Factors Influencing the use of Digital Technologies in the Marketing of Green Leafy Vegetables Among Smallholder Farmers in Lari Sub-County, Kenya

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Abstract

Smallholder farmers in emerging economies have long faced information asymmetry difficulties. To this day, the bulk of agricultural-related information is still conveyed by word of mouth, extension workers, or traditional broadcast strategies. Nonetheless, such information is often released irregularly and for a limited number of markets, leaving the vast majority ignored. As a result, market information becomes available to fewer individuals. Farmers decide to sell their produce through middlemen at relatively low prices, resulting in insufficient profits. Numerous studies have shown that digital technologies in agriculture are an important tool for farmers to be active participants in profitable markets by improving their access to timely and relevant market information. Despite the rapid expansion of digital technology in emerging nations' agricultural sectors, adoption of such technologies in rural areas remains low. The purpose of this study was to identify the characteristics that influence smallholder farmers' usage of digital technology in the selling of green leafy vegetables in Lari sub-County, Kenya. The study specifically attempted to determine the socioeconomic, institutional, and technological factors that influence smallholder farmers' usage of digital technology. A descriptive survey research design was used. A multistage sampling procedure was used to select 376 green leafy vegetable farmers. The semi-structured questionnaire was employed to collect data. A multivariate probit model was used to analyze the data. The results show that years of education positively influenced the use of social media in marketing, household size positively influenced the use of mobile phones and social media, and access to electricity positively influenced the use of mobile phones and the internet. Age had a negative influence on the use of the Internet in the marketing of green leafy vegetables. The adoption of digital technologies in the marketing of vegetables can be influenced by several factors. Therefore, the County Government through extension officers can provide training and education to smallholder farmers on how to use digital technologies effectively for marketing.

Keywords: Agricultural; mobile phone; social media; internet; information; socioeconomic

INTRODUCTION

The agricultural sector remains important for poverty reduction and contributes significantly to the majority of developing countries' economic growth (Eskia, 2019). This sector, which comprises countless small-scale farmers who generate over 80% of the food consumed in developing countries, also provides most rural households with either permanent or temporary employment. According to FAO (2022), Kenya's agriculture industry contributes around 33% of the country's GDP directly and another 27% indirectly through linkages with various other sectors. The subsector that exports the most is horticulture, and its growth continues to be key to the nation's economy. Cut flowers account for 70.3%, vegetables 18.1%, and fruits 11.7%

of the total horticulture export earnings in Kenya, making it the fastest-growing subsector of the country's economy (KNBS, 2022).

Kiambu County is one of the counties where horticulture farming is developing as a viable commercial enterprise. The sub-sector is crucial to the county's economic development (Kiambu-County-ADP, 2016) as vegetables are considered high-value crops because of their health benefits. The growth of the subsector is being driven by the increased nutritional value and health consciousness of consumers, notably for fruits and vegetables. French beans, snow peas, kale, cabbage, garden peas, tomatoes, spinach, and carrots are just a few of the popular vegetables grown in Kiambu. In 2022, exotic vegetables contributed 42.4 percent to the domestic value of horticulture in Kiambu. The area, production, and value were 158,567 Ha, 3.1 million tons valued at KES 72.65 billion respectively (AFA, 2022).

Spinach, kale, and cabbage are among the exotic vegetables that the majority of smallholder farmers in Lari Sub-County produce and market. The year-round rainfall and consistent low temperatures are favorable for vegetable growing. Vegetables, however, are prone to spoilage (Pokhrel, 2021). It is risky to handle large quantities of vegetables at the outdoor market, especially if growers lack refrigeration to keep excess produce. Consequently, they are unable to market their farm produce directly even though there is a ready urban market in Kiambu, Nakuru, Nairobi, and Mombasa (Kiambu-County ADP, 2016). Therefore, farmers are dependent on market intermediaries who buy their goods for less than market value. Inaccurate second-hand pricing information and a lack of market knowledge have major consequences for agricultural producers Deichman *et al.* (2016). Farmers risk having their produce wither away, being delivered insufficiently or excessively, or underselling their goods.

Market information asymmetry leads to substantial losses in profits (Zodidi, 2022). The use of digital technology would thus go a long way in bridging the market information gap between farmers and consumers (Jerome, 2017). According to Nwafor *et al.* (2020) and Okello *et al.* (2020), digital technologies are thought to have a significant impact on closing the information gap between farmers and markets. In Sub-Saharan Africa, Kenya has become a leader in information and communication technologies (ICT) (Baumüller, 2016). Kenyan farmers may get market and agricultural information on social media platforms including Mkulima Hub Kenya, Digital Farmers Kenya, and Mkulima Young (Kipkurgat *et al.,* 2016). Through social media platforms, farmers may exchange information and communicate with one another (Akashraj & Pushpa, 2014). Social media sites include Facebook, LinkedIn, Twitter, Instagram, and WhatsApp, to name a few.

ICT, such as the Internet for marketing, internet for information awareness, mobile application services, telephone communication, SMS services, radio broadcasting, and TV broadcasting are available in Kiambu County (Warwimbo, 2017). Despite this, most farmers have not fully embraced these new technologies hence they continue to lack full access to market information, impacting negatively their agribusinesses. It is however not clear why the uptake of these technologies remains low. This study therefore seeks to investigate factors that affect the use of mobile phones, social media, and the internet in the marketing of green leafy vegetables among smallholder farmers in Lari sub-County.

1. Literature Review

There are a variety of factors that can influence the use digital technologies by smallholder farmers (Jha *et al.*, 2019). These factors can be classified into categories, (i) farmers' characteristics; (ii) farm characteristics; (iii) technology characteristics; (iv) institutional factors; and (v) finance. They have direct and indirect relationships and influence the use of digital technologies either positively or negatively. Age, gender, and family income are just a few examples of the socioeconomic factors of smallholder farmers that have influenced how they utilize ICT, (Bryan & El Didi, 2019). However, Kante *et al.* (2016) pointed out that ICT's relative benefit, simplicity, compatibility, and observability also have an impact on smallholders' employment of the technology. According to Titilope (2020), smallholder farmers' slow adoption of ICTs may be caused by a variety of factors, including their poor income (or lack thereof), a lack of ICT infrastructure, their state of health, cultural differences, and other factors. Eskia (2019) and Nwafor (2020) claim that the poor adoption of ICTs among smallholder farmers is also a result of a lack of ICT awareness. According to Abebe and Mammo-Cherinet (2019), the key issues influencing smallholder usage of ICTs include limited energy supply, literacy, knowledge, and skills for running ICT applications.

The study conducted by Anthony revealed that the age of the household had a negative influence on the use of income. The implication is that relative to younger household heads, the older ones were less likely to use the internet. Ma *et al.* (2018) also pointed out that the authors argued that young people preferred to possess smartphones compared to older people. Okello (2017) stated that young farmers tend to be innovative and risk-takers and thus would try technologies more than older household heads. Older adopters of technology are usually slower at learning particularly if technology is relatively new.

Murage *et al.* (2015) found that male farmers adopt technology faster than female farmers. Therefore, men have more and easier access to ICT and more readily adopt technology. gender is an important variable in the adoption of innovations. When it comes to choosing which technology to use, the preferences of men and women differ. On the other hand, A big household size was often linked to a favorable effect on ICT use than a smaller household size, according to a study done by Sabuhoro *et al*. (2003) on factors that influence the use of computers by agribusiness owners in South Africa.

According to the reviewed publications, the education level of African smallholder farmers had a beneficial effect on their rate of technology adoption (Oyinbo et al., 2019). Smallholder farmers with some type of formal or informal education embrace new technology faster than illiterate smallholder farmers (Chirwa, 2005; Kassie *et al.*, 2015). Anthony *et al.* (2020) discovered that the off-farm job coefficient was positive and significant, indicating that families with an off-farm income used the Internet more than their counterparts. Off-farm income enabled farmers to acquire new technology like cell phones, which may improve their internet use.

Numerous studies have been undertaken on the usage, effect, adoption, and dissemination of digital technology by smallholder farmers, according to a review of the literature that is currently available. Researchers have attempted to determine the factors that affect smallholder farmers' usage of digital technology. The use of digital technology by smallholder farmers is still lower than anticipated, according to several prior researches. The poor uptake of digital technologies by smallholder farmers has been attributed to a number of challenges, including

a lack of awareness about digital technology, a lack of assistance from the government, a lack of digital infrastructure, a lack of help from banks, and problems with management. However, research on the use of digital technology by rural smallholder farmers in developing countries has been extremely limited. The preceding literature also reveals that there has been no major research on the use of digital technology by smallholder farmers of green leafy vegetables in Lari sub-County, even though such farmers are regarded as a productive basis of the Lari sub-County economy. As a result, this study has been conducted to bridge the gap.

2. Materials and methods

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.

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.

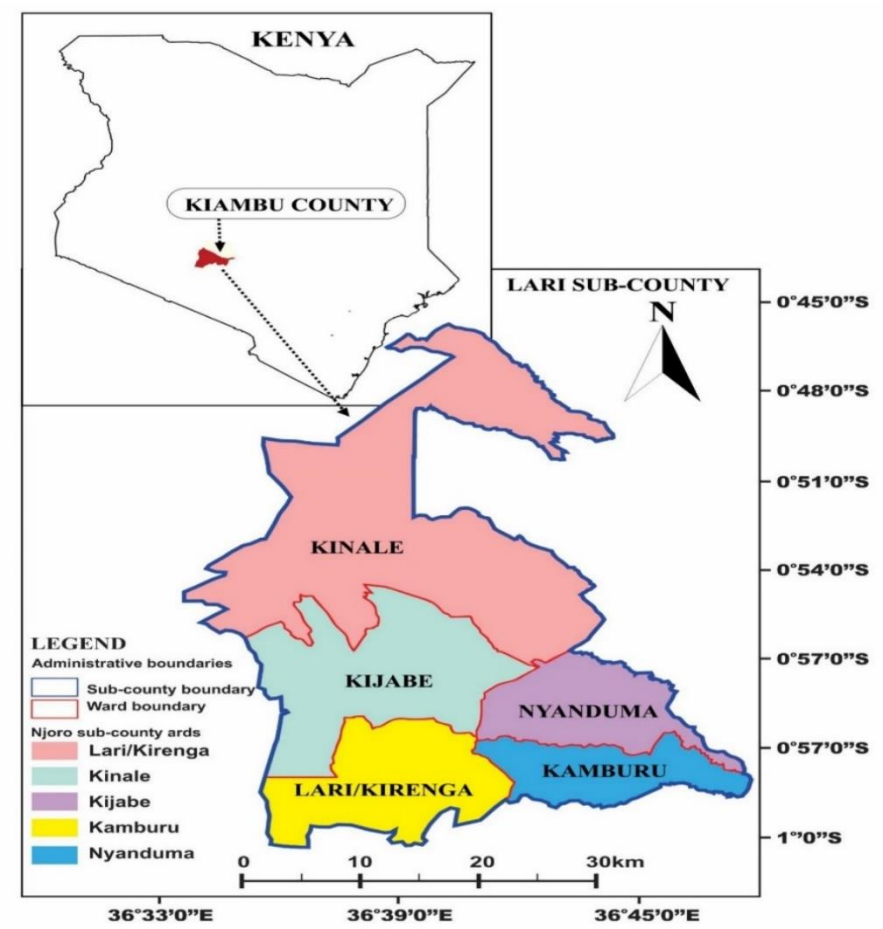

Figure 10. Map of Lari Sub-County, **Source:** IEBC (2022)

This study used descriptive 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. A sampling frame was a list of 376 smallholder green leafy vegetable farmers. 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 this study was obtained from Lari Sub-county agricultural extension officer**.**

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. 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, the majority of farmers in the sub-county own mobile phones, they have internet access, and social media platforms. Lastly, systematic sampling was employed to select the respondents from the five wards (Lari/Kirenga, Kinale, Kijabe, Kamburu, and Nyanduma) in the sub-county.

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;

$$n = \frac{Z^2 pq}{e^2} \quad \text{.....1}$$

$$n = \frac{1.96 \times 1.96 \times 0.5 \times 0.5}{0.05 \times 0.05} = 384$$

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 14: 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**

Data was collected using a structured questionnaire. Piloting was conducted in Limuru, Limuru Central ward, to test for the validity and reliability of the tool. Data was organized into various categories, which are distinct from each other through coding, the data was then analyzed using SPPS version 29 and STATA version 17.

The objective of the study was to provide empirical evidence on the factors that influence the use digital technologies on the marketing of green leafy vegetables among smallholder farmers in Lari sub-County. The empirical specification of choice decision over the three digital tools can be modeled by either multinomial or multivariate regression analysis. However, the choices among the digital tools are not mutually exclusive as farmers are accessing information and use more than one digital tool at the same time and therefore the random error components of the information sources may be correlated. MVP was thus used to analyze the data. 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 to be correlated (Lin *et al.,* 2005). This model would allow possible contemporaneous correlation in the choice to use the three digital tools simultaneously.

Empirically the model can be specified as follows

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

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

$$Y_{i3} = X_{ij3}\beta_3 + \varepsilon_{i3}$$

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 access agricultural information, marketing produce, and mobile financial services (0 = otherwise), X_i = Vector of factors affecting use of digital technology tools, β_j = Vector of unknown parameters (j = 1, 2, 3), and ε = the error term. Factors influencing the use of digital 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 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.

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

where Y_{ij} (j =1….,3) represents the three different digital 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 15: Description and expected signs of the variables of hypothesized dependent and independent variables in the usage of digital technologies

List of variables	Description	Measurement	Expected signs
Dependent			
Usage of digital tool	Usage of digital tools to market and access information.	0 = Use mobile phone, 1 = Use social media, 2= Use the internet,	
Independent			
Age	Age of respondent	Continuous	+/-
Gender	Gender of respondent	Dummy 1=male, 0=female	+/-
Education	Education level	Continuous	+
Experience	Level of experience	Continuous	+
Household size	Household members	Continuous	+/-
Farm size	Size of the land	Continuous	+/-
Off-farm	Total off-farm income	Continuous	+
Awareness Level	Awareness of digital tool	Dummy 0 = aware of mobile phone, 1 = aware of social media, 2 = aware of the internet,	+
Access to Extension	Access to extension services	Dummy 1=yes, 0=no	+
Access to credit	Access to credit	Dummy 1=yes, 0=no	+
Distance	Distance to output Market (km)	Continuous	+/-
Access to electricity	Access to electricity	Dummy 1=yes, 0=no	+
Digital training	Training on digital technologies	Dummy 1=yes. 0=no	+
Relevance	Relevance of digital tool	Likert 1 = SD, 2 = D, 3 = N, 4 = A, 5 = SA	+/-
Accessibility	Accessibility of digital tool	Likert 1 = SD, 2 = D, 3 = N, 4 = A, 5 = SA	+/-
Affordability	Affordability of digital tool	Likert 1 = SD, 2 = D, 3 = N, 4 = A, 5 = SA	+/-

SD =strongly disagree: D = disagree: N= neutral: A =agree: SA =strongly agree

3.0 Results and Discussion

3.1 Socioeconomics and Institutional Characteristics of the Farmers

3.1.1 Farm and Farmers Characteristics

Table 3: Socioeconomic characteristics of the farmers

Characteristics	Description	Frequency	Percentage (%)
Gender	Female	145	38.56
	Male	230	61.17
Education	Adult Education	5	1.33
	No Formal Education	8	2.13
	Primary Education	151	40.43

Secondary Education	168	44.68
College Education	33	8.78
University	9	2.38

The results from Table 3 show that there are more male than female green leafy vegetable farmers in Lari. This means that more men are involved in farming activities. These findings are consistent with Chikaire *et al.* (2017) who found that males dominated farming and agriculture in general since they largely own the land and the decision-makers within the families. According to Sebotsa (2021), men are still more interested in engaging in agriculture using modern technologies than their female counterparts, which may explain the observed gender disparity.

The results on the education level of green leafy vegetable farmers indicate a variance in levels of education with a majority of farmers having secondary and primary levels of education. The majority of farmers had reached at least a secondary level, meaning that more educated farmers are engaging in agricultural activities and that they could be able to comprehend the value of utilizing modern agricultural technologies. These findings agree with Luqman *et al.* (2019), that smallholder farmers had access to literacy made it simple for them to comprehend agricultural information and implement modern farming methods targeted at increasing farm output. This implies that farmers are able to utilize the latest technology and evaluate information about their farms.

Table 4: Mean of the Socioeconomic Characteristics

Characteristics	**Mean Value**	**Std. Dev.**
Age	47.851	13.222
Household Size	6.495	2.430
Farming Experience	7.516	5.295
(Years)	0.5	1.178
Farm Size (Acres)	7,350	6035.13
Off-Farm Income (KES)		

According to the findings, the mean age of respondents was 48 years, which suggests that more young farmers are green leafy vegetable farmers, and they use modern technologies. The findings are in line with those of Okello (2017), who discovered that younger individuals were engaged in farming and used ICT in the best way possible in their agribusinesses. Younger farmers are potentially more innovative and risk-takers than older household heads, making them more inclined to explore new technology.

The survey's findings indicated that there are at least six people living in the household. According to Mdoda (2017), a household is more likely to engage in farming activities the larger it is since it is constantly trying to improve the amount of food available. The size of the household contributes to farm labor and supports the efforts of the household leader (Martey *et al.,* 2013). The availability of family labor enables the household head to divide his or her duties and free up time for other beneficial activities.

According to the findings, an average household marketing experience was at least 7 years. This indicates that the study area's farmers are capable of making sound decisions about marketing. 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 average size of the land owned by the farmers was 0.5 acres. The results imply that majority of the farmers operate on small scale land. Farm size is a critical agricultural asset which have a bearing on production of a marketable surplus. Zodidi (2022) noted that farming households do farming on a relatively large land size; therefore, they could potentially produce for the markets and realize gains from trade.

The mean seasonal off-farm income of the households was KES7,350. Off-farm income is essential for the financial security of the smallholder farmers. Off-income can enable farmers to invest in technologies that facilitate access to market information, such as smartphones, and internet services. The higher the income of the farmer, the more likely he would seek and obtain information for use (Okello, 2017).

Farmers' Institutional Factors

Table 5: Institutional factors affecting the vegetable farmers

Characteristics	Description	Frequency	Percentage (%)
Access to Credit	Yes	167	75.23
	No	54	24.32
Extension Services	Yes	47	12.50
	No	328	87.23
Access to Electricity	Yes	333	88.56
	No	42	11.17
Digital Training	Yes	108	32.71
	No	253	67.29
		Mean	**Std. Dev.**
Distance (KM)		15.85	5.491

The results showed that majority of smallholder farmers had access to credit, while 24% did not have access to credit. This suggests that the households are able to acquire the agribusinesses' essential inputs, as well as bundles that enable them to utilize their digital tools. However, according to Zodidi (2022), most farmers who may obtain finance do so through informal institutions since smallholder farmers do not meet the criteria for formal financial institutions, which demand substantial collateral.

Additionally, the findings indicated that a larger percentage of smallholder farmers lacked access to extension services. This suggests that many smallholder farmers are unaware of new information and technology, as well as its advantages for agribusiness and product marketing. The findings are in contrast with those of Adejuwon (2018) and Oyinbo *et al.* (2019), who found that the majority of smallholder farmers had access to extension services. Farmers who use technology can access the agricultural knowledge they need through extension programs.

The availability of electricity is crucial for using digital equipment. The findings indicate that whereas a few percent of the respondents lacked access to electricity, the majority of respondents had electricity installed in their homes. The majority of digital technologies require power to function, hence access to electricity in homes is necessary for efficient use of these technologies. The findings are consistent with those of Okello (2019), who found that 70% of respondents had access to electricity, with TV viewers having the greatest accessibility. The

success of smallholder farmers' agribusinesses can be aided by training in digital technologies since it can teach them how to operate and use digital tools efficiently. 67.29% of the respondents said they had no prior exposure to digital technology, compared to 32.71% who had.

Distance between the home and the output market is frequently used as a stand-in for market accessibility and, consequently, transaction cost. The average household's travel distance to the output market was 15.85 kilometers. As households go further from the marketplace for their products, they utilize digital tools more frequently. These findings are consistent with those of Sekabira (2012), who discovered that families with limited access to agricultural markets because of distance and transportation costs have accepted the use of digital technologies.

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

Table 4 presents the results of factors influencing the use of digital technologies in the marketing of green leafy vegetables from a multivariate probit model.

Table 4: Multivariate probit results for factors influencing the use of digital technologies

Variable	Mobile phone		Social media		Internet	
	Coef.	Std. Err	Coef.	Std. Err	Coef.	Std. Err
Age	-0.007*	0.004	-0.005	0.005	-0.010**	0.004
Gender	-0.263	0.198	0.014	0.205	0.102	0.193
Education	0.120	0.169	0.436***	0.170	-0.008	0.166
Household size	0.519**	0.245	0.497**	0.248	0.227	0.202
Land size	-0.099	0.067	-0.033	0.055	0.012	0.047
Off-income	0.000	0.000	0.000	0.000	0.000	0.000
Awareness	-0.116	0.308	-0.138	0.295	0.034	0.293
Experience	0.001	0.002	0.005	0.004	0.000	0.002
Extension	0.101	0.288	0.523*	0.281	1.273***	0.299
Training	-0.011	0.362	0.003	0.377	-0.254	0.340
Electricity	0.298***	0.111	0.098	0.110	0.480***	0.110
Distance	0.020	0.028	-0.004	0.026	-0.003	0.029
Accessibility	0.395	0.602	-0.655	0.610	-1.835***	0.687
Affordability	0.075	0.067	0.120	0.075	0.212***	0.071
Relevance	-0.073	0.143	0.019	0.126	0.087	0.132
Constant	-1.806	1.099	-4.386	1.200	-3.562	0.944
Number of Observations 375						
L. R. test of rho21 = rho31 = rho32 = 0: 0 $\chi2(3)$ =108.175 Prob > $\chi2$=0.0000						
Wald χ^2 (3) = 206.84 Prob > $\chi2$ = 0.0000						

The use of mobile phones and the internet was negatively impacted by the age of the household head, with each additional year decreasing usage by 0.7% and 1%, respectively. According to these results, households are less likely to utilize their mobile phones or the internet as sources of marketing and accessing market information as the household head grows older. Older household heads may be less likely to utilize modern digital tools like internet search engines since they may have grown up with less exposure to modern technologies. Once again, elderly

farmers may be less flexible, prefer traditional marketing strategies, and place a high value on traditional knowledge. The findings are consistent with those of Katunyo *et al.* (2018) and Mdoda & Mdiya (2022), who discovered that age had a negative effect on farmers' use of ICT. However, Zodidi (2022) found that age had a positive effect on the use of ICT, and concluded that the older the farmer, the more likely he/she is to use ICTs for accessing market information.

The household head's education level had a positive and significant impact on the utilization of social media as a source of market information and marketing strategy. This implies that with the additional year of schooling, the use of social media increased by 0.44 percentage points. The results show that exposure to education helps a single farmer to use social media platforms to successfully sell their products and build the capacity to retain and retrieve information relating to social media usage. Individual farmers may better themselves via education by learning how to look for and apply new information on improved farming practices and strategies for marketing. Farmers who have received an education are capable of reading and understanding content on social media sites. The findings are consistent with those of Okello (2017), who found that education significantly influenced the use of ICT tools.

The use of mobile phones (calls and SMS) and social media was significantly and positively influenced by household size. This suggests that the chance of using mobile phones and social media will increase by 51.9% and 49.7%, respectively, as household size increases. This could be due to the diverse skill sets in the families. The larger families often have members with diverse skills and interests. Some members can handle social media accounts efficiently, leading to more active online presence for the farm activities. In an effort to produce more, people may utilize their mobile devices and social media platforms to look up agricultural information. Once more, the demand for increased market communication, access to market information, and access to dependable marketplaces for the products may be the driving force for the use of social media and mobile phones in households with multiple members. Farmers who come from large families have an advantage since they may utilize some of their relatives to educate them on how to use technology. The results concur with Mdoda and Mdiya (2022) findings, which indicated that family size had a positive and significant effect on ICT usage.

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. Internet search engine and social media usage will rise by 0.52 and 1.27 percentage points, respectively, for every additional extension service. By encouraging farmers to share their thoughts and experiences and by lowering the cost of knowledge acquisition, extension workers promote innovation. The findings are in line with Tambo *et al.* (2019), who found that access to extension services is crucial for increasing productivity and applying innovation to the farm.

Access to electricity had a positive and significant effect on mobile phone and internet search engine usage. The findings show that families with electricity had a greater probability of using mobile phones and the internet by 0.3 and 0.48 percentage points, respectively. Electricity is needed for mobile phones, therefore having access to it would ensure their efficient operation. The results are consistent with those of Okello (2017), who found a positive correlation between mobile phone use and electricity installation. Nwafor *et al.* (2020) also revealed that an inadequate electricity supply decreases the farmers' marginal use of ICTs.

The accessibility of information through digital tools had a negative and significant effect on internet search engines at a 1% significance level. The likelihood of utilizing internet search engines declined by a proportion of 1.84 as information became more readily accessible.

Farmers may have trouble using search engines and navigating the internet successfully because they lack digital literacy, which might be the cause of this. The impact of accessibility on mobile phones, however, was positive and significant, according to the findings of Okello (2017).

3. Conclusions and Recommendations

The purpose of this paper was to investigate the factors that influence the use of digital technologies in the marketing of green leafy vegetables among smallholder farmers in Lari sub-county. In achieving the objective, the multivariate probit regression model was used, and the results indicate that the majority of smallholder farmers were using mobile phones, followed by social media, the internet search engines. The multivariate probit results showed that years of education positively influenced the use of social media in marketing, household size positively influenced the use of mobile phones and social media, and access to electricity positively influenced the use of mobile phones and the internet in the marketing of green leafy vegetables. Age and accessibility of the information had a negative influence on the use of the Internet in the marketing of green leafy vegetables. The study therefore concludes that the use of digital technologies can either be negatively or positively influenced by various factors. Therefore, the study recommends that the government, with the assistance of extension authorities, start more informational programs to encourage smallholder farmers to adopt digital technologies for agricultural marketing and accessing information. Factors like age should be considered when the new technology is introduced.

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