropriate ICT policies, and low levels of user skills. In order to achieve data-driven policy recommendations, the current study used Heckpoisson to analyze the determinants of the use of ICT platforms in potato production.

Furthermore, Rengaraj and Shibu (2022) conducted a study on the level of use of ICT in agricultural production in India. Descriptive analysis revealed that only 30 of the 115 farmers sampled from the three states of India; Tamil Nadu, Kerala Karnataka, and Andhra Pradesh, used internet platforms to search for agricultural information. They further established that low awareness, inadequate skills, and poor internet connectivity hindered the usage of ICT in these areas. The use of a low sample size limited the generalization of these results to the regional level. In order to improve on this weakness, the current study used a higher sample size of 434 to ensure the representativeness of the wider population of potato farmers.

Additionally, Maina *et al.* (2023) assessed factors influencing access and use of the *M-shamba* platform in potato marketing in Kenya. Both the selection and outcome equations of the Heckprobit model revealed that socio-economic factors, such as age and income, affect the access and use of the platform. The study under review assessed a specific platform at a specific stage in the potato value chain. This omitted the users of other platforms at other levels of the value chain. Potato farmers sampled in the current study were small-scale, who were not bound to any specific source of information. Instead, they gather information from every available platform based on the utility accrued from these sources. The current study included users of all platforms at every level of potato production. This was necessary to capture diversity in the participation of different actors with different platforms in the potato value chain.

2.2.3 Effects of ICT Usage on Agricultural Production

A study by Das *et al*. (2017) on the impact of ICT on potato yields in Bangladesh, used quasi-experiments and difference-in-difference (DID) methods. The study reported a positive impact of using ICT tools such as radio and television on potato yields. The study under review focused on ICT tools, which is defined as a device that facilitates access and exchange of information (Salampasis and Theodoridis, 2013). The current study focused on ICT tool-based platform and information services and their effects on potato income. Unlike these tools, ICT platforms contain regularly updated information that can be accessed at all the time by many users (Spagnoletti *et al.*, 2015).

Marwa *et al*. (2019) assessed the impact of the *iCow* extension service platform on income and milk production in Kenya. The tool showed a positive significance on milk production and income. The propensity score matching (PSM) results showed that using *iCow* increased annual milk production by 797 liters and an annual income of 76,850 Kenya shillings (Kshs). The study under review focused its analysis on the dairy sector using a sector-specific *iCow* platform. In order to have diversity in agricultural policies about the use of ICT technologies, the current study used ICT platforms to build and further the above findings in the potato sector.

Ntiri *et al*. (2022) did a study on the effects of both ICT and ICT-based aquaculture extension platforms on the adoption of good management practices and incomes in Ghana. The PSM results showed that farmers using ICT platforms including *WhatsApp* platform had better management practices and were able to fetch high incomes from aquaculture farming. The current study further

explored if similar findings are true with potato farmers' incomes. The current study also incorporated age diversity into its analysis, an aspect that was omitted from the study under review. Additionally, the current study used the endogenous treatment effect (ETE) model as an alternative to the PSM model used in the study under review due to its ability to correct selection bias problems.

In addition, Mwenda *et al.* (2023) did a study on the effects of ICT on pest control measures in tomato production in Meru and Nyeri counties in Kenya. Using PSM, they established a positive impact of using ICT on the number of pest control measures by 22%. The results contributed partially to the goal of the Kenya National ICT policy. The policy is in line with the Vision 2030 strategy that is committed to availing ICT infrastructure to improve the livelihood of Kenyans in various economic sectors (Republic of Kenya, 2016). In order to build on this initiative, the current study improved on the study under review by explicitly measuring the effect of ICT on a more comprehensive indicator of welfare – potato income. These results underpinned the goal of the Kenyan ICT policy.

2.3 Review of Youth and ICT in Agriculture

Irungu *et al*. (2015) conducted a qualitative study on how ICT has attracted Kenyan youth into profitable agriculture. The study noted that the youth commonly used ICT platforms, such as *KilimoSalama, iCow, M-Farm* and *Mkulima Young.* The use of the *Mkulima Young* platform enabled the youth access to marketing information, thereby improving their incomes. Besides reporting qualitative results, the study under review focused on the benefits of ICT on the entire agricultural sector, limiting sector-specific policies. The current study quantitatively analyzed the effects of ICT platforms on potato incomes using ETE models. Additionally, the current study focused on the potato sector because the use of these platforms varies from one sector to another.

Katunyo *et al*. (2018) assessed the determinants of ICT usage in the agricultural value chain by the youth in western Kenya. The Poisson regression model applied indicated that the use of ICT increases with a decrease in age. This implies that youth embraced the use of ICT more than the old. Despite these established results on youth's behavior with ICT, the study under review analyzed the results from the general agricultural value chain incorporating all the enterprises. This may not be true with potato enterprises, whose production has been associated with women and older farmers (Mudege *et al*., 2019). The current study sought to ascertain these results by

assessing the factors influencing the use of ICT platforms among the youth and older potato farmers.

Additionally, Okello *et al*. (2020) did a study on the effect of ICT tools attributes in accessing dairy technical, market and financial information among the youth in Tanzania. Using multivariate probit models, they analyzed the influence of socio-economic and infrastructural factors on the use of ICT tools. However, the study under review omitted institutional factors from its analysis. The current study filled this gap by incorporating institutional factors, such as access to extension services and membership in agricultural or development groups.

Sebotsa *et al*. (2020) conducted a study on the effects of social media on youth participation in agriculture in Njoro sub-county in Kenya. The study used an ordered logistic regression model to assess the use of social media platforms by the youth. *Mkulima Young*, *M-Shamba* and *DigiCow* platforms were the least used. Awareness was reported as a limiting factor for the low usage of these platforms. The study did not quantitatively assess the factors that contributed to the low awareness among the 150 selected youth. The study also left out potato enterprise among the crops it assessed, which included maize, wheat, tomatoes, kales, cabbages, carrots and onions. The current study filled these gaps by quantitatively assessing the determinants of awareness and use of ICT platforms. The current study also focused on potato enterprise, which is among the enterprises that have benefited from ICT platforms, such as *Viazi Soko*. Potato crop has unique challenges targeted by different platforms. This may lead to differences in the use of ICT in potatoes from other crops.

Lindsjö *et al*. (2020) conducted a study on the generational dynamics of agricultural intensification among maize farmers in Malawi. The descriptive statistics obtained showed that youth are disadvantaged in accessing and ownership of production resources like land and capital. The study noted that the low production of maize is due to older farmers withholding these resources from the youth farmers. The current study improved the study under review by establishing how the use of ICT platforms varies between the two generations of potato farmers. While the study under review elicited policies that promote equal access to physical resources, the current study contributed to policies that ensure equal access and use of ICT for both the youth and older farmers.

Lastly, Jolex and Tufa (2022) did a study on the effects of using ICT on profitability among Malawian youth farmers. The study employed the use of the ordered logit model among 317 youths

to assess this relationship. The results indicated that profitability increases with an increase in the number of ICT tools used. The study under review focused on the effect of ICT use, without assessing other variables that could significantly contribute to the positive profits. Notably, institutional, infrastructural, demographic, and technological factors contribute significantly to welfare. Therefore, the current study addressed the knowledge gap by assessing the effects of ICT platforms alongside other factors on potato income.

2.4 Summary of Knowledge Gaps Addressed

In summary, the main knowledge gaps that the current study addressed include the following: disaggregation the potato farmers into the youth and the older farmers using the age variable. This informed the generational basis for comparing the determinants of awareness, use and intensity of use, and effects of ICT platforms in potato production. Secondly, the current study incorporated key variables omitted from previous studies. These variables include behavioral, institutional, and infrastructural factors, such as the source of agricultural information, access to extension services, membership of agricultural groups and use of the internet. The current study used quantitative analysis to improve on the qualitative results from the previous studies. This was achieved through the use of Logit, Heckpoisson and ETE regression models. Lastly, the current study contributed to the literature on the use of ICT by focusing on ICT platforms rather than the common ICT tools (radio and mobile phones).

2.5 Conceptual Framework

Figure 4 illustrates the interactions between the determinants of awareness and use of ICT platforms, farmers, their actions and the effects on potato income. The upper oval circle represents interrelated factors hypothesized to influence the awareness, use and effects of ICT platforms. These factors influence farmers and their actions through the use of ICT platforms as shown by the arrows entering the lower oval circle. The arrows from the farmers and their actions illustrate the effects of using ICT platforms on potato incomes, which in turn influence the determinants as shown with the outer arrow.

The determinants are informed by past findings in agricultural value chains, (see for example Mtega *et al*., 2014; Okello *et al*., 2014; Wawire *et al*., 2017; Okello *et al*., 2020; Krell *et al*., 2021; Okello *et al*., 2021). Socio-economic factors such as age, the number of years of formal education,

income levels, gender of the household head, household size, and farm size determined the decision on the usage of ICT platforms in potato production.

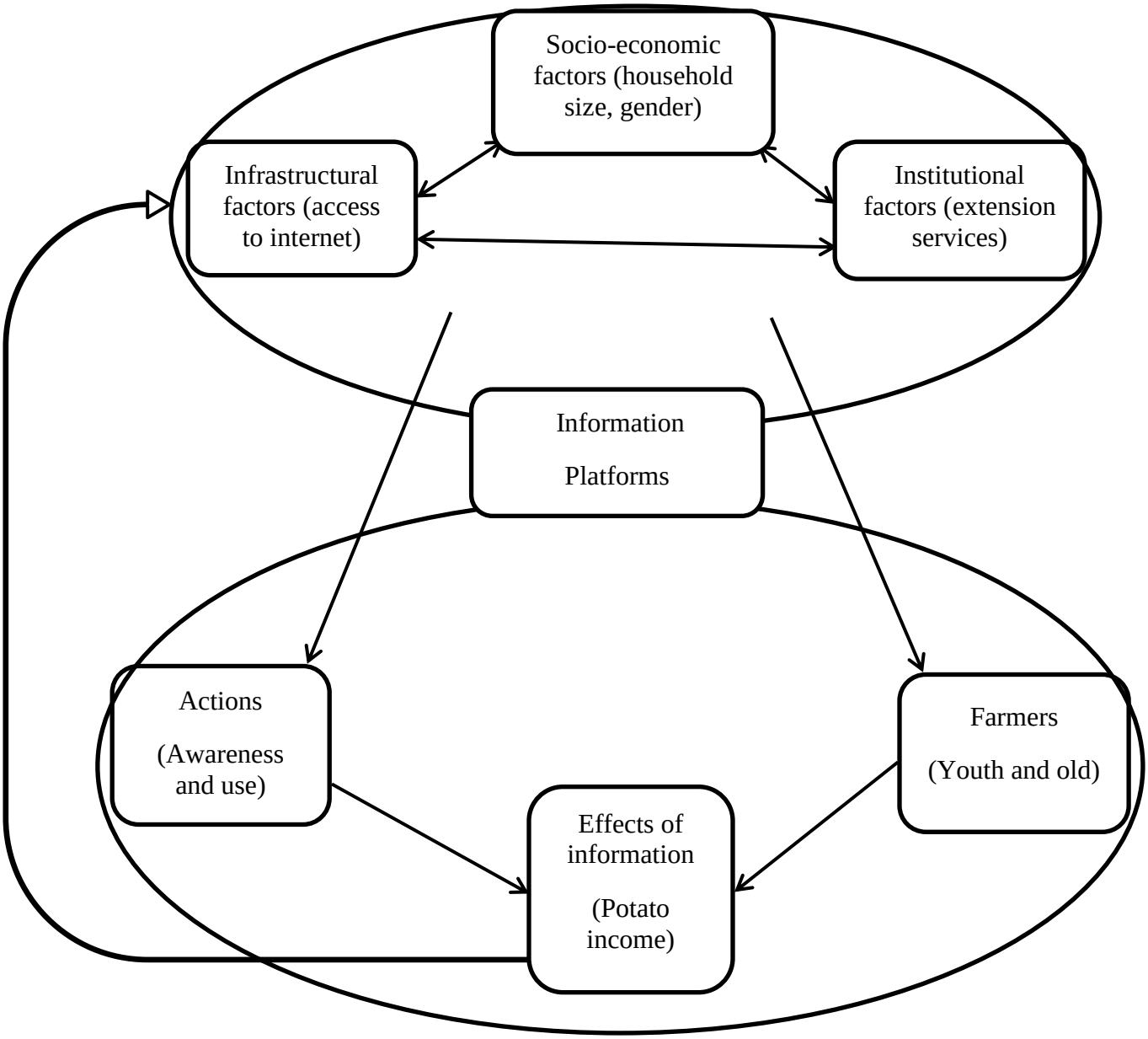

Figure 4: Conceptual framework

Source: Author's conceptualization (2022).

For instance, large households face the burden of producing for domestic consumption and marketable surplus. As such, they are motivated to produce more. Therefore, they are compelled

to use modern technologies like ICT to boost their production. Gender is also expected to influence the use of ICT platforms. Male farmers and male-headed households have demonstrated to have more access to and use of productive resources as compared to their female counterparts. Similarly, male farmers are expected to have access to ICT tools like smartphones, which facilitate their use of these platforms.

Institutional factors such as membership in agricultural groups increase farmers' awareness of the current trends including ICT platforms. Farmers with such membership are likely to be aware of these platforms and therefore, are likely to use and enjoy their benefits. Infrastructural factors such as access to the market and the internet are key enablers in the use of ICT platforms. For instance, access to the internet promotes the use of internet-based platforms. Farmers with internet access are more incentivized to use these platforms than those without.

Additionally, previous studies have linked the use of ICT with farmers' well-being, (see for example Okello *et al*., 2020; Ntiri *et al*., 2022; Mwenda *et al*., 2023). It is expected that the users of these platforms will have access to timely and reliable information, subsequently, enhancing their productivity. Consequently, they will achieve high quality and improved potato yields, leading to a marketable surplus and increased incomes.

2.6 Theoretical Framework

This study was anchored on the diffusion of innovation theory by Rogers (1962) and Random Utility Theory (RUT) Thurstone (1927). The diffusion of innovation theory underpinned awareness of ICT platforms. The diffusion process involves the spread of information on innovation through various channels among potato farmers (Olayemi *et al*., 2021). The factors that affect the diffusion process determine the level and extent of awareness. For instance, the source of information for potato farmers may determine their awareness of ICT platforms. This study used a binary logit model to assess various factors influencing the diffusion process and hence awareness.

Once a farmer is aware of the platform, they then decide on its usage. The decision is based on the perceived usefulness and the utility of that platform. Therefore, the RUT underpinned their decision to use the ICT platforms. The theory is based on the hypothesis that every farmer is a rational decision maker, whose aim is utility maximization. The theory explains that potato farmer chooses to use an ICT platform based on its perceived resulting utility. Based on this theory, the

decision to use an ICT platform is a dichotomous choice made by potato farmers in their attempt to maximize utility.

The utility is illustrated as a function of a deterministic component (v) and the error term (ε_i). The deterministic term is a function of socio-economic, institutional and infrastructural variables. Ideally, the decision to use an ICT platform is logically pegged on the assumption that there is greater satisfaction from use than non-use (Thurstone, 1927). The utility of using the platforms (U_{i1}) was defined as:

$$(U_{i1}) = V_{i1} + \varepsilon_{i1} \quad (1)$$

The probability of using the platforms is determined by comparing the utility of using a platform (U_{i1}) against the probability of not using a platform (U_{i0}). Potato farmers could only use the ICT platforms if U_{i1} is greater than U_{i0} as shown in equation 2.

$$U_{i1} > U_{i0} \quad (2)$$

The various deterministic variables of use and intensity of use were assessed using the Heckpoisson model. Furthermore, the resulting utility of using ICT platforms was analyzed alongside other variables using the ETE model.

CHAPTER THREE

3.0 ASSESSMENT OF GENERATIONAL DIFFERENCES IN DETERMINANTS OF AWARENESS OF ICT PLATFORMS AMONG POTATO FARMERS

3.1 Abstract

The depth of awareness stage of technology adoption significantly informs the likelihood of its uptake. In Kenya, the government through the Ministry of ICT formulated interventions to promote adequate flow of information through integrating ICT in various sectors. This initiative led to the development of ICT platforms through which potato farmers access various agricultural information. Despite these efforts, potato production remains low, posing the question of the effectiveness of the technology awareness stage. While extant literature on ICT has indicated that youth are more receptive to the use of ICT than the older population, they have neglected the analysis of determinants of awareness between the two groups. The current study fills this knowledge gap by analyzing how determinants of awareness of ICT platforms compare between the youth and the older potato farmers from a sample of 434 farmers in Nakuru County. Results from a binary logit model showed a varying significance level on the main drivers of awareness between the two generations of farmers. The use of digital sources of information and the internet positively influenced awareness among the youth more than the older farmers. The number of sources of information and access to extension services had a higher positive significance on older farmers' awareness than the youth. Public institutions and service providers of ICT platforms should tailor their interventions in line with these generational differences to improve awareness of the respective groups.

Keywords: ICT platforms, potato farmers, awareness.

3.2 Introduction

Despite its indispensable role in enlightening farmers on the optimal use of factors of production, access to reliable and timely information remains a nightmare across agricultural value chains in Africa (Kelil *et al*., 2020). For decades, farmers in SSA have been relying on traditional sources of information, which have proven to be untimely and cost-ineffective (Marwa *et al*., 2019). A common example among smallholder farmers is the farmer-to-farmer source of information. This practice often leads to the deconstruction of information and unintended change in its meaning as it passes from one farmer to the other (Adio *et al*., 2016). This has often led to misinformation, whose effects in SSA have been low input uptake leading to severe food shortage and welfare losses (Nsabimana, 2021).

Efforts to address the ineffectiveness and inefficiency of such sources of information feature prominently in various policies and development strategies. In the developed world, the integration of ICT in agriculture has successfully led to improved access to adequate information. Subsequently, these efforts have led to sustainable food production through efficiency in resource use and reduction of transaction costs (Serbulova *et al*., 2019). Developing countries have stepped up their efforts in the digital catch-up process, though at lower rates. In Kenya for instance, the National Potato Strategy outlines the use of ICT and digital avenues as a way to improve information coverage among actors in the potato value chain (Republic of Kenya, 2021). Consequently, ICT platforms have been emerging to equip farmers with production information.

An ICT platform refers to a database resource, which provides information solutions on a defined subject matter (Spagnoletti *et al.*, 2015). Some of the commonly used platforms in Kenya, which provide information on potato production include *SokoShambani, Viazi Soko, DigiFarm, M-farm* and *Mkulima Young* (von Bismarck-Osten, 2021). These platforms have been designed primarily to accelerate access to equitable, reliable and timely information among farmers as well as empower their self-reliance (Drafor, 2016).

In the SSA region, the average potato productivity ranges from 6t/ha to 10t/ha, which is way below the attainable potential of 25t/ha to 40t/ha in developed countries (Muthoni and Shimelis, 2022). In Kenya, this low productivity has been attributed to inadequate certified seeds, poor agricultural practices, pathogens, poor climatic conditions, high cost of inputs, market inefficiencies and poor post-harvest loss management strategies (CIP, 2021). According to McEwan *et al*. (2021), these

challenges have been directly linked to the inability of potato farmers to access timely and reliable information. Despite the availability of ICT platforms in the potato industry in Kenya, potato production varies across many farm households (CIP, 2021). As a result, the livelihood of farmers has persistently worsened.

Like with many technologies, the successful integration of information services is founded on how well farmers are aware of the platforms (Ruzzante *et al*., 2021). While the literature has cited several factors contributing to the low technological adoption in many developing countries, Upreti (2015) confers much emphasis on cultural, economic and social driving factors. Notably, one of the most important impediments to economic reforms is the digital divide (Gibson, 2022). The problem is characterized by the age gap between the users, who have a distinct variation in knowledge and skills, ownership and access to ICT resources (Lai and Widmar, 2021). These variations influence the adoption process of technologies, starting at the awareness stage (Doss, 2018).

While previous studies have explored determinants of awareness among the younger generation (Avis, 2015; Irungu *et al*., 2015; Sebotsa *et al*., 2020), little is known about how they compare with the old generation of farmers. Additionally, as noted by Okello *et al*. (2014), there is a dearth of empirical knowledge on explicit analysis of the determinants of awareness of ICT. Existing literature has mainly focused on measuring the level of awareness without an in-depth quantitative analysis of determinants of awareness (Mabe and Oladele, 2012; Mtega *et al*., 2014). Other studies mainly focused on the independent analysis of awareness of various response factors (see Sebotsa *et al*., 2020).

Due to these analytical shortcomings, adequate, informative, and intuitive results on quantitative analysis of determinants of awareness of ICT technology remain shady, and so are the resulting policies. The current study, therefore, adds to the scanty literature by analyzing how determinants of awareness compare between the age-disaggregated groups: the youth and the older potato farmers. Information from this analysis will help to stimulate evidence-based debate on the need for group-specific policies on ICT awareness.

3.3 Methodology

3.3.1 Sampling Procedure

The study targeted potato farmers aged 18 years and above, with the youth defined as those between 18 and 35 years as per the Kenya youth development policy (Republic of Kenya, 2019). A potato farmer was identified as the household member who grow potatoes and are involved in making decisions on the crop. In the case of joint production, the study considered the most significant decision maker. A multi-stage sampling technique was applied as follows. In the first stage, a purposive sampling approach was used to select the county and the two sub-counties based on high potato production and the usage of ICT platforms (Republic of Kenya, 2018; Maina *et al*., 2023). In the second stage, two wards; Elbargon and Mariashoni of Molo sub-county, and Mau-Narok and Mauche of Njoro sub-county, were selected from all the listed wards using a simple random sampling technique.

In the third stage, a systematic random sampling method was used to select potato farmers. With the insights of a local field guide, the first respondent (a lead potato farmer in each ward) was identified. Thereafter, four homesteads were skipped and the fifth farmer was selected for the interview. This was continued until a determined number for the day was attained. Skipping a fixed number of farmers throughout the selection process enabled the study to reduce the chances of biased responses that would have risen from interviewing close relatives or neighbors (Olumeh *et al*., 2021). This minimized the number of incomplete questionnaires per day. The same number of homesteads were skipped throughout the study in both sub-counties based on their relatively equal population densities; 324 persons per square kilometer (Km^2) for Molo and 341 persons per Km^2 for Njoro (Kenya National Bureau of Statistics - KNBS, 2019).

The sample size was determined using Cochran's (1963) formula as follows.

$$n = \frac{Z^2 pq}{E^2} \quad (3)$$

where n = sample size, p = maximum variance taken as 0.5, Z = desired confidence level and E = desired level of precision.

$$n = \frac{1.96^2 x.5x.5}{0.05^2} = 385 \quad (4)$$

The value of *p* was set at 0.5 owing to the unknown population size and level of variation of potato farmers (Barlett *et al*., 2001). The value of *E* was set at 0.05. The value of *z* was set at 1.96 to

maximize the representativeness of the characteristics of selected potato farmers to the entire population. This helped in increasing the accuracy of the findings (Taherdoost, 2017).

Following Ojwang *et al*. (2021), the sample size was adjusted by 17% to 450 to account for non-response and incomplete questionnaires. It was also to enable the study to obtain adequate degrees of freedom for meaningful statistical inferences for the disaggregated groups; youth and older farmers. The adjustment also allowed for independent analysis and significance tests within the two groups without the risk of committing a Type II error, which is sometimes caused by small sample size analysis (Wooldridge, 2013).

The sample size was distributed between the two sub-counties proportionate to their number of households: 40% from Molo and 60% from Njoro. This distribution was based on the 2019 census report on the number of households per sub-county in Kenya (KNBS, 2019). The choice of household as a parameter for distributing the sample size was based on the fact that most of these households rely on agriculture, especially potato production for their livelihoods (Maina *et al.*, 2023).

A total of 440 farmers participated in the survey. The discrepancy in the intended sample size and the final one was due to the problem of non-response. This was due to insecurity caused by Covid-19 and lack of target respondents, as well as rainy weather. Furthermore, six incomplete questionnaires were dropped during the data cleaning and analysis process. Therefore, the final valid sample size used in the analysis was 434. The sample size is consistent with those used by previous studies on ICT in agriculture (see for example Mtega *et al*., 2014; Katunyo *et al*., 2018).

3.3.2 Data Collection

Data was collected through a combination of methods. They included three key informant interviews (the informants were the Nakuru County potato data officer from the County Agricultural Office, and the two sub-county agricultural officers from Molo and Njoro sub-counties). Secondly, two focus group discussions (FGDs) and individual household surveys on potato farmers. The key informants provided an overview of the availability and use of ICT platforms in the area. The interview also elicited information on the major information needs and challenges targeted by the available ICT platforms. The sessions also gave insights into the interventions aimed at promoting the use of these platforms among potato farmers in the county. The responses to these issues were recorded in a notebook. Each key informant interview lasted

45 minutes. The checklist of questions used in the informant interviews is provided in Appendix A.

The FGDs in Molo and Njoro sub-counties had 17 and 12 potato farmers, respectively. The FGD was composed of the following participants; ten male, seven female, 11 older and 6 youth farmers in Molo, and seven male, five female, eight older and four youth farmers in Njoro sub-country. The FGDs provided general information on the actual platforms available to the farmers, their usage, challenges and benefits. One facilitator and two note-takers were trained on the FGD topics. The topics included information-related challenges in potato production, sources of information from ICT platforms, type of information services from the platforms, distribution of awareness, access and usage of these platforms among the youth, the older and across gender, challenges experienced and benefits accrued from these platforms. Both FGDs were conducted in the Swahili language that most participants could understand. On average, each FGD took an hour to complete. Appendix B provides a checklist of the questions used during the FGD sessions.

Finally, the household surveys were conducted by five well-trained enumerators supported by the area field guides. The primary data was collected through face-to-face interviews using an electronic semi-structured questionnaire, which was administered through the *Kobo Collect* tool. The use of semi-structured questionnaires elicited information based on the genuine opinions and behaviors of potato farmers (Babbie, 2004). The administration of questionnaires through a face-to-face approach enabled enumerators to seek further explanations and clarity on the responses (De Leeuw, 1992). The survey collected information on demographic characteristics, potato farm characteristics, potato production and sales, input use in potato production, group membership, potato markets, income, credit and ICT use in potato production. The household survey questionnaire is shown in Appendix C.

3.3.3 Model Diagnostic Tests

3.3.3.1 Test for Multicollinearity

According to Gujarati (2004), the problem of multicollinearity occurs when there is a linear relationship among the covariates or explanatory variables. One of the consequences of this problem is inefficiency in inferences generated. The problem of inefficiency is due to larger standard errors and wider confidence intervals. Therefore, to achieve reliable and efficient

inferences from this study, the covariates were tested for multicollinearity through the use of variance inflation factors (VIFs) as follows:

$$VIF = \frac{1}{1-R_i^2} \quad (5)$$

where, R_i^2 is the coefficient of determination of the regression equation. Multicollinearity becomes an issue if VIF values exceed 10 (Gujarati, 2004).

The estimated VIF values for the models used are presented in Appendix D, E and F. The VIF values were all below 10, indicating that multicollinearity was not a serious problem in the data collected.

3.3.4 Empirical Data Analysis

The objective of this chapter was to analyze the determinants of awareness of ICT platforms among the two age-disaggregated groups; the youth and the older farmers. Awareness of ICT platforms was modeled as a binary choice; aware = 1, non-aware = 0. Such binary situations can be analyzed using either logit or probit regression models. Both models generate similar predicted probabilities except in their distribution; the probit generates normally distributed probabilities while the logit generates logistically distributed probabilities. This, however, presents no statistical difference between the two binary models (Gujarati, 2004). Therefore, the current study chose a binary logit over probit to analyze determinants of awareness of ICT platforms between the youth and the older potato farmers. This was due to its closed mathematical form that allows faster convergence in the maximum likelihood estimation process (Gujarati, 2004). The model was specified in terms of probability, *P* as follows;

$$P(A) = \beta_0 + \beta_i X_i + \varepsilon_i \quad (6)$$

where *A* is the dependent variable on awareness of ICT platforms with the value of 1 or 0,

β_0 is intercept,

β_i is the slope parameters to be estimated,

X_i are explanatory variables,

ε_i is the error term.

This study improved on the previous studies that used the binary logit model, such as Sebotsa *et al*. (2020) and Krell *et al*. (2021) by incorporating a generational comparison of determinants of awareness. Generational differences were measured in terms of the age differences between the two groups of farmers. The explanatory variables used to model awareness of ICT platforms among the two age-disaggregated groups are shown in Table 1.

Table 1: Expected signs of variables in the awareness model

Variable	Description	Measurement	Expected sign
Dependent variable			
Awareness of ICT platform	Knowledge of any ICT platform by a potato farmer	Dummy (1 = Yes, 0 = No)	
Independent variables			
Age	Age of a potato farmer	Continuous in years	-
Education	Number of years of formal education of a potato farmer	Continuous in years	+
Gender	Gender of a potato farmer	Dummy (1 = Male, 0 = Female)	+
Number of sources of information	Number of sources of agricultural information used by a potato farmer	Continuous	+
Type of source of information	The main type of source of agricultural information used by a potato farmer	Dummy (1 = digital, 2 = analog - family, neighborhood, agro-dealers, extension services, agricultural groups)	+
Extension services	Access to extension services by a potato farmer	Dummy (1 = Yes, 0 = No)	+
Group membership	Membership of an agricultural or development group by a potato farmer	Dummy (1 = Yes, 0 = No)	+
Use of internet	Access and use of the internet by potato farmers (include mobile data bundles or internet WIFI)	Dummy (1 = Yes, 0 = No)	+

The age of a potato farmer was expected to reduce awareness of ICT platforms. Youth use the internet more and have more access to smartphones (Sebotsa *et al*., 2020). Due to this, they would be expected to be more aware of current technology such as ICT platforms. An increase in years of education of a potato farmer was expected to increase awareness of the ICT platforms. Education increases the knowledge of modern technologies, hence increasing awareness (Ntiri *et al*., 2022).

The gender of a potato farmer was expected to increase awareness of the selected ICT platforms in potato production. Men interact more with the outside world and therefore are more likely to increase their awareness. The number of sources of information and digital sources of information were expected to increase a potato farmer's awareness of ICT platforms. Such avenues increase the exposure of farmers to innovation leading to an increase in their awareness and knowledge of existing innovations (Muatha *et al.*, 2017).

Access to extension services and membership in an agricultural group by a potato farmer were expected to increase awareness of the ICT platforms. These institutional factors provide avenues through which farmers learn and share new knowledge on technologies. Finally, the study hypothesized that the use of the internet by a potato farmer would increase awareness. The use of the internet increases the chances of learning and knowing about the existence of ICT platforms in potato production (Okello *et al*., 2014).

3.4 Results and Discussion

3.4.1 Socio-economic Characteristics of Potato Farmers

Table 2 shows the socio-economic characteristics of the households and significant differences between the two generations of potato farmers. The average years of education of potato farmers were above eight with young farmers having more. This was consistent with the basic requirement for education in Kenya as outlined in the constitution of the year 2010 (Republic of Kenya, 2010). The significant difference in average years of education between the two groups could be due to the increased advocacy of youth empowerment. Enhanced training features in many strategies, such as the Sustainable Development Goal (SDG) number four as a sustainable way of empowering men and women (United Nations, 2015).

Table 2: Socio-economic characteristics of respondents

Variables	Young potato farmers (n = 210)	Older potato farmer (n = 224)	Pooled sample (n=434)	Test of statistically significant differences between youth and older potato farmers
Continuous variables				***t-test***
Average years of education	10.24[a] (2.90)	9.03[b] (2.78)	9.63 (2.90)	-4.404***
Average household size	4.70[b] (1.98)	5.43[a] (1.96)	5.06 (2.00)	3.896***
Average land size (acres)	1.44[b] (1.76)	1.85[a] (1.67)	1.65 (1.73)	2.482**
Average seasonal potato output (tons)	4.33[b] (5.22)	4.74[a] (5.26)	4.54 (5.24)	0.816
Average number of sources of information	2.47[b] (1.32)	2.67[a] (1.24)	2.58 (1.28)	-1.648
Average annual potato income (Kshs)	145861.80[b] (177469.30)	168097.00[a] (186656.90)	156979.40 (182250.80)	1.272
Average annual household income (Kshs)	166000.00[b] (180556.10)	187037.10[a] (191949.80)	176518.50 (186422.40)	1.176
Average years of potato farming	5.10[b] (3.35)	11.89[a] (9.03)	8.50 (7.60)	10.385***
Average distance from potato farm to the nearest market (Km)	3.10[b] (1.92)	3.27[a] (1.93)	3.19 (1.93)	0.920
Average frequency of platform use per week	3.01[a] (2.90)	2.60[b] (2.35)	2.86 (2.72)	-0.832
Categorical variables				***χ^2 test***
Awareness of ICT platform (% yes)	68.20[a]	53.47[b]	60.82	9.903***
Use of ICT platform (%yes)	58.10[a]	41.38[b]	50.76	7.281***
Gender of potato farmer (%male)	53.00 [a]	50.69 [b]	51.84	0.231
Main type of source of information (%digital source)	40.55[a]	32.26[b]	53.41	4.215
Group membership (% yes)	17.05[b]	27.65[a]	22.35	7.023***
Access to extension services (% yes)	26.72[b]	29.49[a]	28.11	0.411
Use of internet (% yes)	52.07[a]	38.25[b]	45.16	8.373***

Note: Asterisks ***, **, * denote significant statistical differences at 1%, 5% and 10%, respectively, the superscripts [a, b] denote the magnitude of the differences in descending order, while the values in parentheses are standard deviations.
Source: Survey Data (2022).

The average household size across the groups was above the four reported in the 2019 census report (KNBS, 2019). This underpins the census report that classified the county among the densely populated regions in Kenya. Youthful farmers were slightly closer to the nearest market than the older farmers. On average, the distance to the nearest market from older farmers was slightly more than that of the young farmers. Descriptive results also revealed that male farmers dominated the production of potato farming. This could be due to its ability to generate short-term cash.

There was a significant difference in the average land size under potato production between the two generations. On average older farmers had a larger land size (1.85 acres) than their younger counterparts (1.44 acres). This disparity in land ownership conforms to the finding by Lindsjö *et al*. (2020), who observed a relative advantage of older farmers in accessing production resources.

Consequently, ownership of large sizes of land by the older potato farmers enabled them to enjoy higher potato outputs and incomes than the young farmers. Wamuyu (2019) also observed that inequality in land ownership is a major factor contributing to differences in farm output and incomes among farmers. Older farmers had on average more years of experience in potato farming. The significant difference could be due to the traditional beliefs about crop production being dominated by older farmers (Mudege *et al.*, 2019).

The youthful farmers dominated the use of the internet, awareness and use of ICT platforms. Additionally, they frequently used the platforms more than their older counterparts. The differences between the two generations in access and use of ICT platforms could be explained by high access to ICT resources, such as access to smartphones among the youth. They also have more time to use these resources compared to the older group (Wamuyu, 2019). Similarly, previous studies also indicated higher access to and frequency of use of smartphones among the youth (Sebotsa *et al*., 2020).

Youth farmers had a high proportion of the use of digital sources of information as compared to older farmers. On the other hand, older farmers had a higher number of sources of information than young farmers. This observation implies a difference in the quality and number of sources of information used by the two generations of potato farmers. Access to digital sources is a better predisposing factor to awareness of ICT platforms and hence, is of more value than non-digital sources of information.

There was a low proportion of potato farmers who were members of development groups and had access to extension services. During the survey, farmers noted that social marginalization hindered their access to extension services. As a result, only lead farmers or large-scale farmers benefited from these institutional support services.

3.4.2 Sources of Awareness of ICT Platforms

Figure 5 shows various sources of awareness among potato farmers. The main sources of awareness were family and social media. In each case, the youth farmers benefited the most from the sources. These findings not only show the existence of strong social capital among youth farmers but also indicate their ability to get valuable information from social media avenues.

On the other hand, extension services and farmers' seminars had the least contribution to awareness. These findings imply low availability of farmers' support services as well as inadequate knowledge of ICT platforms among the available extension officers. However, on the positive side, these results indicate that farmers can gain knowledge by participating in support services, interacting with family, friends, and farmer groups as well as using social media.

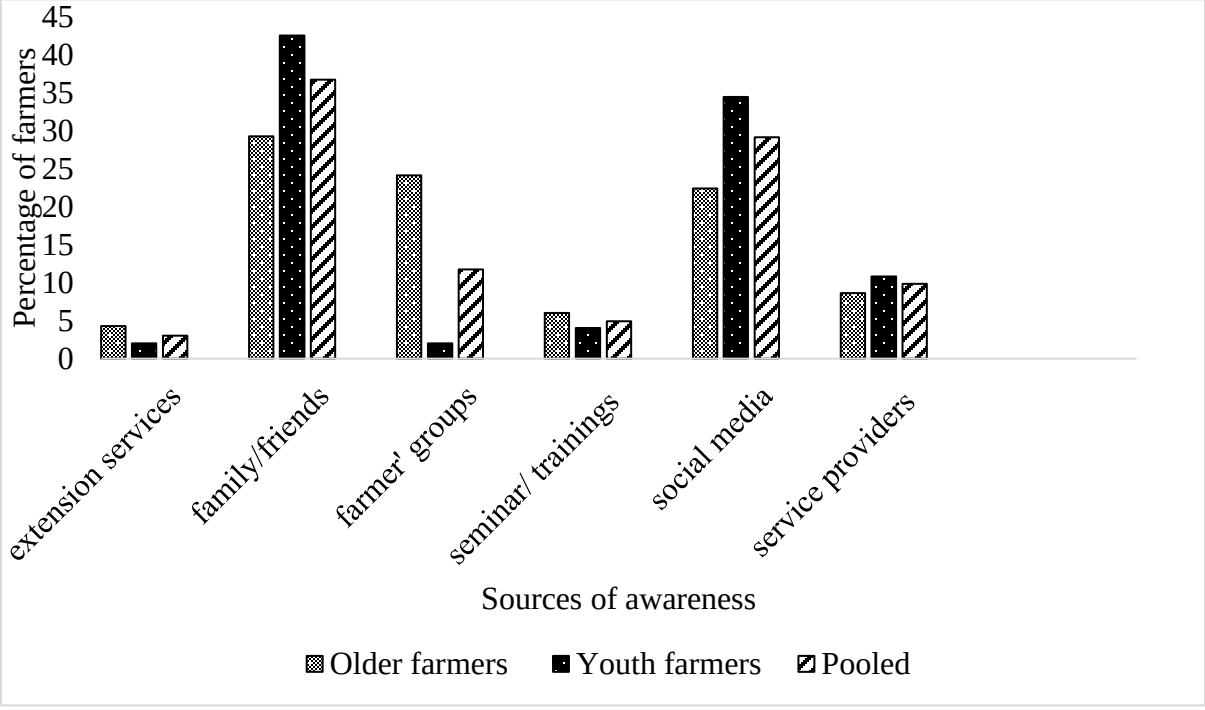

Figure 5: Sources of awareness of ICT platforms

Source: Survey Data (2022).

Service providers of ICT platforms ranked low in creating awareness of their respective platforms. In theory, it is expected that the service providers of a technology would lead the process of creating user awareness. This process often includes selling the technology to the target group through training and demonstration events (Ruzzante *et al*., 2021). However, the above findings contradict this reality. This shows the less effort devoted by the platform experts to increasing the awareness of information technologies among potato farmers.

3.4.3 Farmers' Awareness of ICT Platforms

Figure 6 shows the distribution of ICT platforms and the level of awareness as reported by potato farmers. The study used literature to identify ICT platforms available in Nakuru County. They included *SokoShambani, Viazi Soko, DigiFarm, M-Farm, Mkulima Young and KACE.* These were validated during key informant and FGD interviews.

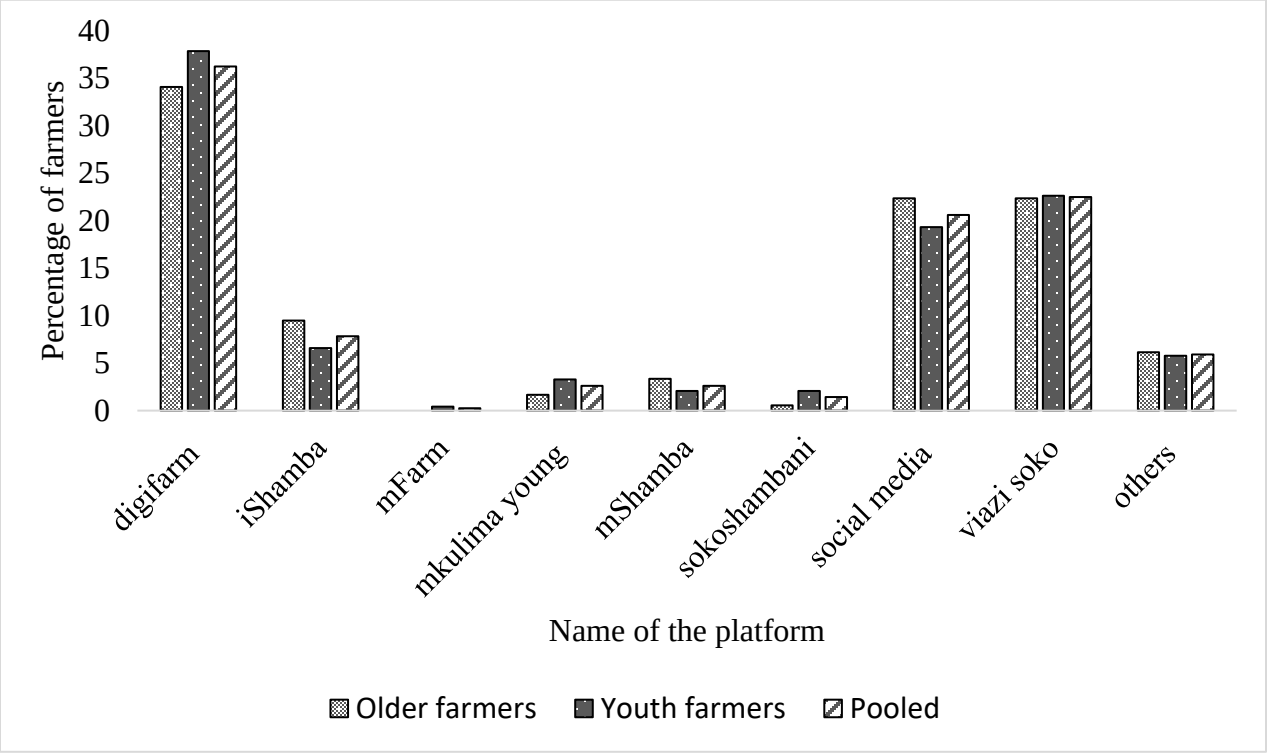

Figure 6: Comparison of farmers' awareness of ICT platforms

Source: Survey Data (2022).

From the key informant interviews conducted with agricultural experts at the county and sub-county levels, there were over 15 platforms available and used by potato farmers. The interview sessions also noted the availability of *M-shamba, Kuza, Yara Farmgo, Nakuru Farmer Call Centre*

(NFCC) and *social media (WhatsApp groups, Facebook, Twitter and Instagram).* There was a further discrepancy in the number of platforms reported by the county experts and the ones reported by farmers during the FGDs. The FGDs showed awareness of fewer platforms; *iShamba, Viazi Soko, DigiFarm, KAOP* and *social media platforms (mainly Facebook and WhatsApp groups).*

Furthermore, the above results indicated that *DigiFarm, Viazi Soko* and *social media* were the most popular platforms among the farmers. The results show a relatively higher level of awareness of these platforms over the other non-popular platforms like *iShamba*. This may be due to the intensive work on creating awareness that has been done by their service providers – Safaricom company and NPCK.

Additionally, the *Viazi Soko* platform made a major contribution to the history of potato production in Nakuru county and therefore, was regarded as the best platform. The county expert reported that the platform provided Nakuru farmers with information and enabled over 2,000 farmers access to clean and certified seeds in the year 2021. The other platforms that farmers were aware of included *Apollo Agriculture, One Acre Fund, Kilimo Trust, Farm Kenya, Yara Farmgo, Wefarm, Syngenta* and *Riari Agri Hub.*

3.4.4 Determinants of Awareness of ICT Platforms

Table 3 shows results from the binary logit regression on determinants of awareness among disaggregated potato farmers as well as the pooled sample. Unlike the youthful farmers, an increase in years of education by a unit among the older potato farmers increased the probability of their awareness by 2.8%. This implies that more educated older farmers are likely to be aware of information technologies. This could be because they are constantly engaged in current affairs and technical learning through various avenues. Furthermore, attaining higher education enhances potato farmers' ability to learn and adapt to innovations (Joshi *et al*., 2019). These findings concur with those of Muatha *et al.* (2017), who also found a positive effect of education on awareness of devolved extension services in Kenya.

An increase in the number of sources of agricultural information used by farmers increased awareness among older farmers than on the youth farmers. The higher the number of information sources, the more exposed a farmer is and hence the more aware they are of innovations (Muatha *et al*., 2017). This implies that older farmers are more experienced and have multiple sources of

agricultural information than the young farmers, hence, an increase in their awareness. An increase in the number of channels of information was one of the factors noted by Olayemi *et al*. (2021) to increase the diffusion process of innovations.

Digital sources of agricultural information increased youth farmers' awareness more than older farmers. These sources are more resourceful than the traditional ones (Marwa *et al*., 2019), and hence they hold more quality and credibility than the traditional sources. They included the use of radio, television, computer and mobile phones. The traditional sources used by potato farmers included information from families, neighborhoods, agro vets, print media, extension officers and farmer groups. Unlike digital sources of information, which are regularly updated, traditional sources are constrained by distortion of the quality of information (Adio *et al*., 2016). This finding implies that young farmers have access to more quality sources of information. Therefore, they benefit more in terms of increasing their awareness of ICT platforms in potato production.

Male youth farmers were more aware of ICT platforms than female youth farmers. Generally, men have more exposure through their interactions with sources of information like the internet. They are therefore more likely to be more aware of innovations than females. A similar finding on the effect of gender on awareness was also observed by Muatha *et al*. (2017).

Access and use of internet connectivity increased awareness of ICT platforms among the youth farmers more than the older farmers. The internet provides avenues through which farmers can discover current information, such as through online advertisements. The observed variation could be explained by the high affinity of the youth towards the use of the internet and ICT in general as was noted by Sebotsa *et al*. (2020).

Table 3: Determinants of awareness of ICT platforms

	Youth farmers (n = 210)		**Older farmers (n = 224)**		**Pooled sample (n = 434)**	
Variables	**dy/dx**	**SE**	**dy/dx**	**SE**	**dy/dx**	**SE**
Education (years)	0.002	0.002	0.028*	0.017	0.010**	0.005
Number of agricultural information sources	0.039**	0.018	0.242***	0.060	0.114***	0.027
Main type of source of information (1 = digital sources)	0.331***	0.062	0.213**	0.105	0.351***	0.060
Gender (1 = male)	0.810*	0.015	0.011	0.080	0.032	0.027
Extension services (1 = yes)	-0.002	0.011	0.242***	0.093	0.054*	0.030
Group membership (1 = yes)	0.016	0.016	0.096	0.098	0.034	0.033
Internet use (1 = yes)	0.013***	0.015	0.192**	0.091	0.067**	0.031
Constant	-5.261***	1.192	-5.351***	0.946	-5.267***	0.512
Prob > Chi2	0.0000		0.0000		0.0000	
Log-likelihood	-69.3938		-82.7913		-160.4838	
Pseudo-R^2	0.4886		0.4477		0.4447	

Note: Asterisks ***, **, * denote statistically significant differences at 1%, 5%, and 10%, respectively; dy/dx denotes marginal effects; SE denotes standard errors.
Source: Survey Data (2022).

Access to extension services increased the probability of older farmers being aware of ICT platforms by 24.2%. One of the findings from key informant interviews indicated the use of extension agents as an intervention placed by Nakuru County to promote awareness of information technologies among potato farmers. This explains the positive influence on awareness, especially among the older farmers, who registered higher access than the youth farmers. This finding implies that the effect of extension services on awareness was better for the older than for youth farmers. Similar findings on the positive effect of access to extension services were also reported by Nyaaba *et al*. (2019), who observed that extension service was the main source of information among smallholder rural farmers.

The current study established differences in the main drivers of awareness of ICT platforms between the youth and older potato farmers. The differences are in terms of the significance level and the type of variables influencing their awareness. Among the youth, the use of digital sources of information and internet usage influenced their awareness more than the older farmers. On the other hand, the number of sources of information and access to extension services had a higher significance on older farmers' awareness than the youth. Based on the above results, the current study rejects the null hypothesis that there are no differences in the effects of determinants of awareness of ICT platforms among age-disaggregated potato farmers. Indeed, the differences noted are worth considering in targeted interventions that aim to improve the uptake of ICT platforms in the agricultural transformation process.

CHAPTER FOUR

4.0 ASSESSMENT OF GENERATIONAL DIFFERENCES IN DETERMINANTS OF USE AND INTENSITY OF USE OF ICT PLATFORMS AMONG POTATO FARMERS

4.1 Abstract

Agricultural digitization is a rapidly emerging trend with potential for rural economic transformation. However, the extant literature tends to focus on differences in the uptake of ICT along gender lines, while neglecting intergenerational and relative resource endowment perspectives. Using a Heckpoisson regression model on 434 smallholder potato farmers, this study analyzed differences between the determinants of uptake of ICT platforms for young and older farmers in Nakuru County, Kenya. Household income and institutional support services had higher and positive effects on the use of ICT platforms among the youth than the older farmers. Years of formal education, household size, gender and access to extension services influenced the intensity of use of ICT platforms among older farmers. Potato output, distance to the nearest market and use of the internet influenced the intensity of use among youth farmers. Interventions that enhance farmers' incomes are recommended to promote more usage of ICT platforms. Such interventions include equal access to land especially among the youthful farmers.

Keywords: ICT platforms, intensity of use, Heckpoisson.

4.2 Introduction

The use of emerging ICT tools in agriculture is a potential way of achieving sustainable food production. The use of ICT tools is also considered a key strategy in enticing the youth into agriculture, otherwise regarded as an unattractive enterprise for the young generation (Irungu *et al.*, 2015). In developed countries, the use of ICT has enabled farmers attain self-reliance through enhanced access to relevant and timely information (Drafor, 2016).

In Africa, the digital agricultural transformation agenda is taking shape with the integration of ICT platforms in the sector. The use of the platforms aims to provide information solutions on agricultural credit, farm inputs, production practices, markets, weather and climate (Abate *et al.*, 2023). In Kenya, the use of these platforms has been intensified, particularly in potato enterprises, an intervention that is led by the NPCK (CIP, 2021).

The Kenya potato sector is bedeviled by several challenges from the farm level to the final consumption. The crop is majorly grown by smallholder farmers, who are resource-poor and experience many information-related challenges. These include inadequate information on certified planting material, affordable inputs, pests and disease control, post-harvest management practices and competitive market prices (Komen *et al.*, 2017). These challenges justified the effort by stakeholders in the sector to foster the use of ICT platforms in Kenya (Republic of Kenya, 2021).

Among the information services provided by these platforms, information on the access to clean and certified planting material and output market remains a significant goal (Baumüller, 2016). Driven by the goal to improve production efficiency, the increasing number of agricultural ICT applications are transforming the extension service delivery, particularly in the SSA region, where the practice is constrained by many infrastructural challenges (Tata and Mcnamara, 2018). The use of these platforms is aimed at improving the livelihood of rural resource-poor smallholder farmers (Ayisi and Kozári, 2021).

However, unlike the developed nations where the use of ICT has been intensified, the developing world is still characterized by poor integration and adoption of these technologies (Aker *et al.*, 2016). Despite the opportunities that ICT presents, its benefits in developing countries like Kenya are dependent on factors, which are yet to be strengthened. These factors include user, institutional, infrastructural and technology characteristics (O'Donnell and Sweetman, 2018).

Despite limited access to physical resources like land, the youthful farmers are relatively endowed with ICT tools like mobile phones, and the knowledge and skills in using the ICT services (Marwa *et al*., 2019). The young generation is therefore considered high receptors of technology and information-rich compared to their older counterparts, who on the other hand, are better in physical resource endowment (Mengui *et al*., 2019). This paradox in the nature and significance of resource ownership between the two generations implies their absolute importance in rural economic development.

Although previous studies have explored how farmers along the diverse agricultural value chains are using various ICTs to acquire information, the potato sector has negligibly been explored (see Enwelu *et al*., 2014; Wawire *et al*., 2017; Okello *et al*., 2020; Krell *et al*., 2021; Okello *et al*., 2021). Secondly, very little knowledge exists on how determinants of use and intensity of use of various ICT platform services compare between the young and the old generation. The current study, therefore, fills these gaps.

4.3 Methodology

The use and intensity of use of ICT platforms by a household were considered a two-stage decision-making process. The intensity of use in this study referred to the weekly frequency of using a service from a given platform. In the first stage, a farmer decides to use a service from the platform. This is a binary choice modeled as use = 1, and non-use = 0. In the second stage, the farmer decides the frequency of using the service in a week; this was measured as a discrete non-negative count value.

Two-step sample selection models include Heckman sample selection, double hurdle and Heckpoisson models. Both Heckman and double hurdle treat the second stage of count data as continuous, making them unsuitable for this analysis (Gujarati, 2004; Wooldridge, 2013). The Heckpoisson models treats the second stage as a count variable, making it suitable for the analysis of determinants of use and intensity of use of ICT platforms between the youth and the older potato farmers. In addition to its ability to combine both Probit and Poisson to estimate parameters of binary and count data, respectively, the Heckpoisson model also corrects the problem of sample selection bias (Cameron and Kolstoe, 2022). Following Waruingi *et al*. (2021) and Sumo *et al.* (2022), the Heckpoisson model was specified as selection and intensity equations (7) and (8) respectively;

$$U_i = \begin{Bmatrix} 1, X_i'\beta + \varepsilon_{1i} > 0 \\ 0, \text{if otherwise} \end{Bmatrix} \quad (7)$$

$$I_i = X_i'\beta + \varepsilon_{2i} \quad (8)$$

where U_i is the binary indicator showing whether the farmer used any ICT platform or not,

I_i is the intensity of use of an ICT platform; the sum of frequencies of use of all platforms by a farmer per week, measured as a continuous count,

X_i' are the set of explanatory variables,

β is a vector of parameters to be estimated,

ε_{ii} are the error terms.

Equation (7) is the selection part of the model and is applied in assessing the determinants of using an ICT platform. The indicator *U* is observed and takes the value of 1 or 0, depending on whether the farmer used the ICT platform or not. The second equation (8) is used to assess the determinants of intensity of use of the ICT platform conditional on only if the farmer used the platform; if *U* = 1.

Table 4 shows the expected signs of determinants of use and intensity of use of ICT platforms. The age of a potato farmer was expected to negatively influence the use of ICT platforms. Youth were expected to be excited about innovations and technology and therefore, were expected to be active users of social media platforms (Sebotsa *et al*., 2020). Youth have better technical capabilities that enable them to learn and use ICT platforms faster than older persons (Marwa *et al*., 2019).

An increase in years of education of a potato farmer was expected to positively influence the use of ICT platforms. Education increases technical literacy, which is needed in operating most ICT tools and platforms (Treinen and Van der Elstraeten, 2018). The gender of a potato farmer was expected to have a positive influence on the use of ICT platforms. Male farmers were expected to use these platforms more than their female counterparts. Women generally earn less income than men and are likely to buy and control fewer ICT tools (Treinen and Van der Elstraeten, 2018).

Table 4: Expected signs of variables in the Heckpoisson regression

Variable	Description	Measurement	Expected sign
Dependent variables			
Platform use	Use of any ICT platform by potato farmer	Dummy (1 = Yes, 0 = No)	
Intensity of use	The sum of frequencies of use of all ICT platforms by a farmer per week	Continuous counts	
Independent variables			
Age	Age of the potato farmers	Continuous in years	-
Education	Number of years of formal education of potato farmer	Continuous in years	+
Farming experience	Number of years of potato farming	Continuous in years	-
Gender	Gender of the potato farmer	Dummy (1 = Male, 0 = Female)	+
Household income	Total household income per month	Continuous in Kshs	+
Household size	Number of people who regularly reside in the house of the potato farmer	Continuous	+/-
Potato output	The seasonal output of potatoes produced from total land first quarter of the year 2022	Continuous in tons	+
Extension services	Access to extension services by potato farmer	Dummy (1 = Yes, 0 = No)	+
Group membership	Membership of agricultural or development group by potato farmer	Dummy (1 = Yes, 0 = No)	+
Distance to the nearest market	Average distance to the nearest market from the potato farm	Continuous in Kilometers	+
Use of internet	Access and use of internet by potato farmers (include mobile data bundles or internet Wifi)	Dummy (1 = Yes, 0 = No)	+

The total household income of a potato farmer was expected to increase the use of ICT platforms. Income determines the ability of farmers to purchase ICT tools like smartphones, which enables them to access these platforms (Krell *et al*., 2021). Gillwald *et al*. (2010) noted that among the poor households in SSA, access and usage of radio were constrained by the financial inability to buy batteries or pay for electric power to recharge the batteries. Household size was expected to increase or decrease the use of these platforms in potato production. Large households are always compelled to meet their livelihood needs by using every available technology (Maina *et al*., 2023).

Potato output was expected to positively influence the use of ICT platforms. The output provides an incentive for market participation, which attracts the use of ICT to search for market information (Michels *et al*., 2020). Years of farming potatoes were expected to reduce the use of ICT platforms. Older farmers with many years of farming tend to stick to their old practices and may show laxity in using modern technology.

Membership in development groups was expected to increase the chances of using the platforms. Belonging to a relevant group increases the exposure and knowledge of emerging issues including innovations (Olumeh *et al*., 2021). Access to extension services was expected to increase the use of the ICT platforms. It exposes farmers to new technologies such as the use of ICT, which enables them to adopt and use these technologies (Ntiri *et al*., 2022).

Access to and use of internet connectivity was expected to positively influence the use of ICT platforms. The internet enables users to access information and is useful for internet-based ICT platforms (Irungu *et al*., 2015). Distance to the nearest market was expected to positively influence the use of ICT platforms. Users far away would prefer using ICT as the quickest means of getting market information. Increased distance to the nearest market implies high transport costs, which increases the preference for using ICT (Katunyo *et al*., 2018).

4.4 Results and Discussion

4.4.1 Distribution of ICT Platforms Used by Potato Farmers

Figure 7 shows the ICT platforms used by farmers. *DigiFarm* was the most used platform followed by *Viazi Soko* and social media platforms (Facebook and WhatsApp groups). Farmers used these platforms to access different services. For instance, *DigiFarm* provided them with support services, such as storage facilities, information on affordable *Yara* fertilizer and markets,

transportation services as well as the establishment of service provider agents (mini-shops) and *DigiFarm* depots, from which farmers accessed inputs.

On the other hand, *Viazi Soko* platform provided information on inputs, especially the certified planting materials, locally known as *wanjiku.* Farmers reported that the new variety had improved resistance against blights. The variety also has a longer storage period of up to four months and produces twice as much as the old *shangii* variety.

Social media platforms also enhanced peer learning and information sharing on various opportunities. These attempts are geared towards countering the enormous challenges in potato production, which include losses due to the recycling of planting material, ineffective pest and disease control measures, and uncompetitive prices offered by brokers in the market (Muthoni and Shimelis, 2022).

Farmers also reported other less popular platforms, which provide them with agricultural information services. Platforms like *KAOP and Yara Farmgo* provided the farmers with daily weather information services. The other platforms used included: *Apollo Agriculture, One Acre Fund, Yara Farmgo,* and *Wefarm.*

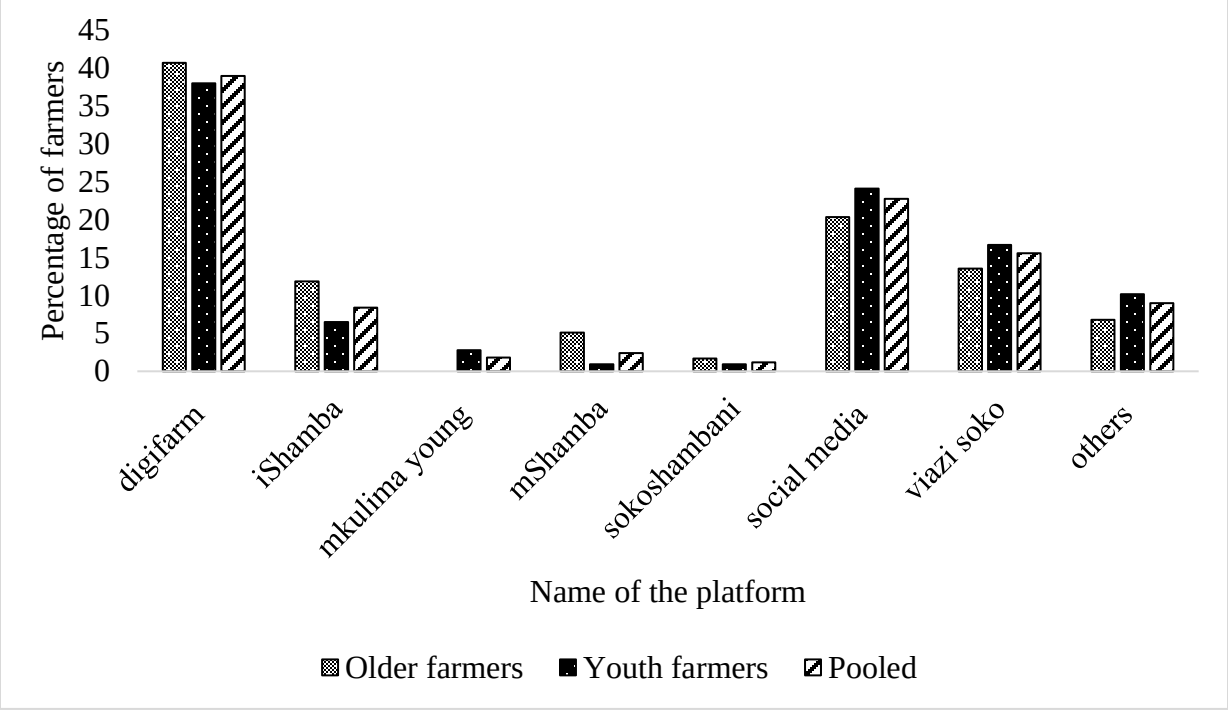

Figure 7: ICT platforms used by potato farmers

Source: Survey Data (2022).

4.4.2 Distribution of Platform Tools

Figure 8 illustrates various tools farmers used in accessing information from respective ICT platforms. Although the mode of information delivery is determined by the service providers, farmers can choose from a variety of tools to enable them to access information. These modes included *mobile applications* from the *play store*, SMSs and online *websites*. For instance, farmers who used the *DigiFarm* platform were able to get information through the *DigiFarm* play store application, text messages, or by logging into the *DigiFarm* website.

The diversification in the mode of accessing information from the platforms enhances the ability of smallholder potato farmers to access and remain connected to timely agricultural information. It allows farmers with no access to the internet to acquire agricultural information via SMS. Similar observations were made by Ayim *et al.* (2022), who noted that a combination of mobile and web services improved farmers' access to extension services and marketing information via the *Esoko* platform.

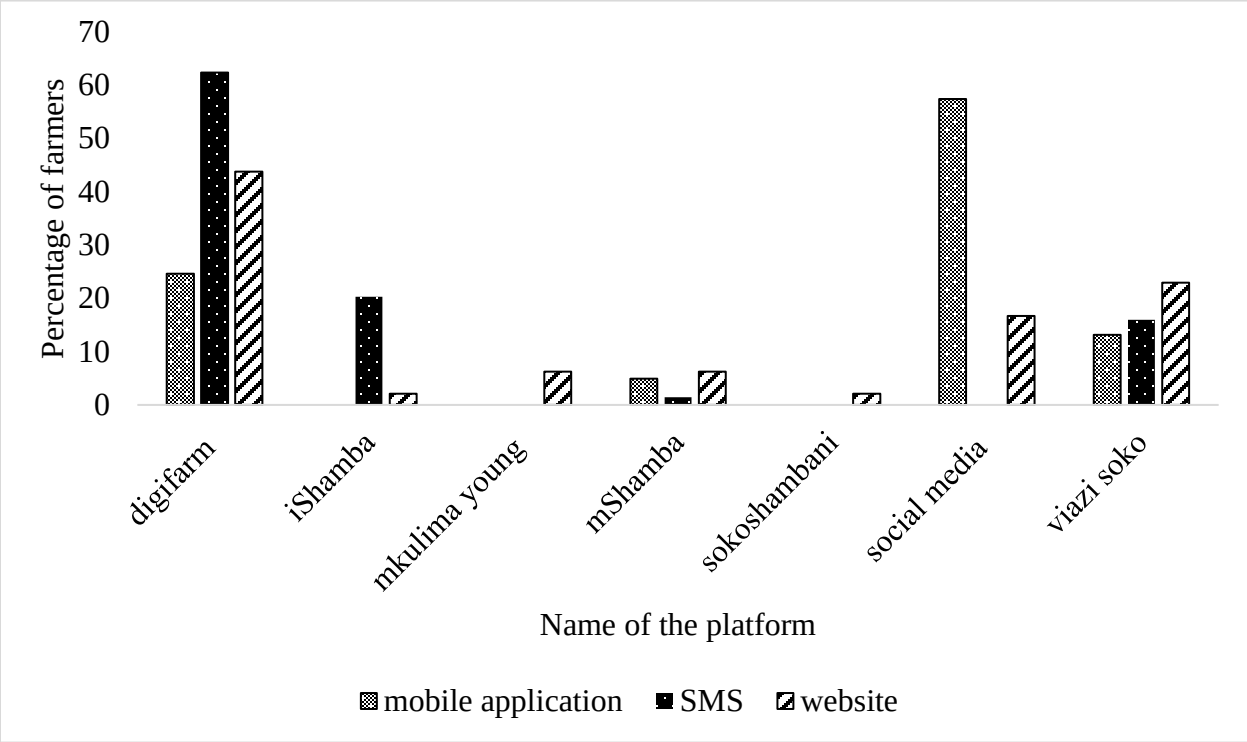

Figure 8: ICT platform tools

Source: Survey Data (2022).

4.4.3 Information Services from the Platforms

Figure 9 shows various information services obtained by the potato farmers. Among the services reported by farmers, information on potato inputs and markets was the most used service. These findings conform to those of Sebotsa *et al.* (2020), who observed that farmers mostly used social media platforms to seek information on agricultural inputs, crop and animal husbandry practices and marketing. Similarly, Ayim *et al.* (2022), noted that most of the ICT innovations, especially the mobile applications and platforms are mostly packed with advisory and marketing information. These platforms reduce transaction costs and provide up-to-date information that enables them to make informed decisions.

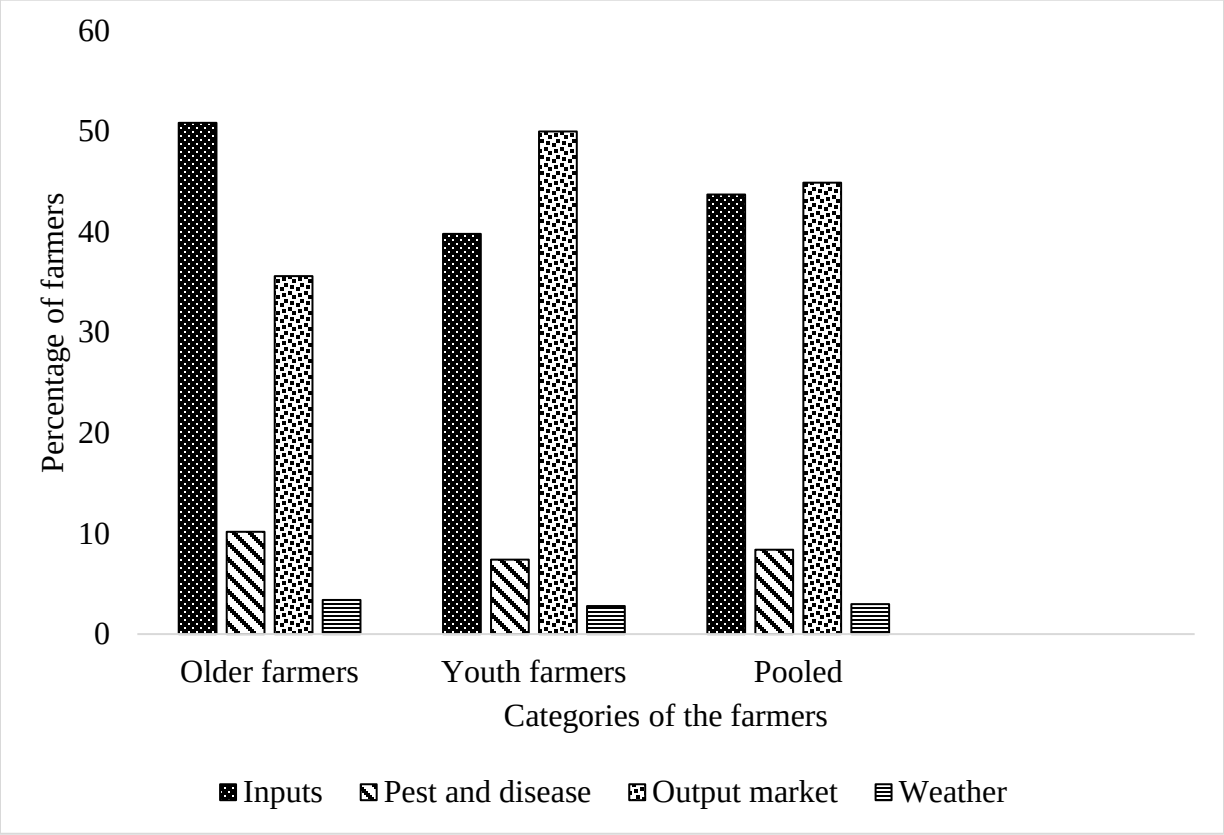

Figure 9: ICT platform services

Source: Survey Data (2022).

In addition to the type of information accessed, the results also indicate a generational distinction in the type of information. Youth mostly accessed information on output markets while older farmers dominated more on accessing information on inputs. This shows a difference in the role played by the two generations of farmers in the potato value chain. According to Jolex and Tufa

(2022), youth are more dominant in the market node of the agricultural value chain than at the farm level.

4.4.4 Determinants of Use and Intensity of Use of ICT Platforms

Table 5 shows the Heckpoisson results on the determinants of use and intensity of use of ICT platforms between the young and the old generation of potato farmers. Unlike the youthful farmers, a unit increase in years of formal education increased the probability of using ICT platforms by 0.8 among the older farmers. This shows how knowledge, especially technical literacy, is an important factor among older farmers in facilitating the usage of ICT platforms. Similar positive effects of education on the use of ICT tools and platforms were reported previously (see Wawire *et al*., 2017; Krell *et al.*, 2021). However, these results contradict the findings of Okello *et al*. (2021), who noted a negative relationship between education and the use of agricultural technology. This could be due to the high technical skills required to use ICT compared to other technologies.

An increase in household income raised the likelihood of usage of ICT platforms for both youth and older farmers. However, the magnitude of the influence was slightly higher for the youth (0.28) than for the older farmers (0.20). Income was previously observed as an enabler, which helps farmers attain self-reliance and independence in terms of information use (Drafor, 2016). Additionally, income was observed to increase the purchasing power of farmers enabling them to acquire ICT tools that facilitate more usage of the platforms (Maina *et al*., 2023).

From the pooled results, years of farming negatively influenced the use of ICT platforms. This implies that potato farmers with more experience in the crop shy away from adopting the use of information technology. Instead, they prefer relying on their past experiences as alternative sources of information. This finding is in line with the observations of Okello *et al*. (2021) and Sumo *et al.* (2022).

Household size among the youthful farmers positively influenced the use of ICT platforms, unlike the older farmers. The large household size among the young farmers could demand more livelihood resources like food. Likewise, previous study by Kumar and Karthikeyan (2019) argued that more household members could mean diversity in knowledge resources facilitating the use of technologies.

Table 5: Regression results from the Heckpoisson model

Selection equation: Use of ICT platforms							**Outcome equation: Intensity of use**					
	Youth farmers (n = 148)		**Old farmers (n = 116)**		**Pooled sample (n = 264)**		**Youth farmers (n = 86)**		**Old farmers (n = 48)**		**Pooled sample (n = 134)**	
Variables	**Coef.**	**SE**	**Coef.**	**SE**	**Coef.**	**SE**	**Coef.**	**SE**	**Coef.**	**SE**	**Coef.**	**SE**
Education (years)	0.526	0.398	0.795*	0.462	0.070**	0.030	-0.123	0.272	0.682*	0.400	0.008	0.026
Household income (Ksh)	0.275***	0.798	0.200***	0.640	0.209***	0.478	-	-	-	-	-	-
Seasonal potato output (tons)	-	-	-	-	-	-	0.034***	0.013	0.008	0.015	0.022**	0.010
Distance from potato farm to the nearest market (Km)	0.031	0.172	0.236	0.215	0.021	0.125	0.110**	0.045	0.108**	0.044	0.104***	0.034
Years of farming experience	-0.117	0.172	0.091	0.187	-0.206*	0.110	-	-	-	-	-	-
Household size	0.543**	0.230	0.216	0.344	0.334*	0.180	-0.034	0.053	-0.173***	0.057	-0.085**	0.039
Gender (1 = male)	0.421*	0.239	0.069	0.269	0.303*	0.170	-0.131	0.213	-0.339*	0.190	-0.182	0.152
Group membership (1 = yes)	0.657**	0.312	0.203	0.283	0.355*	0.195	0.158	0.208	0.115	0.225	0.185	0.156
Extension services (1 = yes)	-0.012	0.269	0.665**	0.272	0.229	0.184	-0.162	0.203	-0.400*	0.236	-0.315**	0.157
Use of internet (1 = yes)	-	-	-	-	-	-	0.635**	0.284	0.371	0.286	0.448**	0.206
Constant	-2.481	1.104	-3.695	1.330	-1.659	0.503	0.604	0.911	-0.013	1.195	0.777	0.537
Wald chi2 (8)	20.13		32.19		30.73							
Prob > Chi2	0.0098		0.0001		0.0002							
Log-likelihood	-250.709		-146.586		-415.390							

Note: Asterisks ***, **, * denote statistically significant differences at 1%, 5%, and 10%, respectively, coef. denotes coefficients of the parameters; SE denotes standard errors.
Source: Survey Data (2022).

The male youthful potato farmers had a positive significance on the use of ICT platforms. They had higher usage of the platform compared to their female counterparts. This could be due to resource constraints among female youth, which include low years of education, low land ownership, and low income. Consistent with the observations of Feyisa (2020), these constraints imply low incentives for the use of agricultural technologies among female farmers.

Both institutional support services (group membership and access to extension services) had positive effects on the use of ICT platforms. However, the influence varied from one group to another. While membership in a development group positively influenced the youthful potato farmers more than the older farmers, access to extension services influenced the older farmers more than the youthful farmers. Apart from creating awareness, these services, especially agricultural extension, equip farmers with the practical skills of technology adoption and use (Ayisi and Kozári, 2021). These findings concur with the previous results from Wawire *et al.* (2017).

Like the effect on use, years of formal education among older potato farmers positively determined the intensity of use of ICT platforms. Farmers with more years of education are equipped with the high technical skills required in operating ICT platforms. Therefore, they are more likely to use them more frequently compared to their less educated counterparts. Similar findings were reported by Wawire *et al*. (2017), who emphasized the critical role played by technical literacy in the adoption of any technology.

The potato output of the youthful farmers had a positive influence on the weekly frequency of using the ICT platforms. As the output increases, the youthful farmers are motivated to seek market information and post-harvest management skills and facilities (Michels *et al.*, 2020). This finding underpins the important role of youth in rural agricultural transformation through their usage of ICT. They are able to access market information as well as create more diverse farm and non-farm employment opportunities (Yeboah *et al*., 2020). Awotide *et al.* (2016) also reported a positive influence of agricultural output on the intensity of adoption of rice technologies among rural farmers in Nigeria.

The distance from potato farms to the nearest market, which served as both an input and output market, had a similar influence on the intensity of use of ICT platforms between the young and old farmers. An increase in distance to the nearest market by a kilometer, increased the intensity

of use by 0.11. From a cost-minimization perspective, rational farmers who are far from the market are expected to minimize transportation and transaction costs by using more ICT platforms. These platforms provide farmers with the right competitive market prices and connect them to direct buyers. In addition, having access to information enabled farmers to sell their potatoes at far markets that offers better prices than the local markets. Consequently, they are able to forgo the negotiation costs as well as the cost of searching for information from brokers or other marketing agents (Chete and Fasoyiro, 2014).

An increase in household size among older farmers reduces the intensity of use of ICT platforms by 0.17. Older farmers are characterized by older household members, whose vigor and frequency of using ICT declines with an increase in age. This implies a reduction in their energy, and physical and cognitive abilities (Menéndez Álvarez-Dardet *et al*., 2020). A similar negative relationship between family size and intensity of use was earlier observed by Wawire *et al.* (2017).

Contrary to expectations, older male farmers had a reduction in the intensity of use of ICT platforms. Male farmers who are the household heads, provide less labor compared to their female counterparts. Therefore, they are less likely to use the ICT platforms (Rapsomanikis, 2015). This finding corroborates those of Sumo *et al.* (2022), who found a negative relationship between males and demand for extension services in Liberia.

The use of the internet by young farmers positively influenced the intensity of use of ICT platforms. As shown in Figure 8, there was high usage of the website and mobile applications tools, which require internet connectivity. In addition, the youthful farmers had higher usage of the internet (see Table 2). These two observations could explain why the use of the internet significantly influences their intensity of use of ICT platforms. Wyche and Olson (2018) associated higher access to the internet with higher access to online information and higher use of internet-enabled ICT tools.

Lastly, the negative effect of access to extension services on the intensity of use of ICT platforms among older potato farmers contradicts the expectations. This can be explained by low access to extension services (see Table 2). This study has established variations and differences in the magnitude of determinants of use and intensity of use of ICT platforms between the youth and older potato farmers. Therefore, it rejects the null hypothesis of no differences in determinants of use and intensity of use of ICT platforms between the two generations of potato farmers.

CHAPTER FIVE

5.0 EFFECTS OF USING ICT PLATFORMS ON POTATO INCOME BETWEEN THE YOUTH AND OLDER FARMERS

5.1 Abstract

Integration of ICT platforms in the potato sector was primarily aimed at improving potato yields and incomes by providing information on constraints impeding potato production. To justify the attainment of this goal, the study established the effects of using ICT platforms on potato incomes among potato farmers in Nakuru County, Kenya. Unlike other agricultural sectors, scanty literature has measured the effects of using ICT in the potato sector. Additionally, studies comparing the effects of ICT on income between youth and older farmers are yet to be featured in the scientific literature. The current study fills these gaps. A sample size of 434 farmers was drawn using multistage sampling techniques, while the endogenous treatment effect (ETE) model was used in econometric analysis. The results show higher positive effects of ICT platforms among the older than the youth potato farmers. In addition, land size had a higher positive effect on incomes among youth farmers than their older counterparts. These results do not only show a paradox in resource ownership but also in the effects of using these resources between the two generations. These findings demonstrate the economic importance of advocating for equal access to both technical and physical resources between these two generations.

Keywords: ICT platforms, income, endogenous treatment effect.

5.2 Introduction

The smallholder agriculture sector is one of the leading sectors with the biggest information gap in Africa. As a result, rural farmers, the majority of whom are relied upon to accelerate food production for the growing population, realize poor- and low-quality outputs (Brown *et al*., 2018). Additionally, the cost of asymmetric information incurred by these farmers has over time compelled them to rely on their past experiences and information from their peers (Phiri *et al*., 2017).

Driven by both global, continental and national goals of achieving sustainability, various policies have been aimed at transforming the agricultural sector through the use of new technologies (Barber *et al*., 2016). Consequently, ICT innovations, which are cost-effective, are developed from time to time to lessen the burden associated with information accessibility among farmers (Chege *et al*., 2019). This has been achieved in developed economies, where the effects of using ICT have significantly yielded measurable results.

Similarly, the use of ICT in agriculture in developing countries has been highly embraced by different actors along the value chain (Okello *et al*., 2020). The use of ICT is being recognized as the most modern technology to bridge the information gap in the agricultural sector (Mwenda *et al*., 2023). This is based on the fact that ICT can equip farmers with information on various production-related problems they are facing (Ali *et al*., 2016).

In Kenya, low potato productivity of 7.9t/ha has been associated with information asymmetric challenges (CIP, 2021). In order to curb this problem, various ICT service providers have developed platforms to enable farmers to effectively and efficiently access information. The platforms have been designed to provide information on inputs, crop husbandry practices, post-harvest management, marketing and weather, (see Sebotsa *et al*., 2020; CIP, 2021; von Bismarck-Osten, 2021).

The development of these platforms, which include *Viazi Soko*, was integrated into potato production together with other interventions to empower the farmers to achieve the potential productivity of 40t/ha (Muthoni and Shimelis, 2022). While this target is yet to be achieved, a collaborative approach between the key stakeholders in the sector and various ICT service providers is ensuring adequate, timely and reliable information access by potato farmers (Krell *et al*., 2021). These include information on planting materials, fertilizer, pest and disease control

measures, management of post-harvest losses, weather and climate change and competitive market prices.

Various sub-sectors in agriculture have gained considerable literature on the effects of the use of ICT on incomes and yield as well as on the information intelligence of the actors. These sub-sectors include tomato, dairy, aquaculture, maize, pulse and wheat sectors, (see Marwa *et al*., 2019; Ntiri *et al*., 2022; Mwenda *et al*., 2023). These studies have reported positive effects of ICT in the respective sectors.

However, the potato sub-sector has documented scanty literature on the effects of ICT, particularly on the income of the farmers. This is beside the study done by Das *et al*. (2017) in Bangladesh, which focused on the effects of ICT on potato yields. Consequently, there is a sectoral knowledge gap on how the availability and use of the aforementioned information affect potato incomes.

Additionally, literature has demonstrated greater effects of ICT among youth farmers in terms of income, access to production information as well as their participation in the sector, (see Irungu *et al*., 2015; Okello *et al*., 2020; Sebotsa *et al*., 2020). While the same effects can be assumed for the youth potato farmers, there is little empirical evidence comparing them to their older counterparts. Therefore, this study aimed to address the potato sectoral gap by assessing the effects of using ICT platforms on potato incomes. Secondly, the study established a comparison of the effects of ICT platforms on potato income between the youth and older potato farmers. Information from this study will provide evidence for policy interventions to continue promoting the use of ICT platforms in potato production in Kenya and other SSA countries.

5.3 Methodology

The study used a two-step endogenous treatment effect (ETE) model to analyze the causal effects of the ICT platforms on potato income. The model was chosen over PSM and instrumental variable (IV) due to its stronger ability to test and control for unobserved endogeneity and selection bias (Wooldridge, 2013). Endogeneity is a problem that causes the unobserved variables to affect the outcome variables (Wooldridge, 2013). The model corrects the unobserved endogeneity, which arose from a random effect of freedom to use any ICT platform for both users and non-users (Anang *et al*., 2020). Therefore, the model provided unbiased estimates of the effect of ICT platforms on potato income.

After controlling for the endogeneity problem, the model measured the average treatment effects (ATE) of the effect of ICT platforms on income from potato farming. The model specified a correlation structure between the unobserved effects associated with the treatment and the unobserved effects associated with the outcome variables (Anang *et al*., 2020). The effect of ICT platforms on income was modeled in two stages as follows.

In the first stage, a binary logit model was estimated with the use of ICT platforms as the dependent variable as shown in equation (9).

$$P(U) = \beta_0 + \beta_i X_i + \varepsilon_i \quad (9)$$

where *U* is the dependent variable on the use of ICT platforms, which took the value of 1 or 0,

β_0 is intercept,

β_i is the slope parameters to be estimated,

X_i are the set of exogenous factors affecting the use of the ICT platforms,

ε_i is the error term.

In the second stage, in order to control for the unobserved endogeneity effect, the model used the predicted probabilities of using ICT platforms (U_i) from equation (10). The resulting relationship between the outcome variable, Y_i, exogenous variables, X_i and use of ICT platforms, U_i were analyzed using ordinary least squares (OLS) regression. Equation (10) illustrates this relationship.

$$Y_i = \beta_i X_i + U_i \alpha + e_i \quad (10)$$

where; α is a scalar capturing the treatment effects in the use of ICT platforms,

β_i captures the parameter of exogenous variables to be estimated,

e_i is the error term.

Contrary to the approach by Anang *et al*. (2020) who used aggregate income from the broad agricultural sector, the current study used income from the target potato crop. This approach enabled a sector-specific analysis targeted at influencing specific policies in the potato sector. Table 6 shows the expected signs of variables for the endogenous treatment regression model.

The use of an ICT platform by a potato farmer was expected to increase potato income. The use of these platforms equips farmers with information and increases their agricultural knowledge.

Farmers use such information to boost production and tackle various challenges along agricultural value chains leading to more output and income (Marwa *et al*., 2019).

The male gender of a potato farmer was expected to have a positive effect on potato income. Women are disadvantaged in access and use of productive resources like land. They are also overburdened with domestic chores compared to their male counterparts (Wamuyu, 2019). Therefore, they produce less, leading to less income.

Household size and years of farming experience were expected to have either a positive or negative effect on potato income. Large household sizes can imply a high dependency ratio reducing production. It can also be a source of free labor, which increases production (Olumeh *et al*., 2021). Years of farming experience, on the other hand, could mean holding on to the use of obsolete techniques or the adoption of modern technology. These may lead to a reduction or increase in income from potato production.

An increase in the age of potato farmers was expected to have a positive effect on potato income. The older farmers have better experience in farming compared to the youth (Alulu, 2020). An increase in years of education of a potato farmer was expected to have a positive effect on potato income. Education increases the capacity to use emerging technologies to reduce agricultural challenges, which leads to high output and income (Treinen and Van der Elstraeten, 2018).

Table 6: Expected signs of the effects of using ICT platforms on potato income

Variable	Description	Measurement	Expected sign
Dependent variable			
Potato income	Incomes generated from potato farming for the previous year (2021)	Continuous in Kshs	
Independent variables			
Platform use	Use of any ICT platform by potato farmer	Dummy (1 = Yes, 0 = No)	+
Age	Age of the potato farmers	Continuous in years	+
Education	Number of years of formal education of potato farmer	Continuous in years	+
Farming experience	Number of years of potato farming	Continuous in years	**+-**
Gender	Gender of the potato farmer	Dummy (1 = Male, 0 = Female)	+
Household size	Number of people who regularly reside in the household of the potato farmer	Continuous	+/-
Land size	Size of the farm under potato production	Continuous in acres	+
Extension services	Access to extension services by potato farmer	Dummy (1 = Yes, 0 = No)	+
Group membership	Membership of agricultural group by potato farmer	Dummy (1 = Yes, 0 = No)	+
Distance to the nearest market	Average distance to the nearest market from the potato farm	Continuous in Kilometers	+

Distance to the nearest market from a potato farm was expected to have a negative effect on potato income. The closer one is to the market, the higher the incentive to produce more, which leads to higher income because of reduced transport costs (Okello *et al*., 2020). The land size was expected to have a positive influence on potato yield and income. Large farm size enhances the quantity of produce (Nsabimana, 2021).

Access to extension services by a potato farmer was expected to increase potato yield and income. It enriches farmers with new information and better techniques, which improves husbandry practices. This leads to increased yield and hence higher incomes (Ntiri *et al*., 2022). Group membership was expected to have a positive effect on potato yields and income. Agricultural groups among farmers enable them to interact and share information and opportunities (Marwa *et al*., 2019). These benefits help individual farmers to raise their output and income.

5.4 Results and Discussion

Table 7 shows the OLS results from the second step of the endogenous treatment regression. The use of ICT platforms had a positive effect on potato incomes for both the youth and older farmers as well as the pooled sample. Farmers who used various ICT platforms had better access to information, which they used to improve their potato production. These resulted in higher output and incomes.

However, the study noted a higher effect of ICT platforms on potato income among the older farmers (1.07) than the youth farmers (0.94). This finding underpins the important role of both generations of farmers in the phase of agricultural transformation. The positive effect of using technology on incomes among farmers was also reported by Anang *et al*. (2020) and Okello *et al*. (2020).

Table 7: Results of the effect of using ICT platforms on potato income

	Youth farmers (n = 148)		**Older farmers (n = 116)**		**Pooled sample (n = 264)**	
Variables	**Coef.**	**RSE**	**Coef.**	**RSE**	**Coef.**	**RSE**
Use of ICT platform	0.939***	0.134	1.067***	0.175	1.003***	0.087
Education (years)	-0.120	0.149	-0.349**	0.175	-0.193*	0.110
Household size	-0.100	0.116	0.164	0.160	-0.003	0.097
Years of farming experience	0.009	0.074	0.093	0.078	0.116**	0.052
Land size (acres)	0.864***	0.052	0.778***	0.092	0.821***	0.049
Distance from potato farm to the nearest market (Km)	-0.134**	0.068	-0.178**	0.081	-0.141**	0.057
Gender (1 = male)	0.026	0.108	-0.023	0.125	-0.008	0.082
Access to extension services (1 = yes)	0.157	0.114	-0.205	0.138	0.011	0.089
Group membership (1 = yes)	-0.480***	0.118	-0.147	0.128	-0.306***	0.091
Constant	11.433	0.425	11.660	0.524	11.380	0.337
Prob > Chi2	0.0000		0.0000		0.0000	
Rho	-0.9264	0.0382	-0.8692	0.0543	-0.8787	0.0305
Sigma	0.5982	0.0686	0.6249	0.0627	0.6311	0.0459
Lambda	-0.5542	0.0826	-0.5431	0.0842	-0.5546	0.0548

Note: Asterisks ***, **, * denote statistically significant differences at 1%, 5%, and 10%, respectively, coef. denotes coefficients of the parameters; RSE denotes robust standard errors.
Source: Survey Data (2022).

Besides the effect of the ICT platforms on potato income, the model also provided other estimates of potato income. Contrary to the hypothesized results, an increase in years of education negatively influenced potato incomes among older farmers. The production of potatoes in SSA was in earlier generations linked to the old and women farmers who are resource-poor and illiterate (Giller *et al*., 2021). This could explain the lower incomes from potatoes among the educated older farmers compared to the illiterate fellows. This finding contradicts the findings from Anang and Yeboah (2019), who observed a positive effect of education on rice incomes. Compared to potato, which is perceived as a low-value food crop in rural households, rice production is regarded as a high-value cash crop, whose production has been dominated by mostly literate and male farmers.

An increase in land size by an acre increased the potato income of the youth by 0.86 compared to 0.78 for older farmers. This shows the economic benefits of promoting equal access to capital endowment among the youth. An increase in land size increases the quantity of yield produced leading to increased incomes. Similar findings on the positive influence of farm size on income were previously reported by Ansah *et al*. (2017) and Ho and Ha (2017). The result is also consistent with the findings of Bongole (2016), who assessed the determinants of income in Tanzania. However, this result contradicts the previous studies by Kabir *et al*. (2019) and Alulu (2020), whose arguments were based on the inefficiency of large farm sizes in realizing higher outputs.

An increase in distance to the nearest market had a negative effect on incomes for both generations of farmers. This may be due to inadequate market information, perishability of the crop and high transportation costs experienced by farmers far away from the markets. This may force them to sell their produce to the locals and the brokers at lower prices, leading to lower incomes. The effect was, however, more intense for the older farmers than their youthful counterparts. The youth farmers may be able to navigate through the mentioned predisposing factors better than the older farmers. Previous studies also reported a similar relationship between market distance and income, (see Ansah *et al*., 2017; Ho and Ha, 2017; Anang and Yeboah, 2019).

Contrary to a priori expectation, institutional factors like membership in agricultural groups had a negative effect on potato incomes. This was, however, significant in the pooled sample and among the youth potato farmers. The negative effect may be due to the local composition of the groups as was reported by the farmers during the survey. This may imply the sharing of old and obsolete techniques among the farmers, which may lead to the deterioration of the quality and quantity of

produce leading to low incomes. However, this finding contradicts those of Alulu (2020) and Anang *et al*. (2020). This could be due to the existence of well-established farmer groups in these areas, unlike in the current study.

Lastly, years of farming potatoes had a positive influence on the income of the pooled sample. Potato farmers with many years of farming had higher incomes than their less experienced counterparts. This could be because experienced potato farmers are equipped with skills for managing risks, better crop husbandry practices, post-harvest management and better market linkages. Similar observations were earlier made by Beckman and Schimmelpfennig (2015).

In conclusion, the above results have established a difference in magnitude in the major determinants of potato incomes; land size, and use of ICT platforms between the two generations. Based on these results, the study rejects the null hypothesis of no differences in the effects of ICT platforms between the youth and the older potato farmers.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The current study analyzed generational differences in awareness, use and effects of the use of ICT platforms on potato income among the age-disaggregated potato farmers in Nakuru County. Descriptive results revealed that older farmers dominated the production of potato farming. The majority of potato farmers who participated in this study were smallholders with land sizes less than 2 acres. Older farmers had access to larger sizes of land. Consequently, they ranked higher in terms of potato output and income compared to younger farmers.

The study found that older farmers had more years of experience in potato farming than younger farmers. This shows the active role of the older generation in food crop production. Older farmers also registered a high proportion in group membership showing their power to embrace collective action initiatives. Youth farmers, on the other hand, had more years of schooling. Consequently, due to their high technical knowledge, they reported a high proportion of access to the internet, awareness, use and frequency of using ICT platforms. *DigiFarm* and *Viazi Soko* were the most popularly known platforms. *DigiFarm, social media* and *Viazi Soko* were the most used platforms. Among the services provided by these platforms, information on input and output markets was the most accessed and used service by the potato farmers.

Furthermore, this study established that there are differences in the significance of determinants of awareness of ICT platforms between the youth and older farmers. Results from a binary logit model showed that the main drivers of awareness among the youth were the main sources of agricultural information and the use of the internet. Access to extension services and the number of sources of information significantly determined the awareness among older potato farmers.

Additionally, resource endowment factors like household income had a varying magnitude and a positive effect on the use of ICT platforms among young and older farmers. Both institutional support services (group membership and access to extension services) had a positive effect on the use of ICT platforms. Group membership on youth farmers' usage, and extension services on older farmers' usage of the platforms. On the other hand, access to extension services negatively

influenced older farmers' intensity of use of ICT platforms. Seasonal potato output and access and use of the internet influenced the intensity of use of platforms among the youth farmers.

Lastly, the results indicated a higher positive effect of ICT platforms on potato income among older farmers than the youth farmers. This is despite the high affinity of the youth to the use of ICT. There was also a higher positive effect of land size on potato income among the young generation.

6.2 Recommendations

6.2.1 Policy Recommendations

Considering the positive effect of ICT platforms on potato incomes, this study suggests policy interventions targeting the low awareness and use of such ICT platforms. Investment in ICT platforms and their integration into the potato sector should be pursued to facilitate rapid rural agricultural transformation. However, such investments should consider the variations in the main determinants of awareness and use of ICT platforms between young and older potato farmers.

In order to increase awareness among the youth, provisions for online advertisement should be enhanced by platform service providers. The advertisements should demonstrate how to use various ICT platforms, their benefits and the success stories of these technologies among potato farmers. This should include the use of *Google advertisements* or *pop-up videos*, which should be targeted at the more frequently used social media platforms like *Facebook.* The advertisements should be made mandatory before the intended information is displayed to capture the attention of the viewer.

Lead farmers should help mobilize youthful potato farmers to form more agricultural groups. The groups increase dissemination coverage due to increased economies of scale. The groups should be geared towards peer farmer learning and information sharing on the availability of ICT platforms and their benefits in boosting potato production.

In order to increase awareness among older farmers, interventions like field days should be formalized both at the sub-county and ward levels by the respective agricultural officers. Service providers should use these events to create knowledge on ICT platforms. The events should also enhance the dissemination of new information technologies through demonstrations and practical

approaches. These can include demonstrating to the farmers how to search for information on the platforms using tools like mobile phones.

The county government should invest in enhancing the technical knowledge of extension agents on various ICT platforms. The ICT platform service providers should aid in the training of the extension officers on the use of various platforms. This should strengthen the quality of information transfer between the extension officers and the older farmers increasing their awareness level.

Among the youthful farmers, interventions that promote their access to production assets like land should be pursued by the county government. The Ministry of Public Service, Gender and Affirmative Action should aid in this sensitization. This should enlighten the older farmers on the benefits of bestowing the youth with equal access and ownership to land, a key driver of agricultural production and subsequent farm incomes.

Lastly, interventions that improve income-earning capacity among older potato farmers should be prioritized to promote more usage of ICT platforms. The provision of affordable inputs like fertilizer and planting materials would provide a stronger incentive to the better physical resource-endowed older farmers to increase their usage of ICT platforms. Subsequently, the role of older farmers in rural food security through increased potato yield and incomes will be enhanced.

6.2.2 Suggestions for Further Studies

This study established differences in magnitude and significance on the determinants of use and intensity of use of ICT platforms between the young and the older generation of potato farmers. It also contributed to the literature by establishing the actual platforms and services used by potato farmers in Nakuru County. However, the analyses did not focus on any specific ICT platform or service. Instead, they were considered a mixture of platforms used per farmer. Therefore, the study failed to measure certain characteristics of these platforms like perceived ease of use, affordability of the services, and relevance of information obtained from these platforms. It is therefore important that future researchers address these shortcomings by focusing on the analysis of a specific platform and its services from the list of platforms established in the current study.

REFERENCES

Abate, G. T., Abay, K. A., Chamberlin, J., Kassim, Y., Spielman, D. J., and Paul Jr Tabe-Ojong, M. (2023). Digital tools and agricultural market transformation in Africa: Why are they not at scale yet, and what will it take to get there? *Food Policy*, *11*(6), 102–439. https://doi.org/https://doi.org/10.1016/j.foodpol.2023.102439.

Adio, E., Yusufu, A., Yusuf, S. K., and Nansoh, S. (2016). Use of Agricultural Information Sources and Services by Farmers for Improve Productivity in Kwara State. *Library Philosophy and Practice (e-Journal)*, *14*(56), 1–6.

African Development Bank. (2016). *Feed Africa: Strategy for Agricultural Transformation in Africa 2016–2025*. Abidjan: African Development Bank Group (AFDB). https://www.afdb.org/fileadmin/uploads/afdb/Documents/Generic-Documents/Feed_Africa-_Strategy_for_Agricultural_Transformation_in_Africa_2016-2025.pdf.

African Union. (2014). *Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods. Tech. Rep. African Union*.

Aker, J. C., Ghosh, I., and Burrell, J. (2016). The promise (and pitfalls) of ICT for agriculture initiatives. *Agricultural Economics*, *47*(S1), 35–48. https://doi.org/https://doi.org/10.1111/agec.12301.

Ali, S., Jabeen, A., and Nikhitha, M. (2016). Impact of ICTs on Agricultural Productivity. *European Journal of Business, Economics and Accountancy*, *4*(5), 82–92.

Alulu, J. (2020). *Participation in Contract Farming and Its Effects on Technical Efficiency and Income of Vegetable Farmers in Western Kenya*. Masters dissertation, University of Nairobi.

Anang, B. T., Bäckman, S., and Sipiläinen, T. (2020). Adoption and income effects of agricultural extension in northern Ghana. *Scientific African*, *7*, e00219. https://doi.org/https://doi.org/10.1016/j.sciaf.2019.e00219.

Anang, B. T., and Yeboah, R. W. (2019). Determinants of Off-Farm Income among Smallholder Rice Farmers in Northern Ghana : Application of a Double-Hurdle Model. *Advances in Agriculture*, *19*(2), 336–361. https://doi.org/https://doi.org/10.1155/2019/7246176 Research.

Ansah, I. G. K., Tetteh, B. K. D., and Donkoh, S. A. (2017). Determinants and income effect of

yam postharvest loss management : evidence from the Zabzugu District of Northern Ghana. *Food Security*, *9*(3), 611–620. https://doi.org/10.1007/s12571-017-0675-1.

Avis, W. R. (2015). Mobile phone and social media interventions for youth development outcomes. *Journal of Applied Knowledge Services*, *1*(1), 1–26.

Awotide, B. A., Karimov, A. A., and Diagne, A. (2016). Agricultural technology adoption, commercialization and smallholder rice farmers' welfare in rural Nigeria. *Agricultural and Food Economics*, *4*(1), 1–24. https://doi.org/10.1186/s40100-016-0047-8.

Ayim, C., Kassahun, A., Addison, C., and Tekinerdogan, B. (2022). Adoption of ICT innovations in the agriculture sector in Africa: a review of the literature. *Agriculture and Food Security*, *11*(1), 1–16. https://doi.org/10.1186/s40066-022-00364-7.

Ayisi, D., and 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*(3), 164–172. https://doi.org/10.1016/j.jssas.2021.01.002.

Babbie, E. (2004). *The Practice of social research* (10th edition). Thomson Wadsworth, Belmont, California.

Barber, J., Mangnus, E., and Bitzer, V. (2016). Harnessing ICT for agricultural extension. *Sustainable Economic Development and Gender*, *91*(120), 31–35.

Barlett, J. E., Kotrlik, J., and Higgins, C. (2001). Organizational Research: Determining Appropriate Sample Size in Survey Research. *Information Technology, Learning, and Performance Journal*, *19*.

Baumüller, H. (2016). Agricultural Service Delivery Through Mobile Phones: Local Innovation and Technological Opportunities in Kenya. In *Technological and Institutional Innovations for Marginalized Smallholders in Agricultural Development* (pp. 143–162). Springer. https://doi.org/10.1007/978-3-319-25718-1.

Beckman, J., and Schimmelpfennig, D. (2015). Determinants of farm income. *Agricultural Finance Review*, *1*(1), 10–15.

Bongole, A. J. (2016). Determinants of Farm and Non-Farm Activities as Sources of Income

amongst Rural Households: Evidence from Kahama District in Tanzania. *Journal of Economics and Sustainable Development*, *7*(4), 2222–1700. www.iiste.org.

Bright, M. P., Kudzai, N. T., and Ngavaite, C. (2021). The impact of COVID-19 on agricultural extension and food supply in Zimbabwe. *Cogent Food and Agriculture*, *7*(1), 1–12. https://doi.org/10.1080/23311932.2021.1918428.

Brown, B., Llewellyn, R., Nuberg, I., Brown, B., and Llewellyn, R. (2018). Why do information gaps persist in African smallholder agriculture ? Perspectives from farmers lacking exposure to conservation agriculture to conservation agriculture. *The Journal of Agricultural Education and Extension*, *24*(2), 198–208. https://doi.org/10.1080/1389224X.2018.1429283.

Cameron, T. A., and Kolstoe, S. H. (2022). Using auxiliary population samples for sample-selection correction in models based on crowd-sourced volunteered geographic information. *Land Economics*, *98*(1), 1–21.

Chege, S. M., Wang, D., and Suntu, S. L. (2019). Information Technology for Development Impact of information technology innovation on firm performance in Kenya Impact of information technology innovation on firm performance. *Information Technology for Development*, *26*(2), 316–345. https://doi.org/10.1080/02681102.2019.1573717.

Chete, O. B., and Fasoyiro, S. B. (2014). Impact of ICT-Based Initiative (Mobile Phone) on Market Access By Women Farmers in Nigeria. *World Rural Observations*, *6*(3), 125–132. http://www.sciencepub.net/rural.

Christophers, B. (2017). Intergenerational Inequality? Labour, Capital, and Housing Through the Ages. *Antipode*, *50*(1), 101–121. https://doi.org/10.1111/anti.12339.

CIP. (2021). *Enhancing the Digital Platform Viazi Soko to Support Seed and Potato Marketing in Kenya*. https://doi.org/10.4160/9789290605713.

Das, S., Munshi, M. N., and Kabir, W. (2017). The impact of ICTs on agricultural production in Bangladesh: A study with food crops. *SAARC Journal of Agriculture*, *14*(2), 78–89. https://doi.org/10.3329/sja.v14i2.31247.

Daum, T. (2018). ICT Applications in Agriculture. In P. Ferranti, E. M. Berry, and J. R. B. T.-E. of F. S. and S. Anderson (Eds.), *Encyclopedia of Food Security and Sustainability* (Vol. 1, pp. 255–260). Elsevier. https://doi.org/https://doi.org/10.1016/B978-0-08-100596-5.22591-

2.

De Leeuw, E. D. (1992). *Data quality in mail, telephone and face to face surveys.* TT Publikaties, Plantage Daklaan 40, 1018 CN Amsterdam.

DeGhetto, K., Gray, J. R., and Kiggundu, M. N. (2016). The African Union's Agenda 2063: Aspirations, challenges, and opportunities for management research. *Africa Journal of Management*, *2*(1), 93–116. https://doi.org/http://dx.doi.org/10.1080/23322373.2015.1127090.

Doss, C. R. (2018). Women and agricultural productivity: Reframing the Issues. *Development Policy Review*, *36*(1), 35–50. https://doi.org/10.1111/dpr.12243.

Drafor, I. (2016). Access to Information for Farm-Level Decision-Making. *Journal of Agricultural and Food Information*, *17*(4), 230–245. https://doi.org/10.1080/10496505.2016.1213170.

Enwelu, I. A., Uramah, K. O., Asadu, A. N., and Chah, J. (2014). Assessment of ICT Utilization in Agriculture Across-Gender in Enugu-Ezike Agricultural Zone of Enugu State, Nigeria. *Journal of Agricultural Extension*, *18*(2), 10–20. https://doi.org/10.4314/jae.v20i2.10.

FAOSTAT. (2021). *Potato production by country*. Retrieved August 10, 2023, from https://www.fao.org/faostat/en/#data/QCL.

Feyisa, B. W. (2020). Determinants of agricultural technology adoption in Ethiopia: A meta-analysis. *Cogent Food and Agriculture*, *6*(1), 90–236. https://doi.org/10.1080/23311932.2020.1855817.

Freeman, S., Marston, H. R., Olynick, J., Musselwhite, C., Kulczycki, C., Genoe, R., and Xiong, B. (2020). Intergenerational effects on the impacts of technology use in later life: Insights from an international, multi-site study. *International Journal of Environmental Research and Public Health*, *17*(16), 1–14. https://doi.org/10.3390/ijerph17165711.

Geza, W., Ngidi, M., Ojo, T., Adetoro, A. A., Slotow, R., and Mabhaudhi, T. (2021). Youth participation in agriculture: A scoping review. *Sustainability (Switzerland)*, *13*(16), 1–15. https://doi.org/10.3390/su13169120.

Gibson, K. (2022). Bridging the digital divide: Reflections on using WhatsApp instant messenger interviews in youth research. *Qualitative Research in Psychology*, *19*(3), 611–631.

https://doi.org/https://doi.org/10.1080/14780887.2020.1751902.

Giller, K. E., Delaune, T., Silva, J. V., Descheemaeker, K., van de Ven, G., Schut, A. G. T., van Wijk, M., Hammond, J., Hochman, Z., and Taulya, G. (2021). The future of farming: Who will produce our food? *Food Security*, *13*(5), 1073–1099.

Gillwald, A., Milek, A., and Stork, C. (2010). Gender Assessment of ICT Access and Usage in Africa. *Towards Evidence-Based ICT Policy and Regulation*, *1*(5), 1–44.

Gujarati, D. N. (2004). Applied Econometrics. *Singapore (SG): Mc. Graw-Hill International Editions*. https://doi.org/https://doi.org/10.1126/science.1186874.

Guner, H., and Acarturk, C. (2020). The use and acceptance of ICT by senior citizens: a comparison of technology acceptance model (TAM) for elderly and young adults. *Universal Access in the Information Society*, *19*(2), 311–330. https://doi.org/10.1007/s10209-018-0642-4.

Ho, T. N. D., and Ha, T. V. (2017). Determinants of income diversification and its effects on rural household income in Vietnam. *Can Tho University Journal of Science*, *6*(17), 153–162. https://doi.org/10.22144/ctu.jen.2017.039.

Iazzolino, G., and Mann, L. (2019). Harvesting data: who benefits from platformization of agricultural finance in Kenya. *Developing Economics*, *29*.

Irungu, K. R. G., Mbugua, D., and Muia, J. (2015). Information and Communication Technologies (ICTs) Attract Youth into Profitable Agriculture in Kenya. *East African Agricultural and Forestry Journal*, *81*(1), 24–33. https://doi.org/10.1080/00128325.2015.1040645.

Jolex, A., and Tufa, A. (2022). The Effect of ICT Use on the Profitability of Young Agripreneurs in Malawi. *Sustainability*, *14*(5), 1–10. https://doi.org/10.3390/su14052536

Joshi, A., Kalauni, D., and Tiwari, U. (2019). Determinants of awareness of good agricultural practices (GAP) among banana growers in Chitwan, Nepal. *Journal of Agriculture and Food Research*, *1*(11), 5–17. https://doi.org/10.1016/j.jafr.2019.100010.

Kabir, S., Radovic, M., and Dejan, R. (2019). The Determinants of Income of Rural Women in Bangladesh. *Sustainability*, *11*(20), 58–112.

Katunyo, P. N., Oluoch-kosura, W., and Okello, J. J. (2018). *Factors influencing the intensity of*

use of ICT tools by youth along agricultural value chains: Evidence from Busia County, Kenya. *8*, 1–14.

Kelil, A., Girma, Y., and Hiruy, M. (2020). Access and Use of Agricultural Information in Africa: Conceptual Review. *Information and Knowledge Management*, *10*(7), 1–5. https://doi.org/10.7176/ikm/10-7-01.

KilimoSTAT. (2021). *Kenya Irish potato production per county, 2017-2021*. Retrieved August 12, 2023, from https://statistics.kilimo.go.ke/en/cd_s_crops/.

KNBS. (2019). Population by county and sub-county. In *Kenya National Bureau of Statistics* (Vol. 1).

Komen, S. K., Ngeny, J. M., and Osena, E. (2017). Bridging the potato variety gap: a review of the Kenya-The Netherlands potato project (2012–2015): its success, challenges and opportunities. *Open Agriculture*, *2*(1), 267–273. https://doi.org/https://doi.org/10.1515/opag-2017-0030.

Krell, N. T., Giroux, S. A., Guido, Z., Hannah, C., Lopus, S. E., Caylor, K. K., and Evans, T. P. (2021). Smallholder farmers' use of mobile phone services in central Kenya. *Climate and Development*, *13*(3), 215–227. https://doi.org/10.1080/17565529.2020.1748847.

Kumar, S. A., and Karthikeyan, C. (2019). Status of Mobile Agricultural Apps in the Global Mobile Ecosystem. *International Journal of Education and Development Using Information and Communication Technology (IJEDICT)*, *15*(3), 63–74. https://www.goodworklabs.com/2017.

Kwambai, T. K., Struik, P. C., Griffin, D., Stack, L., Rono, S., Nyongesa, M., Brophy, C., and Gorman, M. (2022). Understanding Potato Production Practices in North-Western Kenya through Surveys: an Important Key to Improving Production. *Potato Research*, *66*(23), 751–791. https://doi.org/10.1007/s11540-022-09599-0.

Lai, J., and Widmar, N. O. (2021). Revisiting the Digital Divide in the COVID-19 Era. *Applied Economic Perspectives and Policy*, *43*(1), 458–464. https://doi.org/10.1002/aepp.13104.

Lindsjö, K., Mulwafu, W., Djurfeldt, A. A., Mulwafu, W., and Djurfeldt, A. A. (2020). Generational dynamics of agricultural intensification in Malawi : Challenges for the youth and elderly smallholder farmers. *International Journal of Agricultural Sustainability*, *1*(3),

1–14. https://doi.org/10.1080/14735903.2020.1721237.

Luo, L., Qiao, D., Zhang, R., Luo, C., Fu, X., and Liu, Y. (2022). Research on the Influence of Education of Farmers' Cooperatives on the Adoption of Green Prevention and Control Technologies by Members: Evidence from Rural China. *International Journal of Environmental Research and Public Health*, *19*(10), 6255. https://doi.org/10.3390/ijerph19106255.

Mabe, L. K., and Oladele, O. I. (2012). Awareness level of use of information communication technologies tools among extension officers in the North-West Province, South Africa. *Life Science Journal*, *9*(3), 57–62.

Maina, F., Mburu, J., and Nyang'anga, H. (2023). Access to and utilization of local digital marketing platforms in potato marketing in Kenya. *Heliyon*, *9*(8), e19320. https://doi.org/10.1016/j.heliyon.2023.e19320.

Marwa, M. E., Mburu, J., Oburu, R. E. J., Mwai, O., and Kahumbu, S. (2019). Impact of ICT Based Extension Services on Dairy Production and Household Welfare: The Case of iCow Service in Kenya [University of Nairobi]. In *Journal of Agricultural Science* (Vol. 12, Issue 3). https://doi.org/10.5539/jas.v12n3p141.

McEwan, M. A., Spielman, D. J., Okello, J. J., Bartle, B., Mbiri, D. G., Atieno, E. O., Omondi, B. A., Wossen, T., and Cortada, L. (2021). *Exploring the regulatory space for improving availability, access and quality of vegetatively propagated crop seed : potato in Kenya.* (RTB Working Paper 2021-1). https://doi.org/10.4160/23096586RTBWP20211.

Mdoda, L., and Mdiya, L. (2022). Factors affecting the use of information and communication technologies (ICTs) by livestock farmers in the Eastern Cape province. *Cogent Social Sciences*, *8*(1), 202–601. https://doi.org/10.1080/23311886.2022.2026017.

Menéndez Álvarez-Dardet, S., Lorence Lara, B., and Pérez-Padilla, J. (2020). Older adults and ICT adoption: Analysis of the use and attitudes toward computers in elderly Spanish people. *Computers in Human Behavior*, *110*(57), 106–377. https://doi.org/https://doi.org/10.1016/j.chb.2020.106377.

Mengui, K. C., Oh, S., and Lee, S. H. (2019). The technical efficiency of smallholder Irish potato producers in Santa subdivision, Cameroon. *Agriculture*, *9*(12), 21–59.

Michels, M., Fecke, W., Feil, J. H., Musshoff, O., Pigisch, J., and Krone, S. (2020). Smartphone adoption and use in agriculture: empirical evidence from Germany. *Precision Agriculture*, *21*(2), 403–425. https://doi.org/10.1007/s11119-019-09675-5.

Mongin, P. (1997). Expected Utility Theory. In: Davis, J., Hands, W. and Maki, U. Eds., Handbook of Economic Methodology., London, 342-350. In *Choice Reviews Online* (Vol. 36, Issue 08). https://doi.org/10.5860/choice.36-4259.

Mtega, W. P., Dulle, F. W., Malekani, A. W., and Chailla, A. M. (2014). Awareness and use of Web 2.0 technologies in sharing of agricultural knowledge in Tanzania. *Knowledge Management and E-Learning: An International Journal*, *6*(2), 188–202.

Muatha, I. T., Jakinda, D. O., and Nyikal, R. A. (2017). Determinants of smallholder farmers' awareness of agricultural extension devolution in Kenya. *African Journal of Agricultural Research*, *12*(51), 3549–3555. https://doi.org/10.5897/ajar2017.12603.

Mudege, N. N., Temesgen, B. B., and Brouwer, A. R. (2019). *Gender situational analysis of the sweetpotato value chain in selected districts in Sidama and Gedeo Zones, in southern Ethiopia. Lima: Perú. International Potato Center.* (Working Paper No. 2019-1; 111 p. Social Sciences). https://doi.org/10.4160/02568748CIPWP20191.

Mulbah, F. F. B., Ritho, C., and Mburu, J. (2020). Do transaction costs influence smallholder rubber farmers' choice of selling outlets? Evidence from Liberia. *Development in Practice*, *31*(1), 69–80. https://doi.org/10.1080/09614524.2020.1789068.

Muthoni, J., and Shimelis, H. (2022). An overview of potato production in Africa. In M. E. Çalişkan, A. Bakhsh, and K. B. T.-P. P. W. Jabran (Eds.), *Production Worldwide* (pp. 435–456). Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-12-822925-5.00020-7.

Mwenda, E., Muange, E. N., Ngigi, M. W., and Kosgei, A. (2023). Impact of ICT-based pest information services on tomato pest management practices in the Central Highlands of Kenya. *Sustainable Technology and Entrepreneurship*, *2*(2), 100–136. https://doi.org/10.1016/j.stae.2022.100036.

Nsabimana, A. (2021). Is change worth it ? The effects of adopting modern agricultural inputs on household welfare in Rwanda. *African Journal of Agricultural and Resource Economics*, *16*(3), 216–236. https://doi.org/doi.org/10.53936/afjare.2021.16(3).15–41.

Ntiri, P., Ragasa, C., Afotey, S., Kuwornu, J. K. M., and Nimorme, E. (2022). Does ICT-based aquaculture extension contribute to greater adoption of good management practices and improved incomes ? Evidence from Ghana. *Aquaculture*, *557*(11), 738–850. https://doi.org/10.1016/j.aquaculture.2022.738350.

Nyaaba, J. A., Nkrumah-Ennin, K., and Anang, B. T. (2019). Willingness to pay for crop insurance in Tolon District of Ghana: Application of an endogenous treatment effect model. *AIMS Agriculture and Food*, *4*(2), 362–375. https://doi.org/10.3934/agrfood.2019.362.

O'Donnell, A., and Sweetman, C. (2018). Introduction: Gender, development and ICTs. *Gender and Development*, *26*(2), 217–229. https://doi.org/10.1080/13552074.2018.1489952.

Ojwang, S. O., Otieno, D. J., Okello, J. J., Muoki, P., and Nyikal, R. A. (2021). Do Nutrition Education Approaches With Preschoolers and Their Caregivers Influence Retention of Biofortified Orange-Fleshed Sweet Potato on Farms? Evidence From Homa Bay County, Kenya. *Food and Nutrition Bulletin*, *42*(3), 347–360.

Okello, D. O., Feleke, S., Gathungu, E., Owuor, G., and Ayuya, O. I. (2020). Effect of ICT tools attributes in accessing technical, market and financial information among youth dairy agripreneurs in Tanzania. *Cogent Food and Agriculture*, *6*(1), 2–17. https://doi.org/10.1080/23311932.2020.1817287.

Okello, D., Owuor, G., Larochelle, C., Gathungu, E., and Mshenga, P. (2021). Determinants of utilization of agricultural technologies among smallholder dairy farmers in Kenya. *Journal of Agriculture and Food Research*, *6*(September), 100–213. https://doi.org/10.1016/j.jafr.2021.100213.

Okello, J. J., Kirui, O. K., and Gitonga, Z. M. (2020). Participation in ICT-based market information projects, smallholder farmers' commercialization, and agricultural income effects: findings from Kenya. *Development in Practice*, *30*(8), 1043–1057. https://doi.org/10.1080/09614524.2020.1754340.

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

Olayemi, S. S., Ope-oluwa, A. A., and E, S. O. (2021). Agricultural Extension Theories and Practice in Sub-Saharan Africa : A Critical Agricultural Extension Theories and Practice in Sub-Saharan Africa : A Critical Review. *Journal of Agricultural Science and Soil Science*, *1*(1), 20–28. https://doi.org/10.5281/zenodo.4587438.

Olumeh, D., Otieno, D. J., and Oluoch-Kosura, W. (2021). Effects of gender and institutional support services on the commercialization of maize in Western Kenya. *Development in Practice*, *31*(8), 1–11. https://doi.org/10.1080/09614524.2021.1937532.

Osiemo, J., Girvetz, E. H., Hasiner, E., Schroeder, K., Treguer, D., Juergenliemk, A., Horst, A., Jarvis, A., and Kropff, W. (2021). *Digital Agriculture Profile: Kenya*. Food and Agriculture Organization of the United Nations.

Panos, C., Henfridsson, O., and Parker, G. (2018). Introduction—Platforms and Infrastructures in the Digital Age. *Information Systems Research*, *29*(2), 381–400. https://doi.org/https://doi.org/10.1287/isre.2018.0794.

Phiri, A., Chipeta, G. T., and Chawinga, W. D. (2017). Information needs and barriers of rural smallholder farmers in developing countries: A case study of rural smallholder farmers in Malawi. *Information Development*, *35*(3), 421–434. https://doi.org/10.1177/0266666918755222.

Rapsomanikis, G. (2015). The economic lives of smallholder farmers: An analysis based on household data from nine countries. *Food and Agriculture Organization of the United Nations, Rome*.

Rengaraj, D., and Shibu, N. S. (2022). Use of information and communication technology in agriculture among farmers in the south region of India. *International Journal of Advanced Research in Engineering and Technology*, *11*(11), 240–261. https://doi.org/10.34218/IJARET.11.11.2020.240.

Republic of Kenya. (2019). *Kenya-Youth-Development-Policy-2019*. Government Printers. https://ict.go.ke/wp-content/uploads/2020/08/Kenya-Youth-Development-Policy-2019.pdf.

Republic of Kenya. (2016). *National Information and Communication Technology (ICT) Policy*. Government Printers.

Republic of Kenya. (2018). *Nakuru County Integrated Development Plan (2018-2022)*.

Government Printers.

Republic of Kenya. (2010). *The constitution of Kenya: 2010*. Chief Registrar of the Judiciary.

Republic of Kenya. (2021). The National Potato Strategy 2021-2025. In *Nairobi: Ministry of Agriculture, Livestock and Fisheries (MoALF)*.

Rigg, J., Phongsiri, M., Promphakping, B., Salamanca, A., and Sripun, M. (2020). Who will tend the farm? Interrogating the aging Asian farmer. *Journal of Peasant Studies*, *47*(2), 306–325. https://doi.org/10.1080/03066150.2019.1572605.

Rose, D. C., Barkemeyer, A., de Boon, A., Price, C., and Roche, D. (2023). The old, the new, or the old made new? Everyday counter-narratives of the so-called fourth agricultural revolution. *Agriculture and Human Values*, *40*(2), 423–439. https://doi.org/10.1007/s10460-022-10374-7.

Ruzzante, S., Labarta, R., and Bilton, A. (2021). Adoption of agricultural technology in the developing world: A meta-analysis of the empirical literature. *World Development*, *1(46)*, 105–199. https://doi.org/https://doi.org/10.1016/j.worlddev.2021.105599.

Salampasis, M., and Theodoridis, A. (2013). Information and Communication Technology in Agricultural Development. *Procedia Technology*, *8*(9), 1–13. https://doi.org/10.1016/j.protcy.2013.11.001.

Sam, A. K., and Grobbelaar, S. S. (2021). Research Trends, Theories and Concepts on the Utilization of Digital Platforms in Agriculture: A Scoping Review. *Responsible AI and Analytics for an Ethical and Inclusive Digitized Society, Springer International Publishing (2021), 12896*(1), 342–355. https://doi.org/10.1007/978-3-030-85447-8_30.

Sebotsa, K. O., Nkurumwa, A., and Kyule, M. (2020). Effect of utilization of social media platforms on youth participation in agriculture in Njoro sub-county, Kenya. *International Journal of Agricultural Extension*, *8*(3), 235–250. https://doi.org/10.33687/ijae.008.03.3400.

Serbulova, N., Kanurny, S., Gorodnyanskaya, A., and Persiyanova, A. (2019). Sustainable food systems and agriculture: The role of information and communication technologies. *IOP Conference Series: Earth and Environmental Science*, *403*(1), 012127. https://doi.org/10.1088/1755-1315/403/1/012127.

Shakhovskoy, M., Saab, W., and Colina, C. (2021). *Agricultural Platforms in a Digital Era: Defining the Landscape. ISF Report*. https://isfadvisors.org/wp-content/uploads/2021/03/ISF_RAFLL_Agricultural_Platforms_Report.pdf.

Spagnoletti, P., Resca, A., and Lee, G. (2015). A design theory for digital platforms supporting online communities: A multiple case study. *Journal of Information Technology*, *30*(4), 364–380. https://doi.org/10.1057/jit.2014.37.

Sumo, T. V., Ritho, C., and Irungu, P. (2022). Effect of farmer socio-economic characteristics on extension services demand and its intensity of use in post-conflict Liberia. *Heliyon*, *8*(12), e12268. https://doi.org/10.1016/j.heliyon.2022.e12268.

Taherdoost, H. (2017). Determining sample size; how to calculate survey sample size. *International Journal of Economics and Management Systems*, *2*, 1–3. https://ssrn.com/abstract=3224205.

Tata, J. S., and Mcnamara, P. E. (2018). Impact of ICT on agricultural extension services delivery : evidence from the Catholic Relief Services SMART skills and Farmbook project in Kenya Impact of ICT on agricultural extension services delivery : evidence from the Catholic Relief Services SMART. *Journal of Agricultural Education and Extension*, *24*(1), 89–110. https://doi.org/10.1080/1389224X.2017.1387160.

Thurstone, L. L. (1927). A law of comparative judgment. In *Psychological Review* (Issue 107). https://doi.org/10.4324/9781315128948-7.

Treinen, S., and Van der Elstraeten, A. (2018). *Gender and ICTs: Mainstreaming gender in the use of information and communication technologies (ICTs) for agriculture and rural development*. Food and Agriculture Organization of the United Nations (FAO).

Ugwu, P. C. (2019). Women in Agriculture: Challenges facing women in African farming. In *Project report of African women in agriculture.* https://www.researchgate.net/publication/332053861.

United Nations. (2015). *Transforming our world: the 2030 agenda for sustainable development*. https://sustainabledevelopment.un.org/post2015/transformingourworld/publication.

Upreti, P. (2015). Factors Affecting Economic Growth in Developing Countries. *Major Themes in Economics*, *17*(1), 37–54.

https://scholarworks.uni.edu/cgi/viewcontent.cgi?article=1114andcontext=mtie

von Bismarck-Osten, M. (2021). Understanding Strategic Decisions of Digital Agricultural Platform Companies: Six Case Studies of Sub-Saharan African Platforms. In *ZEF Working Paper Series* (No. 209; ISSN 1864-6638, Issue 5). https://doi.org/http://dx.doi.org/10.2139/ssrn.3849193.

Wakaba, D., Ateka, J., Mbeche, R., and Oyugi, L. (2022). Determinants of Irish potato (Solanum tuberosum) commercialization and market participation by farmers in Nyandarua County, Kenya. *Journal of Agriculture and Food Research*, *10*(8), 100382. https://doi.org/10.1016/j.jafr.2022.100382.

Wamuyu, R. (2019). *An Analysis of Men and Women's Participation in the Potato Value Chain: a Case of Kinangop Sub-County, Nyandarua County, Kenya*. Masters dissertation, University of Nairobi.

Waruingi, E., Mbeche, R., and Ateka, J. (2021). Determinants of forest-dependent household's participation in payment for ecosystem services: Evidence from Plantation Establishment Livelihood Improvement Scheme (PELIS) in Kenya. *Global Ecology and Conservation*, *26*, e01514. https://doi.org/10.1016/j.gecco.2021.e01514.

Wawire, A. W., Wangia, S. M., and Okello, J. J. (2017). Determinants of use of information and communication technologies in agriculture: the case of Kenya agricultural commodity exchange in Bungoma county, Kenya. *Journal of Agricultural Science*, *9*(3), 128–137.

Wooldridge, J. M. (2013). Introductory Econometrics. In *Introductory Econometrics* (Fifth Edition). https://doi.org/10.4324/9780203157688.

Wyche, S., and Olson, J. (2018). Kenyan Women's Rural Realities, Mobile Internet Access, and "Africa Rising." *Information Technologies and International Development*, *14*, 33–47.

Yang, Z., Paudel, K. P., and Wen, X. (2022). On-line marketing of fresh fruits by New Farmers: Use of a WeChat platform in China. *Computers and Electronics in Agriculture*, *19(9)*, 107–117. https://doi.org/https://doi.org/10.1016/j.compag.2022.107117.

Yeboah, T., Chigumira, E., John, I., Anyidoho, N. A., Manyong, V., Flynn, J., and Sumberg, J. (2020). Hard work and hazard: Young people and agricultural commercialization in Africa. *Journal of Rural Studies*, *76*(April), 142–151. https://doi.org/10.1016/j.jrurstud.2020.04.027.

APPENDICES

Appendix A: Key Informant Interview Checklist

UNIVERSITY OF NAIROBI

Key Informant Interview

October 2022

Understanding the usage of ICT platforms by older and youthful potato farmers

The purpose of this interview is to gain overall insights on the use of ICT information services among potato farmers in Njoro and Molo sub-counties in Nakuru County, I.

Name of enumerator _____

Name of the county/ sub-county _____

Name of the key informant _____

Position held _____

Contact _____

Date of interview _____

Estimated number of potato farmers in the county or sub-county _____

Questions

1. What challenges are potato farmers facing in Nakuru? (Are they information-related challenges?)
2. What sources of information are available to farmers in Nakuru?
3. What ICT platform services are available for agricultural use by farmers?
4. Which of these platforms are specific for potato production in Nakuru?
5. What information needs by potato farmers are targeted by these platforms?
6. Who is managing the provision of these platforms to the farmers?
7. How many farmers are using them? From which areas? Through which cooperatives? Is it group or individual usage?
8. What is the estimate of users in terms of men, women and youth farmers among potato farmers?
9. What are the reported benefits and challenges of the use of these platforms?
10. What interventions are provided to support the use and to counter the challenges mentioned?

Appendix B: Focus Group Discussion Checklist

UNIVERSITY OF NAIROBI

Focus Group Discussion

October 2022

Understanding the usage of ICT platforms by older and youthful potato farmers

The purpose of this focus group discussion is to gain actual insights on the use of ICT information services among potato farmers in Njoro and Molo sub-counties in Nakuru County, I.

Name of facilitator _____

Name of notes taker _____

Name of sub-county _____

Date of interview _____

Questions

1. a. Generally, who between men and women grow potatoes in this area? Who makes decisions on the quantity and the use of potato produce in such households?

   b. Generally, who between youth and adults grow potatoes in this area? Who makes decisions on the quantity and the use of potato produce in such households?

2. a. What challenges in potato production are rampant in this area? (Probe if possible – Challenges related to production, credit access, marketing, post-harvest management...)

   b. Which of these challenges are caused by lack of adequate information?

3. a. Name some of the information needs in potato production in this area. (Probe where possible)

   b. What are some of the reliable sources of information used in potato production? (Extension agent, community leader, NGO, ICT, friends, family…)

   c. Please rank the mentioned sources in order of preference.

   d. What information is available about potato production in this area?

4. a. Which ICT tools or platforms are we aware of as sources of information in potato production? (Probe if possible)

   b. Which of the above are used in this area? (Probe if possible)

   c. What are some of the traits/ characteristics that have attracted us to using these platforms?

d. In your opinion, who uses these platforms more between men and women, youth and adults?

e. What information is provided by these platforms? (Probe if possible)

f. What other information would you suggest to be included on the platforms?

5. What are the benefits and challenges of using these sources of information? In each specify for men, women and the youth.

6. In your opinion, are these platforms:

a. Reliability

b. Timely

c. Relevance

d. Affordability

Appendix C: Household Survey Questionnaire

GENDER DIFFERENCES IN AWARENESS, USE AND EFFECTS OF ICT PLATFORMS AMONG POTATO FARMERS IN I

Household Survey Questionnaire

October 2022

SECTION A: INTRODUCTION

My name is _____ from the University of Nairobi conducting a survey on gender use of ICT platforms in the potato value chain in Nakuru County. The main objective is to learn more about the disparities between men, women, and young potato farmers in terms of their knowledge, access, usage, benefits, and ability to obtain information services from various platforms. The results of this study will play a significant role in advising policymakers and the companies that supply these services on how to improve users' access to facilitate potato output and profitability. Your extremely confidential responses will only be used for educational purposes. This is a voluntary interview and will take an hour. Your consent for the interview is highly appreciated.

(1) Name of the respondent _____ (2) Date _____

(4) Sub-county _____ (5) Ward _____ (6) Village _____

SECTION B: DEMOGRAPHIC CHARACTERISTICS OF POTATO FARM MANAGER

(8) Who is in charge of potato production? _____ 1 – wife

2 – husband

3 – Children

4 – Joint (any combination of husband, wife, or children)

5 – other (specify)

(9) Kindly fill in the demographic characteristics of the one in charge of potato production below.

a. Relation of the potato producer to the household head.
b. Age and
c. Gender
d. Marital status
e. Years of education
f. Primary occupation
g. Household size

SECTION C: POTATO FARM CHARACTERISTICS

(10) Kindly fill the table below for farm characteristics.

Total land size under potato production (in acres)	**Tenure system** 1 – private 2 – public/ communal 3 – rented	**If owned, by whom?** 1 – household head 2 – wife 3 – husband 4 – joint (household head and spouse) 5 – Children (Son/ Daughter) 6 – other (specify)	**If rented, by whom?** 1 – household head 2 – wife 3 – husband 4 – joint (household head and spouse) 5 – Children (Son/ Daughter) 6 – other (specify)	**Rent value** (in KSH/year)

SECTION D: POTATO PRODUCTION AND SALES

(11) What is the selling price per unit of potato? Specify the units used. _____

(12) How many seasons do you plant in a year? _____

(13) Kindly fill the table below.

Average seasonal yield (specify the units)	**Years of experience in potato production**	**The main reason for growing potato** 1 – Food 2 – cash crop 3 – both	**Sources of planting materials** 1 – recycling 2 – neighborhood farmers 3 – agro-dealers 4 – other (specify)	**Are you producing under contract farming** 1 –YES 2 – NO	**if YES specify the name of the contracting institution or buyer**	**What are the services you get from the contract?** 1 – inputs (specify) 2 – market 3 – storage 4 – value addition 4 – information 6- Others (specify)

SECTION E: FERTILIZER USE IN POTATO PRODUCTION

(14) Do you use fertilizer in the production of potatoes? _____ (YES -1 or NO – 0)

(15) If NO, why? _____

(16) If YES, what type of fertilizer do you apply? _____

1 – Artificial manure, 2 – Organic manure, 3 – Others (specify)

(17) How much quantity do you use in a planting season? _____

(18) What is the price per unit of fertilizer? Specify the units used. _____

SECTION F: LABOR USE IN POTATO PRODUCTION

(19) What sources of labor do you use? _____

1 – Household Labor, 2 – Hired labor, 3 – Both

(20) If household labor, how many members participate in labor provision? _____

(21) If you use hired labor, is it 1 – permanent, 2 – casual labor, or 3 – both? _____

(22) If permanent, how much is the monthly wage? _____Ksh; how many permanent laborers do you have? _____

(23) If casual, how much wages are per man-day? _____Ksh, how many workers are hired in a day? ____; for how many days a season? _____days.

SECTION G: GROUP MEMBERSHIP

(24) Are you a member of any association or group dealing in agriculture? __ (YES -1 or NO – 0)

(25) If NO, why? _____

(26) If YES, what is the name of the association or group? _____

(27) How would you classify the above group you have mentioned? _____

1 – Local, 2 – Government, 3 – NGO, 4 – other (specify)

(28) For how long have you been a member? _____ (in years)

(29) Please mark in the table below the type of services offered from the association or group you have mentioned, and the ones you are receiving currently.

Services offered	**Services I am receiving and how I perceive them**				
	Service	**Affordability** 1 – affordable 2 – expensive	**Relevance** 1 – useful 2 – not useful	**Are the services timely** YES – 1 NO – 0 **If NO, why?**	**Are the services reliable** YES – 1 NO – 0 **If NO, why?**
1 – Training/ extension 2 – input provision 3 – marketing services 4 – Financial/ credit 5 – transportation 6 – value addition	1 – Training/ extension 2 – input provision 3 – marketing services 4 – Financial/ credit 5 – transportation 6 – value addition 7 – storage				

7 – storage 8 – other (specify)	8 – other (specify)				

SECTION H: MARKET INFORMATION AND ACCESS

(30) How far is the preferred market for selling potatoes? _____KM

(31) How much is the transport cost to the market? _____Ksh

(32) What mode of transport do you use for transporting potatoes to the market? _____

1 – Foot, 2 – Bicycle, 3 – Motorbike, 4 – vehicle, 5 – others (specify)

(33) What is the ease of accessing this market? _____

1 – Very accessible, 2 – difficult to access

(34) Fill the table below to capture the marketing channels and proportion of the produce that are sold via each channel.

Marketing channel	**The proportion of the output sold per harvesting season**
1 – farm gate 2 – brokers 3 – online markets 4 – farmer groups/ associations 5 – contract markets 6 – open-air market 7 – export market 8 – other (specify)	

SECTION I: HOUSEHOLD INCOME

(35) Fill the following table

Sources of income (mark all that are applicable)	**Proportion of income (indicate against the marked sources)** 1 – Below KSH. 10,000 2 – KSH. 10,000 – 20,000 3 – KSH. 20,000 – 30,000 4 – KSH. 20,000 – 40,000 5 – KSH. 40,000 – 50,000	**Who controls income sources (indicate against the marked sources)** 1 – household head 2 – wife 3 – husband 4 – joint (household head and spouse) 5 – Children (Son/ Daughter)

	5 – Above KSH. 50,000	6 – other (specify)
1 – potato farming 2 – other farming enterprises including livestock and fishing 3 – Business (non-agricultural) 4 – Salaried employment (non-farm e.g. civil servants) 5 – pensions 6 – remittances 7 – casual labor 8 – other (specify)		

SECTION J: ACCESS TO CREDIT

(36) Do you always apply for credit or loans for potato production? _____ (YES -1 or NO – 0)

(37) If NO, why? _____

(38) If YES specify the_____

(39) Did/ do you get the loans applied for? _____ (YES -1 or NO – 0)

(40) If **NO**, why? _____

(41) If YES, fill in the following table for further details on the loans

Which are the sources of credit you apply from? 1 – Family and friends 2 – Microfinance institutions – SACCOs 3 – Commercial banks 4 – Agricultural Finance Corporations (AFC) 5 – Mobile loans 6 – Farmer or youth groups 7 – Local money lender 8 – NGOs	**Who accesses the loan in the household?** 1 – household head 2 – wife 3 – husband 4 – joint (household head and spouse) 5 – Children (Son/ Daughter)	**Frequency of application** 1– monthly 2 – quarterly 3 – every 6 months 4 – yearly 5 – other (specify))	**Amount applied**	**Amount received**	**Proportion repaid**	**Credit terms**	**Perception on credit** **1– reliability** **2 – timely** **3 – cost**

9 – Government schemes – (UWEZO Fund, Youth and Women Enterprise Fund, CDFs) 10 – others (specify)	6 – other (specify)						

SECTION K: INFORMATION USE IN POTATO PRODUCTION

(42) What channels or sources of information do you use? _____ (mark all that are applicable) Mention the main one as well.

1 – Digital sources (ICT tools, platforms and social media)
2 – Extension officer
3 – Farmer groups
4 – Neighborhood sources
5 – Print media (newspapers)
6 – Other family members and friends
7 – Other (specify)

(43) What are some of the information needs you search for in potato production? _____ (mark all that are applicable)

1 – planting material
2 – Fertilizers
3 – pest and disease management
4 – weather/climate
5 – market prices and linkages
6 – value addition
7 – contracts farming on potato
8 – credit/ loans services
9 – land
10 – storage information
11 – postharvest management
12 – others (specify)

(44) Do you access extension services? _____ (YES -1 or NO – 0)

(45) If YES, how frequent?

1 – Weekly, 2 – monthly, 3 –yearly, 4 – others (specify)

(46) If NO, why? _____

(47) What is the mode of service delivery?

1 – Contact, 2 – virtual, 3 – others (specify)

SECTION L: ICT PLATFORM SERVICES IN POTATO PRODUCTION

(48) Which of these ICT platform service providers are you aware of? _____

1. Viazi Soko
2. DigiFarm
3. Mkulima Young
4. M-Farm
5. SokoShambani
6. KACE

7. Social Media (Google, Facebook, Instagram, Twitter pages)

8. Others (Specify)

(49) If NO, why? _____

(50) If YES, how did you learn about the platforms? _____ (specify for each platform mentioned)

(52) Do you use any of the platforms? _____ (YES -1 or NO – 0)

(53) If NO, why? _____

(54) If YES, fill the following table (Mark all applicable)

Platform used	**Information Services** 1 – planting materials/ seeds 2 – fertilizer/ e-subsidy 3 – Credit 4 – Contract information 5 – Pest and disease management 6 – Post-harvest management 7 – Weather/ climate information 8 – crop insurance 9 – Marketing information 10 – others (specify)	**Tools used to access information services?** 1 – mobile phone applications 2 – SMSs 3 – Website 4 – others (specify)	**Which gadgets do you use in accessing the information services?** 1 – Smartphone 2 – non-smartphone 3 – laptop/computer 4 – others (specify)	**For how long have you been using each of the platforms?**	**How many times a week do you use these platforms** (Mark all that apply) **If 0 times, why?** **What is the alternative frequency of use?**

(55) Fill the following table on the perception of the platform used

Platform used	**Ease of use and access** 1 – easy 2 – complicated **State why**	**Affordability** 1 – affordable 2 – expensive **Name some of the costs you incur**	**Relevance of the platform** 1 – useful 2 – not useful **State why**	**Are the services timely** YES -1 NO – 0 **If NO, why?**	**Are the services reliable?** YES – 1 NO – 0 **If NO, why?**

(56) Do you have access to the internet _____ (YES -1 or NO – 0)

(57) If YES, what sources of internet connections do you use? _____

(Example – Wi-Fi hotspots, mobile data bundles, cable internet, satellite…)

(58) Is the internet a challenge in using these platforms? _____ (YES -1 or NO – 0)

(59) Do you have access to electricity? _____ (YES -1 or NO – 0)

(60) Is electricity a challenge in using the mentioned platform services? _____ (YES -1 or NO – 0)

(61) List challenges that using the above-mentioned platforms has helped you solve.

Appendix D: VIF Values for Logit Model

Variables	**VIF (awareness)**
Years of education	6.09
Number of sources of information	4.92
Main source of information	1.86
Gender	2.21
Access to extension services	1.50
Group membership	1.43
Access to internet	2.37
Mean VIF	**2.91**

Appendix E: VIF Values for Heckpoisson Model

Variables	**VIF (use)**	**VIF (intensity of use)**
Years of education	7.40	5.00
Household size	8.29	6.31
Market distance	3.10	3.98
Years of farming experience	5.46	-
Household income	2.29	-
Potato output	-	4.26
Gender	2.57	2.99
Access to extension services	1.74	1.94
Group membership	1.60	1.78
Access to internet	-	5.30
Mean VIF	**4.06**	**3.94**

Appendix F: VIF Values for Endogenous Treatment Effect Model

Variables	**VIF (awareness)**
Platform use	2.37
Education	5.47
Household size	8.02
Land size	2.15
Market distance	3.14
Gender	2.62
Access to extension services	1.75
Group membership	1.60
Years of farming experience	2.80
Mean VIF	**4.73**