EFFECTS OF DIGITAL MARKETING TECHNOLOGIES ON MARKETING OF GREEN LEAFY VEGETABLES AMONG SMALLHOLDER FARMERS IN LARI SUB-COUNTY, KENYA

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DECLARATION AND RECOMMENDATION

Declaration:

I declare that this research thesis is my original work and has not been presented in this university or any other for any award of any degree in any other University.

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DEDICATION

This thesis is dedicated to my dearest parents, my siblings, and my friends for their everyday prayers and support.

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ABSTRACT

Vegetable farming is one of the growing sub-sectors in Kenya, contributing significantly to the country's agricultural growth and development. Green leafy vegetables like spinach, cabbage, and kale are widely produced and intensively commercialized in Lari sub-county. However, farmers do not have direct access to lucrative markets thereby selling their vegetables through the middlemen at relatively low prices with minimal returns. Numerous studies have shown that digital marketing technologies including social media, mobile phones, and internet search engines are essential tools in agriculture that improve farmers' access to timely and relevant market information and facilitate their participation in lucrative marketplaces. Nevertheless, there is low utilization rate of digital marketing technologies in Lari sub-county, despite the rise of such technologies in the area. Therefore, this study focuses on the effects of digital marketing technologies on the marketing of green leafy vegetables among smallholder farmers in Lari sub-county. The study's specific objectives were to: identify the digital marketing technologies utilized by smallholder farmers; determine the factors influencing the use of digital marketing technologies in marketing green leafy vegetables; determine the effect of digital marketing technology use on the farmers income. A survey research design was used, and multistage sampling procedure was used to select 374 green leafy vegetable farmers in Lari sub-county. Semi-structured questionnaire was employed to collect qualitative and quantitative data. The determinants of digital marketing technology use were estimated using multivariate probit model and the effect of digital marketing technology on farmers income was estimated using the multinomial switching regression model. The results were analyzed using Statistical Package for Social Sciences (SPSS) version 29 and Statistics and Data Analysis (STATA) version 17. Mobile phone was the mostly used tool, with SMS being utilized the majority of farmers. The results of the study showed that education level, access to extension services, electricity installation positively influenced the use of mobile phone, social media, and internet search engines in marketing of green leafy vegetables. The results showed that farmers who used one or two tools realized high income, positive and significant average treatment effect. The results show the need for targeted educational initiatives that focus on digital literacy for smallholder farmers. Expand and enhance agricultural extension services to include training on digital marketing tools.

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LIST OF ABBREVIATIONS AND ACRONYMS

ADP	Annual Development Plan
ATT	Average Treatment Effect on the Treated.
ATU	Average Treatment Effect on the Untreated
CIDP	County Integrated Development Plan
IMRS	Inverse Mill's Ratio
MESR	Multinomial Endogenous Switching Regression
MNLS	Multinomial Logit Selection
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GLV	Green Leafy Vegetables
ICT	Information Communication Technology
KARI	Kenya Agricultural Research Institute
KNBS	Kenya National Bureau of Statistics
MVP	Multivariate Probit Model
NAHF	National Animal Health Forum
OLS	Ordinary Least Squares
NGO	Non-governmental Organization
SPSS	Statistical Package for Social Sciences
STATA	Statistics and Data Analysis
UN	United Nations

CHAPTER ONE
INTRODUCTION

1.1 Background of the study

Agriculture contributes significantly to developing countries' economic growth (Diallo *et al*., 2020; Islam, 2016). The agricultural sector plays an important role in employment creation and improving the living standards of people (Ministry of Agriculture Livestock and Fisheries, 2017). In Kenya, the agriculture sector accounts for around 33% of the Gross Domestic Product (GDP) and another 27% indirectly through links with other sectors, with the majority of exports from the horticulture sub-sector (FAO, 2022). Consequently, the development of horticulture remains a key to the country's economy. However, the horticulture sub-sector is mainly dominated by smallholder farmers who rely on agriculture for most of their income. Most of these smallholder farmers are resource constrained and produce mainly to meet household subsistence needs.

Kenya's horticulture is the fastest-growing sub-sector comprised of flowers, vegetables, and fruits, with cut flowers accounting for 70.3%, vegetables 18.1%, and fruits 11.7% of the total horticulture export earnings (KNBS, 2022). Kiambu County is one of the counties where horticultural farming is growing and extensively practiced. The sub-sector plays an important role in the county's economic growth (County Government of Kiambu, 2016). The rising nutritional value and health awareness of people, particularly for vegetables, is driving the sub-sector's expansion. On the other hand, most smallholder farmers grow vegetables because of their quick maturity and high earnings within a short time. Due to their higher earning potential, they present an alternative for farmers with too small land to provide enough income from field crops (Mhango *et al.,* 2014). Hence, the level of production of fresh vegetables is increasing and there is still enormous unutilized potential in the county.

Major vegetables produced in Kiambu include French beans, snow peas, kales, cabbage, garden peas, tomatoes, spinach, and carrots among others. The production of exotic vegetables increased from 4,145,900 tonnes to 4,404,171 tonnes representing a 4.0 % and 6.2 % increase respectively (Amare *et al.,* 2023). Among these exotic vegetables, spinach, kale, and, cabbage are highly grown and commercialized by the majority of smallholder farmers in Lari Sub-County. Vegetable production is largely favored by the large amounts of rainfall received throughout the year and the continuous cold seasons. However, horticultural crops are highly perishable (Pokhrel, 2021; Tadesse & Bahiigwa, 2015).

It is risky to handle large quantities of vegetables at the open market particularly because farmers do not have cooling facilities to store what is not sold. In places where cold storage is available, the cost of storage is beyond the affordability of small farmers (Rabbi *et. al.,* 2020). Therefore, most of the farmers decide to dispose of the surplus farm produce quickly. Moreover, the majority of the farmers are constrained by a lack of access to information about potential markets and price of the farm produce, and lack of marketing skills among others (Rabbi *et. al.,* 2020). Consequently, they are unable to market their farm produce directly even though there is a ready urban market in Kiambu, Nakuru, Nairobi, and Mombasa (County Government of Kiambu, 2016).

Farmers, therefore, are dependent on local traders, middlemen, and contractors for the marketing of their vegetables. The market intermediaries purchase farmers' produce at a lower price than the market price. Agricultural supply chains are often dominated by various intermediaries with substantial market power (Deichman *et al.,* 2016). Information asymmetry between buyers and sellers resulting in exploitative behavior on the part of the buyer. According to Deichman *et al.* (2016) the lack of market information and misinterpretation of second-hand pricing information has serious consequences for agricultural producers. Farmers may end up underselling their products, delivering too little or too much, or having their products wither away (Man & Zain, 2014).

Middlemen have a negative impact on income and commercialization by taking advantage of farmers' lack of information and market access (Abebe *et al.,* 2016). Therefore, access to adequate market information is crucial for smallholder green leafy vegetable farmers. The use of digital technologies would be helpful in the sub-sector, with accruing benefits to both farmers and consumers (Jerome, 2017). Obtaining information regarding market prices, weather predictions, transportation, storage facilities, crop and livestock diseases, and general agricultural guidance is all made possible by digital technology (Kirui *et al.,* 2012).

This study therefore, focuses on smallholder green leafy vegetable (spinach, kale, and cabbage) farmers who use different digital technologies (mobile phones, social media, and the Internet) to market their vegetables and access market information, in the Lari Sub-County. Mobile phones and social media are the most used digital technologies by smallholder farmers due to their versatility and easiness to use, portable nature, and relatively affordable (Jain *et al.,* 2015).

Kenya has emerged as a frontrunner in information and communication technologies (ICT) in Sub-Saharan Africa (Baumüller, 2012). The government has been actively supporting the ICT sector as one of the key drivers of economic growth. Feature phones and smartphones are being used by the majority of farmers in Kenya. Kenya's agricultural sector has been experiencing a rise in mobile farming applications that seek to solve common problems encountered by farmers. These mobile farming applications have helped in reducing information gaps facing farmers, such as variations in market prices and conditions, new farming technologies, fluctuations in weather patterns, and knowledge on where to buy farm inputs (Kadenyi, 2017).

Farmers in Kenya acquire production and market information from social media sites such as Mkulima Young, Digital Farmers Kenya, and Mkulima Hub Kenya (Kipkurgat *et al.*, 2016). Farmers can develop information and interact with one another via social media platforms (Akashraj & Pushpa, 2014). Facebook, LinkedIn, Twitter, Instagram, and WhatsApp are a few examples of such social media platforms. In addition, most agricultural institutions in Kenya have incorporated social media as part of their information systems. The Kenya Agricultural and Livestock Research Organization (KALRO) and the Agricultural Information Resource Center (AIRC) for example use, Twitter, YouTube, and Facebook platforms as well as blogs to gather information (Kimani *et al.*, 2019).

Kiambu County has 98% mobile network coverage owing to its location and proximity to Nairobi City (Kiambu CIDP, 2017). There are quite a number of cyber cafes offering internet access hence easy access to communication. This has been possible due to the introduction of fibre optic cables in the county. In the Lari sub-county, the majority of farmers own mobile phones (Sang, 2020). Additionally, over 70% of Agribusinesses in Kiambu County, including the horticulture sector use ICT such as the Internet for marketing, SMS services, mobile application services, internet for information awareness, telephone communication, radio broadcasting, and TV broadcasting (Warwimbo, 2017). Despite this, the majority of green leafy vegetable farmers have not taken advantage of these marketing technologies yet they continue to have limited access to lucrative markets and valuable market information.

The internet, mobile phones, and other technologies that promote the collection and sharing of information are transforming many aspects of life for a big and growing portion of the world's population. The Internet search engines like YouTube have evolved into a powerful interface that

serves as an access point to all types of information, as well as an important marketing channel through which businesses can reach out to and convince potential customers (Xiang *et al.,* 2008).

Digital marketing technologies can reduce persistent information asymmetries caused by reliance on market intermediaries (Deichman *et al.,* 2016). Agriculture can benefit from major innovations including logistics platforms that better link buyers and sellers along the agricultural production chain. Short messaging service (SMS) or "texting" is the most used technology because even poor farmers now tend to have access to feature phones, but about a quarter of projects now employ internet tools. The application of digital technology may support efficient agricultural markets, which would result in higher earnings and thereby support rural development. Therefore, the purpose of this study is to investigate the variables that affect the use of mobile phones, social media, and the internet as well as the effect of this usage on the marketing of green leafy vegetables.

1.2 Statement of the problem

Vegetable farming is one of the growing sub-sectors in Kenya. It is attractive to smallholder farmers in Lari sub-County due to quick maturity and high returns. However, farmers get insufficient returns from their vegetables because they do not have access to adequate information about market, hence they sell their vegetables through the middlemen at relatively low prices. Digital marketing technologies like mobile phones, social media, and the Internet search engines are being utilized all over the world. These could be used as tools for providing market information to the farmers and linking them to high-end markets. However, these digital marketing technologies have not been fully integrated in Lari sub-county. They are available and accessible but farmers have not taken full advantage, thus losing out on potential benefits. Therefore, the study seeks to understand the types of digital marketing technologies used by smallholder green leafy vegetable farmers, the factors influencing the usage of digital marketing technologies in marketing the green leafy vegetables, and to determine how digital technologies; mobile phone, social media, and the Internet search engines affect the income of the green leafy vegetable farmers in Lari sub-county.

1.3 Objectives

1.3.1 General objective

To contribute to improved income of smallholder green leafy vegetable farmers through the use of digital marketing technologies in Lari sub-county, Kenya.

1.3.2 Specific objectives

i. To identify the digital marketing technologies utilized by smallholder green leafy vegetable farmers in Lari sub-County.

ii. To determine the factors that influence the use of digital marketing technologies in the marketing of green leafy vegetables in Lari sub-County.

iii. To determine the effect of digital marketing technologies on the income of smallholder green leafy vegetable farmers in Lari sub-County.

1.4 Research questions

i. What are the digital marketing technologies utilized by smallholder green leafy vegetable farmers in Lari sub-County?

ii. What are the factors influencing the use of digital marketing technologies in the marketing of green leafy vegetables in Lari sub-County?

iii. What is the effect of digital marketing technologies on the income of the smallholder green leafy vegetable farmers in Lari sub-County?

1.5 Justification of the study

Digital marketing technology usage may empower farmers to better understand their costs, make better decisions, and facilitate the exchange of agricultural information. Furthermore, digital marketing technologies will enable farmers to avoid middlemen who may deny them to enjoy their full profits as the network will enable them to identify markets for their produce. Consequently, the application of digital marketing technology may support efficient

agricultural markets, which would result in higher earnings. This study will provide the required knowledge for enhancing the sector's competitiveness and enabling it to fulfill the expectations of the government. The study's results will also assist smallholder farmers in making an informed choice regarding the digital technologies they will employ. This might lead to an increase in the adoption and use of digital technologies by growers of green leafy vegetables, enhancing on-farm employment opportunities and raising incomes.

The study may be important to policy makers and the government since it will be utilized as a strategic approach to alter the marketing of green leafy vegetables in the country and can be adopted by other developing countries in the African continent. It will be useful to researchers, scholars and organizations who are interested in understanding the efficiency of digital technologies as tools for market access. The study will further contribute in achieving the Kiambu CIDP 2018-2022 which aims to improve the standard of living and welfare of the farmers. The study will contribute to the five pillars of The Kenya National Digital Masterplan 2022-2032. It will contribute to eradicating hunger goal of Bottom-Up Economic Transformation Agenda 2022-2027, and Sustainable Development Goals (SDGs) 1 (no poverty) and 2 (no hunger).

1.6 Scope and Limitations of the Study

The study only targeted smallholder farmers of green leafy vegetables, who grow cabbage, spinach, and kale for sale in Lari Sub-county. It included smallholder green leafy vegetable farmers who use either mobile phones, social medial, and internet search engines to market and access market information. The primary and secondary data was used to accomplish the objectives of the research. It only concentrated on the marketing of green leafy vegetable farming in relation to digital technologies. Structured questionnaire was used to gather information on the different types of digital marketing tools used, the factors influencing the use of digital marketing technologies, and the effect of digital marketing technologies on farmers' income. The research study was constrained by the participants' lack of cooperation, since some of the respondents did open up to the questions. Therefore, researcher used Key Informants who provided information about farmers and the researcher had an ethical permit beforehand. The study was also limited by the language barrier, hence there was an interpreter.

1.7 Definition of terms

Digital marketing technologies – These are tools used to promote green leafy vegetables through online platforms. These technologies leverage digital platforms such as Mobile phones applications, social media, and the internet search engines to engage with potential customers.

Mobile phone – a digital tool that green leafy vegetable farmers use to promote their vegetables to the customers. Smallholder farmers can reach customers directly through SMS, mobile apps, and phone calls.

Social media – refer to platforms that smallholder green leafy vegetable farmers use to promote their vegetables by engaging with audience on social networks such as Facebook, WhatsApp, Twitter, and TikTok.

Internet search engines – they are platforms that smallholder green leafy vegetable farmers use to promote their vegetables by increasing visibility in search engines. Internet search engines leverage platforms such as YouTube, Yahoo, Google.

Market – any place where buyers and sellers meet to exchange any type of green leafy vegetables (spinach, cabbage, or kales), services, and information.

Smallholder green leafy vegetable farmers – these are farmers who cultivate their vegetables on small piece of land, less than ten acres.

Green leafy vegetables – are vegetables with edible leaves. They can also be called greens or leafy greens. A person can eat some leafy greens raw, while others may require cooking. As the name implies, people can typically identify these vegetables by their green color and edible leaves. Examples of green leafy vegetables are; spinach, cabbage, and kale.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The main objective of this study determines the effect of digital technologies on the performance of green leafy vegetable farming in the Lari sub-County. This chapter will review the literature which guides the study. The first section will review digital technologies in agriculture. The second section will provide literature on the levels of awareness of digital technologies among smallholder farmers in Kenya. The third section will provide literature on the use of digital technologies in marketing agricultural produce. The fourth section will review factors influencing the use of digital technologies among smallholder farmers. The fifth section will review the effect of the choice of digital technology on the income of smallholder farmers. The last section will provide the theoretical and conceptual frameworks of the study.

2.2 Digital marketing technology usage in agriculture

Digital marketing technology interventions can lead to positive economic outcomes such as reducing costs as well as increasing productivity and profitability. Mobile phones, tablets, and other present technologies have occupied marketplaces in both developed and developing nations over the past ten years (Cranston & Painting, 2010). As a result, agriculture is becoming increasingly information-intensive, and sharing this knowledge may be challenging because it needs to be adjusted for local circumstances (NAHF, 2017). Digital marketing technologies can help agriculture have better access to commercial markets by improving information availability and removing geographical barriers by connecting farmers and buyers (Krone & Dannenberg, 2018). Mobile phones, social media, and the internet are examples of digital technology that might be useful in agriculture, particularly for smallholder farmers. Digital innovations empower women and young farmers through better access to information about how to improve agricultural production and connect them to finance opportunities and markets (Bayer, 2018).

Information and communication technologies (ICTs), including mobile phones, are hailed as digital platforms with the potential to reach a large number of farmers simultaneously throughout rural settings (Santosham & Lindsey, 2015; World Bank Group, 2018). Nowadays, mobile phones are a must to transfer technologies, and the pace of dispersion seems to be accelerating. Agriculturalists can control risk and lessen vulnerabilities to a changing climate by

having access to information via mobile phones and mobile internet (Baumüller, 2013). Since more people are using mobile phones, they can sign up to receive "m-services," or mobile phone-enabled services, to access market and agrometeorological information (Baumüller, 2013; Wyche & Steinfield, 2016).

According to Baumüller (2018), m-services can be used to link buyers and sellers, communicate general information on farming and livestock (such as market information on prices), and provide alerts about pest and disease threats. By reducing market information asymmetries, increasing demand for fast and accurate technical information, and enhancing links between actors in agricultural value chains through messaging, mobile phones and the internet have the potential to help raise productivity in the rural sector (Deichmann *et al*., 2016). Additionally, the advantages of social media transcend beyond low-cost methods of communication to promote strong social ties and ongoing participation in extension programs (O'Neill *et al*., 2011). Social media has the ability to improve the search for the dissemination and sharing of innovative technologies in Africa where access to agricultural outputs produced by public research institutions is a problem (Chisenga *et al.,* 2014). A variety of social media innovations have been created in Kenya with the goal of increasing agricultural output, including Mkulima Young, Digital Farmers Kenya, Young Farmers Market, and Mkulima Hub (Kipkurgat *et al.,* 2016).

On the same note, social media offers farmers the chance to collaborate on content creation and encourages farmer-to-farmer learning (Jackson *et al*., 2009). Further, creating content for social media is quicker than for traditional mass media channels of communication (Fuess, 2011). According to Moyo *et al*. (2021) it may be argued that the public's increased awareness of the health benefits of natural foods and green leafy vegetables is the reason for the increasing demand for the product. Due to the ease of access to farmers and suppliers through social media platforms, it is simple for them to choose the specific type green vegetable they require and place an order.

Smallholder farmers heavily rely on the Internet as a source of information, which has a considerable impact on their behavior and mental processes. The first advantage of using the Internet for farming is that it can make it easier and less expensive for farmers to find technical knowledge. Internet use, according to Genius (2006) also changes farmers' perspectives on production technology and aids in their understanding of the risk-benefit factors of agricultural technology. The availability of the Internet, on the other hand, can provide smallholder farmers more negotiating power, expand the market for agricultural goods, and increase the efficiency of

agricultural production, all of which can encourage farmers to use new technologies (Aker & Ksoll 2016; Donovan 2017). This agrees with Malabo Montpellier Panel (2019) by making it easier for farmers to obtain price and marketing information, digital solutions have the ability to increase their negotiating power and lower their risk of selling their produce at low prices.

According to Feizollahi *et al.* (2014) internet technology also serves as a foundation for the growth of electronic marketing, particularly in developed countries. For the majority of enterprises, it serves as the medium for distribution, organization, and communication. Additionally, using the Internet can enhance smallholder farmers' human capital skills, management, and learning capacity, as well as their income (Gao, 2018; Leng *et al.,* 2020). According to Mtibe *et al*. (2021) one of the initial advantages of digital technologies is that they raise consumer awareness of the availability of goods on the market. This means that potential customers learn about the product's availability in the market and, should they need to make a purchase, can do so, they will only need to initiate the buying process (Okello *et al*., 2015).

According to Stugeon (2017) the “New Digital Economy" opens up possibilities for digitally driven solutions to several issues pertaining to agricultural development. Digital technologies also improve small-scale farmers' access to the agricultural value chain (FAO, 2015) and they advance knowledge by using creative delivery methods for extension services (Deichmann *et al*., 2016). Digital platforms allow for the sharing of production techniques, which may subsequently be used across the nation and alter the sector as a whole (Juswadi *et al.*, 2019). Additionally, the nature of communication is changing as a result of digital technology like internet apps and mobile phones (Boateng *et al.,* 2017). Access to the Internet can provide smallholder farmers more negotiating power, broaden the market for agricultural products, and boost agricultural production efficiency, all of which can motivate farmers to adopt new technology (Aker & Ksoll, 2016; Donovan, 2017). However, the potential of these digital marketing technologies to disseminate agricultural information and market information has not been fully exploited.

2.3 Awareness levels of digital marketing technologies among smallholder farmers

For agriculture to thrive sustainably in the twenty-first century, it is essential to use the right instruments for information dissemination (Ashraf *et al.,* 2018; Kumar & Karthikeyan, 2019). Technology adoption in agriculture, according to Mwangi and Kariuki (2015), is the mental

process that a smallholder farmer goes through from hearing about a technology to actually using it. For technology to be adopted, the technology needs to be accessible to smallholder farmers (Andrade *et al.,* 2019). Illiteracy among rural farmers has been demonstrated to be a major barrier to their usage of digital technology like smartphones and mobile phones. The majority of these farmers lack the skills and information necessary to operate their touch screens and input numbers. In contrast, farmers tend to use digital technology less frequently, which is linked to a lack of awareness (Rhoades & Aue, 2010). In the study that was conducted by Sebastian and Jayalekshmi (2018), it was observed that all the respondents were aware of tools like mobile phones, and social media which were the popular digital tools at the time of the investigation. On the same hand, the results are supported by the findings of (Khidir *et al.,* 2019 & Kumar, 2018).

A high level of awareness was also found for the internet (96.67%), email (85%), search engines (80.83 %), and e-newspapers (75.83%). The results mainly show that farmers were mostly aware of the tools that were most commonly used by everyone. According to Jain *et al.* (2015) mobile phones and social media were mostly preferred by farmers which may be due to their versatility and easiness to use, portable nature, and relativity affordable. The unawareness of some tools may be due to a lack of popularity and lack of accessibility of these tools. Farmers were found to be bound to simple and easy technologies like mobile phones. On Harry and Stanley (2022) study, the results indicated that farmers were aware of mobile phones and that are used to source for improved farming practices and help to get agricultural information that will increase productivity or yield. On the other hand, the study results by Thuo (2018) revealed that despite respondents having access to smartphones with mobile applications, some of them were not aware of how they could use them to access agricultural information.

Many farmers lack awareness of the full range of internet uses and content available and consequently do not feel the internet is relevant or useful to them. The results of the study conducted by Ahmad *et al*. (2021) indicated that not all farmers are aware of agricultural applications that can be downloaded and installed through the Google Play Store and not all farmers who are aware of farming applications install it on their smartphones. However, the results also showed that 75 farmers who participated in the study had used smartphones and were connected to the WhatsApp (WA) application.

On the other hand, Edeoghon and Esene (2018) found that respondents are aware of Facebook (88.3%), Google (78.3%), WhatsApp (74.2%), YouTube (74%), and BBM (60%). This implies that the respondents are very conversant with these particular forms of social media. Umunakwe *et al*. (2018) confirm the high usage of Facebook and WhatsApp in agriculture by indicating that the most dominantly used social media platforms in agriculture are Facebook, WhatsApp, and Twitter with Facebook being the most used, followed by WhatsApp and Twitter being the least of the two. This confirms that farmers are aware of social media platforms. However, it is not clear if farmers utilize these technologies in their agribusinesses to access different types of information like prices of the products in the market.

Brown *et al.* (2019) found that smallholder farmers are more likely to embrace accessible technologies. Furthermore, Ochieng *et al.* (2019) discovered that smallholder farmers adopted technology that they were aware or knowledgeable. Yet, Abdul-Hanan (2017) observed that just awareness of technology may not result in its adoption. As a result, it is critical for smallholder farmers to understand the technology, its applications, and its advantages in order to increase adoption. As a result, smallholder farmers must be instructed in how to utilize and, in some cases, maintain these new technologies for long-term adoption (Krah *et al.,* 2019). Smallholder farmers were found to embrace technologies they regard as useful, compatible with their requirements, and easily adaptable to their farm after becoming aware of it (Okello *et al.*, 2019).

2.4 The use of digital technologies in marketing agricultural produce

Today, digitization plays a bigger role in the marketing of agricultural products than it does in many other economic sectors (Jairath & Yadaw, 2021). Information technologies are developing faster in the agricultural marketing sector as a result of the use of digital platforms in all industries, which significantly boosts productivity. Over time, there has been a growth in the use of ICT in agriculture. According to Hooker (2020), there has been a major increase in the number of agribusinesses searching for the Internet as a tool for coordination, marketing, management, and services. E-marketing, sometimes referred to as Internet, Web, digital, or online marketing, is the term for marketing strategies and tactics that leverage online channels to connect with target consumers, obtain relevant information, and deliver the necessary products. Digital technologies are used throughout the entire process.

The study by Jiang Zhao (2019) confirms that using digital technologies to market agricultural products is beneficial because they help create targeted product positioning, which in turn helps create product differentiation. Since it has increased agricultural competitiveness and broadened the global market for agricultural products, the emergence of e-commerce, a new transaction mode founded on technical innovation, is forming a powerful force that encourages the transformation of the entire agricultural sector. Expanding the market will be aided by the digitalization of agriculture marketing.

Farmers can approach a global market with a greater number of prospective clients by using the Internet. A free and easy flow of information will undoubtedly increase awareness, which will make the hassle-free and easy transaction of agricultural output possible (Jiang Zhao, 2019). The development of this market is being helped by the availability of knowledge on various aspects of agriculture and its marketing, which has been made possible by the spread of the Internet in rural areas. Due to the availability of the internet, this market is open all the time, allowing farmers—who are by far the most significant stakeholders—to access it whenever it is most convenient for them. This has increased the market's size.

Farmers can sell their goods via websites, online marketplaces, and mobile applications. Marketing products through mobile apps is much more affordable when using mobile services. Farmers and consumers have instant access to market updates. Direct product delivery from farmers is possible owing to market updates (Nezamova & Olentsova, 2020). When using digital marketing in agriculture, intermediaries are not needed. Poor farmers have been observed to be more inclined to participate in the market and diversify into high-value crops when they use mobile phones. Mobile devices offer an efficient means of disseminating market prices, news, inputs, and advice particular to agriculture. Farmers are already receiving information from a number of private sector initiatives with success on a regular basis. A little over 20% of farmers have been able to improve the quality of their market trips, which has increased market participation (Deichmann, 2016). In addition, price tracking encouraged growers and producers to select the marketable crop in order to benefit from a higher price, which raised their profitability.

2.5 Factors influencing the use of digital marketing technologies in agriculture

The use of digital marketing technologies by smallholder farmers in Africa is influenced by a variety of factors (Jha *et al.*, 2019; Tey *et al*., 2017). This is because smallholder farmers need to learn the application of new technologies and processes, as well as how to integrate these new technologies and processes into existing systems (Salami *et al*., 2010). These factors can be classified into categories, (i) farmers' characteristics; (ii) farm characteristics; (iii) technology characteristics; (iv) institutional factors; and (v) finance. These factors have direct and indirect relationships and influence the use of digital marketing technologies either positively or negatively. Several studies on technology adoption in Africa have attempted to explain the characteristics of individual smallholder farmers that affect the use of technology. These include the farmer's age, gender, education, marital status, household size, off-farm income, farming experience, group membership, attitude, culture, and religion (Makate *et al*., 2018; Mutenje *et al.*, 2019; Okello *et al.*, 2019; Oyinbo *et al*., 2019; Vidogbéna *et al*., 2016).

The study conducted by Elvira *et al.* (2020) on Internet literacy, revealed that the age of farmers negatively influenced farmers' internet literacy, illustrating that the increasing age of farmers led to a lower rate of internet literacy. The results of field observation showed that younger farmer was more aware of internet use as a source of information. Conversely, the age coefficient was negative and significant in the study conducted by Anthony *et al.* (2020) on the impact of internet use on income. This implies that relative to younger household heads, the older ones were 11.7% less likely to use the internet. A finding that confirms with the study of Ma *et al.* (2018) where the authors argued that young people preferred to possess smartphones compared to older people.

In addition to that, Okello (2017) stated that young farmers tend to be innovative and risk-takers and thus would try technologies more than older household heads. Suchiradipta and Saravanann (2016) observed that while there was a growing number of young people using social media platforms the older generation's online presence is still low. Also, Okello (2017) observed that age of the key decision maker had a negative effect on mobile phone and television usage with an additional age reducing their usage by 2.8% and 2.7% respectively. These results show that an additional year to the age of the household head is associated with less probability of that household to use mobile phones and television as sources of agricultural information. According to Bolarinwa (2015) the reason could be that older adopters of technology are usually slower at

learning particularly if technology is relatively new. Further, Wesseler *et al*. (2017) stated that older smallholder farmers adopt new technologies under the influence of other factors such as the relative cost of the technology, perceived ease of use, and perceived advantage of the use of the new technology. Kinyangi (2014) observed that smallholder farmers are slow to embrace new technology, in some cases, they tend to avoid new technology. Therefore, this reveals that the level of smallholder utilization of digital technologies is not yet up to satisfactory standards.

Moreover, gender is an important variable in adoption of innovations. When it comes to choosing which technology to use, the preferences of men and women differ. Mudhara *et al*. (2003) and Murage *et al.* (2015) observed that male farmers adopt technology faster than female farmers. Men can easily access and use technology as compared to women. This is also in agreement with Odendo *et al*. (2009) who stated that male headed households, have higher access to productive resources and information that increases the chances of using new technologies.

Education of the respondent on the other hand is another key factor in the acceptance and use of technologies (Tang & Wu, 2015). From the reviewed articles, it was identified that the education level of smallholder farmers in Africa had a positive influence on their rate of technology adoption (Oyinbo *et al.,* 2019). Smallholder farmers who were considered educated - with some form of formal or informal education adopt new technologies faster than uneducated smallholder farmers (Chirwa, 2005; Kassie *et al*., 2015). The study collaborates the findings of Okello (2017) who found that in comparison to sub-optimal users of ICT tools, the household head's education level was noticeably higher for optimal users of ICT tools. They might be better able to comprehend the value of utilizing modern farm technologies as a result. The level of education has an impact on a farmer's ability to understand information from any digital source. On the same hand, Nenna (2014) observed that the higher the years of education, the knowledgeable the farmer will be in the technicalities involved in the use of mobile phones. The results conform to Aldosari *et al.* (2017) findings. Furthermore, Chirwa (2005) and Kassie *et al*. (2015) observed that smallholder farmers who were regarded as educated having had formal or informal education adopted new technologies more quickly than those who were not educated.

Mwombe *et al.* (2014) found that an increase in farm size leads to an increase in the intensity of ICT tools usage as a source of agricultural information for smallholder farmers. Fisher and Carr (2015) stated that the size of the farm can influence the decision of the household head to adopt new agricultural technologies. Apart from farm size, income is an important resource in

agriculture because the higher the income of the farmer, the more likely he would seek and obtain information for use. Mudhara *et al*. (2003) and Ojiem *et al.* (2006) found that off-farm income has a positive impact on the adoption of modern technologies by smallholder farmers. This is due to the fact that off-farm revenue frequently provides smallholder farmers with an alternative to overcome financial obstacles, which may be used to adopt new technology. The study of Anthony *et al.* (2020) revealed that the coefficient of the off-farm job was positive and significant, indicating that households with an off-farm job tended to use the internet more than their counterparts. Off-farm income helped farmers afford new technologies (e.g., the purchase of smartphones, which may enhance their internet use). This finding is consistent with Ma *et al.* (2018) where researchers revealed that off-farm income enabled farmers to purchase smartphones.

Additionally, the experience of the farmer is one of the important factors that affect the use of digital technologies. Another key element of technology adoption revealed in the studies under consideration was the smallholder farmer's years of agricultural expertise. The more experience a smallholder farmer has farming or growing a particular crop, the more conscious they are of the necessity for technology and the extent to which it should be used (Matata *et al.*, 2010).

2.6 The effects of the digital marketing technologies on the income of smallholder farmers

Constraints in agricultural sector have been a major cause of the loss of revenues to the smallholder farmers in many developing countries, but with increasing globalization and revolution in the advancement of digital technologies such as telephone, and wireless mobile, smartphones, social media, and internet technology have been found to influence agriculture productivity and farmers' and household incomes. Technology as a tool for doing business is adopted in businesses with the goal of maximizing profits and increasing output. Hence, when used in the production of the green leafy vegetable industry, it is expected that there should be an increase in the earnings for farmers both in the short-term and in the long term. The use of mobile phones for agricultural applications can give positive results if farmers have experience in using other mobile applications such as social networking applications, mobile banking, and remittance applications and weather information (Chhachhar & Hassan, 2013).

Van Dijk *et al*. (2022) stated that in Kenya, telephone farmers have emerged which is technically farming and managing the supply chain through smartphones. Such individuals are aware of the sophisticated transport system from the farmers to the market, and their willingness to market their commodities through digital platforms makes it easy for them to enjoy profits

(Njenga *et al.,* 2011). Additionally, some digital technologies such as mobile phones have been found to help reduce marketing costs and increase the productivity of certain agricultural crops (Jehan *et al.,* 2014). Odhiambo *et al.* (2021) noted that smallholders are likely to have their incomes increase consistently if they maintain open communication and contact with the market, through digitized channels. This could be done with the presence or absence of intermediaries. However, little has been done on how the digital technologies affect the income of smallholder farmers.

Anthony *et al.* (2020) findings implied that off-farm income and jobs can be secured through internet use or social media, and therefore, served as incentives to internet users. Market information is easy and convenient to acquire through internet use. This, in turn affects farm productivity and other off-farm generating activities, hence income. This finding that internet use, farm income, and household income have a positive relationship provides evidence supporting the researchers in (Ma *et al.,* 2018) who revealed that the use of smartphones helps rural households to increase both the farm and household income. On the same hand, Khanal and Mishra (2016) found that internet usage will increase the financial performance of small farm business households in the USA. In addition, the internet promotes economic growth in rural areas (Whitacre *et al.,* 2014) and increases rural household income (Gao *et al*., 2018; Ma *et al*., 2020). However, the potential of these digital tools to disseminate marketing information and increasing the household income has not been fully exploited.

2.7 Theoretical Framework

The framework for any research is to include the belief about reality (ontology), the knowledge that exists and use in our research (epistemology), and the data gathered, analyzed, and processed to create new knowledge (Tuli, 2005). This study was guided by the Technology Acceptance Model (TAM).

Technology Acceptance Model

Technology Acceptance Model (TAM; Davis, 1989) has been one of the most influential models of technology acceptance, and it is an information-systems theory that explains how to encourage users to accept and utilize new technology. The TAM suggests that perceived usefulness (PU) and perceived ease of use (PEOU) are the two most important factors in explaining individual users' adoption intention. PU is defined as the degree to which a person believes that using a

particular system will enhance his or her job performance, PEOU refers to the degree to which the person believes that using the system will be free of effort.

Perceived Usefulness (PU) refers to how smallholder farmers believe that using digital marketing technologies will enhance their ability to market their vegetables more efficiently. PU will measure whether the farmers think these technologies will increase their sales, reduce market costs, or expand their customer base. If a farmer believes that using mobile phone or social media or internet search engines to reach customers leads to faster sales of the vegetables, their PU of the technology will be high.

Perceived Ease of Use (PEOU) measures how easy farmers believe it is to use digital marketing technologies. For smallholder farmers with limited digital literacy, PEOU is crucial. If the tools are seen as too complicated, they may resist adopting them, even if they see potential benefits. If a farmer finds it difficult to use internet search engines they may choose not to use it even if it promises good sales opportunities.

2.8 Conceptual Framework

A conceptual framework explains the phenomenon understudy in a structural context. It clearly shows the independent and dependent variables and the relationships that exist among them. The choice of the digital marketing technology that smallholder farmers of green leafy vegetables make is influenced by demographic, farm, institutional, and technology-related factors. The assumption was that these factors will influence the farmers whether to use or not use the digital marketing technologies. The assumption is that farmers who use digital marketing technologies gain access to lucrative markets and market information. Digital marketing technologies enable farmers to market their products. As a result of farmers using digital marketing technologies, it is predicted that their profitability will increase due to lower transaction costs, better access to market information, and increased market access. Consequently, this has an impact on how the farm performs in terms of income generation, as shown in **Figure 1** below.

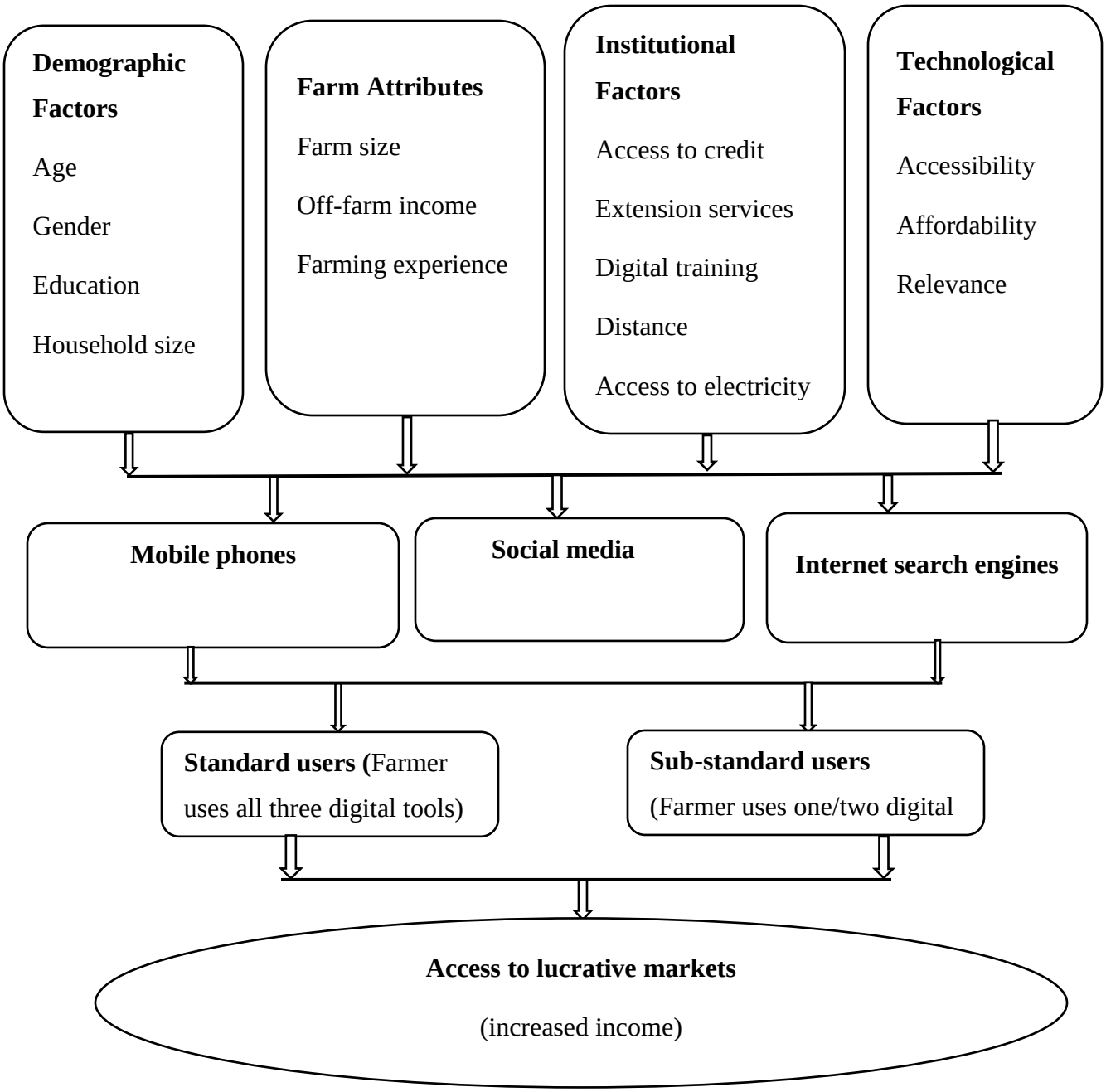

Figure 1.Conceptual Framework

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter presents the research methodology that was adopted in carrying out the study. The research methodology consists of research design outlining the study approach that was undertaken. The study area, population of the study is explained, the sampling technique, sample size, data collection methods, research procedures and data analysis methods.

3.2 Study area

The study was conducted in Lari sub-county, Kiambu County. Kiambu County borders Nairobi and Kajiado Counties to the South, Machakos to the East, Murang'a to the North and North East, Nyandarua to the North West, and Nakuru to the West and has a population of 2,417,735. The county is divided into four broad topographical zones; Upper Highland, Lower Highland, Upper Midland and Lower Midland Zone. The Upper Highland Zone is found in Lari sub-county and it is an extension of the Aberdare ranges that lies at an altitude of 1,800-2,550 meters above sea level. It is dominated by highly dissected ranges and it is very wet, steep and important as a water catchment area (Kiambu County CIDP, 2016). Lari sub-county is one of the twelve sub-counties in Kiambu County. The sub-county has five wards namely Lari/Kirenga, Kinale, Kijabe, Kamburu and Nyanduma Ward. It covers an area of 439.20 square kilometers. The constituency borders several other constituencies which include Githunguri Latitude and longitude.

Lari sub-county is largely forested, with Uplands Forest, Kinale Forest, Escarpment Forest found in the area. The sub-county was purposively selected because majority of farmers practice agriculture as the main source of livelihood. Crops grown for sale in Lari include vegetables such as cabbage, coriander, spinach, and kale. Additionally, vegetable farming in the sub-county is largely favored by large amounts of rainfall received throughout the year and the continuous cold seasons. The area is relatively cold because of its location on the windward side of Aberdare Range. It receives a considerable amount of rainfall in a year. The majority of farmers in Lari own and use digital technologies like mobile phones. Some farmers have access to different social media platforms, and the internet search engines.

Kiambu County experiences bi-modal type of rainfall. The long rains fall between Mid-March to May followed by a cold season usually with drizzles and frost during June to August and the short rains between mid-October to November. The annual rainfall varies with altitude, with higher areas receiving as high as 2,000 mm and lower areas receiving as low as 600 mm. The average rainfall received by the county is 1,200 mm. The mean temperature in the county is 26°C with temperatures ranging from 7°C in the upper highlands areas. Furthermore, Agriculture is the predominant economic activity in the county and contributes 17.4 % of the county‘s population income. It is the leading sub-sector in terms of employment, food security, income earnings and overall contribution to the socio-economic wellbeing of the people. Majority of the people in the county depend on the sub sector for their livelihood, with 304,449 directly or indirectly employed in the sector. Coffee and tea are the main cash crops in the county. The main food crops grown in the county are maize, beans, pineapples and Irish potatoes.

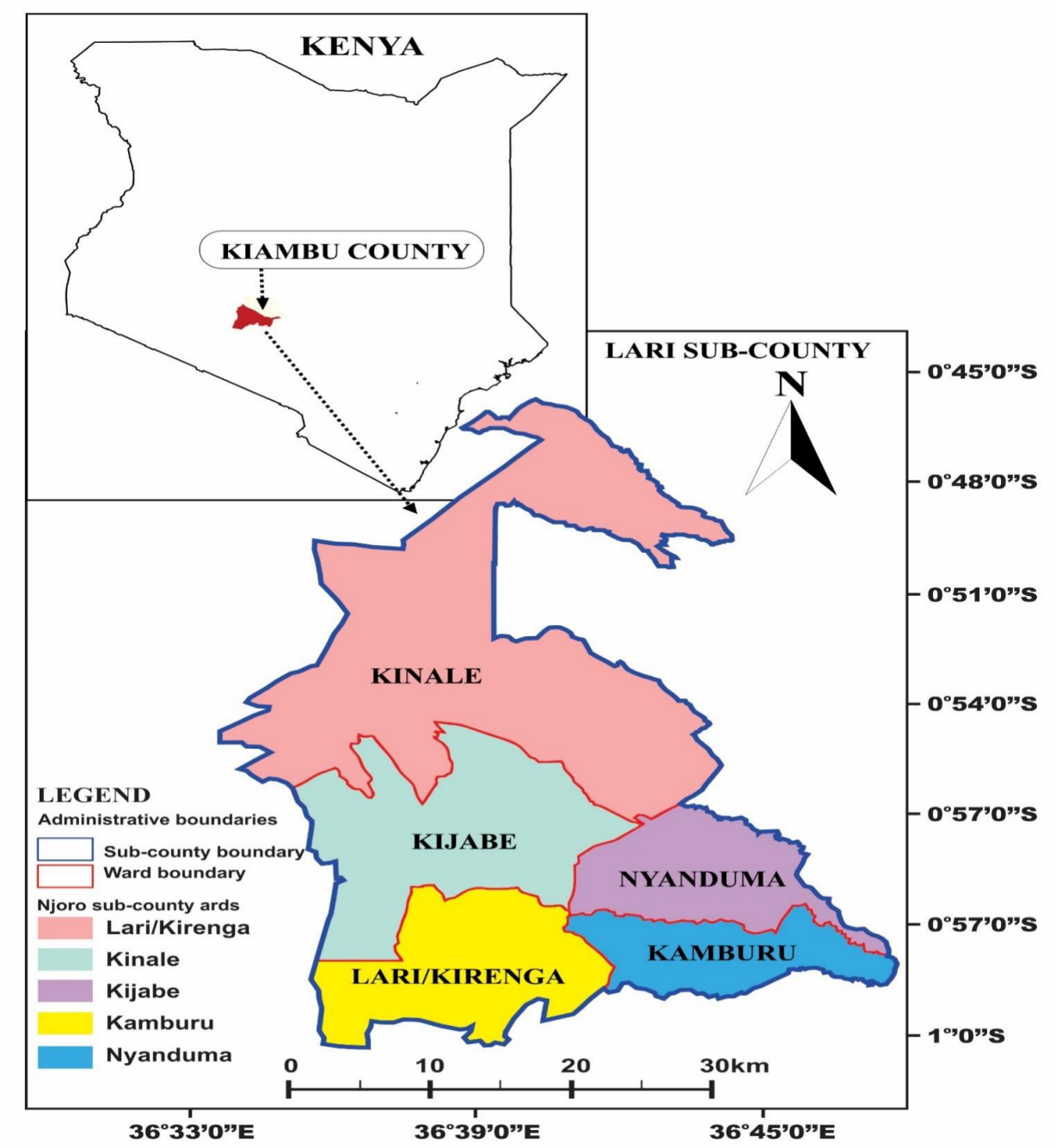

Figure 2. Map of Lari Sub-County

Source: IEBC (2022)

3.3 Research design

Research design refers to the overall strategy that the researcher uses in integrating various elements of the study with the purpose of addressing the research problem (Cooper & Schindler, 2013). Descriptive design refers to the design that is used in describing characteristics of a population or phenomenon being investigated (Ahlstrom & Bruton, 2013). This study used survey design, since it enables both collection of qualitative and quantitative data without influencing the environment of the study, it also entails the descriptions of the attributes the target population exhibits, and hence its application is justifiable. Survey design is flexible enough to provide opportunity for considering different aspects of a problem under study (Creswell, 2003).

3.4 Sampling design

3.4.1 Sampling frame

Ragab and Arisha (2018) define the sampling frame as the final list that represents the population which the researcher intends to select the sample from. The sampling frame of 384 smallholder green leafy vegetable farmers obtained from Lari sub-county agricultural extension officer**.**

3.4.2 Sampling procedure

The sample unit for this study consisted of smallholder green leafy vegetable (cabbage, spinach, and kales) farmers using different digital technologies (mobile phones, social media, and internet) in Lari sub-county. A multistage sampling procedure was employed to select the respondents. Kiambu County was purposively selected for it is well known for its potential in agriculture, specifically the horticulture sector. The county is an important agricultural center, and it is under major seven vegetable producing counties of Central Province. It is among the counties that have embraced the use of digital technology, more especially the use of mobile phones and social media in agriculture. Therefore, there is a possibility of growth in digital technology in the county. In the second stage, Lari sub-County was selected purposively because it is dominated by smallholder farmers who grow vegetables like cabbage, spinach, and kale for sale. On the other hand, majority of framers in the sub-county own mobile phones, they have access to internet, and social media platforms. The sub-county is also known as a source of food for Nairobi. The smallholder farmers in the area meet the characteristics of the study. Lastly, systematic sampling

was used to select the respondents from the five wards (Lari/Kirenga, Kinale, Kijabe, Kamburu, and Nyanduma) in the sub-county since they are not equal in size.

3.4.3 Sample size

Kothari (2004) advocates that good sample should be truly representative of the population, result in a small sampling error, viable, economical, and systematic. Determination of the sample size followed a proportionate-to-size sampling methodology as specified by Kothari (2004) using Cochran (1963) formula and was calculated as;

$$n = \frac{Z^2 pq}{e^2}$$

$$n = \frac{1.96 \times 1.96 \times 0.5 \times 0.5}{0.05 \times 0.05} = 384 \qquad (1)$$

where: n= Sample size; Z= Standard variation given confidence level of α= 0.05; p= Proportion of the population containing the major interest; q= 1- p and e = acceptable error or precision of 5%. Since the proportion of the population is unknown, p= 0.5, q= 1- 0.5= 0.5, Z= 1.96 and e= 0.05 (acceptable error term). This resulted in a sample of 384 respondents. The formula above is justified because the total number of smallholder green leafy vegetable farmers in Lari sub-county is not known. Because of this, the assumption of the formula will be that 50% of the subject interest (farmers) possesses major attributes of interest for the study. The acceptable precision of 5% was chosen because of the smaller sample size and hence higher confidence level.

Table 1: Sample size distribution

Lari sub-county wards	Total population	Proportion sample (%)	Sample
Kinale	26,007	21	81
Kijabe	27,627	22	84
Nyanduma	23,454	19	73
Kamburu	18,951	15	58
Lari/Kirenga	27,871	23	88
Total	**123,965**	**100**	**384**

3.5 Data collection and data analysis

Data from this study was collected from both primary and secondary sources of information. For quantitative data, the structured questionnaire was prepared and used. The questionnaires had both open and closed-ended questions. Piloting was conducted to test for the validity and reliability of the tools. It was conducted in Limuru sub-county, Limuru Central ward, using 50 questionnaires. Limuru sub-county was selected because it has similar agro-ecological conditions with those in Lari. Secondary data was obtained from different sources, including handbooks, policy statements, published statistics, national government sources, planning documents, reports, and other official documents. Data was organized into various categories, which are distinct from each other through coding, and the data was then analyzed using SPPS version 29 and STATA version 17.

3.5.1 Validity

Validity measures the extent to which the instrument measures what is supposed to measure (Drost, 2011). To obtain precise and consistent findings, instrument validity needs to be guaranteed (Mugenda & Mugenda, 2003). The instrument should be both face and content validated. Face validity is the extent to which the respondents view the appearance of the instrument and its items

as relevant to the context in which the test is being administered (Holden, 2010). Content validity determines if the instrument effectively covers all of the information about the variables under study (Heale & Twycross, 2015). As a result, the researcher verified the instrument's validity by examining all of the items and ensuring that it measures all of the variables under observation. The researcher also ensured that the questionnaire's look was appealing to the respondents and that it did not contain any irrelevant images or items to the study. Furthermore, the questionnaire was reviewed by professionals from the Department of Agricultural Economics and Agribusiness Management (AGEC/AGBM) to ensure its accuracy. The researcher additionally submitted the instrument to research methodological specialists and peers for validation.

3.5.2 Reliability

According to Drost (2011), reliability refers to the consistency of the instrument in measuring the construct. To estimate reliability, a pilot study was carried out in which the questionnaire was administered to a different population from that of the study before it was administered to the actual target population of the study. The questionnaire was piloted in Limuru sub-county, Limuru Central ward, which has similar agro-ecological conditions with those in Lari sub-county. A sample of 50 respondents was used, which is more than 10 % of the total sample hence sufficient to carry out the reliability test. According to (Connelly, 2008), 10 % of the total sample is sufficient to test for the reliability of the instrument. The Cronbach alpha coefficient obtained after testing for reliability was 0.74 which is above the required threshold of 0.7 hence the instrument was found to be reliable.

3.6 Data collection procedure

The researcher initially obtained approval from the Board of Postgraduate Studies and thereafter requested for Ethical Approval from the Egerton University Research Ethics Committee. Then applied for a research permit at the National Commission for Science, Technology, and Innovation (NACOSTI). After receiving the permit, the researcher requested authorization from the Lari sub-county administration. After receiving authorization from the sub-county authorities to gather data, the researcher coordinated with the head chief of Lari, who arranged for agricultural extension agents in the wards to host a meeting of the farmers, during which the questionnaire was given. The researcher requested separate meetings with the respondents in their respective wards.

Some respondents were in their different households while some were at one location in their respective wards where the researcher met them. The questionnaire was conducted by the researcher with the help of enumerators, resulting in a high response rate. This enabled the respondents to articulate their thoughts and provided the researcher with deeper insights into the facts. The researcher administered the questionnaire and recorded the answers given by the respondents for those respondents who were not able to answer by themselves to improve accuracy.

3.7 Analytical framework

3.7.1 Identifying the digital marketing technologies utilized by smallholder green leafy vegetable farmers

To analyze this objective, descriptive analysis was employed, and this was captured through quantitative and qualitative variables which are important in understanding the demographic, farm attributes and institutional factors of smallholder green vegetable farmers. This involved the use of mean, standard deviation, percentage, and tables of various variables to analyze the usage of digital marketing technologies among smallholder green leafy vegetable farmers. To compare the household and farm characteristics of farmers who use different combinations of tools (mobile phone, social media, and the internet search engines), t-test and Chi-square tests were used.

3.7.2 Factors influencing the use of digital marketing technologies in the marketing of green leafy vegetables

The empirical specification of choice decision over the three digital tools can be modeled in several ways, by either univariate regression, multinomial or multivariate regression analysis. Univariate regression models each of the digital tools individually as functions of the common set of explanatory variables. The disadvantage of this approach is that it is prone to biases caused by ignoring common factors that might be unobserved and unmeasured and affect the different digital tools. Furthermore, independent estimation of individual discrete choice models fails to take into account the relationships between uses of different digital marketing tools. A farmer might consider some combinations of digital marketing tools as complementary and others as competing. According to Lin *et al.* (2005), by neglecting these common factors the univariate method ignores

potential correlations among the unobserved disturbances in digital marketing tools, and this may lead to statistical bias and inefficiency in the estimates.

Multinomial regression is another alternative which has one underlying assumptions of independence of error terms of the choice equations are mutually exclusive (Greene, 2003). However, the choices among the digital tools are not mutually exclusive as farmers are using more than one digital tool at the same time and therefore the random error components of the digital tools may be correlated. The shortfall of this technique is that all multinomial replications of a multivariate choice system have problems in interpreting the influence of explanatory variables on the original separate digital tools. Therefore, multivariate probit model seemed to be the best model for this study.

The multivariate probit model was used to analyze the factors influencing the use of digital marketing technologies among smallholder green leafy vegetable farmers. This model simultaneously models the influence of socio-economic, institutional and digital technology related factors on each of the different digital tools while allowing the unobserved and unmeasured factors (error terms) to be correlated (Lin *et al.,* 2005). This model would allow possible contemporaneous correlation in the choice to use the three digital tools simultaneously.

Multivariate probit estimation has already been used in a number of studies that evaluate factors that affect the adoption of agricultural technologies (Gillespie *et al.,* 2004; Jenkins *et al.,* 2011). Jenkins uses this approach to evaluate factors that affect cotton producers' adoption pattern of different information sources i.e., private, extension and media, and Gillespie *et al.* (2004) used this to estimate factors that affect the adoption of four breeding technologies in hog production. They argue that modeling adoption decisions using a multivariate probit framework allows for increased efficiency in estimation in the case of simultaneity of adoption.

Empirically the model can be specified as follows:

$$Y_{i1} = X_{ij1}\beta_1 + \varepsilon_{i1}$$

$$Y_{i2} = X_{ij2}\beta_2 + \varepsilon_{i2}$$

$$Y_{i3} = X_{ij3}\beta_3 + \varepsilon_{i3} \qquad (2)$$

where, i = farmer identification, Y_{i1} = 1, if a farmer uses mobile phone to access agricultural information (0 = otherwise), Y_{i2} = 1, if farmer uses social media to access agricultural information (0 = otherwise), Y_{i3} = 1, if farmer uses the internet search engines to market the vegetables, and

access market information (0 = otherwise), X_i = Vector of factors affecting use of digital marketing technology tools, β_j = Vector of unknown parameters (j = 1, 2, 3), and ε = the error term. Factors influencing the use of digital marketing tools can be tested by running three different independent binary probit or logit models by assuming that error terms are mutually exclusive. However, the decision to use different digital marketing tools may be correlated, thus the elements of error terms might experience stochastic dependence. In this situation, a multivariate probit model of the following form is used to test the hypothesis.

$$Y_{ij} = X_{ij1}\beta_1 + \varepsilon_{ij} \quad (3)$$

where Y_{ij} (j =1….,3) represents the three different digital marketing technologies faced by the ith farmers (i = 1.…384), X_{ij1} is a 1 × k vector of observed variables that affect the choice decision of farmers, β_j is a k × 1 vector of unknown parameters (to be estimated), and ε_{ij} is the unobserved error term. Assuming the error terms (across j = 1… m alternatives) are multivariate and are normally distributed with a mean vector equal to zero, the unknown parameters in the above equation are estimated using simulated maximum likelihood. The method used Geweke Hajivassiliour-Keane smooth recursive conditioning simulator procedure to evaluate the multivariate normal distribution.

Table 2: Description and expected signs of variables used in regression model

List of variables	Description	Measurement	Expected signs
Dependent			
Digital tools	Use of digital tools to market and access market information	1=mobile phone 2=social media 3=internet search engines	
Independent			
Age	Age of respondent	Number of years	+/-
Gender	Gender of respondent	Dummy 1=male, 0=female	+/-
Education	Education level	Number of years	+
Experience	Level of experience	Number of farming years	+

Household size	Household members	Number of individuals in the household	+/-
Farm size	Size of the land	Acres	+/-
Off-farm	Total off-farm income	Total amount earned in KES	+
Access to Extension	Access to extension services	Dummy 1=yes, 0=no	+
Access to credit	Access to credit	Dummy 1=yes, 0=no	+
Distance to market	Distance to output Market (km)	Distance in kilometers	+/-
Access to electricity	Access to electricity	Dummy 1=yes, 0=no	+
Digital training	Training on digital technologies	Number of digital trainings	+
Relevance	Relevance of digital tool	Likert 1 = SD, 2 = D, 3 = N, 4 = A	+/-
Accessibility	Accessibility of digital tool	Likert 1 = SD, 2 = D, 3 = N, 4 = A	+/-
Affordability	Affordability of digital tool	Likert 1 = SD, 2 = D, 3 = N, 4 = A	+/-

SD =Not: D = Slightly: N= Moderately: A = Very

3.7.3 Effect of digital marketing technology use on the income of smallholder green leafy vegetable farmers

To achieve this objective, a two-stage multinomial endogenous switching regression model (MESR) was employed. The specification of the model is adapted from the works of Teklewold *et al.* (2013), Danso-Abbeam and Baiyegunhi (2018), Kassie *et al.* (2018), and Belay and Mengiste (2021). The model addresses the selection bias problems induced by observable and unobservable heterogeneity. The MESR model consists of two stages. In the first stage, farmers' utilization of alternative digital marketing technologies is estimated by the multinomial logit selection (MNLS) model. In the second stage, the effects of digital marketing technologies on the income of farmers are evaluated by the ordinary least square (OLS) with an inverse Mills' ratio (IMRs) to correct selection bias (Khonje *et al.*, 2018).

Stage one: Multinomial adoption selection model

At this stage multinomial logit was used to determine the determinants of choice of digital marketing technology packages. According to Teklewold *et al.* (2013), in a multinomial adoption selection model, we assume that green leafy vegetable producers have an objective of maximizing their utility, U_i , by comparing the income obtained from different m digital marketing technologies. Thus, the green leafy vegetable producer i will choose a particular digital marketing technology j, over an alternative digital marketing technology k, if $U_{ij} > U_i k, k \neq j$. The expected utility, U^*_{ij}, that the producer derives from the adoption of digital marketing technology j is the latent variable determined by observed demographic, social-economic, and farm-level variables (X_i) and unobserved characteristics ($£_{i1}$):

$$U^*_{ij} = X_i\beta_j + £_{ij} \quad (4)$$

where X_i is observed exogenous variables (demographic, socio-economic, institutional factors, and farm-level variables) and $£_{i1}$ is an error term accounting for unobserved characteristics. Let (A) be an index that indicates the choice the farmer has made, such that:

$$A = \begin{cases} 1if\ U^*_{i1} > max_{k\neq j}\,(U^*_{ik})\ or\ \eta_{i1} < 0 \\ \qquad\qquad for\ all\ k \neq j \\ Jif\ U^*_{ij} > max_{k\neq j}\,(U^*_{ik})\ or\ \eta_{ij} < 0 \end{cases} \quad (5)$$

In the above, $\eta_{i1} = max_{(k\neq j)}\,(U^*_{ik} - U^*_{ij}) < 0$. Eq. (5) suggests that the i^{th} green leafy vegetable producer will adopt digital marketing technology j , to maximize his expected utility if the digital marketing technology j provides greater expected utility than any other digital marketing technology $k \neq j$, that is, if $\eta_{ij} = max_{(k\neq j)}(U^*_{ij} - U^*_{ik}) > 0$. Following McFadden (1973), the probability that a green leafy vegetable producer i with characteristics X_i will choose the digital marketing technology j can be specified by a multinomial logit model as:

$$P_{ij} = Pr(\eta_{ij} < 0 | X_i) = \frac{\exp(X_i\beta_j)}{\sum_{k=1}^{J}\exp(X_i\beta_k)} \quad (6)$$

Second stage: Multinomial endogenous switching regression

We estimate the relationship between outcome variables and a set of explanatory variables (Z) for each selected digital marketing technology. In the model's specification for the three digital marketing technologies, green leafy vegetable farmers are expected to have four alternative

combination options (j=1,2,3, &4). The study assumes that the non-adoption decision of digital marketing technologies denoted by j = 1 is the base category, while at least one digital marketing technology is adopted in the remaining choices (j = 2, . …4). The outcome equation for each possible regime j is given as:

$$\begin{cases} Regime\ 1: Y_{i1} = Z_{i1}\alpha_1 + u_{i1}\ if\ U = 1 \\ Regime\ J: Y_{iJ} = Z_{iJ}\alpha_J + u_{iJ}\ if\ U = J \end{cases} \quad (7)$$

where Y_{ij}'s denotes the outcome variable which represents the income for the non-adopters and adopters, Z_i denotes a set of explanatory variables that influence the green leafy vegetable income; α_i are the vectors of parameter to be estimated, and u_i represents error terms with zero mean and constant variance assumption. The error term (u_{ij}) involves the unobserved individual effects and random error term. Consequently, estimating Eq. (7) using OLS will give biased results if the error terms of adoption ($£_{ij}$'s) and outcome (u_{ij}'s) equations are not independent. To get consistent estimates of α_j, it is necessary to include the selection correction terms derived from Eq. (7). Following Bourguignon *et al.* (2007), the multinomial endogenous switching model in Eq. (7) can be specified as in Eq. (8) below, which is also called the selection bias-corrected outcome equation or the second stage of multinomial endogenous switching regression.

$$\begin{cases} Regime\ 1: Y_{i1} = Z_{i1}\alpha_1 + \sigma_1\,\lambda_{i1} + e_{i1}\ if\ U = 1 \\ Regime\ J: Y_{iJ} = Z_{iJ}\alpha_J + \sigma_1\,\lambda_{iJ} + e_{iJ}\ if\ U = J \end{cases} \quad (8)$$

where e_{ij} is the error term with an expected value of zero, α_j is the covariance between $£_{ij}$'s and u_{ij}'s, λ_{ij} is the inverse Mills ratio computed from the estimated probabilities in Eq. (9) as follows:

$$\sum_{k=1}^{J} \rho j \left[\frac{\hat{P}_{ik}\ln(\hat{P}_{ik})}{1-\hat{P}_{ik}} + \ln(\hat{P}_{ij})\right] \quad (9)$$

Here, ρ is the correlation coefficient between $£_{ij}$'s and u_{ij}'s. In the multinomial choice setting, there are $J - 1$ selection correction terms to be included in the outcome equations, one for each alternative digital technology. The standard errors in Eq. (9) are bootstrapped to control the heteroscedasticity associated with the generated explanatory variables in the estimation procedure.

Estimating average treatment effects

The multinomial endogenous switching regression model is used to compute both the average treatment effect on the treated (ATT) and the untreated (ATU). This can be done by a simple comparison of the expected values of the outcome of the treated (users) and untreated (non-users) in actual and counterfactual situations. Following, Teklewold *et al.* (2013), Danso-Abbeam and Baiyegunhi (2018), and Kassie *et al.* (2018); the conditional expectations for the outcome variables in both the observed and their counterfactual scenarios can be specified as follows:

Expected income status with usage of digital marketing technologies (observed)

$$E(Y_{ij}/\ U = j) = \ \alpha_j Z_{ij} + \sigma_j \lambda_{ij} \quad (10a)$$

$$E(Y_{i1}/\ U = 1) = \ \alpha_1 Z_{i1} + \sigma_1 \lambda_{i1} \quad (10b)$$

Expected income status without usage of digital marketing technologies (counterfactual)

$$E(Y_{ij}/\ U = 1) = \ \alpha_1 Z_{ij} + \sigma_1 \lambda_{ij} \quad (10c)$$

$$E(Y_{i1}/\ U = j) = \ \alpha_j Z_{i1} + \sigma_j \lambda_{i1} \quad (10d)$$

The average treatment effect on the treated (ATT) is calculated as the difference between eq. (10a) and eq. (10c); and specified as:

$$ATT = \ E(Y_{ij}/\ U = j) - E(Y_{ij}/\ U = 1) \quad (11)$$

Similarly, the average treatment effect on the untreated (ATU) is the difference between equation (10b) and equation (10d) and can be specified as:

$$ATU = \ E(Y_{i1}/\ U = 1) - E(Y_{i1}/\ U = j) \quad (12)$$

The difference between eq. (11) and eq. (12) provides in transitional heterogeneity (TH) that shows whether the effect of adoption is higher or lower for the adopters than the non-adopters.

Table 3: Description and signs of hypothesized dependent variables that have an effect on income

Variable	Description	Measurement	Expected sign
Dependent			
Income	Total farm income	Amount in KES	+
Independent			
Digital technologies	Choice of digital technology	Dummy 0=Mobile phone 1=Social-media 2=Internet	+
Age	Age of respondent in years	Number of years	+/-
Gender	Gender of respondent	Dummy 1=male, 0=female	+/-
Education	Level of education	Number of years	+
Experience	Level of experience	Number of farming years	+
Household size	Members of the household	Number of individuals in the household	+/-
Farm size	Size of land accessed	Acres	+/-
Extension	Access to extension services	Number of contacts with extension agents	+
Credit	Access to credit	Dummy 1=Yes, 0=No	+
Distance	Distance to the market	Kilometers (km)	+/-
Electricity	Access to electricity	Dummy 1=Yes, 0=No	+
Training	Digital technology training	Number of trainings	+

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results and discussions of the findings on the effect of digital technologies on the marketing of green leafy vegetables among smallholder farmers in Lari Sub-county. The focus is on the usage of digital marketing technologies, the factors that influence the usage of digital marketing technologies, and how using digital marketing technologies in marketing affects the income of the smallholder green leafy vegetable farmers. The digital marketing technologies considered were social media, mobile phone, and the internet. The mean, standard deviation, frequencies and percentages are presented interpreted and the findings from objectives two and three are discussed.

4.2 Questionnaire return rate

The researcher administered a total of 384 questionnaires to the respondents in Kinale, Kijabe, Kirenga, Nyanduma, and Kaburu wards in Lari sub-county. Out of 384 questionnaires, 374 of them were filled and returned. The response rate is considered very good for making the study conclusions. According to Mugenda and Mugenda (2003), a response rate of 50% is adequate for analysis and reporting; a rate of 60% is good and a response rate of 70% and over is excellent. The excellent response rate was due to the pre-notification of the key informants about the intended survey.

4.3 Descriptive analysis

In this study, there were 374 farmers from Lari sub-county who responded to the questionnaires. In this section, results on socio-economic characteristics, institutional characteristics, technological factors, and usage of digital marketing technologies are presented.

4.3.1 Farmer's socioeconomic characteristics

Table 4 presents the results of the gender and the level of education of the respondents.

Table 4: Gender and education level of the household by digital marketing technology usage

Variable	Standard users (N=145)	Sub-standard users (N=229)	$\chi 2$	p-value
Gender (%)				
Female	41.4	40.2	0.084	0.834
Male	58.6	59.8		
Education level (%)				
No formal education	0.0	0.9	70.042***	0.001
Adult education	0.0	2.2		
Primary education	32.4	38.0		
Secondary education	51.1	45.8		
College education	13.1	11.8		
University education	3.4	1.3		

*** = significant at 1% level.

Table 4 presents the results of gender and education level of the households. The majority of households were male headed, with standard users, male being 58.6% and female, 41.4%, while the proportion of sub-standard users, male was 59.8%, and 40.2% were female. Male headed households have better access and control over productive resources than women, influenced decisions on household farm activities, marketing and utilization of the benefits from the farm. In the study by Elias *et al.* (2018), males are more likely than females to engage in agricultural activities and have access to information. According to Sebotsa (2021), males are still more interested than women in engaging in agriculture and employing technologies in their farms.

Education plays a crucial role for household heads as it equips them with knowledge, skills, and critical thinking abilities to make informed decisions about the digital marketing technologies. The results on the education level of the household head indicate a significant difference with a majority of household heads having secondary education among the two groups. About 51.1% of standard users had attained secondary education as compared to 45.8% of sub-standard users. Generally, the level of education of the household head for standard users was significantly

higher than sub-standard users. Farmers' degree of education affects their ability to understand information from any digital marketing technologies and how to utilize digital tools. Therefore, farmers with higher levels of education are more likely to be creative and adept at using digital marketing tools in their agribusinesses. The findings are supported by Sebotsa (2021), who noted that educated farmers are familiar with modern technologies and have increased knowledge of innovative farming practices.

Table 5: Mean of household characteristics by digital marketing technology usage

	Standard users (N=145)		Sub-standard users (N=229)		
Variable	Mean	Std.dev	Mean	Std.dev	t-test
Age	37.6	8.64	47.9	13.24	6.432***
Household size	4.6	1.85	6.5	2.43	1.985*
Experience	7.5	5.30	10.7	10.89	-2.230***
Farm size	0.5	1.18	0.4	0.21	1.855*
Income (seasonally)	19,600.05	38,367.48	24,092.30	42,905.65	-1.682*

* and *** = significant at 10% and 1% level, respectively.

Table 5 presents the mean differences of household characteristics by digital marketing technology usage. The results showed that the standard users had the mean age of 37.6 years while sub-standard users had 47.9 years. The association between digital marketing technology usage and age of the household heads was statistically significant at 1%. The results indicate that more young farmers are involved in the usage of modern technologies in marketing their produce. Age is an important factor that can influence the usage of digital technologies by farmers. The results conform to the findings of the study conducted by Okello (2017) who found that young farmers used ICT in their enterprises. Younger farmers are more innovative and risk-takers, therefore they are more likely to test new technologies than older household heads.

According to the results, standard users had a mean household size of 4.6 individuals while sub-standard users had 6.5 individuals. The association between digital marketing tools usage and household size was statistically significant at 10%. The results imply that households with fewer members were likely to use digital marketing technologies to market their produce and seek market information from different tools. These results are in conformity with Okello (2017) who found that mean household size of optimal users was smaller than that of sub-optimal users.

The mean marketing experience of standard and sub-standard users was 7.5 and 10.7 years, respectively. The experience and digital marketing technology usage was statistically significant at 10%. This is an indication that farmers in the study area are equipped to make sound marketing decisions. Experienced farmers are risk-takers and are always looking for new and improved technologies that will increase production and marketing (Aker & Mbiti, 2010). Mdoda (2017) asserts that farmers with greater experience are more likely to embrace agricultural practices that will increase their output and enable them to compete in marketplaces.

The mean farm size of standard users and sub-standard users were 0.5 and 0.4 acres, respectively. The association between farm size and digital marketing technology usage was statistically significant at 10%. The standard users owned larger land than sub-standard users use digital marketing tools that enable them to access market information and maximize their outputs from their large land size. Farm size is a major agricultural asset that influences the creation of marketable surplus. An increase in farm size leads to an increase in the intensity of digital marketing tools usage as a source of marketing and market information. According to Zodidi (2022), farming households farm on very big land sizes, potentially allowing them to produce for marketplaces and profit from trade.

The mean seasonal income from green leafy vegetable production was statistically different at a 10% significance level with standard and sub-standard users getting KES19,600.05 and KES24,092.30 respectively. Earning higher income could help farmers have access too real-time market data through digital platforms, which allows the farmers to be better informed about prevailing prices. Farmers with higher incomes may be able to invest in tools like smartphones and internet connections that make it easier to acquire market information and market their vegetables. According to Okello (2017), the likelihood that a farmer would look for and acquire useful information increased with his income.

4.3.2 Institutional Factors

Table 6 presents the institutional characteristics for discrete dummy variables. Access to credit is important for farmers because it gives them access to capital that might not otherwise be available to them. The association between digital marketing technology usage and access to credit is statistically significant at 1% with 75.9% proportion of standard users accessing credit, while sub-standard users was 72.9%. This implies that the households are able to purchase necessary

inputs for the agribusinesses, and they are able to buy bundles that help them to operate their digital tools. They can also use the credit they receive from financial institutions to implement the information they receive from digital tools. According to Okello (2017), credit is required for enhanced expansion of business activities and agrienterprises development.

Table 6: Institutional characteristics for discrete dummy variables

Variable		Standard users (N=145) %	Sub-standard users (N=229) %	$\chi 2$
Credit access	Yes	75.9	72.9	32.1025***
	No	24.1	27.1	
Extension services	Yes	55.2	63.3	14.2938***
	No	44.8	36.7	
Access to electricity	Yes	91.0	67.7	18.7293***
	No	9.0	32.3	
Digital marketing technology training	Yes	75.2	60.3	12.2580***
	No	24.8	39.7	

*** Significant at 1% level.

Furthermore, the results show that the association between access to extension services and digital marketing technology usage is statistically significant at 1%. Among standard users 55.2% had access to extension services while 63.3% of sub-standard users had access to extension services. The results imply that farmers are being guided on utilizing digital marketing technologies to market their vegetables and accessing market information. The results are in line with the findings of Adejuwon (2018) and Oyinbo *et al.* (2019) who reported that the majority of smallholder farmers had access to the extension services hence their adoption of new technologies was high. Extension services provide farmers with the agricultural information they need in the usage of technologies.

Access to electricity plays an important role in the utilization of digital tools. The results show that among standard users 90% had electricity installed in their households, while 67.7%

was sub-standard users. The association between access to electricity and digital marketing technology usage is statistically significant at 1%. Most digital marketing tools depend on electricity for them to operate, therefore, households should have access to electricity for effective utilization of these tools. The results conform with the findings of Okello (2019) who reported that 70% of respondents had access to electricity, with users of TV having the highest access to electricity.

Training on digital marketing technologies is important because it can help smallholder farmers on how to effectively operate and use digital marketing tools to access better market information and market their commodities for the success of their agribusinesses. Among standard users 75.2% were trained on digital marketing technologies, while among sub-standard users, 60.3% were trained. Okello (2017) noted that access to trainings acts as an important factor in the usage of technologies among farmers.

Table 7: Household distance to the market

Variable	Standard users (N=145)		Sub-standard users (229)		
	Mean	Std.dev	Mean	Std.dev	t-test
Distance	15.8	17.54	13.7	15.55	-0.8733

Standard users' mean distance from the output market was 15.8 kilometers longer, while the mean distance for sub-standard users was 13.7 kilometers. Distance between the households and the output market is frequently used as a proxy for market accessibility, and thus transaction costs. Households use digital marketing tools more often as they get farther away from the marketplace for their products. These findings are in line with those of Sekabira (2012), who showed that households with limited access to agricultural markets due to distance and transportation costs are adopting digital technologies.

4.3.3 Types of green leafy vegetables produced and marketed by farmers

Table 8: Types and quantities of vegetables produced and sold in the previous season

Type of Vegetable	Number of Farmers	Percentage (%)	Average Quantities Produced (kg)	Average Quantities Sold (kg)
Cabbage	179	47.61	4003	3661
Spinach	269	71.51	6016	5501
Kales	315	83.78	7045	6443

The results on table 8 show that the majority of smallholder farmers in the study area produce and sell kales more, followed by spinach, and less percentage produce and sell cabbage. Kale is a popular green vegetable consumed by almost every household in Kenya has been shown to be a major source of cash for many households. The study by Salasya (2015) revealed that kale made the highest contribution to household income among the crops and also had the highest returns to variable inputs among the crops. On the same hand, spinach is a popular leafy vegetable and its farming is practiced in many parts of Kenya. Farmers produce it as an important cash crop since it is highly marketable. Spinach also takes a very short time of about 6 to 8 weeks to mature, hence giving the investor quick returns. Cabbage is still one of the popularly produced green vegetables, however its marketing is high during dry seasons.

4.3.4 Digital marketing technologies usage

Table 9 presents the results on digital marketing technologies utilized by the farmers in marketing the green leafy vegetable. Concerning the mobile phone usage, SMS (96.8%) are mostly used by the farmers, while phone calls are used by 86.5% of the farmers. The SMS are regarded a low-cost method of getting information out to a large number of smallholder farmers and used to market the commodities. Text messages can be delivered and received with and without internet access. On social media, various platforms were utilized by the farmers, and it was found that Facebook (90.4%) was mostly used, followed by WhatsApp (79.3%), Twitter (23.8%), Instagram (14.2%), LinkedIn (7.9%), Snapchat (1.5%), and Pinterest (1.5%). The results are in line with the findings of Umunakwe *et al.* (2018) who indicate that the most dominantly utilized social media

platforms in agriculture are Facebook, WhatsApp, and Twitter with Facebook being the most used, followed by WhatsApp and Twitter being the least of the two. Sebotsa (2021) also confirm that Facebook is mostly used by the youths in agriculture.

Table 9: Mobile phone, social media, and internet search engines utilized

Mobile phone	Percentage (%)	Social media	Percentage (%)	Internet search engines	Percentage (%)
SMS	96.8	Facebook	90.4	YouTube	79.5
Phone Calls	86.5	WhatsApp	79.3	Google	68.3
		Twitter	23.8	Yahoo	14.0
		TikTok	19.5	Bing	0.3
		Instagram	14.2	Baidu	0.3
		LinkedIn	7.9	Dogpile	0.3
		Snapchat	1.5		
		Pinterest	1.5		

The internet search engines that were used are Google, YouTube, Yahoo, Bing, Baidu, Dogpile. The results revealed that YouTube, Google, and Yahoo as top three utilized digital marketing technologies with 79.5, 68.3%, and 14% usage respectively among the smallholder green leafy vegetable farmers. Bing, Baidu, and Dogpile are least utilized, with 0.3% of usage for three of them. The low usage of the least utilized digital marketing tools may most likely be because they are not commonly known in Lari sub-county though they can be of great benefit to the farmers. This means that the farmers might be missing out on very important information issued through these platforms that can help improve their agricultural activities. When a platform is popular, there is more engagement and information accessible and utilized than on less popular platforms (Sebotsa, 2021). It is critical to raise knowledge about the many social media platforms accessible so that farmers may access information on platforms that were previously unfamiliar to them.

Table 10 shows the type of market information that households disseminated from digital tools. Price information and information on whom to sell to (customers) were the main information received from all tools, with mobile phones being mostly used to disseminate the information. Farmers use SMS and calls because they are easily accessible and require less expertise. The farmers considered information on prices important because they need to know current market prices for their products to make informed decisions about when to sell. This helps them maximize their profits by selling when prices are favorable, and they can negotiate fair prices with the buyers. Knowing whom to sell to can help the farmers to understand their customers' price sensitivity and willingness to pay helps them set competitive and fair prices maximizing profit while maintaining customer satisfaction and building relationships.

Table 10: Type of market information accessed from digital technologies

Market Information	Mobile Phone (%)	Social Media (%)	Internet Search Engines (%)
Price Information	87	84	82
Customers	80	71	77
Place to sell	58	35	41
Quantity	47	25	21
Quality	39	24	30

4.3.5 Patterns of mobile money usage

Table 11 presents how mobile money was used and different mobile accounts owned by the farmers. The results revealed that 58.8% had access to mobile credit facilities while 41.2% did not have access to mobile credit. The results further revealed that 57.9% of farmers owned *M-Pesa* account while 42.1% owned Airtel money account. The findings indicate that Safaricom's M-Pesa, a mobile money transfer system, is the respondents' preferred choice and has been a leader in Kenya's agricultural technological advances. Smallholder farmers can facilitate transactions for inputs and outputs, while financial institutions, including banks, SACCOs, and microfinance organizations, can provide loans and collect repayments.

Table 11: Usage of mobile money and mobile banking

Access to mobile credit facilities	**Percentage (%)**
Yes	58.8
No	41.2
Mobile money account owned	
M-Pesa	57.9
Airtel money	42.1
Mobile bank account	
Equitel	58.8
M-Shwari	56.5
KCB mobile money	25.7

The respondents revealed that they had mobile bank accounts and have borrowed money using their accounts. The results show that 58.8% of the farmers borrowed money from Equitel (Equity Bank mobile application), 56.5% borrowed from *M-Shwari*, and 25.7% borrowed from Kenya Commercial Bank (KCB) mobile account.

4.3.6 Smallholder farmers' perception of ICT tools attributes

Table 12 presents the scores of the smallholder green leafy vegetable farmers perceptions in relation to the attributes of the different digital marketing technologies which were on a scale of 1 = not, 2 = slightly, 3 = moderately, and 4 = very.

Table 12: The average scores of farmers' perceptions of digital marketing technologies characteristics

Digital marketing technologies attributes	Mobile phone	Social media	Internet search engines
Accessibility	3.5	3.2	2.2
Affordability	3.8	2.7	0.2
Relevance	3.4	2.1	1.3

The results from table 12 reveal that regarding accessibility of the technologies, mobile phone had the high score of 3.5, while social media scored 3.2. This imply that mobile phone was preferred by most of the respondents to market and access market information. In relation to the affordability of the digital tools, mobile phone scored more with 3.8 scores. The reason could be that marketing and accessing market information through SMS and phone calls does not require any data subscription. Utilizing social media and internet search engines require loads of data bundles or WIFI connection which may not be always affordable for the farmers. In regard to the relevance of the tools, mobile phone scored 3.4, followed by social media with 2.1, and lastly internet search engines scored 1.3. The farmers found mobile phones more relevant because they offer instant communication which is crucial for time-sensitive farming decisions, again, farmers can receive extension services through messages which can help them solve immediate marketing problems.

4.4 Factors Influencing the Use of Digital Technologies in The Marketing of Green Leafy Vegetables

4.4.1 Pre-estimation tests

Multicollinearity test

Table 13: Variance inflation factor

	VIF	1/VIF
Training	2.45	.408
Off-farm income	2.128	.47
Relevance	1.891	.529
Accessibility	1.714	.583
Affordability	1.705	.587
Extension access	1.492	.67
Education	1.397	.716
Electricity	1.304	.767
Credit access	1.154	.866
Distance	1.127	.888
Age	1.069	.935
Household size	1.06	.944
Land size	1.043	.959
Experience	1.019	.982
Gender	1.013	.987
Mean VIF	1.438	.

The Variance inflation factor was used to assess multicollinearity. The VIF values ranged between 1.013 to 2.445 which are below the acceptable threshold of 5, indicating that multicollinearity was not a problem.

Breusch pagan test for heteroscedasticity

The Breusch pagan test was used to test if the if the errors are homoscedastic. The p-value was below 0.05. We reject the null hypothesis that heteroscedasticity is a problem. The study applied a robust standard error to account for this problem.

Pairwise correlation test for categorical variables

Table 14: Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)
(1) Gender	1.000				
(2) Extension access	-0.037	1.000			
(3) Training	0.036	0.374	1.000		
(4) Credit access	0.055	0.142	0.130	1.000	
(5) Electricity	-0.030	0.257	0.182	0.224	1.000

Pairwise correlation test was used to test whether categorical variables were correlated with each other. The pairwise correlation values were below 0.5 which is regarded acceptable.

Normality test

Shapiro Wilkes test was used to test for normality assumption. The p-value was above 0.01 indicating that the errors are normally distributed.

Table 15: Multivariate probit results for factors influencing the use of digital technologies in the marketing of green leafy vegetables

	Mobile phone		Social media		Internet	
	Coeff	Std. Err	Coeff	Std. Err	Coeff.	Std. Err
Age	-0.001	0.003	-0.001	0.003	-0.009***	0.003
Gender	-0.716***	0.188	-0.302*	0.174	-0.336**	0.165
Education	0.126***	0.041	0.187***	0.048	0.188***	0.050
Household size	0.105**	0.046	0.104***	0.038	0.107***	0.039
Farm size	0.106	0.099	-0.114	0.075	-0.080	0.054
Off-farm income	-0.000	0.000	-0.000	0.000	-0.000	0.000
Experience	-0.000	0.002	0.000	0.002	-0.003*	0.002
Extension access	0.897***	0.214	0.560***	0.204	0.622***	0.198
Training	0.026	0.055	0.001	0.060	0.063	0.061
Electricity access	0.794***	0.211	0.511**	0.202	0.285	0.192
Credit access	0.641***	0.191	0.799***	0.194	0.824***	0.193
Affordability	1.204***	0.249	1.319***	0.234	1.055***	0.231
Relevance	-0.108	0.109	-0.184*	0.105	-0.233**	0.115
Distance	0.015	0.024	-0.009	0.018	-0.008	0.020
Accessibility	-1.037***	0.298	-1.007***	0.256	-0.776***	0.240
_cons	-3.867***	0.718	-5.777***	0.662	-4.889***	0.637
Number of Observations 374						
L. R. test of rho21 = rho31 = rho32 = 0: 0			$\chi2(3) = 59.7641$		Prob > $\chi2$=0.0000	
Wald χ^2 (3) = 368.28 Prob > $\chi2$ = 0.0000						

Age of the household head had a negative effect on the usage of internet search engines with additional year reducing the usage by 0.9%. These findings indicate that adding a year to the age of the household head is connected with a decreased likelihood of that household head using

the internet search engines as a source of marketing and accessing marketing information. Older household heads may be less likely to adopt new digital tools such as internet search engines since they may have had less exposure to technology during their formative years and may be less familiar with their use. Again, older farmers may be more resistant to change, prefer traditional marketing strategies. The findings are consistent with those of Katunyo *et al.* (2018) Mdoda and Mdiya (2022), who found that age had a negative impact on farmers' use of ICT. The gender of the household head had a negative effect on the use of mobile phone, social media, and internet search engines as the source of marketing. The female household heads are associated with lower usage of the digital marketing technologies. The possible reason could be due to income disparities and digital literacy.

The education level of the household head had a positive and significant effect on mobile phone, social media, and internet search engines usage as the source of platforms for marketing. An increase in education by one year enhanced digital technologies usage by about 12.6%, 18.7%, and 18.8%, respectively. A farmer can market their products on mobile phone, social media, and internet search engines and learn how to save and retrieve information from the tools by being exposed to education. Through education, individual farmers can learn how to find and use the most recent information on enhanced farming practices and enhanced marketing methods. Farmers who have received education are better able to read and understand content from digital technologies. Okello (2017) supports the findings by indicating that education significantly influenced how ICT tools were used by pineapple agri-prenuers.

Household size had a significant and positive influence on mobile phone, social media, and internet search engines usage. This implies that an increase in household size will yield an increase in the likelihood of the use of mobile phones, social media, and internet search engines by 10.5%, 10.4%, and 10.7%, respectively. This could be the case since individuals of larger families frequently have a variety of interests and skill sets. Some members are skilled at managing social media profiles, which helps the farm's internet operations have a more active online presence. The more the household members, the more ownership of different digital platforms. Once more, the need for enhanced market communication, information availability, and access to reliable marketplaces for the products may be the driving forces behind the adoption of digital technologies in large households. Farmers benefit from having a large family because they may employ certain family members to train them how to use digital technologies.

Access to extension services was significant and it had a positive effect on the use of social media and internet search engines as a source of market information and marketing. An increase in extension services by one will induce an increase in social media and internet search engine usage by 0.52 and 1.27 percentage points, respectively. Extension agents spread innovation by encouraging farmers to share their ideas and experiences, as well as making it more affordable to obtain knowledge. The results are in conformity with Tambo *et al.* (2019) that having access to extension services plays an imperative role in improving production and use of innovation to the farm.

Years of experience has a negative impact on the use of internet search engines as the platform for marketing. The results imply that with the additional year of experience, the likelihood to use internet search engines decreases with 0.3% percentage points. More experienced individuals might rely on established knowledge and networks rather than attempting to use new ones. On the same hand, household heads with more experience may be less comfortable or familiar with new technologies as compared to less experienced heads.

Access to extension services was significant and had a positive effect on usage of mobile phone, social media, and internet search engines. An increase in access to extension by one enhanced the usage of mobile phone, social media, and internet search engines by 87.7%, 56%, and 62.2%, respectively. Extension workers may help farmers better understand the benefits of digital marketing technologies and making the adopt these tools for marketing purposes. Chikaire *et al.* (2017) noted that having access to extension services assist farmers with knowledge and information which in turn is likely to help farmers acquire leadership potential which will help them in disseminating information on important techniques or innovation.

Electricity installation had a positive and significant effect on mobile phone and social media usage. The results indicate that households that have electricity installed at their homes had a higher probability of using mobile phones and social media by 79.4% and 51.1%, respectively. Mobile phones require electricity, so access to electricity would enable the smooth and effective operation of mobile phones. The findings are in line with Okello (2017) who found a positive correlation between electricity installation and mobile phone usage. Zodidi (2022) also revealed a positive and significant effect of access to electricity on the usage of ICT tools.

The accessibility of digital technologies has a negative effect on the usage of mobile phone, social media, and internet search engines. As accessibility to these tools increase, the likelihood to

use them decreases by 1.037, 1.007, and 0.776 percentage points, respectively. The reason for negative relationship could be other barrier such as literacy, high data costs, or technical difficulties that prevent the farmers from fully adopting these digital marketing technologies. Relevance of the digital marketing tools had a negative effect on social media and internet search engines usage. The negative relationship could be due to limited infrastructure. There may be slow connectivity, expensive to use them as they require data bundles. Farmers may feel using the tools for marketing is not worth the cost.

The affordability of the digital marketing technologies was significant and had a positive effect on mobile phone, social media, and the internet search engines. The results mean that as these digital marketing tools become more affordable, smallholder farmers are likely to use these tools by 1.204, 1.319, and 1.055 percentage points, respectively. The affordability of these digital marketing tools increases their usage since the financial burden of accessing and using them is lowered, making it feasible for smallholder farmers to engage in digital marketing activities.

4.5 Effects of digital technologies on the income of smallholder green leafy vegetable farmers

4.5.2 Determinants of choice of digital technology combinations by smallholder farmers

Table 16: Parameter estimates of alternative digital technology using multinomial logit (first stage)

Variable	M	S	I	MS	MI	MSI
Age	-.0040	-.0215	-.0206	.0085	-.06257	-.0148
	(.0088)	(.0297)	(.0131)	(.0112)	(.0217) ***	(.0161)
Gender	-.2580	.5736	1.248	.788	.3246	-.1799
	(.4069)	(1.593)	(.7407) *	(.6186)	(.8577)	(.6972)
Education	.0964	1.628	.3458	.0006	-.0579	.7537
	(.3580)	(1.324)	(.5024)	(.5109)	(.6795)	(.6880)
Household Size	.0017	2.062	.7836	-.7090	-.6087	1.442
	(.5407)	(2.197)	(.8027)	(.7591)	(.778)	(1.009)
Farm size	-.1899	-.9548	-.1527	.0557	.0859	.0872
	(.2098)	(.6803)	(.3345)	(.2569)	(.2259)	(.2686)
Off-income	.000035	.0001	-5.40e-06	.0000436	.0000285	.0001495
	(.00004)	(.0002)	(.000068)	(.0000589)	(.0000887)	(.0000791)**
Experience	.0037	-.0399	.0014	.0037	.0008559	.0060
	(.0039)	(.0218) *	(.0058)	(.0052)	(.0072899)	(.0069)
Extension	.4300	3.849	1.397	-.4562	1.793	1.360
	(.6138)	(2.249) *	(1.009)	(.8578)	(1.641)	(1.241)
Training	-.2786	-5.279	.2195	3.173	.3390	-1.242
	(.7626)	(2.514) *	(1.158)	(1.300) **	(1.742)	(1.613)
Electricity	.1569268	-.2216	2.016	.2958	.7444	1.015
	(.1987)	(.6380)	(1.088) *	(.3216)	(.5829	(.6266)
Credit	.0676	-.0821	.2063	-.4253	1.150	-1.099
	(.4510)	(1.271)	(.7092)	(.6186)	(1.177)	(.7184)
Accessibility	2.863	-11.85	-1.652	-.7069	3.630	-2.943
	(1.593) *	(6.757) *	(1.781) **	(1.952)	(3.550)	(2.298)

Affordability	.1381	-.4228	.4402	.1874	.2100	.3697
	(.1451)	(.4887)	(.2157)	(.2124)	(.2890)	(.2588)
Relevance	-.3040	6.507	-.2921	-.3795	-.1650	.0493
	(.3215)	(2.901)**	(.4541)	(.3878)	(.4648)	(.4835)
Distance	.03928	-.1173	-.1220	-.0806	.04092	.0528
	(.0538)	(.2854)	(.1240)	(.0983)	(.0780)	(.0793)

***, **, * denotes statistical significance at 1%, 5% and 10% level. **M** mobile phone, **S** social media, **I** internet search engines, **MS** mobile phone social media, **MI** mobile phone internet search engines, **MSI** mobile phone social media internet search engines

Table 16 presents the results from the multinomial logit regression for factors influencing the farmers' decision to use different digital tools. Results suggest that age, gender of the household head, education of the household member, off-income, size of the land, awareness of digital tools, and experience of the household head are some of the factors influencing digital technology usage decisions.

Age had a negative and significant effect on the choice of mobile phone – internet search engine combination at a 1% significance level. An increase in the age of the decision maker by one year decreased the likelihood of choosing mobile phone – internet search engines option by 6%. The results imply that green leafy vegetable farmers were less likely to use internet search engines to market their vegetables because older farmers are more likely to be influenced by traditional habits and tend to be more resistant to new technologies. The results are consistent with that of Okello (2017).

Gender had a positive and significant effect on the choice of internet search engines at a 10% significance level. The results indicate that male-headed households increased the likelihood of choosing to use Internet search engines by 1.24 percentage points. The reason could be that men may have a higher interest or passion for technology-related issues, leading them to be more engaged in exploring and adopting new technologies. Again, the authority of decision-making that men have can influence the adoption of new technologies. The results are in line with that of Wawire *et al.* (2017).

Off-farm income was positive and significant at a 5% significance level for the choice of all three digital tools. The findings imply that the amount of off-income that was received last season increased the likelihood of using digital technologies. This can be attributed to the fact that

farming often requires substantial investments in inputs and technology. Off-farm income can provide farmers with additional financial resources, making it easier for them to afford the costs associated with adopting new technologies. Läpple *et al*. (2015) reported that when farmers have a stable off-farm income, they are better positioned to try new and improved technologies because they have sufficient resources to do so.

Farming experience had a negative and significant effect on the choice of social media at a 10% significance level. The likelihood of choosing social media decreased by 3% with an increase in the number of years of farming. This implies that farmers who are more experienced are less likely to use social media in their agribusinesses because experienced farmers often rely on traditional methods of farming, so they may not see the immediate value of using social media in their agribusinesses. The results conform with those of Wu (2022).

Access to extension services was positive and statistically significant for the choice of social media at a 10% significance level. Contact with extension agents increased the likelihood of choosing social media by 2.25 percentage points. The reason could be that the extension agents are active in providing information on digital technologies. Extension services may help farmers stay updated on the latest digital marketing tools and strategies. Okello (2017) also reported a positive and significant effect of extension contacts on the use of ICT.

Training on digital tools had a negative and significant effect on the choice of social media at a 10% significance level. An increase in training decreases the probability of choosing social media by a proportion of 5.28. Training on the other hand had a positive and significant effect on mobile phone – social media combination at a 5% level. The findings imply that an increase in the number of training increases the likelihood of choosing a mobile phone and social media combination by a proportion of 3.17. Farmers that have received training are far more inclined to accept new technology. This is because training experience is a form of education that allows farmers to comprehend and master the usage and economic worth of new technology while also encouraging farmers to adopt new technology. Wu (2022) reported a positive effect of training experience on the adoption of new technology.

Electricity installation was negative and statistically significant for the choice of internet search engines at a 10% significance level. An increase in electricity installation decreased the probability of choosing internet search engines by a proportion of 2.02. The possible explanation could be that smallholder farmers often face financial constraints, and access to electricity can be

an additional cost. They may prioritize basic needs like food and other farming inputs over internet access, even if they have the infrastructure. Even if electricity is available, farmers may lack the digital literacy skills necessary to effectively use internet search engines.

Accessibility of digital marketing tools had a positive and statistically significant effect on the choice of mobile phones at a 10% level. The accessibility of digital marketing technologies increased the probability of choosing mobile phones by a proportion of 2.87. Making a phone call and SMS does not require expensive device or data plans. Farmers also receive timely information about market prices and best agricultural practices via phone calls and SMS. Okello (2017) reported that mobile phones had a positive effect on the usage of ICT. SMS and phone calls can connect farmers directly to potential buyers or marketplaces, reducing the need for intermediaries.

On the other hand, accessibility of digital marketing tools had a negative and significant effect on the choice of social media and internet search engines at 10% and 5% level, respectively. This implies that an increase in accessibility of digital marketing tools decreased the likelihood of choosing to use social media and internet search engines by a proportion of 11.9 and 1.65, respectively. The reason could be prohibitive data costs, smallholder farmers may find it expensive to access online information regularly. Again, much of the online information is available in major languages which may not be the native language of many farmers, creating a language barrier.

The relevance of the digital tools had a positive and statistically significant effect on the choice of social media at a 5% significance level. An increase in relevance led to an increase in the likelihood of choosing social media by a percentage point of 6.51. The results imply that the farmers consider social media platforms as relevant for marketing their vegetables. Social media facilitates the exchange of market information among farmers and connects farmers to potential buyers. Rabbi *et al.* (2022) reported that farmers can choose the appropriate market for their produce without consulting the intermediaries for information related to price and other related information about the marketing their farm produce through the use of ICT.

Table 17: Average expected income from green leafy vegetables (per season)

		Associated	Not associated	ATT/ATU
M	Associated	21452.38	11097.66	ATT=10354.72*
	Not associated	19727.36	18075.76	ATU=1650.45*
	Heterogeneity effect	BH1=1725.02	BH2=-6978.10	TH=8704.27
S	Associated	20708.33	18312.01	ATT=2396.33*
	Not associated	20196.01	18312.04	ATU=1884.00*
	Heterogeneity effect	BH1=512.32	BH2=-0.03	TH=512.33
I	Associated	17093.22	16518.12	ATT=375.11*
	Not associated	18462.01	18841.25	ATU=-418.36
	Heterogeneity effect	BH1=-1368.79	BH2=-2323.13	TH=793.47
MI	Associated	23100.00	20797.76	ATT=2302.24
	Not associated	17650.97	18026.32	ATU=-402.93
	Heterogeneity effect	BH1=5449.03	BH2=2771.44	TH=2705.17
MSI	Associated	16785.71	8496.29	ATT=8289.43
	Not associated	18234.15	18509.76	ATU=-275.60
	Heterogeneity effect	BH1=-1448.44	BH2=-10013.47	TH=8565.03

***, **, * denotes statistical significance at 1%, 5% and 10% level. **M** mobile phone, **S** social media, **I** internet search engines, **MI** mobile phone internet search engines, **MSI** mobile phone social media internet search engines, not associated with a digital marketing tool DO

The multinomial endogenous switching regression model was used to obtain the expected average income from digital technology adoption for both ATT and ATU impacts (Table 17). According to Table 17, farmers should be classified into two groups: those who use a single digital tool, such as a mobile phone, social media, or internet search engine, and those who use two or three digital tools at the same time. The ATT and ATU were both positive and negative, indicating that depending on the digital marketing technology adopted, some farmers realized

higher income while others realized losses. Farmers significantly increased their income by using one digital tool. ATT was reported among farmers who used one digital tool.

The results revealed that farmers who used mobile phones only significantly realized high income. For instance, farmers received (ATT) KES10,355 per season when they sold their vegetables through mobile phone only. Those who used social media only realized (ATT) KES2,396, and those who used the internet search engines received (ATT) KES375. This implies that using mobile phone is cheaper and does not require technical skills like using the internet and social media. For counterfactual cases, farmers who adopted and used digital technologies would have increased their income and realize losses had they not adopted. The ATU estimates for non-users of digital tools would have increased by (ATU) KES 1,650 had they adopted mobile phones, and (ATU) KES 1,884 had they adopted social media. The findings from two scenarios (ATT and ATU) indicated that farmers obtained a high income while others obtained losses by utilizing the combination of their choice. The ATT and ATU for farmers who chose all the digital tools (MSI) was not statistically significant. In the same way, farmers who chose mobile phone internet search engines (MI) was statistically insignificant.

The actual average treatment effect on the treated (ATT) exceeds the (TH=8,709.27), implying a significant positive effect on the mobile phone usage for those who adopted mobile phone. The heterogeneity effect (TH=512.33) for S is significantly lower than both ATT and ATU, and this suggests that the treatment effect for both treated and untreated is above the heterogeneity effect, implying that the usage of social media has a meaningful and substantial impact on the income of smallholder farmers. The TH=793.47 for I indicates a high degree of variability, meaning that the effect of the treatment is not uniform. The treatment has a positive effect on the treated individuals, while negative effect on the untreated. The TH 2705.17 and TH=8565.03 for MSI and MI combinations, respectively, indicate a substantial variability in the treatment effects across different individuals. Farmers who use MI combination and MSI combination benefit more that those who do not use any of the combinations.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The overall objective of this study was to determine the effect of digital marketing technologies on the marketing of green leafy vegetables among smallholder farmers in Lari sub-County, Kenya. The specific objectives of the study were to identify the digital marketing technologies utilized by smallholder green leafy vegetable farmers, to determine the factors that influence the use of digital marketing technologies in the marketing of green leafy vegetables, and to determine the effect of digital marketing technologies on the income of smallholder green leafy vegetable farmers in Lari sub-County. To achieve these objectives, primary data was collected through the use of a semi-structured questionnaire. The study employed descriptive statistics, a multivariate probit model, and a multinomial endogenous switching regression model to achieve the three objectives respectively.

i. In relation to identifying digital marketing technologies used, mobile phone was the mostly used digital marketing tool, with SMS being utilized by the majority of farmers. Social media was the second utilized, with Facebook being used by majority of farmers, followed by WhatsApp. Internet search engine was the least utilized by farmers with YouTube being the utilized by the majority, followed by Google.
ii. In determining the factors that influence the use of digital technologies, the MVP results showed that education level, access to extension services, electricity installation, credit access and affordability positively influenced the use of mobile phone, social media, and internet search engines in marketing of green leafy vegetables. However, age and accessibility of the digital marketing tools had a negative influence on the use of the Internet in the marketing of green leafy vegetables.
iii. In relation to the effects of digital technologies on income, the findings indicated that gender, off-farm income, access to extension services, digital training, accessibility, and relevance factors positively influenced the probability of farmers' intention to choose digital tool combinations. However, there is still low adoption of digital tools among smallholder farmers. The farmers who are sub-standard (using one or two tools) realized

more income. The highest income was realized by farmers who used only mobile phones. It can be concluded that the use of mobile phones can increase smallholder farmers' income if awareness is raised.

5.2 Recommendations

i. Implementation of training programs for smallholder farmers by the government to improve their digital skills, focusing on how to effectively use the mobile phones for marketing, including social media, and internet search engines.
ii. The development of user-friendly digital marketing tools tailored for smallholder farmers. These could help facilitate market access, allow real-time communication with customers and provide other market information.
iii. The government with the help of extension urgents should implement targeted educational initiatives that focus on digital literacy for smallholder farmers. Expand and enhance agricultural extension services to include training on digital marketing tools.
iv. Investment in public infrastructure will be key in promoting use of these digital marketing technologies for improved farmer welfare.
v. Extension workers should educate farmers how to use mobile analytics tools to gather data on customer preferences and market trends, allowing them to tailor their marketing efforts and maximize sales.

5.3 Areas of Further Research

Further research should be done on the attitudes and perceptions of smallholder farmers towards using digital technologies in marketing and sourcing marketing information. On the other hand, research should be done on the effect of mobile phone applications on the market performance of smallholder farmers.

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APPENDICES

Appendix A: Questionnaire

Introduction

The purpose of this study is to examine the **Effects of Digital Marketing Technologies on The Marketing of Green Leafy Vegetables Among Smallholder Farmers in Lari Sub-County, Kenya**. You have been selected as one of the key stakeholders whom I strongly believe can provide valuable information and support towards achieving the objectives of this research project. Your participation is voluntary and you are assured that the information you provide will be treated with strict confidentiality. The results will be published as a collective analysis without mention of any single individual. I therefore, kindly request you to respond to the queries below.

Questionnaire Identification

Questionnaire Number ……. Ward …….

Date (dd/mm/yy) ……

Name of the Enumerator ……

Name of Respondent ……..

Telephone Number ……..

SECTION A: Demographic Information

A1: Please provide the following details about the household head and household size

Gender	a)Age (years)	b)Highest level of education
1. Male [ ] 2. Female [ ]		1.No formal education [ ] 2.Adult education [ ]

		3.Primary education [ ] 4.Secondary education [ ] 5.University education [ ]

A2: Write number of people living in the household.

Number of people living in the household	Males	Females	Total

SECTION B: Farm resources and characteristics

B1: What kind of enterprises are there in the farm?

Type of enterprise	1.Vegetables	2.Fruits	3.Field crops	4.Aquaculture	5.Livestock	6.Others

B2: What type of green leafy vegetables are you growing and selling?

Type of GLV	1.Spinach	2.Kales	3.Cabbage

B3: How long have you been growing and selling vegetables? ……years

B4: What type of land and total land size in acres do you grow your vegetables?

Type of land	1.Totally owned	2.Renting
Size in acres		

SECTION C: Marketing of green leafy vegetables

C1: How often do you harvest your vegetables?.....(weekly, monthly)

C2: What is the price of each vegetable (in KES/Kg)?.....

C3: What is the state of the road, the distance nearest the market, and how much do you spend if you travel by public transport?

State of the road	1.Tarmac	2.Murrum	3.Gravel	4.Other (specify)
Distance in km				
Transport cost in KES				

C4: What was the estimated amount of income in your farm for the last season (in KES)?

a) From farm production KES …….

b) From off-farm KES……

c) Total income (a + b) KES……

C5: Apart from green leafy vegetable production and selling, which other agribusiness are you engaged in?

Other agribusiness	1.Poultry	2.Fruits	3.Dairy	Others

SECTION D: Digital marketing technology usage by farmers

D1: a) Which digital technologies do you use for marketing your green leafy vegetables?

Digital technologies	Aware of	Use for marketing
1.Mobile phone a) phone calls	[ ]	[ ]

b) text messages	[ ]	[ ]
2.Social-media a)WhatsApp b)Facebook c)Others (specify)	 [ ] [ ]	 [ ] [ ]
3.Internet search engines a)Google search b)YouTube c)Other (specify)	 [ ] [ ]	 [ ] [ ]

a) What type of mobile phone do you own?

1. Smartphone [ ] 2. Non-smartphone [ ]

D2: What kind of market information of vegetables do you access from your digital tool?

	Prices	Quality	Quantities	Where to sell (place)	Whom to sell to (customers)	Others
1. Mobile phone						
2. Social-media						
3.Internet						

D3: a) How much in (KES) do you receive if you sell your vegetables through middlemen?

……..

a) How much in (KES) do you receive if you sell your vegetables through digital technologies (mobile phone, social media, internet)?.....

D4: In your own opinion, do you think the information provided by digital tools helps in improving the performance of your agribusiness?

1. Yes [ ] 2. No [ ]

Explain……

……..……

…….

……..

D5: a) How would you rate the accessibility to these digital tools. Tick the appropriate answer.

	1.Not accessible	2.Slightly accessible	3.Moderately accessible	4.Very accessible
Mobile phone				
Social media				
Internet				

b) How would you rate the affordability of these digital tools?

	1.Not affordable	2.Slightly affordable	3.Moderately affordable	4.Very affordable
Mobile phone				
Social media				
Internet				

SECTION E: Access to Credit and source of Credit

E1: Do you have access and use to mobile bank account credit facilities? (If no skip to section F)

1. Yes [ ] 2. No [ ]

b) Have you ever borrowed money using your mobile phone for the farming business?

1.Yes [ ] 2.No [ ]

c) If yes, tick under the name of the source of the credit.

Sources of credit:	1.Mshwari	2.Equitel	3.KCB mobile money	4.Others (specify)

SECTION F: Access to extension services

F1: a) Did you receive extension services in the farm last year? [If no skip to G1]

1. Yes [ ] 2. No [ ]

b) How many times in the last one year and from which extension providers?

Extension agent	1.Government Extension Officers	2. Private extension agents	3. NGOs	4. Others
Number of visits				

c)What is the distance from your resident to the nearest extension agent?

Distance in Kilometers…….

d)Have you ever received any formal training to use of any digital tools in your agribusiness?

1.Yes [ ] 2. No [ ]

If yes, did it influence your decision to adopt usage of digital technologies in your agricultural transactions?

1.Yes [ ] 2.No [ ]

Explain……

……

……..

e) Do you know how to operate these digital tools (Mobile phones, Social-media and Internet)?

1. Yes [ ] 2. No [ ]

f) In your own opinion, do you think these digital tools (Mobile phones, Social-media and The Internet) are affordable to farmers in your area?

1. Yes [ ] 2. No [ ]

Explain……

SECTION G: Access to Electricity

G1: a) Do you have access to electricity in your farm?

1.Yes [ ] 2. No [ ]

b) Do you think access to electricity has contributed to the use digital technologies tools in your agribusiness?

1.Yes [ ] 2. No [ ]

Explain……

THANK YOU FOR YOUR PARTICIPATION!!!

Appendix B: Research Permit

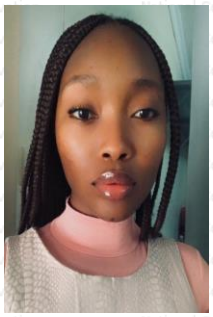
REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **828278**

Date of Issue: **15/June/2023**

RESEARCH LICENSE



This is to Certify that Miss.. MATHAPELO ELIZABETH MOLAPO of Egerton University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Kiambu on the topic: EFFECTS OF DIGITAL TECHNOLOGIES ON THE MARKETING OF GREEN LEAFY VEGETABLES AMONG SMALLHOLDER FARMERS IN LARI SUB-COUNTY, KENYA. for the period ending : 15/June/2024.

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2. The research and its related activities as well as outcomes shall be beneficial to the country and shall not in any way; i. Endanger national security
    ii. Adversely affect the lives of Kenyans
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14. The Commission shall have powers to acquire from any person the right in, or to, any scientific innovation, invention or patent of strategic importance to the country.
15. Relevant Institutional Scientific and Ethical Review Committee shall monitor and evaluate the research periodically, and make a report of its findings to the Commission for necessary action.

National Commission for Science, Technology and
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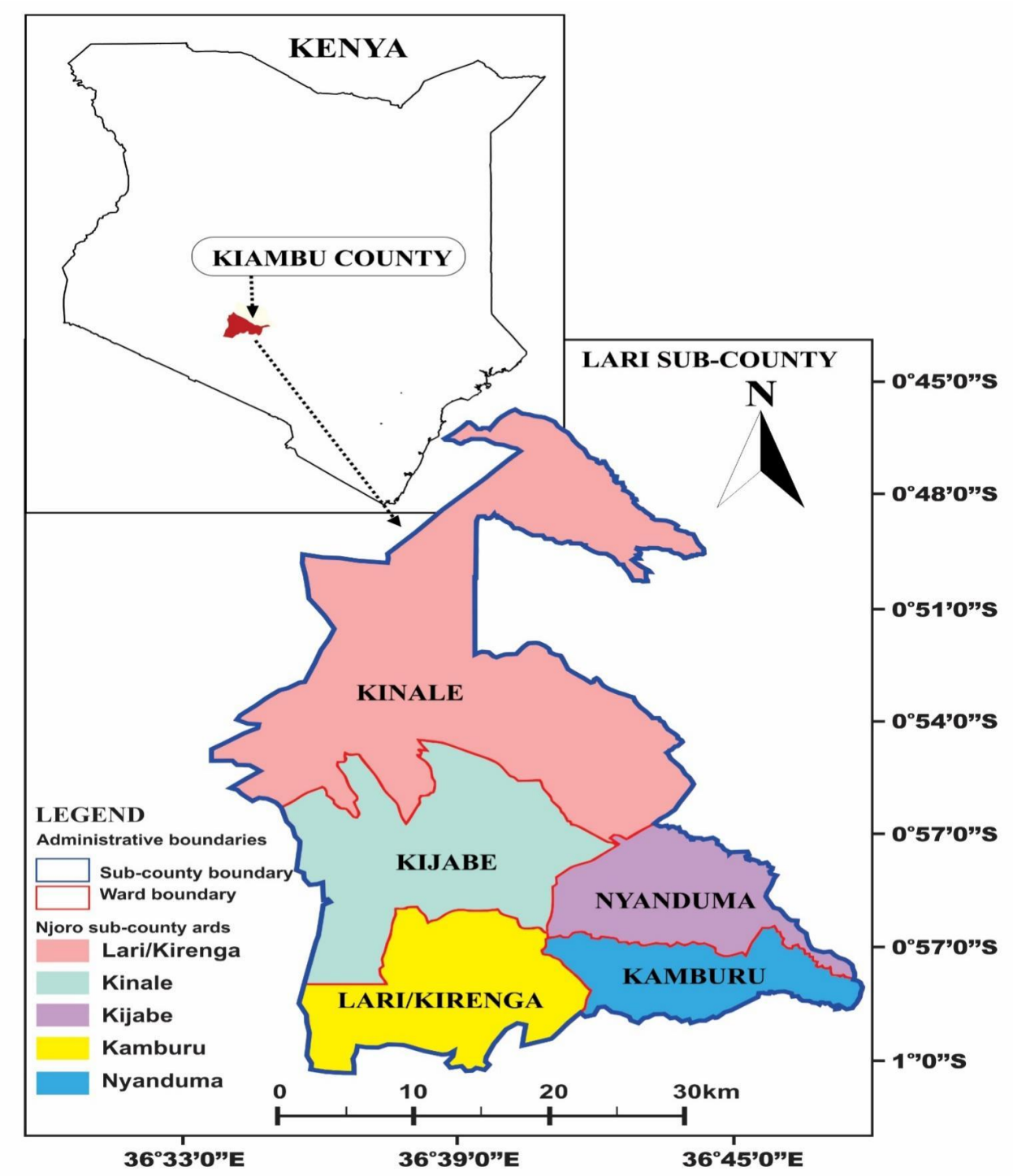
Website: www.nacosti.go.ke

Appendix C: The Map of Lari Sub-County



Map of Lari Sub-County

Appendix D: Multivariate probit regression results

```
vif
```

Variable	VIF	1/VIF
Train	2.45	0.408100
off_incm	2.13	0.469961
relevance	1.89	0.528956
Accessi	1.71	0.583272
Afford	1.70	0.586658
Extacc	1.49	0.670191
edu	1.40	0.715571
Elect1	1.30	0.766751
credit1	1.15	0.866324
distanc	1.13	0.887679
agesq	1.07	0.935276
HHsize	1.06	0.943652
llandsize	1.04	0.958890
gender1	1.02	0.981677
expsq	1.01	0.986681
Mean VIF	1.44	

```
. hettest

Breusch-Pagan/Cook-Weisberg test for heteroskedasticity
Assumption: Normal error terms
Variable: Fitted values of agriz_phoneusage2

H0: Constant variance

    chi2(1) =  46.53
Prob > chi2 = 0.0000
```

. pwcorr gender1 Extacc Train credit1 Elect1

	gender1	Extacc	Train	credit1	Elect1
gender1	1.0000				
Extacc	-0.0375	1.0000			
Train	0.0356	0.3738	1.0000		
credit1	0.0550	0.1422	0.1299	1.0000	
Elect1	-0.0302	0.2569	0.1824	0.2237	1.0000

3) **residuals are normally distributed**	**Shapiro-Wilk W normality test** z: 2.198 p-value: 0.014	**> 0.01**
4) **no specification problem**	**Linktest** t: -4.880 p-value: 0.000	**> 0.05**

Multivariate probit (MSL, # draws = 5)

Log pseudolikelihood = -378.45977

Number of obs	374
Wald chi2(45)	368.28
Prob > chi2	0.0000

	Coefficient	Robust std. err.	z	P>|z|	[95% conf.	interval]
agriz_phoneusage2						
agesq	-.0014229	.0033732	-0.42	0.673	-.0080344	.0051885
gender1	-.7156577	.1880023	-3.81	0.000	-1.084135	-.3471799
edu	.1260463	.0408217	3.09	0.002	.0460372	.2060555
HHsize	.1049237	.0455825	2.30	0.021	.0155838	.1942637
llandsize	.1059429	.0993858	1.07	0.286	-.0888497	.3007356
off_incm	-.0000242	.0000194	-1.25	0.212	-.0000622	.0000138
expsq	-.0002298	.0017894	-0.13	0.898	-.0037369	.0032774
Extacc	.8970488	.2142578	4.19	0.000	.4771112	1.316986
Train	.0264383	.0551609	0.48	0.632	-.0816749	.1345516
Elect1	.7944904	.2113175	3.76	0.000	.3803158	1.208665
credit1	.6405398	.1912199	3.35	0.001	.2657556	1.015324
Afford	1.204063	.2487281	4.84	0.000	.7165653	1.691561
relevance	-.1081544	.1093282	-0.99	0.323	-.3224337	.1061249
distanc	.0152263	.0243558	0.63	0.532	-.0325102	.0629628
Accessi	-1.03736	.2981448	-3.48	0.001	-1.621713	-.4530069
_cons	-3.866769	.7178207	-5.39	0.000	-5.273672	-2.459867
agribiz_socialmediausage2						
agesq	-.0014315	.0034188	-0.42	0.675	-.0081322	.0052692
gender1	-.3017804	.1743357	-1.73	0.083	-.6434721	.0399112
edu	.1866466	.0477263	3.91	0.000	.0931047	.2801885

agribiz_socialmediausage2						
agesq	-.0014315	.0034188	-0.42	0.675	-.0081322	.0052692
gender1	-.3017804	.1743357	-1.73	0.083	-.6434721	.0399112
edu	.1866466	.0477263	3.91	0.000	.0931047	.2801885
HHsize	.1044188	.0379933	2.75	0.006	.0299533	.1788844
llandsize	-.113668	.0747377	-1.52	0.128	-.2601513	.0328153
off_incm	-.0000151	.0000166	-0.92	0.360	-.0000476	.0000173
expsq	.0004	.0016289	0.25	0.806	-.0027925	.0035925
Extacc	.5597057	.2044929	2.74	0.006	.158907	.9605044
Train	.0011123	.0598559	0.02	0.985	-.1162031	.1184276
Elect1	.5110602	.2015413	2.54	0.011	.1160464	.9060739
credit1	.7985523	.1942572	4.11	0.000	.4178151	1.179289
Afford	1.318588	.2341296	5.63	0.000	.8597023	1.777473
relevance	-.1843157	.1045964	-1.76	0.078	-.389321	.0206895
distanc	-.0085518	.0183233	-0.47	0.641	-.0444649	.0273613
Accessi	-1.006745	.2557842	-3.94	0.000	-1.508073	-.5054172
_cons	-5.777008	.6616966	-8.73	0.000	-7.073909	-4.480106
agribiz_internetusage2						
agesq	-.0090099	.0032001	-2.82	0.005	-.015282	-.0027379
gender1	-.3357118	.1650866	-2.03	0.042	-.6592756	-.012148
edu	.1883647	.0502363	3.75	0.000	.0899034	.286826
HHsize	.1067547	.0392127	2.72	0.006	.0298992	.1836102
llandsize	-.0804516	.05427	-1.48	0.138	-.1868187	.0259156
off_incm	-.0000167	.0000149	-1.13	0.260	-.0000459	.0000124
expsq	-.0029473	.0016872	-1.75	0.081	-.006254	.0003595
Extacc	.6220926	.1983499	3.14	0.002	.2333339	1.010851
Train	.0634707	.0608885	1.04	0.297	-.0558685	.1828099
Elect1	.2852077	.1918209	1.49	0.137	-.0907543	.6611697

Appendix E: List of Publications

Academic Paper Acceptance Letter
DOI of the journal: 10.7176/JBAH

Dear Mathapelo Elizabeth Molapo, Patience Mshenga, Mary Mathenge,

It's my pleasure to inform you that, after the peer review, your paper,

FACTORS INFLUENCING THE USE OF DIGITAL MARKETING TECHNOLOGIES IN THE MARKETING OF GREEN LEAFY VEGETABLES AMONG SMALLHOLDER FARMERS IN LARI SUB-COUNTY, KENYA

has been ACCEPTED with content unaltered to publish with **Journal of Biology, Agriculture and Healthcare,** ISSN (Paper)2224-3208 ISSN (Online)2225-093X.

In order to fit into the publishing and printing schedule, please re-submit your complete publication package by directly replying this acceptance email within 15 days so we can make your article available online/print in the next issue (usually at the end of each month) . If you failed to prepare your complete files on time, the publication of your article might be delayed.

Though the reviewers of the journal already confirmed the quality of your paper's current version, you can still add content to it, such as solidifying the literature review, adding more content in the conclusion, giving more information on your analytical process and giving acknowledgement.

To help the editor of the journal process your final paper quickly, you need to prepare your paper based on the attached "publication_package_instruction.pdf".

Again, thank you for working with IISTE. I believe that our collaboration will help to accelerate the global knowledge creation and sharing one step further. IISTE looks forward to your final publication package. Please do not hesitate to contact me if you have any further questions.

Sincerely,

Alexander Decker,

Adecker

November 5, 2024

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Academic Paper Acceptance Letter
DOI of the journal: 10.7176/JBAH

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- Aristotle University of Thessaloniki, Greece
- Universiteit Leiden, Netherlands